The Hegemon's Dilemma.[*]

Emile Alexandre Marin[†]
University of Cambridge

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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 existing 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 a corrective macro-prudential tax 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 matters for distribution as well as efficiency. 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.

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

1 Introduction

In periods of global financial distress, international capital systematically flows into dollar assets. Dollar shortages in foreign markets are an important and recurrent feature of recent financial crises, including as the 2007 Great Financial Crisis (GFC) and the early-stages of the Covid-19 pandemic. Foreign investors demand dollar debt in large quantities even though, as dollars becomes scarce, the dollar tends to appreciate and the return on a portfolio that is long in dollar bonds, funded by borrowing in foreign currencies becomes significantly negative.[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. but are associated with a dollar appreciation.In this paper, I focus on the implications that the supply and demand of dollar assets in foreign markets has for U.S. domestic outcomes and how this drives optimal policy.

To set the stage for my analysis, Figure 1 documents the recurrent pattern in dollar markets during periods of international turmoil. In particular, the dollar appreciates at the onset of crises and depreciates thereafter. Interest rates on 3-month U.S. treasuries fall, but only moderately (see Figure 1, Panel a). Together, these patterns imply that foreign investors forego significant returns to hold a portfolio of dollar debt which they finance by borrowing in foreign currency during crises (see Figure 1, Panel b). For example, the return on this portfolio in August 2008 was -6% over the next 12 months.[3] 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 repaying foreign debt rises, even if interest rate differentials are small. Additionally, since the GFC, the Federal Reserve has systematically extended dollar swap lines during crises reflecting the dollar shortages which arise. Furthermore, when dollar swap uptake is high, the dollar tends to stop appreciating and the borrowing spread systematically narrows.

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

[1] Dollar shortages in foreign markets can be large. McGuire and Peter (2009) document that European Banks' short term dollar funding gap (i.e dollar roll-over needs) were at least 7% of U.S. GDP at the onset of the GFC. 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.

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

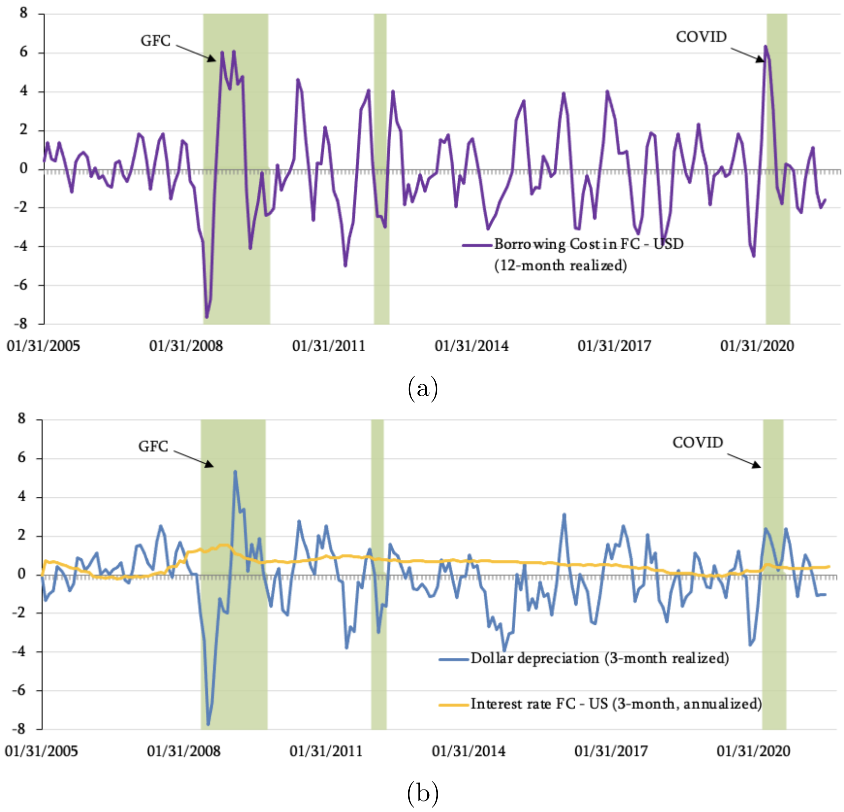

Figure 1: (a) 2-month forward sum of ex-post deviations from the uncovered interest rate parity (UIP) based on a trade-weighted average of G10 and EM7 currencies in *p.p.* (b) 3-month Interest rate differentials, 3-month dollar index movements Shaded regions reflect periods when dollar swap facilities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

internal objectives (output and prices) *or* maximizing monopoly rents earned in international financial markets. The trade-off is driven by the following elements. A scarce dollar leads to a higher return on the net investment position of the U.S.– interpretable as monopoly rents from issuing dollar debt which result in a transfer from abroad.[4] However, this transfer leads to an equilibrium appreciation of the dollar which depresses the global demand for U.S. exports, resulting in unemployment and, on impact, results in losses on the portfolio of foreign-currency denominated assets coming due.[5] Critically, the demand for dollars also causes the private sector in the hegemon 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

[4]Farhi and Maggiori (2016)) also consider a model where a hegemon issuer of reserve currency earns monopoly rents, but they do not consider optimal monetary policy in the hegemon and, in their framework, monopoly rents arise only through lower interest rates.

[5]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. Jiang, Krishnamurthy, and Lustig (2020) descrive the higher expected future returns on the U.S. portfolio as a "capitalization" effect and 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.

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 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 that 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.[6] 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. I define the constrained efficient allocation as the best feasible allocation that can 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, 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

[6] 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).

borrowing externality. Because of this, monetary policy cuts interest rates by less than it would in the constrained efficient allocation— to encourage households to borrow less.[7] 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. I adopt a strict characterization of monetary policy independence,consistent with Farhi and Werning (2014), in the spirit Mundell's policy trilemma.[8] I define monetary policy to be independent if it can achieve the constrained efficient allocation absent the use of any tax on borrowing. Based on this definition, my findings suggest that the U.S. *also* faces a Mundellian policy dilemma, since monetary policy does not achieve the constrained efficient allocation due to capital flows driven by foreigners' demand for dollars.

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.[9] 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 as dollar assets become more easily available. Since dollar swaps address over-borrowing, they help the hegemon regain monetary 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

[7]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.

[8]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.

[9]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).

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 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. Quantitative easing by which the Fed purchases U.S. treasuries also results in a reduction in the supply of dollar assets domestically and abroad.[10]

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.[11] 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 rent maximization to boost aggregate welfare, at the expense of inactive households who suffer from depressed export demand.

I close the paper with a simple quantitative exercise.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 earned on the gross position of the U.S. in dollar debt which is invested abroad, are large and amount to

[10] Krishnamurthy and Lustig (2019) show that quantitative easing where the Fed purchased treasuries indeed widened the treasury basis, consistent with larger shortages in my model.

[11] 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.

about 7% of GDP.[12]

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 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, with equal Pareto weights, 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 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 con-

[12]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.

tributions, I show that these externalities result in a U.S. policy dilemma which, absent capital controls, compromises U.S. monetary and fiscal policy independence.[13] 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.

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.[14] 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 restricted to a three-period model of global banks which later allows for a basic model of production and investment. 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 that studies the implications of limited financial market participation on risk-sharing outcomes in closed and open economies.[15] 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 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.

This paper is structured as follows. Section 2 lays out the model. Section 3 considers a stylized framework which outlines the key trade-offs. Section 4 solves for welfare maximizing policy and analyzes the hegemon's policy dilemma. Section 4.3 considers the distributional implications of dollar shortages in a two-agent version of the model. Section 5 conducts a calibration exercise. Section 6 concludes.

[13] 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.

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

[15] See e.g Alvarez, Atkeson, and Kehoe (2002), Alvarez, Atkeson, and Kehoe (2009), Kollmann (2012) and Cociuba and Ramanarayanan (2017)

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 adopted 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 market 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.[16]

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 borrow in one-period, non-contingent bonds x_t at time t, denominated in domestic currency, and repay R_t at $t+1$. I also allow households to have an exposure to foreign-currency denominated assets. Households take a long position of a_t^F dollars in foreign currency debt (purchasing $\frac{1}{\mathcal{E}_t} a_t^F$ units)

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

with a dollar return $R_t^* \mathcal{E}_t$ at $t+1$.[17] Households also receive a lump-sum rebate from the government T_t in every period. The budget constraint is given by,

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

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.

In the standard segmented markets framework of Gabaix and Maggiori (2015), households can only hold domestic currency assets. Here, households can take a limited position in foreign currency assets a_t^F which I take as exogenous and calibrate to U.S. gross foreign assets in the quantitative exercise.[18]

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

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

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

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

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

[17] 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.

[18] n Fanelli and Straub (2018), the authors assume there is a maximum position in foreign currency that households can take, i.e $\overline{a}^F$. If there is no uncertainty, households will take a position $\overline{a}^F$ at time t as long as $R^* \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} > R_t$. Partial segmentation is considered in the online appendix of Gabaix and Maggiori (2015) where the demand a_t^F is limited to linear rules.

I focus on the case where prices are perfectly rigid.[19] I allow for a constant employment tax τ^L and define the effective wage for firms by $\tilde{W}_t = W_t(1+\tau^L)$.[20] When prices are rigid, I distinguish between two pricing paradigms. Under producer currency pricing (PCP), domestic producers set identical domestic prices for all the goods they produce, regardless of whether they are consumed domestically or exported, as assumed in Galí and Monacelli (2005) and Farhi and Werning (2012). However, 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.[21]

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 labour 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

[19] 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.

[20] 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.

[21] 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).

index $P_t^* = \int (P_{i,t}^{i\ 1-\theta} di)^{\frac{1}{1-\theta}}$ where $P_{i,t}^i$ is the price of good i in country i expressed in domestic currency. I define $\mathcal{E}_t$ as the effective dollar nominal exchange rate, where an increase in $\mathcal{E}_t$ reflects a depreciation of the dollar. Import and export prices for the home country satisfy:

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

where λ is exchange rate pass-through to imports in $i = 0$ and λ^* is exchange rate pass-through on hegemon exports. Under (full) DCP, $\lambda = 0, \lambda^* = 1$.[22] 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 I assume the elasticity of substitution between H and F varieties is the same as in (2) and 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 lump-sum taxes T_t.[23] The government budget constraint is given by:

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

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

[23] In the representative agent model, Ricardian equivalence holds, therefore fluctuations in B_t are 'undone' by household savings decisions, however this result breaks in Section 4.3 where I consider limited financial market participation. Furthermore,I assume the interest rate on (US) household and government bonds is equal. In practice, there is a spread between U.S. treasury yields and corporate debt (TED spread), see Krishnamurthy and Vissing-Jorgensen (2012), Valchev (2020) and Liao (2020).

2.1 International Financial Markets

Asset markets are incomplete and segmented. Markets are incomplete because households in each country trade in non-contingent bonds denominated in domestic currency. Markets are segmented because households are confined to trade within their own financial market segment only, i.e. they cannot directly trade with households in other countries. For simplicity, I focus on a '*dollar*' and a '*foreign*' market segment only.[24]

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 $\{-\overline{Q}, \overline{Q}\}$.[25] 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 with dollar return $R_t^* \mathcal{E}_t$. Since foreign countries are symmetric, $R_{i,t} = R_t^*$ for $i > 0$. Financiers choose a position in dollar bonds $q_t(k)$, financed by a position -$\frac{q_t(k)}{\mathcal{E}_t}$ in foreign-currency bonds, to maximize profits earned at $t + 1$. Specifically, $q_t(k) < 0$ denotes a short position in dollar bonds, i.e. financiers sell a promise to a dollar tomorrow in exchange for $q_t(k)$ dollars today. The problem of an individual financier, indexed by k, at time t can be summarised as,

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

Financial intermediaries participate as long as $|R_t - R_t^* \frac{\mathbb{E}_t[\mathcal{E}_{t+1}]}{\mathcal{E}_t}|\overline{Q}_{t+1} > k$. In equilibrium, a measure $\mathbf{k}_t = |R_t - R_t^* \frac{\mathbb{E}_t[\mathcal{E}_{t+1}]}{\mathcal{E}_t}|\overline{Q}_t$ participate. The total demand for dollars by financiers is given by $Q_t = sign(R_t - R_t^* \frac{\mathbb{E}_t[\mathcal{E}_{t+1}]}{\mathcal{E}_t})\overline{Q}_t \mathbf{k}_t$. I define $\Gamma_t = 1/\overline{Q}_t^2$.

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

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

The LHS of (18) reflects the return required by financiers to engage in abritrage across markets. Suppose there is a shortage of dollars $Q_t < 0$. Then, (18) is the compensation financiers require to intermediate dollar shortages for a given level of (inverse) dollar liquidity

[24] Figure 17 in Appendix E illustrates the market structure: trade in goods across markets is unrestricted, but trade in assets must be intermediated.

[25] 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 restrict the level of dollar liquidity in markets. Evidence of this is provided in Appendix A.

Γ.[26] 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.[27] 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,[28]

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

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 model implies an upward sloping supply curve for dollar debt by financial intermediaries. Figure 2 below illustrates the equilibrium in the dollar market.[29]

The framework above captures two key features of dollar markets. First, non-U.S. entities supply substantial amounts of dollar debt in foreign markets, but face costs. Evidence of issuance of U.S. debt by non-U.S. entities 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, following an unanticipated 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 $\mathbb{E}_t[\xi_t] = \overline{\xi}$ (its steady state value), so they did not require $\mathcal{E}_{t-1}$ to appreciate.

Multipolar World. To highlight the special position of the hegemon in the model, consider the case when there are N competing issuers within a segment, and for clarity, consider the

[26] 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 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.

[27] Liao (2020) and Jiang, Krishnamurthy, and Lustig (2020) show that a similar but smaller spread exists for corporate bonds (AAA to AA-) as well, suggesting the private sector in the U.S. also benefits from this.

[28] 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.

[29] For similicity, I assume $B_t = 0$ in Figure 2. The demand faced by financial intermediaries when foreign investors inelastically demand ξ_t and U.S. households supply an exogenous quantity x is $\xi_t - x$.

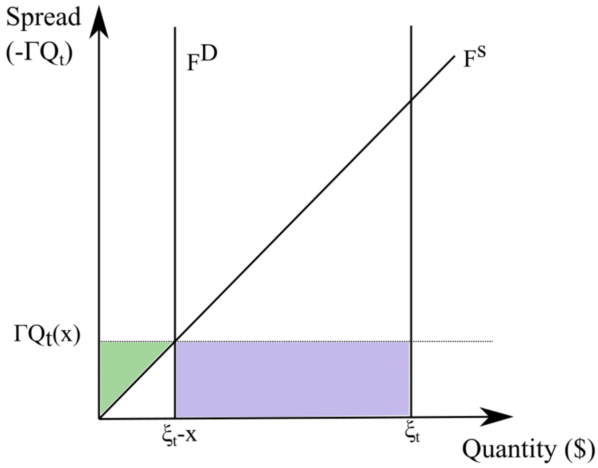

Figure 2: Equilibrium in the dollar market, assuming. F^S denotes the supply of dollars ($Q_t < 0$) by financial intermediaries and F^D denotes the demand for dollar debt financial intermediaries face. The green triangle denotes financiers' profits whilst the purple area captures rents accruing to the hegemon.

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 leads 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. [30]

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 rate, over a 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 so this operation carries minimal risk for the FED. In the model, I assume the FED swaps dollars directly with financial intermediaries expanding the portfolio limits they face.

Whereas absent dollar swaps, each financier could promise a to deliver a maximum $\overline{Q}$ dollars

[30] 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.

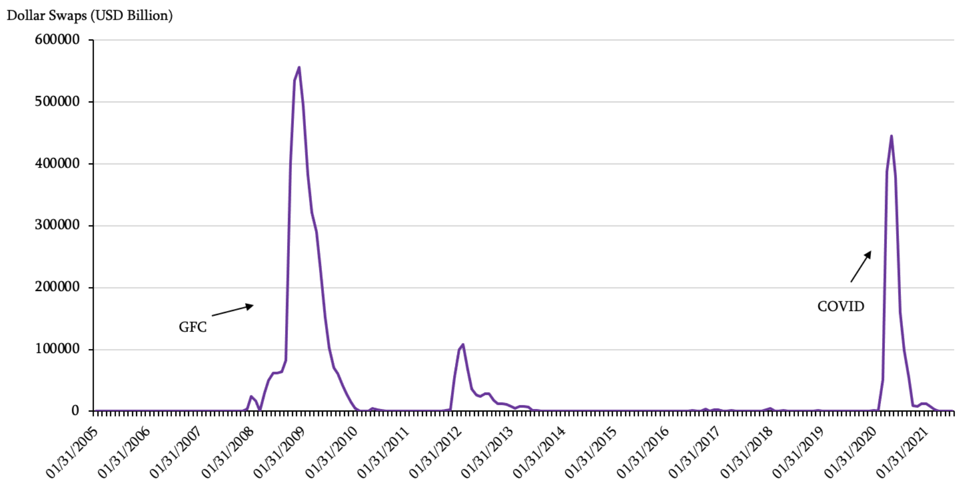

Figure 3: Weekly outstanding dollar swaps (Wednesday level). Source: Federal Reserve

tomorrow, when dollar swaps are available, I assume the financier can promise an additional Q^s dollars tomorrow, which it draws from the swap facility.[31] Financiers will choose to do so as long as the currency-adjusted interest rate differential is greater than the participation cost and the cost of taking up dollar-swaps. Specifically, when dollar swap lines are available, a financier indexed by k faces the following maximization:

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

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

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

In equilibrium, redefining $\Gamma = \frac{1}{\overline{Q}+Q^s}^2$.

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

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

[31] 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.

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:

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

where $\mathbf{k}_t = |R_t - R_t^* \frac{\mathbb{E}_t[\mathcal{E}_{t+1}]}{\mathcal{E}_t}| \overline{Q}_t + Q^s$.

Lemma 1 details that dollar swap lines effectively lower Γ_t, as illustrated in Figure 4 below. Specifically, when dollar swaps are available, fewer, more specialized financiers are able to satisfy the whole demand for dollar debt. Therefore, costs of intermediation are lower as is the equilibrium spread.Financiers' profits captured by the green triangle are lower, as dollars are easier to come by.

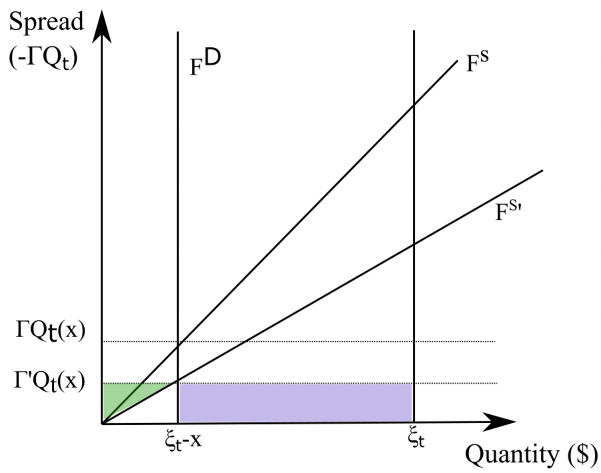

Figure 4: Equilibrium in the dollar market. Extending dollar swaps lines lowers the gradient of F^S, which denotes the supply of dollars by financial intermediaries.

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. When portfolio limits are very tight, e.g. $\overline{Q}_t \to 0$, 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. The spread τ^s is not important to the economics of the model, therefore I consider the limit as $\tau^s \to 0$.[32]

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.*

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. The hegemon is modelled as a small open economy (SOE) which takes P_F^* and R^* as given, but is large in dollar markets. Therefore, the hegemon affects its interest rate only by manipulating excess exchange rate returns.[33] A.2. is a utility specification frequently used in the literature since Cole and Obstfeld (1991), that lends tractability to the model. I relax this assumption in Section 5.

The next lemma summarises the conditions required for an equilibrium.

Lemma 2 (Implementability)
Given $\{\xi_t, \overline{Q}_t, a_t^F\}$, a household allocation $\{C_{H,t}, C_{F,t}, x_t, L_t\}$ and a government allocation $\{G_{H,t}, G_{F,t}, B_t, Q_t^s\}$ with prices $\{\mathcal{E}_t, R_t, W_t, P_{H,t}\}$, taking $\{C_t^*, R_t^*, P_{F,t}^*\}$ as given, constitute part of equilibrium if and only if conditions (5),(7), (9), (16), (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 the expressions for $C_{H,t}^*$, Π_t and T_t into (4), using 9, the expression for T_t and (22) yields the consolidated

[32] 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 $\left(R_t - R_t^* \mathbb{E}_t \left[\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}\right]\right) - \tau^s$ and the hegemon earns $\tau^s \overline{Q}^s \boldsymbol{k}$ rents from extending the dollar swap.

[33] 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.

household budget constraint:[34]

$$C_{F,t} + G_{F,t} \leq \mathcal{E}_t^{-\lambda} \Bigg\{ \underbrace{\zeta \mathcal{E}_t^{\eta} \overline{P}_H^{1-\eta}}_{\overline{P}_H C^*_{H,t}} + (x_t + B_t - a_t^F) - R_{t-1}(x_{t-1} + B_{t-1} - a_{t-1}^F)$$

$$\underbrace{-\Gamma_{t-1} Q_{t-1} a_{t-1}^F}_{\text{(a) Monopoly rents}} \quad \underbrace{-R^* \frac{\mathbb{E}_{t-1}[\mathcal{E}_t] - \mathcal{E}_t}{\mathcal{E}_{t-1}} a_{t-1}^F}_{\text{(b) Valuation effects}} \quad \underbrace{-\omega \Gamma_t Q_t^2}_{\text{(c) Financiers' profits } (-ve)} \Bigg\} \tag{26}$$

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 the U.S. which is financed at cost R_{t-1}. If there are no dollar shortages (or dollar liquidity is abundant $\Gamma = \infty$), and no unexpected movements in the supply or demand for dollars, then $Q_t = 0$ and $\mathbb{E}_{t-1}[\mathcal{E}_t] = \mathcal{E}_t$ so the terms (a), (b) and (c) are zero. The model then coincides with a canonical SOE where dollar and foreign currency debt are interchangeable.

Instead, consider the case of an unexpected increase in the demand for dollars by foreigners $\xi_t - \mathbb{E}[\xi_t] > 0$. Then $Q_t < 0$ and term (a) captures the positive rents from issuing dollar assets and investing them in foreign currency assets. Notice that at time t, monopoly rents are 0 but are positive from $t+1$ onwards since $Q_{t+h} < 0$ for some h. Term (b) captures the valuation effects discussed in Gourinchas, Rey, and Govillot (2018). The contemporaneous appreciation of the dollar at time t lowers the return in dollar terms on foreign assets purchased at $t-1$ and, since this was unexpected, it is not reflected in $\mathcal{E}_{t-1}$ or R_{t-1}. Finally, (c) reflects profits for financial intermediaries of which the hegemon owns a share ω.

2.4 Rents, the Transfer Problem and Monetary Policy.

The hegemon benefits from a transfer of monopoly rents from the foreign sector, akin to seignorage.[35] At time t, foreign investors forego a spread $\Gamma_t Q_t$ on a gross position ξ_t to hold U.S. bonds. Of this, financiers earn a share $\Gamma_t Q_t^2$. In the case that the net investment position of the U.S. is zero ($a_t^F = x_t + B_t$), then, it follows from (26) that the hegemon earns the remaining rents $\Gamma_t Q_t (x_t + B_t)$, shaded in purple in Figure 2.

However, the transfer of wealth leads to a contemporaneous dollar appreciation which can lead to trade-offs. At the crux of the trade-off is a version of the transfer problem, first debated

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

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

[35]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.

in Keynes (1929) and Ohlin (1929).[36,37] Monetary policy in the hegemon has to balance the costs from the dollar appreciation at the onset of the crisis, with the wealth transfer which follows. Note that the hegemon earns rents even if monetary policy keeps interest rates relatively constant, consistent with the relatively narrow interest rate differentials documented in Fig. 1. Monopoly rents then arise through higher future dollar returns on the portfolio of foreign assets, due to the expected depreciation of the dollar moving forward. Monetary policy does determine the magnitude of the rents to the extent that an interest rate movement affects the total supply of dollar debt (akin to a Bernanke and Blinder (1992) credit channel).

3 Analytical Hegemon's Dilemma

In this section, I illustrate the trade-off between maximizing monopoly rents and moderating the demand effects of a dollar appreciation, statically, and for a given monetary policy stance. I describe how debt issuance and dollar swaps affect equilibrium outcomes, and I show that over-borrowing undermines the monopoly rents earned by the hegemon.

Setup. Consider a two-period version $t = \{1, 2\}$ of the model described in Section 2. For simplicity, I abstract from government issuance ($B = 0$) and government spending $G_H = 0$. At time 0, I normalize dollar supply, demand and imbalances to zero ($x_0 = \xi_0 = Q_0 = 0$) and inverse dollar liquidity is given by $\Gamma_0 = \overline{Q}^{-2}$. At $t = 1$, I assume foreigners' demand for dollar debt rises to $\xi_1 = 1$. At $t = 2$, I assume there is no issuance of new households debt in period 2 ($x_2 = 0$) and monetary policy credibly commits to $\mathcal{E}_2 = \overline{\mathcal{E}}$. The monetary authority credibly commits to a long-run exchange rate $\overline{\mathcal{E}}$ in period 2.[38]

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 $R_1 = \beta \frac{\overline{\mu}}{\mu_1}$.[39] I allow μ_1 to depend on Γ_1 and Q_1 as follows:

$$\mu = (1-s)\overline{\mu} + s\overline{\mu}\left(\tfrac{\beta^*}{\beta}(1+\beta^*\Gamma_1 Q_1)\right)^{-1} \tag{27}$$

Rearranging (18) and substituting (27), the exchange rate in the model is expressed as:

$$\mathcal{E}_1 = \overline{\mathcal{E}}\left(\frac{\beta^*}{\beta}\frac{\overline{\mu}}{\mu_1} - \beta^*\Gamma_1[x_1 - \xi_1]\right) \tag{28}$$

The parameter s in (27) governs the responsiveness of monetary policy. Consider two extreme

[36] 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.

[37] In contrast to classical analyses of the transfer problem, I emphasize that transfer leads to macroeconomic externalities not internalized by private agents who trade in financial markets, building on recent theoretical contributions most recently summarized in Bianchi and Lorenzoni (2021). In Section 4.3.

[38] Public debt issuance B_1 enters as a shifter of dollar shortages, with the opposite sign of ξ_1.

[39] As in, e.g, Corsetti and Pesenti (2001), the quantity μ_t is the return on a perpetual bond. This follows from iterating the Euler equation forward and using the identify for μ_t.

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 $\overline{\mathcal{E}}$ and the adjustment happens entirely through a cut in interest rates.

Stabilization and Monopolist Incentives. I posit the hegemon planner optimizes over two main incentives, employment stabilization and maximization of monopoly rents.[40] Define the period-1 labour wedge τ_1 as,

$$\tau_1 = 1 - \frac{1}{A_1}\frac{\kappa}{\chi} C_{H,1} L_1^{\psi}, \tag{29}$$

where $L_1 = C_{H,1} + C^*_{H,1}$. 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. I assume $\tau_0 = 0$ and $\overline{\mathcal{E}}$ is chosen such that $\tau_2 = 0$. 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_2^M as the return on a portfolio x_1 of dollar borrowing, invested in foreign assets and adjusted for the hegemon's share of intermediaries' profits. The hegemon forms an arbitrage portfolio in period 1 $x_1 = a_1^F$ and earns $R_1 - R^* \frac{\overline{\mathcal{E}}}{\mathcal{E}_1}$ in period 2. I further assume that there is a maximum level of borrowing $\overline{x}$.Monopoly rents for the hegemon are given by:

$$\Omega_2^M = -\Gamma_1 Q_1 x_1 + \omega \Gamma_1 Q_1^2 \tag{30}$$

I posit the hegemon planner optimally chooses private debt issuance in period x_1 at $t = 1$, via an implicit macro-prudential tax, 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:

$$\max_{\{B_1, \Gamma_1 \leq \overline{Q}^{-2}\}} \left\{ w^S \; |\tau_0 - \tau_1(x_1, \Gamma_1; \xi_1,)| + (1 - w^S) \; \beta \Omega_2^M(x_1, \Gamma_1; \xi_1) \right\} \tag{HD1}$$

where I make explicit the dependence of the period 1 labour wedge and monopoly rents (earned in period 2) on the supply of dollar assets x_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 τ_0. The second term in (HD1) reflects the incentive to maximize revenues from the hegemon portfolio and 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-

[40]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.

order conditions for (HD1) with respect to x_1 and Γ_1 (if the positive liquidity constraint does not bind) and are presented in Appendix B.

Proposition 1 (Analytical Hegemon's Dilemma)
(i) An increase in dollar shortages $Q_1 < 0$ increases monopoly rents Ω_2^M and widens the labour wedge is $s \neq \bar{s}$.
(ii) Consider the limit $w^S = 1$. The hegemon supplies dollar assets to satisfy demand $x_1 = \xi_1$ or extends dollar swaps such that $\Gamma_1 \to 0$ to perfectly stabilize employment. If $w^s = 0$, the hegemon chooses x_1 at the top of a 'returns Laffer' curve and dollar swaps are not used $\Gamma_1 = \overline{Q}^{-2}$.
Proof. See Appendix B. □

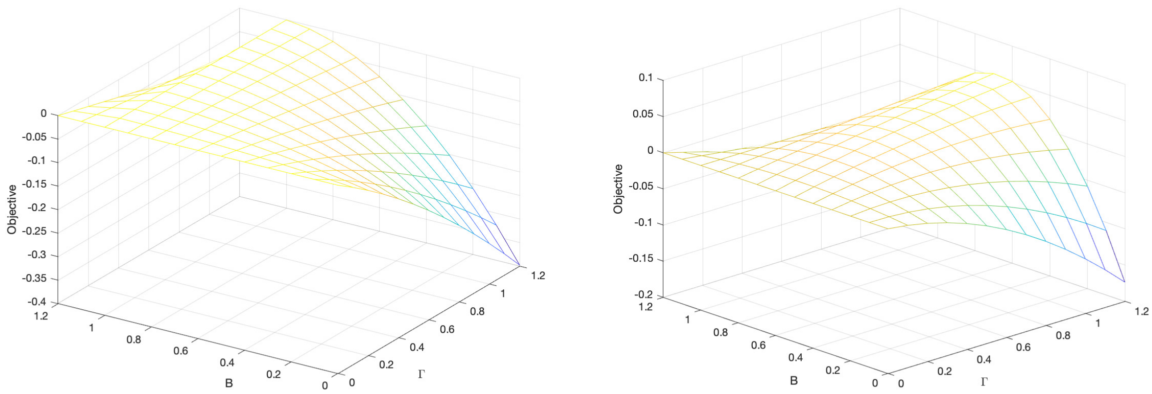

Figure 5: Left panel: $w^S = 1$. Right panel: $w^S = 0$. Parametrization: $s = 0.2, \kappa = \overline{\mu} = \overline{\mathcal{E}} = \zeta = \eta = \psi = 1$, $\chi = 0.6, \chi^G = 0, \beta = \beta^* = 0.99$.

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 $\xi_1 > 0$, this can be achieved using either instrument. The planner can choose debt issuance x_1 such that for any level of dollar demand ξ_1, dollar shortages are zero $Q_1 = 0$ or extend 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. Suppose instead that $w^S = 0$, corresponding to a '*monopolist*' strategy. In this case, the hegemon chooses debt x_1 at the top of a Laffer curve for portfolio returns, detailed in Appendix B and targets a level of dollar shortages $Q_1 < 0$. Monopoly rents are strictly decreasing in dollar liquidity Γ_1 therefore dollar swaps are not used. For intermediate values of ω^S, the hegemon compromises between the two strategies. Figure 5 illustrates the locus of x_1, Γ_1 which maximize the hegemon's objective function in each of the two corner cases.

Exorbitant privilege vs. valuation effects. Monopoly rents represent a wealth inflow to the U.S. during crises, when demand for dollars is high. However, 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. From this, the hegemon earns $R^* \frac{\mathcal{E}_1}{\mathcal{E}_0} - R_0$ in period 1.[41] An unanticipated appreciation of the dollar lowers the dollar-return of the time 0 portfolio at $t = 1$. Proposition 1 (i) continues to hold for a modified range of 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.

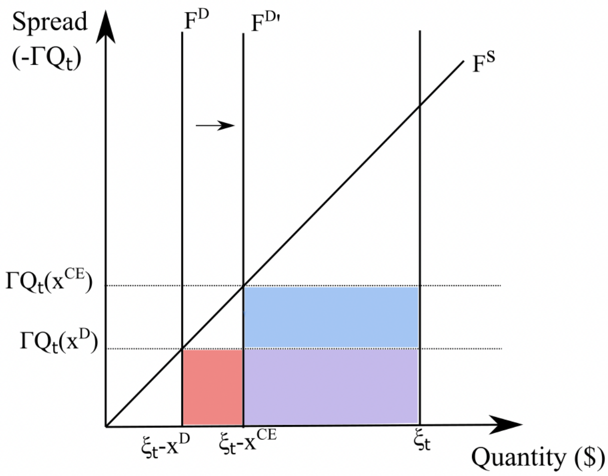

Figure 6: Equilibrium in the dollar market. F^S denotes the supply of dollars ($Q_t < 0$) by financial intermediaries and F^D denotes the demand for dollar debt financial intermediaries face. The foregone rents when issuance is $x^D > x^{CE}$ are given by the difference of the blue and red squares and are always positive. The total rents when issuance is x^{CE} are given by the sum of the purple and blue rectangles.

Over-borrowing and Monetary Policy. (HD1) assumes that private issuance is chosen optimally by the social planner. In practice, absent a tax on private borrowing, households will not make the same economic choices reflecting the presence of macroeconomic externalities. To focus on the financial externality, suppose the planner only cares to maximize monopoly rents ($w^s = 1$) and for simplicity, $\omega = 0$. Then, the planner chooses $x^{CE} = \frac{\xi_1}{2}$, whereas atomistic households who do not internalize that $\frac{dQ_t}{dx_t} > 0$, instead choose $x^D = \overline{x} > x^{CE}$. Figure 6 illustrates the foregone rents for the hegemon if households are over-borrowing.

Returning to the dynamic model in the next section, I show that inefficient levels of private dollar debt issuance constrain the ability of monetary policy to stabilize the economy leading

[41]Notice that this return can be re-written using (18) as $\Gamma_0 Q_0 + (\mathbb{E}_0[\mathcal{E}_1] - \mathcal{E}_1)/\mathcal{E}_0$, where $\Gamma_0 Q_0 = 0$.

to a policy dilemma.Moreover, while the model highlights a key role for the monetary policy rule, it does not pin it down.

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 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.[42] 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:[43]

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

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

where the constraint is the implementability condition to which I attach multiplier η_t^C. 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,

$$\begin{aligned} V(C_{F,t},G_{F,t},\mathcal{E}_t) = \chi \log\left(\tfrac{\chi}{1-\chi}\tfrac{\mathcal{E}_t^\lambda}{\overline{P}_H}C_{F,t}\right) + (1-\chi)\log(C_{F,t}) + \\ \omega^G\left[\chi^G \log\left(\tfrac{\chi^G}{1-\chi^G}\tfrac{\mathcal{E}_t^\lambda}{\overline{P}_H}G_{F,t}\right) + (1-\chi^G)\log(G_{F,t})\right] - \\ \tfrac{1}{1+\psi}\left(\tfrac{1}{A_t}\left[\tfrac{\chi}{1-\chi}\tfrac{\mathcal{E}_t^\lambda}{\overline{P}_H}C_{F,t} + \tfrac{\chi^G}{1-\chi^G}\tfrac{\mathcal{E}_t^\lambda}{\overline{P}_H}G_{F,t} + \zeta\tfrac{\mathcal{E}_t}{\overline{P}_H}{}^\eta\right]\right)^{1+\psi} \end{aligned} \tag{31}$$

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 $C_{F,t}, \mathcal{E}_t$ 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. First, by analogy to the labour wedge τ_t defined in (29), I define the financial (issuance) wedge τ_t^Ω:

$$\tau^\Omega = \frac{R_t + \Gamma_t(x_t + B_t) - 2\omega\Gamma_t Q_t}{R_t} - 1, \tag{32}$$

[42] 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.

[43] 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).

which captures the failure of atomistic private households to internalize the effect of their savings decision on the price of dollar debt. If $x_t + \kappa^G B_t > 0$, $\tau_t^{\Omega} > 0$ as long as $\Gamma_t > 0$.[44]

I combine the first order condition (FOC) for the planner with respect to x_t, which characterizes the socially optimal level of private borrowing, with the FOC with respect to $C_{F,t}$, and the expression for $V_{C_{F,t}}$ detailed in Appendix C. To derive the optimal tax τ_t^x on private borrowing, I compare the planners' optimality condition with the Euler equation (5), which dictates the privately optimal level of borrowing.

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

$$\frac{1 + \frac{\chi}{1-\chi}\tau_{t+1}}{1 + \frac{\chi}{1-\chi}\tau_t}(1 + \tau_t^{\Omega}) > 1, \tag{33}$$

and under-issue otherwise.
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. 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. Market segmentation is particularly important because it exposes the hegemon economy (and optimal policy) to fluctuations in the supply and demand of dollar assets abroad. Moreover, notice that the two externalities which underlie the over-borrowing inefficiency are dynamic versions of the incentives detailed in (HD1). The following corollary details the borrowing tax required at the constrained efficient allocation.

Corollary 1 (Optimal tax on borrowing)
The optimal ex-post borrowing tax is given by:

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

where $\tau_t^x < 0$ denotes a tax on borrowing.

[44] The issuance wedge is also increasing in the share of financiers' profits accruing to the hegemon (ω), since dollar shortages lead to intermediation profits.

Over-borrowing matters because it compromises the ability of other policy instruments to achieve their objectives. To quantify the effects of over-borrowing, I consider the multiplier on the Euler equation denoted by η_t^E,

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

This is derived from the first-order condition of (32) with respect to x_t. The multiplier is greater than zero whenever households are over-borrowing, i.e (33) 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 interest rate faced by the country as a whole (the term in square brackets) is higher than that faced by an atomistic household 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. I assume monetary policy chooses the exchange rate $\mathcal{E}_t$. Combining the FOCs with respect to $\mathcal{E}_t$ and $C_{F,t}$ with $V_{\mathcal{E}_t}$ yields a targeting rule for monetary policy,

$$\underbrace{V_{\mathcal{E}_t} + X_{\mathcal{E}_t}(\eta_t^C)}_{\text{Terms of trade}} + \underbrace{\mathcal{F}_{\mathcal{E}_t}(\eta_t^C, \eta_{t-1}^C, \eta_t^G, \eta_{t-1}^G)}_{\text{Risk sharing}} + \underbrace{\mathcal{R}_{\mathcal{E}_t}(\eta_t^E, \eta_{t-1}^E)}_{\text{Over-borrowing inefficiency}} = 0 \tag{36}$$

where $X_{\mathcal{E}_t}$ denotes the effect of a depreciation on the foreign demand for exports, $\mathcal{F}_{\mathcal{E}_t}$ denotes the effect of a depreciation on households' and governments' returns on their financial position and $\mathcal{R}_{\mathcal{E}_t}$ is the implicit formulation of the Euler equation (5). These terms depend on the constraint multipliers and each term is detailed in Appendix C.

When macro-prudential policy is available ($\mathcal{R}_{\mathcal{E}_t} = 0$ because $\eta_t^E = \eta_{t-1}^E = 0$), the monetary policy targeting rule faces familiar trade-offs. The partial derivative $V_{\mathcal{E}_t}$ captures the direct effects on a depreciation on households' utility. This 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. Monetary policy also take into account that a depreciation increases export revenue expressed in terms of imports. Together these channels capture the terms of trade motive of monetary policy. 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, although this effect is anticipated by investors.

As part of the risk-sharing motive of monetary policy, monopoly rents and valuations effects play an important role in the determination of the optimal policy response. Monetary policy has a strong incentive to fight the appreciation because of valuation effects (the losses accruing on the U.S. portfolio at the onset of the crisis), and so pursues lower interest rates. On the other hand, while the spread $\Gamma_t Q_t$ does not directly depend on the interest rate response, it does depend on the effect of interest rates on the supply of dollar debt (akin to the Bernanke and Blinder (1992) credit channel). Moreover, 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 $\eta_t^E > 0$, $\mathcal{R}_{\mathcal{E}_t} \neq 0$ monetary policy no longer efficiently balances the terms-of-trade and risk-sharing incentives. Because there is over-borrowing in the economy, monetary policy faces an additional incentive to raise interest rates to encourage households to borrow less– partly internalizing the over-issuance. [45] This can result in a larger appreciation which further depresses export demand and lowers the dollar return on foreign currency assets coming due at the onset on the crisis, even though there is still over-borrowing in equilibrium.

This finding can be interpreted in terms of the classical Mundellian Trilemma. Using (36), I can tightly define hegemon monetary policy to be independent when it can achieve the constrained efficient allocation, independent of the level of dollar shortages abroad. 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. In particular, a shortage of dollars provides an incentive for higher interest rates in the U.S. This in itself reduces the supply of dollar debt, perpetuating dollar shortages and potentially worsening outcomes for the rest of the world.

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

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

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

$$\underbrace{-\eta_t^C \mathcal{E}_t^{-\lambda}\{Q_t(x_t+B_t)+\omega Q_t^2)\}}_{\text{cost of foregone issuance rents}} = \underbrace{\eta_t^E \frac{1}{\mathcal{E}_t^{\lambda} C_{F,t}} Q_t}_{\text{cost of over-borrowing}} \tag{37}$$

The left hand side of (37) 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 (37) 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, lowering over-borrowing ($\eta_t^E \downarrow$). 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).[46] 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.

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

Public debt issuance –a first pass. I next investigate whether fiscal policy can be used in place of the optimal borrowing tax or dollar swaps. Consider the limiting case where there is no lump-sum tax available and all government spending is on imports.[47] Consider first the optimal level of debt issuance by the hegemon, described by the FOC of (HD2) with respect to B_t:

$$
\begin{aligned}
\underbrace{\eta_t^G \mathcal{E}_t^{-\lambda}}_{\substack{\text{gain from} \\ \text{issuing unit } B_t}} &= \underbrace{\beta \eta_{t+1}^G \mathcal{E}_{t+1}^{-\lambda} + \Gamma_t \left\{ \eta_{t+1}^G \mathcal{E}_{t+1}^{-\lambda} B_t + \eta_{t+1}^C \mathcal{E}_{t+1}^{-\lambda} (x_t + 2\omega Q_t) \right\}}_{\text{cost of issuing unit } B_t} \\
&\quad - \underbrace{\eta_t^E \Gamma_t \frac{1}{\mathcal{E}_t^{\lambda} C_{F,t}}}_{>0 \ \text{ if over-borrowing}}
\end{aligned}
\tag{38}
$$

The first line of (38) compares the benefit of a unit of debt issued today (LHS) against the cost of a foregone unit of government spending tomorrow (RHS). If macroprudential policy is available ($\eta_t^E = 0$), the optimality condition determines level of public debt issuance which trades-off stabilization incentives (smoothing government spending and aggregate demand) and monopolist incentives captured by the term on Γ_t (manipulating the price of dollar debt). Critically, in the absence of the optimal macroprudential tax, over-borrowing by the private sector incentivizes the government to reduce debt issuance today because the cost of borrowing tomorrow –the RHS of (38)– falls. This comes at the cost of lower government spending today.

However, unlike monetary policy, fiscal policy can directly manipulate dollar imbalances through the supply of public debt. Consider the limit $\omega^G = 0$, in which case $V_{G_{F,t}} = 0$ and dollar debt issuance is not driven by fiscal motives. Rearranging (38) yields:

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

As mentioned above, if macro-prudential policy is optimaly set, then $\eta_t^E = 0$. Notice that (39) suggests that optimal public debt issuance targets the same allocation (under the assumptions detailed above), 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 macro-prudential taxation. However, away from this limit, optimal public debt issuance trades off fiscal incentives and financial terms of trade manipulation but is compromised by the over-borrowing inefficiency. In periods of fiscal downturns (when $G_{F,t}$ is low) $V_{G_{F,t}}$ will rise and the stabilization incentives will dominate the incentive for fiscal policy to monopolistically manipulate dollar supply. This leaves scope for dollar swaps, which affect the level of dollar liquidity, to become a key instrument during crises.

[47] To ensure government spending is positive, I assume there is a fixed level of pre-installed spending $\underline{G}_H$ and $\underline{G}_F$ that are sufficiently large.The level $G_{F,t}$ can then be interpreted as cyclical or discretionary public spending. I relax these assumptions in Section 5 where Ricardian equivalence fails due to limited participation by households.

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.[48] Define,

$$\mathcal{E}_t^{\lambda} C_{F,t} = \mu_t(1-\chi), \tag{40}$$

where μ_t is a synthetic monetary instrument, detailed in Appendix E. When μ grows at a constant rate, (40) 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 (40) and define a corresponding monetary policy wedge:

$$\tau_t^{\mu} = \frac{C_{F,t}^{-\sigma} + \eta_t^{\mu}}{C_{F,t}^{-\sigma}} - 1 \tag{41}$$

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:

$$\frac{1 + \frac{\chi}{1-\chi}\tau_{t+1} - \tau_{t+1}^{\mu}}{1 + \frac{\chi}{1-\chi}\tau_t - \tau_t^{\mu}}(1 + \tau^{\Omega}t + 1) > 1, \tag{42}$$

and under-issue otherwise. Specifically, if $C_{F,t} > C_{F,t+1}$ because of monopoly issuance rents, then $\tau_t^{\mu} > \tau_{t+1}^{\mu}$ and η_t^E will be higher. In this case, the marginal social benefit of increasing dollar swaps rises because η_t^E 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 $\tau_t^{\mu} > \tau_{t+1}^{\mu}$. The marginal social benefit of dollar swaps rises when interest rates do not adjust.

Intuitively, macro-prudential policy acts as a second best instrument for the missing monetary policy as well.

[48] 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 $\beta \to 1$.

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.[49] I make the following assumptions to extend the basic model to the case of limited financial market participation.

A.3 (Limited Financial Market Participation)

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

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

(iii.) Profits from ownership of financial firms Π_t^f accrue 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:

$$\frac{1}{\mathcal{E}_t^\lambda C_{F,t}^A} = \beta R_t \frac{1}{\mathcal{E}_{t+1}^\lambda C_{F,t+1}^A}, \tag{43}$$

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

$$Q_t = \alpha_t x_t + B_t - \xi_t \tag{44}$$

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

[49] 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.

Proposition 5 (Dollar Shortages and Redistribution)
Consumptions of individual active and inactive households are given by,

$$C^A_{F,t} + G_{F,t} \leq \mathcal{E}_t^{-\lambda}\Bigg[\zeta\left(\frac{\mathcal{E}_t}{P_{H,t}}\right)^{\eta} P_{H,t} + (1-(1-\mathbf{a}_t)\chi)F_t + B_t - R_{t-1}B_{t-1}\Bigg], \tag{45}$$

$$C^{NA}_{F,t} + G_{F,t} \leq \mathcal{E}_t^{-\lambda}\Bigg[\zeta\left(\frac{\mathcal{E}_t}{P_{H,t}}\right)^{\eta} P_{H,t} + \mathbf{a}_t\chi F_t + B_t - R_{t-1}B_{t-1}\Bigg], \tag{46}$$

respectively, where,

$$F_t = x_t - a^F_t - R_{t-1}(x_{t-1} - a^F_{t-1}) - \Gamma_{t-1}Q_{t-1}a^F_{t-1} - R^* \tfrac{\mathbb{E}_{t-1}[\mathcal{E}_t]-\mathcal{E}_t}{\mathcal{E}_{t-1}} a^F_{t-1} - \omega\Gamma_t Q_t^2$$

Labour, rationed equally across households, is given by,

$$L_t = \frac{1}{A_t}\frac{1}{\overline{P}_{H,t}}\frac{\chi}{1-\chi}\left\{\zeta\mathcal{E}_t^{\eta-\lambda}P_{H,t} + \frac{\chi^G}{1-\chi^G}G_{F,t} + \mathbf{a}_t F_t + B_t - R_{t-1}B_{t-1}\right\} \tag{47}$$

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,

$$\max_{\{C^A_{F,t}, C^{NA}_{F,t}, \mathcal{E}_t, G_{F,t}, B_t, x_t\}} \sum_{t=0}^{\infty} V(C^A_{F,t}, C^{NA}_{F,t}, G_{F,t}, \mathcal{E}_t; \boldsymbol{\lambda}, \mathbf{a}_t)$$
$$\text{s.t.} \qquad (45), (46)$$

where (45) and (46) 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:[50]

$$1-\tau_t^x = \frac{1+\frac{\chi}{1-\chi}\tau_{t+1}^A+\delta_{t+1}^{NA}}{1+\frac{\chi}{1-\chi}\tau_t^A+\delta_t^{NA}}(1+\tau_t^{\Omega}(\mathbf{a})) \tag{48}$$

where $\delta_t^{NA} = \frac{(1-\mathbf{a})\chi}{1-(1-\mathbf{a})\chi}\left(1+\frac{\chi}{1-\chi}\tau_t^{NA}\right)\frac{C_{F,t+1}^A}{C_{F,t+1}^{NA}}$. This inefficiency and the distributional effects of dollar shortages are quantified in the exercise below.

Fiscal Policy. Two points are noteworthy regarding fiscal policy in the model with limited financial market participation. First, redistributive taxation could complete the market domestically, recovering the representative agent case, much like in Farhi and Werning (2017). Second, even with a lump-sum tax, if it is levied equally across all households, Ricardian equivalence fails and an increase in the supply of public debt will result in a higher net supply of dollar assets to abroad. So fiscal policy faces an analogous trade-off to (38).

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 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.[51] 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.[52] I choose $\frac{1}{Q}^2 = 0.14$, based on an internal calibration such that

[50] The derivation follows the proof to Proposition 1, using (45) and (46).
[51] See e.g Valchev (2020), Eichenbaum, Johannsen, and Rebelo (2020).
[52] 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.

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.

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.

5.1 Dollar demand shock.

The analysis focuses on a shock to dollar demand by foreign agents ξ_t.[53] 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 7 (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-

[53] 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.

ure 7 (right panel). The implied size of the dollar demand shock is about 7% of U.S. GDP.[54]

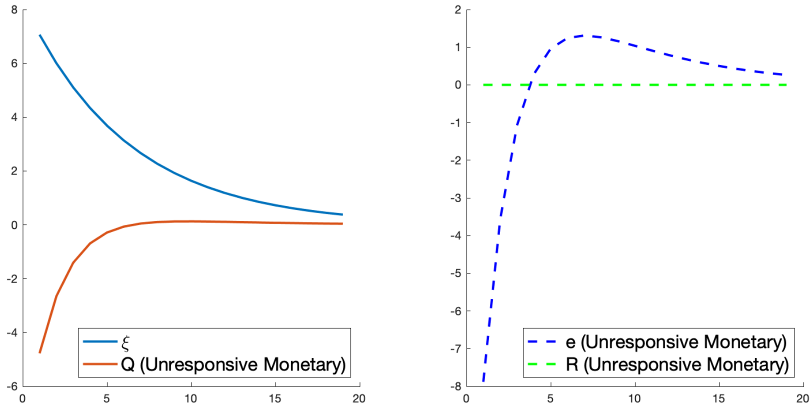

Figure 7: Impulse response to dollar demand shock ξ_t. Left panel: Dollar demand shock dollar shortages expressed in % of U.S. GDP. Right panel: Exchange rate appreciation in % deviations from steady state.

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.

Starting from the left panel of Figure 8, 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

[54] 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.

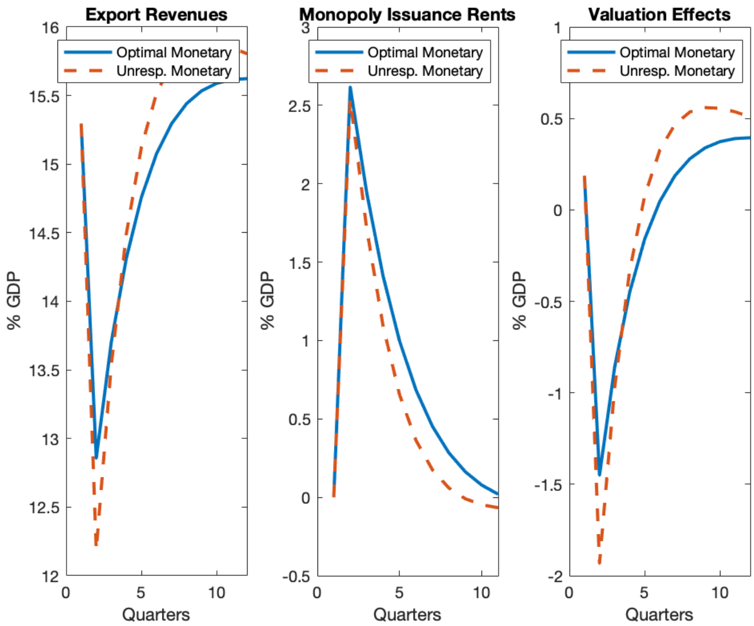

Figure 8: Impulse response to $\xi > 0$. Comparison of export revenues, monopoly rents from issuance and valuation effects, as % of GDP per quarter (flow), under the optimal and unresponsive monetary regimes.

movements and two-thirds were due to a fall in returns on risky assets.[55]

5.3 Evaluating the effectiveness of policy

Monetary Policy. Figure 9 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 (36). 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 7. 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.[56] As reflected in the monetary policy targeting rule (74), absent a borrowing tax, the monetary authority accepts a degree of externally induced employment volatility and private

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

[56]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.

sector over-borrowing.[57]

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.

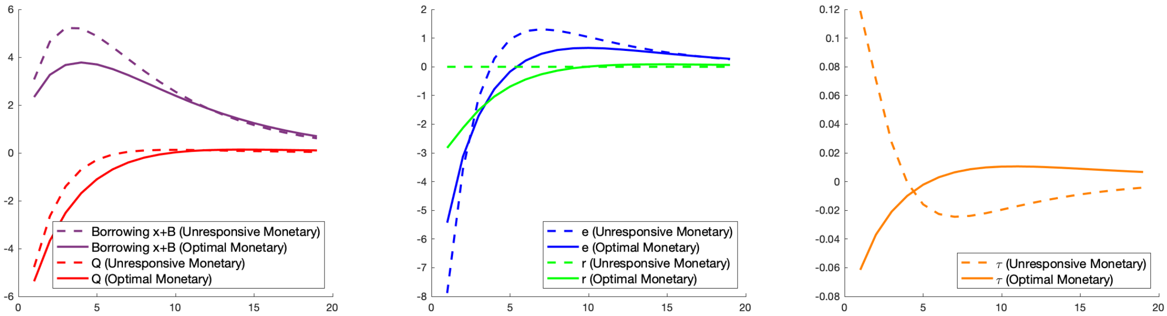

Figure 9: Impulse response to dollar demand shock ξ_t Comparison of optimal monetary (solid line) policy vs. passive monetary policy (dashed line). Left Panel: Sum of private and public borrowing expressed as % GDP in deviations from steady state. Middle panel: Exchange rate and interest rate movements expressed in % deviations from steady state. Right panel: Labour wedge deviations.

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 10 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.[58]

Constrained Optimal Allocation and Monetary Policy Trade-offs. Consider now the constrained optimal allocation which is achieved by the combination of monetary policy and a borrowing tax. At the constrained optimum allocation, the interest rate cut is larger (5% vs. 3%, subject to the effective lower bound), lowering the pressure on the exchange rate to appreciate, as illustrated in Fig. 11 (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

[57] 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.

[58] 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.

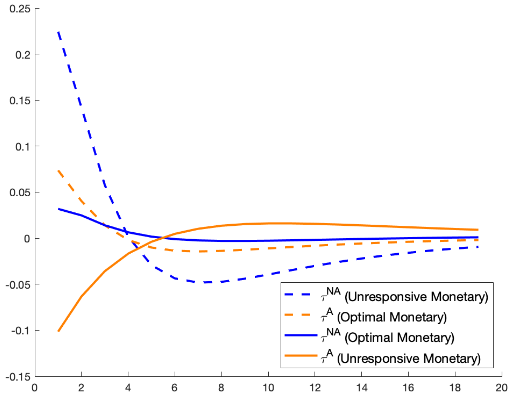

Figure 10: Impulse response to dollar demand shock ξ_t. Labour wedge deviations.

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.[59]

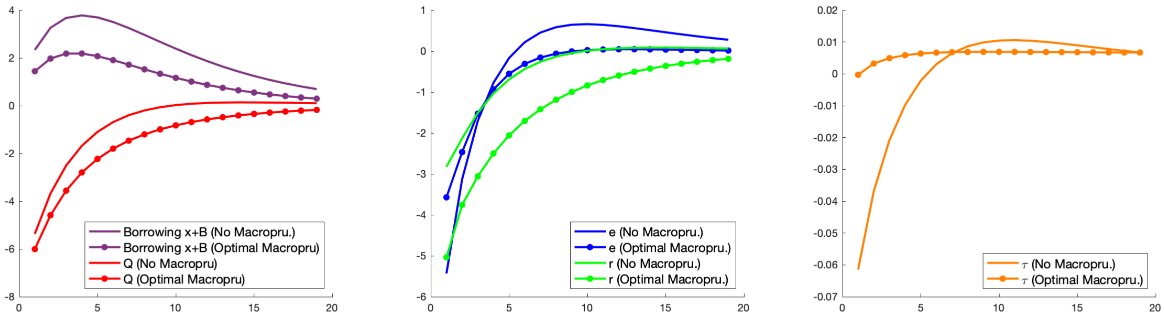

Figure 11: Impulse response to $\xi^* > 0$. Comparison of optimal macropru (rivetted line) vs. no macropru.(solid line). Left Panel: Sum of private and public borrowing expressed as % GDP in deviations from steady state. Middle panel: Exchange rate and interest rate movements expressed in % deviations 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

[59]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.

liquidity is Γ by,

$$\mathcal{W}(\{\mathcal{E}_t, \tau_t^x\}; \{\Gamma, \xi_t\}) \tag{49}$$

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

$$\sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^i (1+\nu_t^i)^{1-\sigma}}{1-\sigma} - \kappa \frac{L_t^{1+\psi}}{1+\psi} + V(G_t) \right] = \mathcal{W}(\{\mathcal{E}_t, \tau_t^x\}; \Gamma, 0), \tag{50}$$

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.[60] 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.

	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.

When interest rates do not respond (first row of Table 2), dollar shortages cost about 0.31% 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, 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%).

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:

$$\mathcal{W}(\{\mathcal{E}_t, \tau_t^x\}; \{\tfrac{1}{Q+Q^s}^2, \xi_t\}) > \mathcal{W}(\{\mathcal{E}_t, \tau_t^x\}; \{\tfrac{1}{Q}^2, \xi_t\}) \tag{51}$$

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

Dollar demand shocks on their own 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 interest rates in the U.S. have been at or near the zero lower bound since the GFC and have likely responded less to inflows than they otherwise would have. I show that this results in a higher level of over-borrowing. 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 $\mathbf{a}_t\lambda^A + (1-\mathbf{a}_t)\lambda^{NA} = 1$, 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. The cost of a dollar appreciation is higher if it depresses exports and imports fo not become substantatially cheaper (i.e λ is low).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.[61]

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

[61]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.

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.

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A Additional Empirical Evidence.

Evidence on deviations from the Uncovered Interest Parity and Monopoly Rents. Figure 12 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.

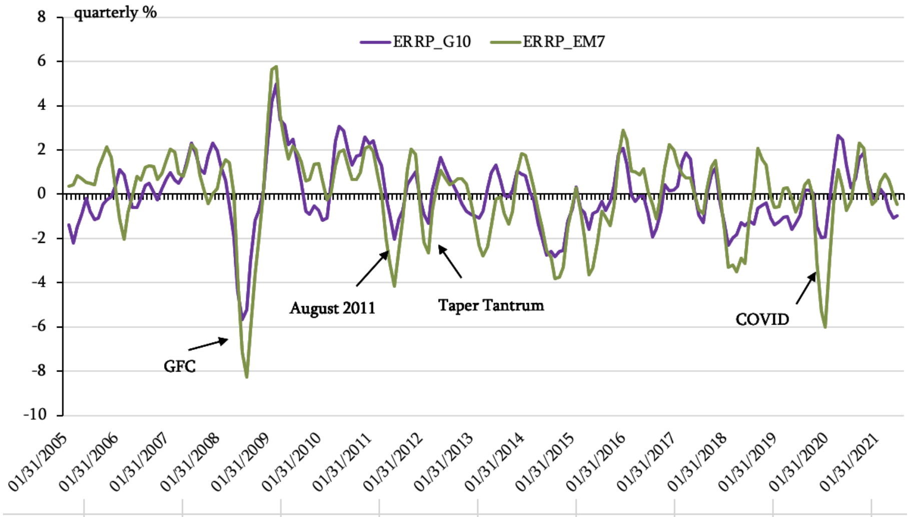


Figure 12: Source: Federal Reserve

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 13 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 14, 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

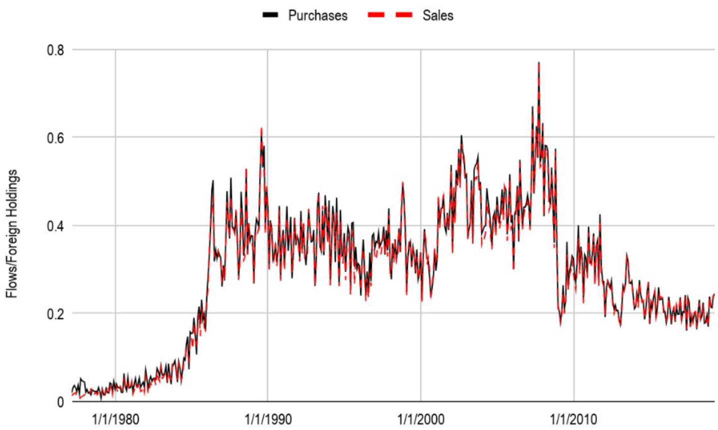
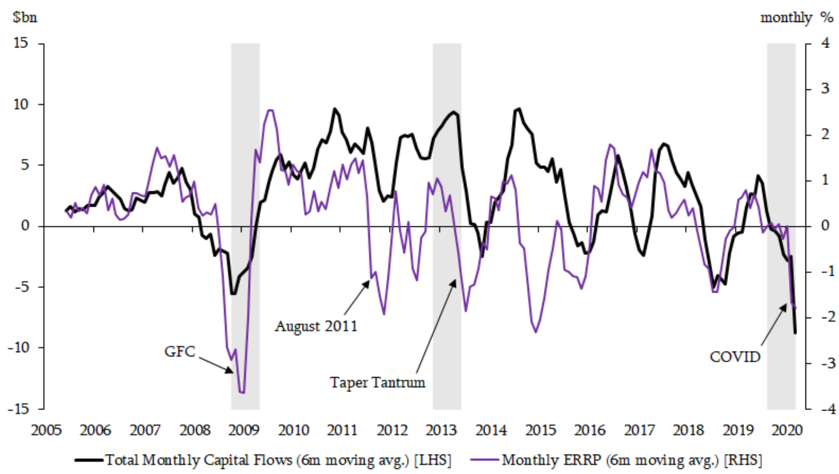


Figure 13: Evidence on timing of purchases of U.S. bonds by foreigners. Purchases by foreign investors and sales to foreign investors normalised by the foreign holdings of Treasuries. Source: Krishnamurthy and Lustig (2019).

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 14: 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 15 (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 15: 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.

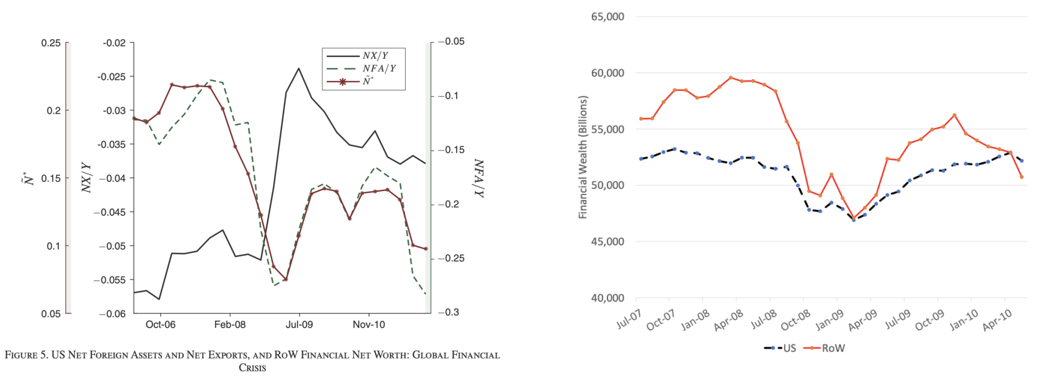


Figure 16: Left panel: Figure 5 from Maggiori (2017). Right panel: Figure 5 from Jiang, Krishnamurthy, and Lustig (2020).

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

The exchange rate can be expressed as,

$$\mathcal{E}_1 = \overline{\mathcal{E}}\left(\frac{\beta}{\beta^*}\frac{\mu_1}{\overline{\mu}} + \frac{\Gamma_1}{\beta^*}Q_1\right) \tag{52}$$

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

$$\mu = \overline{\mu}(1-s) + s\overline{\mu}\left(\tfrac{\beta^*}{\beta}\tfrac{\hat{\mathcal{E}}}{\overline{\mathcal{E}}} - \tfrac{\Gamma_1 Q_1}{\beta}\right) \tag{53}$$

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,

$$\frac{d\mathcal{E}_1}{dB_1} = \left(\beta\frac{d\mu_1}{dQ_1} - \Gamma_1\right)\frac{\overline{\mathcal{E}}}{\beta^*}, \tag{54}$$

$$\frac{d\mathcal{E}_1}{d\tilde{\Gamma}_1} = \left(\beta\frac{d\mu_1}{d\tilde{\Gamma}_1} - Q_1\right)\frac{\overline{\mathcal{E}}}{\beta^*} \tag{55}$$

Consider the labour wedge τ_1, given by (29). The derivatives with respect to Q_1(holding B_1 and x_1 constant), B_1 and $\tilde{\Gamma}_1$ respectively:

$$\frac{d\tau_1}{dB_1} = -\frac{1}{A_1}\frac{\kappa}{\overline{p}_H}\left\{\frac{d\mu_1}{dB_1}L_1^{\psi} + \mu\psi L^{\psi-1}\left[\frac{\chi}{\overline{p}_H}\frac{d\mu_1}{B_1} + \frac{\zeta}{\overline{p}_H}\mathcal{E}_1^{\eta-1}\eta\frac{d\mathcal{E}_1}{dB_1}\right]\right\}, \tag{56}$$

$$\frac{d\tau_1}{d\Gamma_1} = -\frac{1}{A_1}\frac{\kappa}{\overline{p}_H}\left\{\frac{d\mu_1}{d\Gamma_1}L_1^{\psi} + \mu\psi L^{\psi-1}\left[\frac{\chi}{\overline{p}_H}\frac{d\mu_1}{d\Gamma_1} + \frac{\zeta}{\overline{p}_H}\mathcal{E}_1^{\eta-1}\eta\frac{d\mathcal{E}_1}{d\Gamma_1}\right]\right\}, \tag{57}$$

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:

$$\frac{d\Omega_1^M}{dB_1} = -\Gamma_1 Q_1 - \Gamma_1 B_1 + 2\omega\Gamma_1 Q_1 \tag{58}$$

$$\frac{d\Omega_1^M}{d\Gamma_1} = -Q_1 B_1 + \omega\Gamma_1 Q_1^2 \tag{59}$$

Additionally,

$$\frac{d\tau_1}{dQ_1} = -\frac{1}{A_1}\frac{\kappa}{\overline{p}_H}\left\{\frac{d\mu_1}{dQ_1}L_1^{\psi} + \mu\psi L^{\psi-1}\left[\frac{\chi}{\overline{p}_H}\frac{d\mu_1}{B_1} + \frac{\zeta}{\overline{p}_H}\mathcal{E}_1^{\eta-1}\eta\frac{d\mathcal{E}_1}{dQ_1}\right]\right\}, \tag{60}$$

$$\frac{d\Omega_1^M}{dQ_1} = \beta\frac{1}{\overline{\mu}}\frac{d\mu_1}{dQ_1}(B_1 + x_1) + \omega\Gamma_1 2Q_1, \tag{61}$$

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

First, rearranging (60) and substituting (27), I derive $\frac{d\tau_1}{dQ_1} < 0$ if:

$$\frac{d\mu_1}{dQ_1} > -\frac{\frac{1}{\beta^*}\mu_1\psi L_1^{\psi-1}\frac{\zeta}{p_H}\mathcal{E}_1^{\eta-1}\eta\overline{\mathcal{E}}\Gamma_1}{L_1^{\psi}+\mu_1 L_1^{\psi-1}\psi(\frac{\chi}{p_H}+\frac{\zeta}{p_H}\mathcal{E}_1^{\eta-1}\eta\overline{\mathcal{E}}\frac{\beta}{\beta^*}\frac{1}{\overline{\mu}})} \leftrightarrow \tag{62}$$

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

where $\overline{s} \in [0,1]$. Using (61), $\frac{d\Omega_1^M}{dQ_1} < 0$ 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 ,

$$\omega^S \text{sign}(\overline{\tau}-\tau_1)\frac{d\tau_1}{dB_1} + (1-\omega^S)\frac{d\Omega_1^M}{dB_1} = 0, \tag{63}$$

$$\omega^S \text{sign}(\overline{\tau}-\tau_1)\frac{d\tau_1}{d\Gamma_1} + (1-\omega^S)\frac{d\Omega_1^M}{d\Gamma_1} = 0, \tag{64}$$

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 (56)-(59). If $\Gamma_1 \geq \frac{1}{Q}$ then 64 is replaced by $\Gamma_1 = \frac{1}{Q}$.

Combining (63) and (64) with (56)-(61) 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 (63) and substituting (27):

$$B_1 = \xi_1\frac{1-2\omega}{2-2\omega} \tag{65}$$

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 (67) is satisfied, then, from (64) we see that dollar swaps become useful as $|\tau - \overline{\tau}|$ grows. This completes the proof of (ii). □

Proof to Proposition 1. From (56) 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 (58) 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:

$$\underline{s} = 1 - \frac{\Gamma_1 B_1 - 2\omega \Gamma_1 Q_1}{\Psi_1^* \Gamma_1 \overline{E} \beta^*} \tag{66}$$

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 analyze the effects of international competition in issuance of dollar (or close-substitute) assets, building on Farhi and Maggiori (2016). Dollar market clearing is given by (20) when there are substitute assets. I focus on the case $w^S = 0$ assume for simplicity that $x_0 = 0$. Imposing symmetry, it can be shown that the social planner chooses issuance, [62]

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

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.

[62] To derive this, notice that (63) implies

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

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):

$$V(C_{F,t}, \mathcal{E}_t, G_{F,t}) = \chi \log\left(\frac{\chi}{1-\chi}\frac{\mathcal{E}_t^\lambda}{\overline{P}_H}C_{F,t},\right) + (1-\chi)\log(C_{F,t}) \tag{67}$$
$$-\kappa\frac{\left(\frac{1}{A_t}\left[\frac{\chi}{1-\chi}\frac{\mathcal{E}_t^\lambda}{\overline{P}_H}C_{F,t}, +(1-\chi)\frac{\mathcal{E}_t^\lambda}{\overline{P}_H}C_t^* + \frac{\chi^G}{1-\chi^G}\frac{\mathcal{E}_t^\lambda}{\overline{P}_H}G_{F,t}\right]\right)^{1-\psi}}{1-\psi}$$
$$+\omega^G\left[\chi^G\log(\frac{\chi^G}{1-\chi^G}\frac{\mathcal{E}_t^\lambda}{\overline{P}_H}(G_{F,t}+\underline{G}_F)] + (1-\chi^G)\log(G_{F,t}+\underline{G}_F)\right]$$

Assuming prices are perfectly rigid, $P_{H,t} = \overline{P}_H$, $P_{F,t} = \overline{P}_F^*\mathcal{E}_t^\lambda = \mathcal{E}_t^\lambda$. 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,

$$C_H^* = \chi\left(\frac{P^*}{P_H^*}\right)^\eta C^* = \underbrace{\chi\mu^*}_{\zeta}\left(\frac{\mathcal{E}_t}{\overline{P}_H}\right)^\eta, \tag{68}$$

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

When prices are flexible, the indirect utility function is given by $V^{flex}(C_{F,t}, G_{F,t})$. Defining $S_t = \frac{P_{F,t}}{P_{H,t}}$, we can show S_t is a function of C_t and G_t using the following condition, derived from (29) and setting $\tau_t = 0$:

$$\frac{1}{A_t}\frac{\kappa}{1-\chi}\frac{S_t}{\overline{P}_H}C_{F,t}\left[\frac{1}{A_t}\left(\frac{\chi}{1-\chi}\frac{S_t}{\overline{P}_H}C_{F,t} + (1-\chi)S_tC_t^* + \frac{\chi^G}{1-\chi^G}S_tG_{F,t}\right)\right] = 1 \tag{69}$$

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

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

$$V_{C_{F,t}} = \frac{1-\chi}{C_{F,t}}\left(1 + \frac{\chi}{1-\chi}\tau_t\right), \tag{70}$$

$$V_{\mathcal{E}_t} = \frac{1-\chi}{C_{F,t}}\left(\mathcal{E}_t^{-1}\tau_t\left(\frac{\chi}{1-\chi}\lambda C_{F,t} + \zeta\mathcal{E}_t^{1-\lambda} + \frac{\chi^G}{1-\chi^G}\lambda G_{F,t}\right) - \zeta\mathcal{E}_t^{-\lambda} - \frac{\chi^G}{1-\chi^G}\lambda\mathcal{E}_t^{-1}G_{F,t}\right) \tag{71}$$
$$+\omega^G\frac{1-\chi^G}{G_{F,t}+\underline{G}_F}\frac{\chi^G}{1-\chi^G}\lambda\mathcal{E}_t^{-1}G_{F,t},$$

$$V_{G_{F,t}} = \frac{1-\chi}{C_{F,t}}(\tau_t - 1)\frac{\chi^G}{1-\chi^G} + \omega^G\left\{\frac{1-\chi^G}{G_{F,t}+\underline{G}_F}\left(\frac{1}{1-\chi^G}\right)\right\} \tag{72}$$

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:

$$C_{F,t}: \qquad \beta^t V_{C_{F,t}} - \eta_{1,t} - \eta_{2,t} + \frac{1}{\mathcal{E}_t^{\lambda} C_{F,t}^2}\left[\eta_t^E \frac{1}{R_t} - \eta_{t-1}^E\right] = 0, \tag{73}$$

$$\mathcal{E}_t: \qquad \beta^t V_{\mathcal{E}_t} + \eta_t^C \zeta(\eta-\lambda)\mathcal{E}_t^{\eta-\lambda-1} - \eta_t^C \left\{\lambda \mathcal{E}_t^{-\lambda-1}\kappa^G \Psi_t^G - (1-\lambda)\mathcal{E}_t^{-\lambda}\Psi_t^*\right\} \tag{74}$$
$$+ \eta_t^C \left\{\frac{1}{R^*}(1-\lambda)\frac{\mathcal{E}_t^{-\lambda}}{\mathcal{E}_{t+1}} x_t + \lambda \mathcal{E}_t^{-\lambda-1}(x_{t-1} + \kappa^G B_{t-1}) + \lambda \mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t^2(1-\omega) + \lambda \mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t(\xi_t - B_t)\right\}$$
$$- \frac{1}{\beta}\eta_{t-1}^C \frac{1}{R^*}\frac{\mathcal{E}_{t-1}^{1-\lambda}}{\mathcal{E}_t^2} x_{t-1} + \eta_t^G \left\{-\lambda \mathcal{E}_t^{-\lambda-1}\Psi_t(1-\kappa^G) + (1-\lambda)\Psi^* \mathcal{E}_t^{-\lambda}(1-\kappa^G)\right\}$$
$$+ \eta_t^G \left\{\frac{1}{R^*}\frac{\mathcal{E}_t^{-\lambda}(1-\lambda)}{\mathcal{E}_{t+1}} B_t + \lambda \mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t + \lambda \mathcal{E}_t^{-\lambda-1}(1-\kappa^G)B_{t-1}\right\} - \eta_{t-1}^G \frac{1}{\beta}\frac{1}{R^*}\frac{\mathcal{E}_{t-1}{}^{1-\lambda}}{\mathcal{E}_t^2} B_{t-1}$$
$$- \eta_t^E \frac{1}{C_{F,t}}\left\{\frac{1}{R^*}(1-\lambda)\frac{\mathcal{E}_t^{-\lambda}}{\mathcal{E}_{t+1}} + \lambda \mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t B_t\right\} + \eta_{t-1}^E \frac{1}{C_{F,t}}\left\{\frac{1}{\beta}\frac{1}{R^*}\frac{\mathcal{E}_{t-1}^{1-\lambda}}{\mathcal{E}_t^2}\right\},$$
$$- \eta_t^{\mu}\lambda \mathcal{E}_t^{-\lambda-1}\mu(1-\chi) = 0,$$

$$x_t: \qquad \eta_t^C \mathcal{E}_t^{-\lambda}\left[\frac{1}{R_t} - \Gamma_t x_t + 2\omega \Gamma_t Q_t\right] - \beta \eta_{t+1}^C \mathcal{E}_{t+1}^{-\lambda} - \eta_t^G \mathcal{E}_t^{-\lambda}\Gamma_t B_t + \eta_t^E \left\{\Gamma_t \tfrac{1}{\mathcal{E}_t^{\lambda} C_{F,t}}\right\} = 0, \tag{75}$$

$$G_{F,t}: \qquad \beta^t V_{G_{F,t}} + \eta_t^C \left\{\frac{\chi^G - \kappa^G}{1-\chi^G}\right\} - \eta_t^G \left\{\frac{1-\kappa^G}{1-\chi^G}\right\} = 0, \tag{76}$$

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

Focusing on monetary policy, using (74) the monetary policy targetting rule can be written as:

$$V_{\mathcal{E}_t} + \eta_t^C \frac{dC_{H,t}^*}{d\mathcal{E}_t} + \left\{\eta_t^C \frac{dF_t}{d\mathcal{E}_t} + \eta_{t-1}^C \frac{dF_{t-1}}{d\mathcal{E}_t}\right\} + \left\{\eta_t^G \frac{dF_t^G}{d\mathcal{E}_t} + \eta_{t-1}^G \frac{dF_{t-1}^G}{d\mathcal{E}_t}\right\} \tag{78}$$
$$+ \left\{\eta_t^E \frac{d\mathcal{R}_t}{d\mathcal{E}_t}\right\} + \left\{\eta_{t-1}^E \frac{d\mathcal{R}_{t-1}}{d\mathcal{E}_t}\right\} = 0,$$

where,

$$\frac{dC^*_{H,t}}{d\mathcal{E}_t} = \zeta(\eta - \lambda)\mathcal{E}_t^{\eta-\lambda-1}, \tag{79}$$

$$\frac{dF_t}{d\mathcal{E}_t} = -\left(\lambda\mathcal{E}_t^{-\lambda-1}\kappa^G\Psi_t^G - (1-\lambda)\mathcal{E}_t^{-\lambda}\Psi_t^*\right) + \tag{80}$$

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

$$\frac{dF_{t-1}}{d\mathcal{E}_t} = -\frac{1}{R^*}\frac{\mathcal{E}_{t-1}^{1-\lambda}}{\mathcal{E}_t^2}x_{t-1} \tag{81}$$

$$\frac{dF_t^G}{d\mathcal{E}_t} = \frac{1}{R^*}\frac{\mathcal{E}_t^{-\lambda}(1-\lambda)}{\mathcal{E}_{t+1}}B_t + \lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t + \lambda\mathcal{E}_t^{-\lambda-1}(1-\kappa^G)B_{t-1} \tag{82}$$

$$\frac{dF_{t-1}^G}{d\mathcal{E}_t} = -\frac{1}{R^*}\frac{\mathcal{E}_{t-1}}{\mathcal{E}_t^2}B_{t-1}, \tag{83}$$

$$\frac{dR_t}{d\mathcal{E}_t} = -\frac{1}{C_{F,t}}\left\{\frac{1}{R^*}(1-\lambda)\frac{\mathcal{E}_t^{-\lambda}}{\mathcal{E}_{t+1}} + \lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t\right\}, \tag{84}$$

$$\frac{dR_{t-1}}{d\mathcal{E}_t} = \frac{1}{C_{F,t}}\left\{\frac{1}{\beta}\frac{1}{R^*}\frac{\mathcal{E}_{t-1}^{1-\lambda}}{\mathcal{E}_t^2}\right\} \tag{85}$$

In the main body, (36) follows from grouping the terms in (87) as follows:

$$V_{\mathcal{E}_t} + \underbrace{\eta_t^C\frac{dC^*_{H,t}}{d\mathcal{E}_t}}_{X_{\mathcal{E}_t}} + \underbrace{\left\{\eta_t^C\frac{dF_t}{d\mathcal{E}_t} + \eta_{t-1}^C\frac{dF_{t-1}}{d\mathcal{E}_t}\right\}}_{\mathcal{F}_{\mathcal{E}_t}} \tag{86}$$

$$+ \underbrace{\left\{\eta_t^E\frac{d\mathcal{R}_t}{d\mathcal{E}_t}\right\} + \left\{\eta_{t-1}^E\frac{d\mathcal{R}_{t-1}}{d\mathcal{E}_t}\right\}}_{\mathcal{R}_{\mathcal{E}_t}} = 0$$

Specifically, with respect to the over-borrowing inefficiency, if $\eta_t^E > 0$, the hegemon has an incentive to appreciate the exchange rate (higher interest rates) so that households delay consumption to the future. Since policy is set with commitment this is expected. Households at t expecting an appreciation at time $t+1$, would instead increase their consumption and borrowing. Rolling the periods back by one, this is reflected in the term on η_{t-1}^E.

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:

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

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

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

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

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

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

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

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

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

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

$$C_{F,t}\leq\mathcal{E}_t^{-\lambda}\Bigg\{P_{H,t}^{1-\eta}\zeta\mathcal{E}_t^{\eta}+\mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right]\frac{1}{R^*}x_t \qquad \underbrace{-\Gamma Q_t(\xi_t-B_t)}_{\text{(a) Monopoly issuance rents (+ve)}} \qquad \underbrace{-\Gamma Q_t^2(1-\omega)}_{\text{(b) Cost of segmentation }(-ve)}$$

$$-(x_{t-1}+\kappa^G B_{t-1})+G_{F,t}\left(\frac{\chi^G(1-\kappa^G)}{1-\chi^G}P_{H,t}^{1-\frac{1}{\theta}}P_{F,t}^{\frac{1}{\theta}}-\kappa^G P_{F,t}\right)+\kappa^G\hat{\Psi}_t(\mathcal{E}_t)\Bigg\} \quad (91)$$

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

$$C^{NA}_{F,t} \leq \mathcal{E}_t^{-\lambda}\left[\frac{\mathbf{a}_t\chi}{1-(1-\mathbf{a}_t)\chi}\mathcal{E}_t^{\lambda}C^A_{F,t} + \frac{1-\chi}{1-(1-\mathbf{a}_t)\chi}\left(\zeta\mathcal{E}_t^{\eta} + \frac{\chi^G-\kappa^G}{1-\chi^G}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1}\right)\right] \tag{92}$$

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

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

$$\left.\frac{1}{R_t}x_t - x_{t-1} + \omega\Gamma_t Q_t^2\right] \tag{94}$$

Solving (92) and (94) jointly and substituting T_t yields :

$$\begin{aligned} C^A_{F,t} \leq \mathcal{E}_t^{-\lambda}\Bigg[&\zeta\mathcal{E}_t^{\eta} + \frac{\chi^G-\kappa^G}{1-\chi^G}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1}) + \\ &(1-(1-\alpha)\chi)\left(\frac{1}{R_t}x_t - x_{t-1}\right) + \omega\Gamma_t Q_t^2\Bigg], \end{aligned} \tag{95}$$

as detailed in (45). Substituting back into (92) yields:

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

Substituting the above into market clearing yields:

$$L_t = \frac{1}{A_t}\frac{\mathcal{E}_t^{\lambda}}{\overline{P}_{H,t}}\left(\frac{\chi}{1-\chi}\frac{\mathbf{a}_t}{1-(1-\mathbf{a}_t)\chi}C^A_{F,t} + \frac{(1-\alpha)\chi}{1-(1-\mathbf{a}_t)\chi}\left(\zeta\mathcal{E}^{\eta-\lambda} + \frac{\chi^G-\kappa^G}{1-\chi^G}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1})\right)\right) \tag{97}$$

which can be re-written as:

$$\begin{aligned} L_t = \frac{1}{A_t}\frac{1}{\overline{P}_{H,t}}\frac{\chi}{1-\chi}&\left\{\zeta\mathcal{E}^{\eta-\lambda} + \frac{\chi^G-\kappa^G}{1-\chi^G}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1})\right\} + \\ &\frac{1}{A_t}\frac{1}{\overline{P}_{H,t}}\frac{\chi}{1-\chi}\left(\frac{1}{R_t}x_t - x_{t-1} + \omega\Gamma_t Q_t^2\right) \end{aligned} \tag{98}$$

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,

$$V\left(C^{A}_{F,t}, C^{NA}_{F,t}, \mathcal{E}^{\lambda}_{t} G_{F,t}; \boldsymbol{\lambda}, \mathbf{a}_t\right) = \mathbf{a}_t\, \mathcal{U}\left(\frac{\chi}{1-\chi}\mathcal{E}^{\lambda}_{t}\frac{\overline{P}^{*}_{F,t}}{\overline{P}_{H,t}}C^{A}_{F,t}, C^{A}_{F,t}, L_t\right) + \tag{99}$$

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

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

where $C^{A}_{F,t}$ is given by (94), $C^{NA}_{F,t}$ is given by (96) and $L^{A}_{t} = L^{NA}_{t}$ is given by (97).

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:

$$V_{C^{A}_{F,t}} = \alpha\lambda^{A}\frac{1-\chi}{C^{A}_{F,t}}\left(1+\frac{\chi}{1-\chi}\tau^{A}_{t}\right), \tag{100}$$

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

$$V_{\mathcal{E}_t}(C_{F,t}, \mathcal{E}_t; \mathbf{a}_t) = \ \mathbf{a}_t\lambda^{A}\ \frac{1-\chi}{C^{A}_{F,t}}\Bigg\{\frac{\chi}{1-\chi}C^{A}_{F,t}\lambda\mathcal{E}^{-1}_{t} + \tag{102}$$

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

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

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

The condition characterising unresponsive monetary policy is given by,

$$\overline{P}^{*}_{F,t}\mathcal{E}^{\lambda}_{t}C^{A}_{F,t} = \mu(1-\chi), \tag{103}$$

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 (43).

The hegemon maximizes (99) subject to (94) and (94), where L_t by (97). 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 :

$$C_{F,t}^{A}: \qquad \beta^t V_{C_{F,t}^{A}} - \mathbf{a}\eta_t^A - \eta_t^{\mu} + \frac{1}{\mathcal{E}_t^{\lambda} C_{F,t}^2}\left[\eta_t^E \frac{1}{R_t} - \eta_{t-1}^E\right] = 0, \tag{104}$$

$$C_{F,t}^{NA}: \qquad \beta^t V_{C_{F,t}^{NA}} - (1-\mathbf{a})\eta_t^{NA} = 0, \tag{105}$$

$$\mathcal{E}_t: \qquad \beta^t V_{\mathcal{E}_t} + [\mathbf{a}\eta_t^A + (1-\mathbf{a})\eta_t^{NA}]\left\{\zeta(\eta-\lambda)\mathcal{E}_t^{\eta-\lambda-1} - \left(\lambda\mathcal{E}_t^{-\lambda-1}\kappa^G\Psi_t^G - (1-\lambda)\mathcal{E}_t^{-\lambda}\Psi_t^*\right)\right\} \tag{106}$$

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

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

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

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

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

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

$$x_t: \qquad [\mathbf{a}\eta_t^A(1-(1-\mathbf{a})\chi) + (1-\mathbf{a})\eta_t^{NA}\mathbf{a}\chi)]\mathcal{E}_t^{-\lambda}\left[\frac{1}{R_t} - \mathbf{a}\Gamma_t x_t + 2\omega\mathbf{a}\Gamma_t Q_t\right] - \tag{107}$$

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

$$G_{F,t}: \qquad \beta^t V_{G_{F,t}} + [\mathbf{a}\eta_t^A + (1-\mathbf{a})\eta_t^{NA}]\left\{\frac{\chi^G - \kappa^G}{1-\chi^G}\right\} - \eta_t^G\left\{\frac{1-\kappa^G}{1-\chi^G}\right\} = 0, \tag{108}$$

$$B_t: \qquad \eta_t^G\mathcal{E}_t^{-\lambda}\frac{1}{R_t} = \beta\eta_{t+1}^G\mathcal{E}_{t+1}^{-\lambda}(1-\kappa^G) + \beta[\mathbf{a}\eta_{t+1}^A + (1-\mathbf{a})\eta_{t+1}^{NA}]\mathcal{E}_{t+1}^{-\lambda}\kappa^G + \tag{109}$$

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

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,

$$C_{i,t} = \left[\chi C_{ii,t}^{\frac{\theta-1}{\theta}} + (1-\chi) C_{i,t}^{*\,\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}, \tag{110}$$

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,

$$C_{ji,t} = \left(\int_\omega C_{ji,t}(\omega)^{\frac{\epsilon-1}{\epsilon}} d\omega\right)^{\frac{\epsilon}{\epsilon-1}} \tag{111}$$

The country i consumer-price index is given by,

$$P_{i,t} = \left[\chi P_{ii,t}^{1-\theta} + (1-\chi) \int_j P_{ji,t}^{1-\theta} dj)\right]^{\frac{1}{1-\theta}}, \tag{112}$$

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,

$$C_{ii,t} = \chi \left(\frac{P_{ii,t}}{P_{i,t}}\right)^{-\theta} C_{i,t}, \quad C_{ji,t} = (1-\chi) \left(\frac{P_{ji,t}}{P_{i,t}}\right)^{-\theta} C_{i,t}, \tag{113}$$

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,

$$Q_{i,t} = \frac{\mathcal{E}_{i,t} P^*_t}{P_{i,t}}, \quad S_{i,t} = \frac{P^*_t}{P_{i,t}}, \quad \Phi_{i,t} = \frac{\mathcal{E}_{i,t} P^*_{i,t}}{P_{ii,t}} \tag{114}$$

where, from (113),

$$Q_{i,t}^{\theta-1} = \chi + (1-\chi)(S_{i,t}\Phi_{i,t})^{\theta-1} \tag{115}$$

The households' budget constraint is given by,

$$P_{i,t}C_{i,t} = W_{i,t}L_{i,t} + \Pi_{i,t} + T_{i,t} + x_{i,t} - R_{i,t-1}x_{i,t-1}, \tag{116}$$

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

$$Y_{i,t} = C_{ii,t} + \int_j C_{ij,t} dj \tag{117}$$

Firm's pricing conditions. For country $i > 0$, the price-setting problem for domestic sales is given by,[63]

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

and for exports,

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

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,

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

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,

$$\Pi_t^g = (P_{ii,t} - MC_{i,t}) Y_{i,t} + (\mathcal{E}_{i,t} P_{i,t}^* - MC_{i,t}) Y_{i,t}^E \tag{122}$$

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 (113) and (114), the market clearing equation (117) can be expressed as,

$$A_{i,t} L_{i,t} = \chi \Phi_{i,t} S_{i,t}^{\theta} Q_{i,t}^{-\theta} C_{i,t} + (1 - \chi) S_{i,t}^{\theta} C_t^* \tag{123}$$

where I have assumed production is linear and only uses labour. Similarly, the consolidated budget constraint (116) can be rewritten as,

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

[63] 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,

$$\max_{P_t} \sum_{t=0}^{\infty} \Lambda_{i,t} \left[(P_t - \tilde{MC}_{i,t}) \left(\frac{P_t}{P_{ii,t}} \right)^{-\epsilon} Y_t^D \right] - \chi \frac{\phi}{2} \left(\frac{P_t}{P_{t-1}} \right)^{-\epsilon} Y_{i,t}^D \tag{118}$$

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

where,

$$F_{i,t} = \mathcal{E}_{i,t}\left(x_{i,t} - R_{i,t}x_{i,t-1} + \Pi^f_{i,t}\right) \tag{124}$$

In complete markets, $F_{i,t} = x^h_{i,t}$, where h denotes the realisation of history, and $\sum_{t,h} x^h_{i,t} = 0$. [64] Converting to dollar terms, the consolidated budget constraint can be further simplified to,

$$(1-\chi)P^*_t \left[S^{\theta-1}_{i,t} \int_j Q^{-\theta}_j C_{j,t} dj - Q^{-\theta}_{i,t} C_{i,t}\right] + F_{i,t} = 0 \tag{125}$$

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

$$\begin{aligned} &\max_{\{C_{i,t}, L_{i,t}, \Phi_{i,t}, Q_{i,t}\}} && u(C_{i,t}, L_{i,t}) \\ &\text{s.t} && (115), (116), (117). \end{aligned}$$

The monetary policy instrument is $\Phi_{i,t}$ which relates to $\mathcal{E}_{i,t}$ as per (114), where $P_{ii,t}$ is preset and $P^*_{i,t}$ is taken as given. Condition (115) 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 (116), (117). 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 (124) 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:

$$C_{i,t}: \qquad u_{C_{i,t}} - \eta^*_{1,t}\{\chi Q^{\theta}_{i,t}\Phi^{\theta}_{i,t}S^{\theta}_{i,t}\} - \eta^*_{2,t}\{(1-\chi)P^*_t Q^{-\theta}_{i,t}\} = 0, \tag{126}$$

$$L_{i,t}: \qquad u_{L_{i,t}} + \eta^*_{1,t}A_{i,t} = 0, \tag{127}$$

$$\begin{aligned} \Phi_{i,t}: \qquad & -\eta^*_{1,t}\{\chi(\theta Q^{2-\theta}_{i,t}\Phi^{2\theta-2}_{i,t}S^{2\theta-1}_{i,t}C_{i,t} + \theta Q^{-\theta}_{i,t}S^{\theta}_{i,t}\Phi^{\theta-1}_{i,t}C_{i,t})\} \\ & + \eta^*_{2,t}(1-\chi)P^*_t\theta Q^{1-2\theta}_{i,t}\chi\Phi^{\theta-2}_{i,t}S^{\theta-1}_{i,t}C_{i,t} = 0 \end{aligned} \tag{128}$$

where the last FOC uses the chain rule. Factorizing and using (115) to simplify (128) yields,

$$\eta_{i,t}S_{i,t}\Phi_{i,t} = \rho_{i,t}P^*_t \tag{129}$$

Then combining (126) and (129) yields,

$$\frac{-u_{L_{i,t}}}{u_{C_{i,t}}} = \frac{A_{i,t}}{S_{i,t}\Phi_{i,t}Q^{-1}_{i,t}} \tag{130}$$

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

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

fore ensures,

$$\frac{W_{i,t}}{A_{i,t}P_{ii,t}} = 1 \tag{131}$$

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 (131), 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 $\psi = 0$, (131) can be rewritten as,

$$\frac{P_{i,t}C_{i,t}}{A_{i,t}}\frac{\chi}{\kappa} = 1 \tag{132}$$

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

$$R_{i,t} = \frac{1}{\beta}\frac{\mu_t}{\mu_{t+1}} \tag{133}$$

If $A_{i,t} = \overline{A}_t$, from (132), μ_t must be constant. (Then, 133) 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 (124) portfolio returns for any country $i > 0$ can be expressed as,

$$\frac{1}{\mathcal{E}_t}F_t^* = \left[x_t^* - R^*x_{t-1}^* + \frac{1}{\mathcal{E}_t}Q_{t-1}\left(R_t - R_t^*\tfrac{\mathcal{E}_t}{\mathcal{E}_{t-1}}\right)\right] \tag{134}$$

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,

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

Finally, rearranging, and expressing in \$ terms,

$$F_t^* = -Q_t + R_t Q_{t-1}, \tag{136}$$

which is exogenous to monetary policy in $i > 0$. (136) 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,

$$\Pi_{t-1}^f = x_t^* - R^* x_{t-1}^* + \xi^* \left(R_t - R_t^* \frac{\mathcal{E}_t}{\mathcal{E}_{t-1}} \right), \tag{137}$$

$$Q_t^* = x_{t-1}^* + \xi_{t-1}^* \tag{138}$$

Substituting these quantities into (124) yields (136) 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. [65] 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.[66] While I focus on the DCP case, stabilisation of marginal costs is optimal under PCP as well, see e.g. Corsetti et al. (2007).

[65]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.

[66]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.

Market Structure Diagram Figure 17 below details the asset market structure.

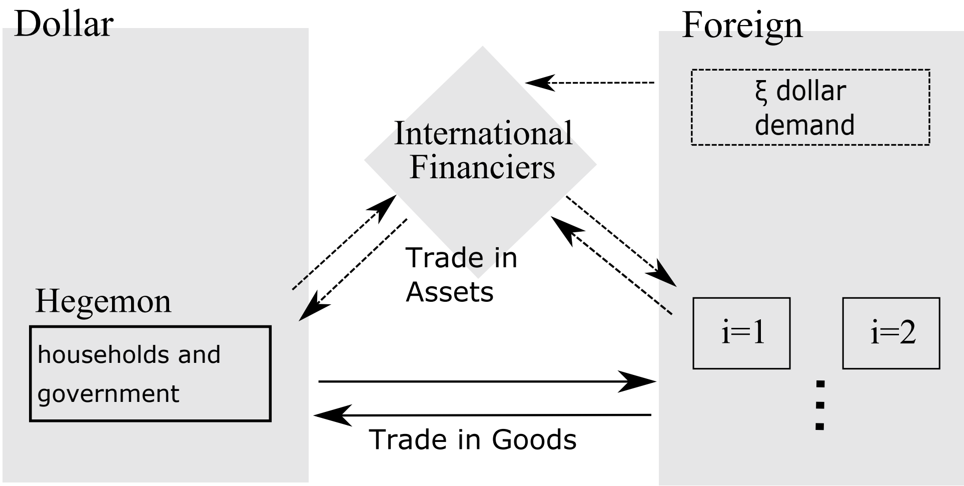


Figure 17: International financial market structure

F Further Results for Calibration Exercise

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

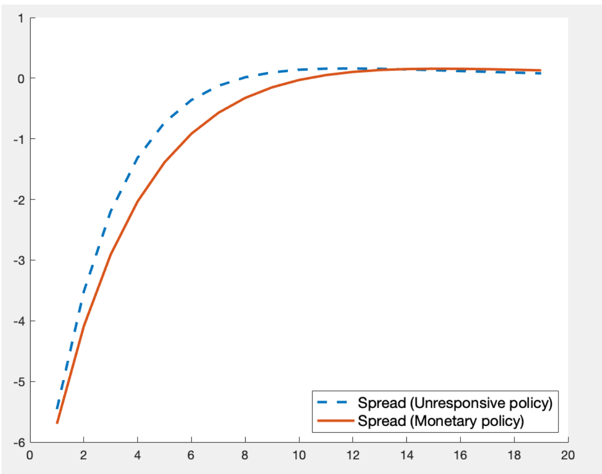


Figure 18: Impulse response to $\xi^{>}0$. Difference in cost of borrowing in dollars vis-a-vis foreign currency expressed in % (quarterly) , if interest rates are fixed or monetary policy is optimally set.

Next, Figure 17 illustrates the impulse response for the ramsey multiplier on the Euler equation η_t^E, given by (35). The multiplier takes a positive value if there is over-borrowing by prviate households in the economy and is zero if an optimal borrowing tax is levied. The figure below illustrates that monetary policy alone, is able to partly narrow η_t^E, but over-borrowing persists absent the optimal borrowing tax.

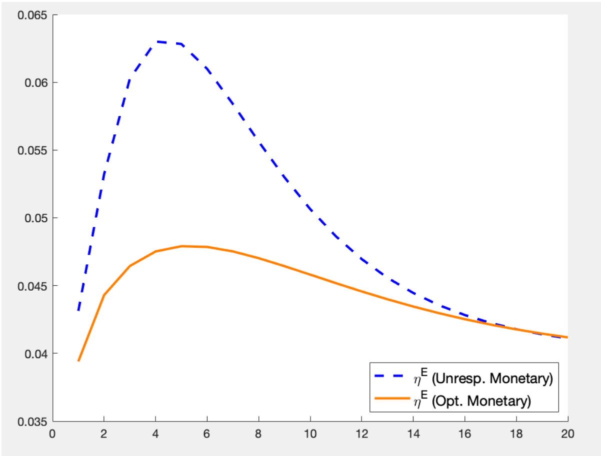


Figure 19: Impulse response to $\xi > 0$. Difference in cost of borrowing in dollars vis-a-vis foreign currency expressed in %, if interest rates are fixed or monetary policy is optimally set.

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

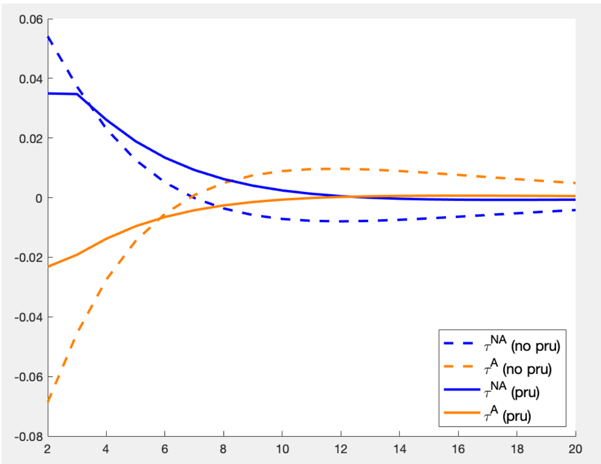


Figure 20: Impulse response to $\xi > 0$. Labour wedge for active and inactive households when a borrowing tax is and is not available, and monetary policy is optimally set.

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

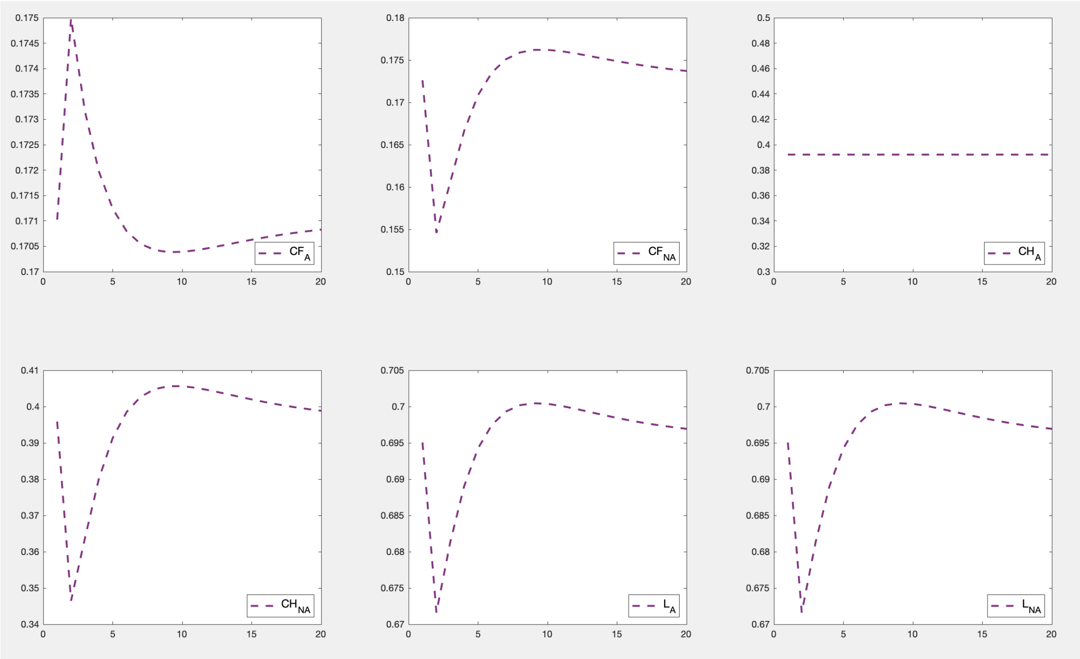


Figure 21: Impulse response to $\xi > 0$. Allocations when interest rates are held constant.

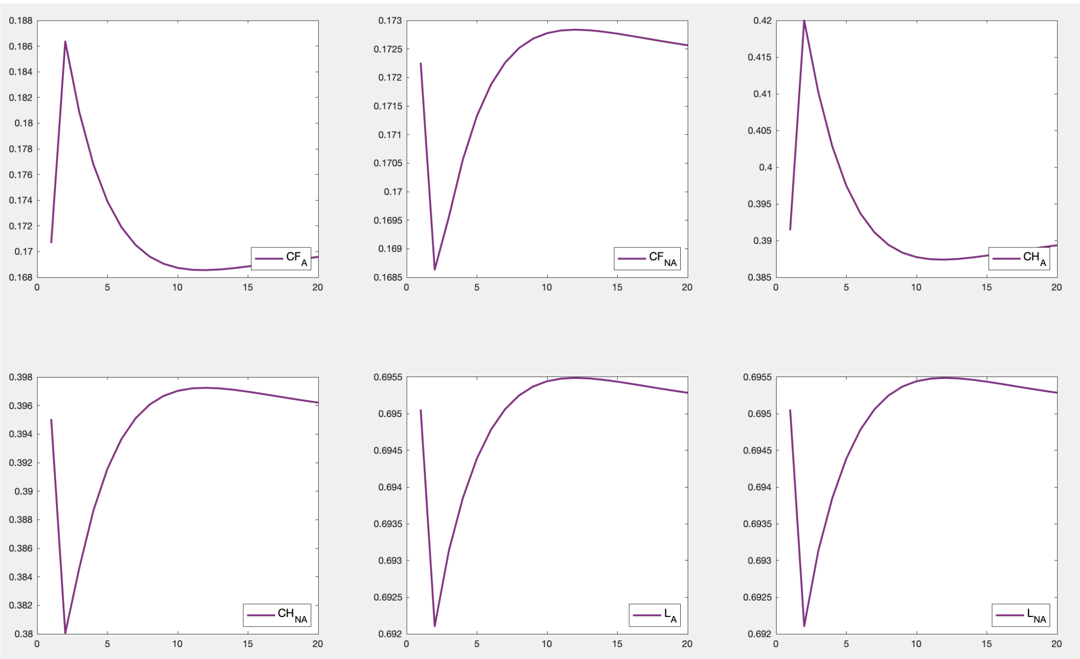


Figure 22: Impulse response to $\xi > 0$. Allocations when monetary policy is optimally set.

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.

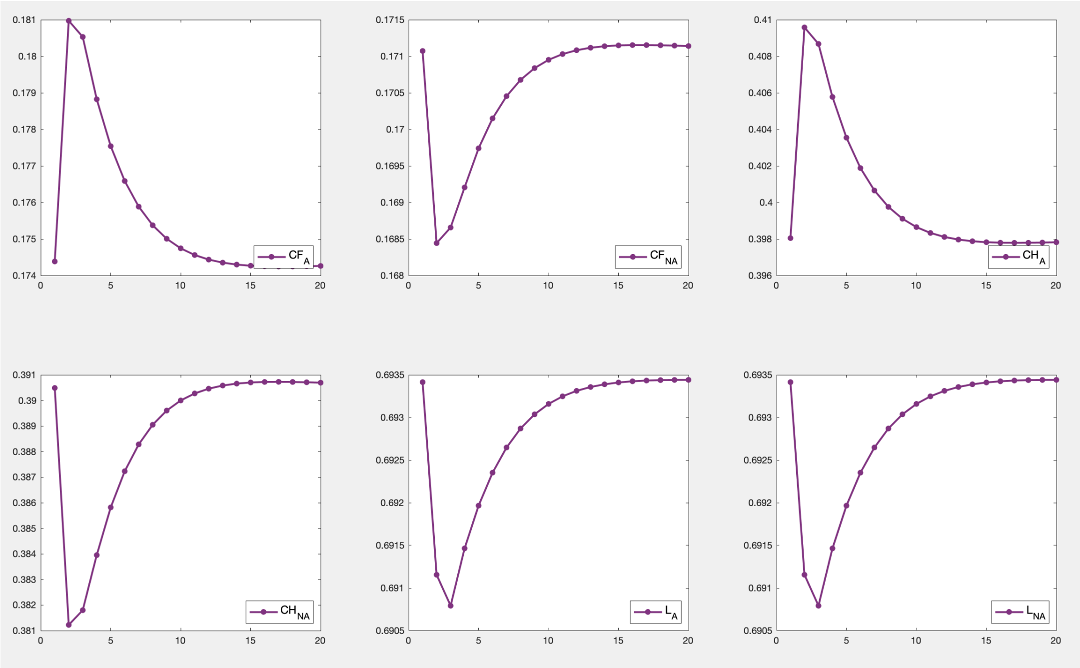


Figure 23: Impulse response to $\xi > 0$. Allocations at the constrained optimal allocation (monetary policy+optimal borrowing tax).

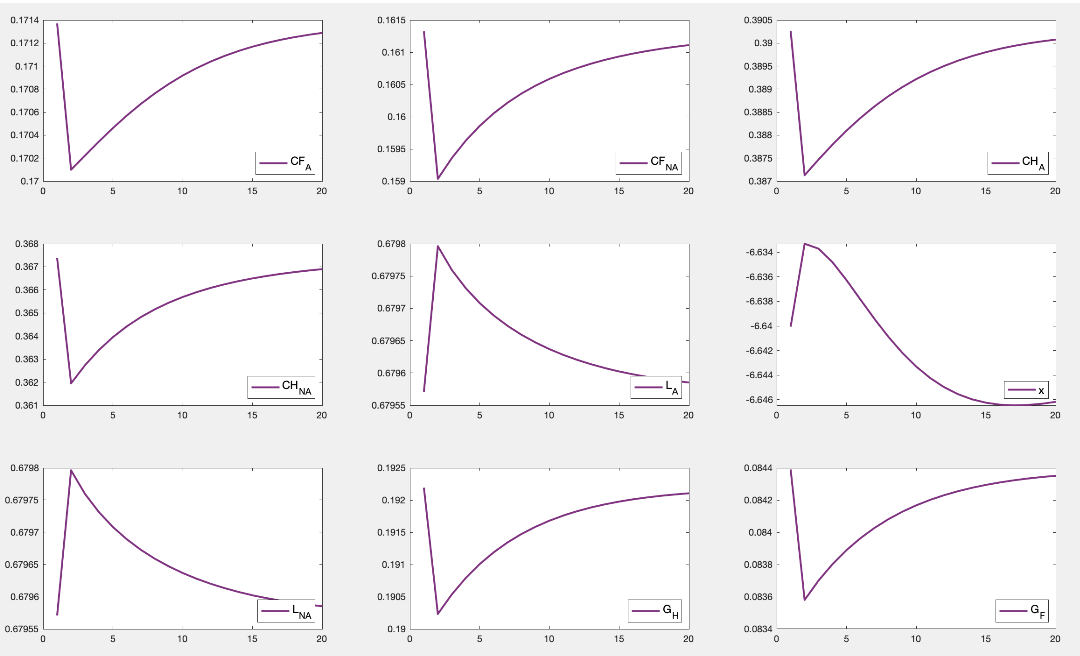


Figure 24: Impulse response to $\Delta A > 0$. Allocations when monetary policy is optimally set.

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.

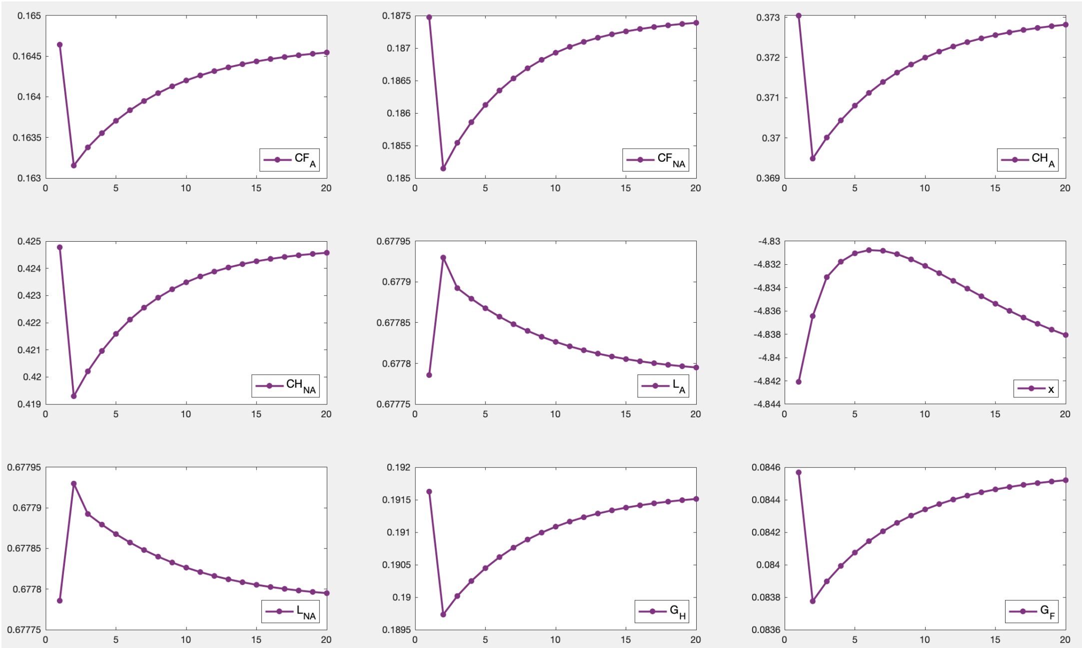


Figure 25: Impulse response to $\Delta A > 0$. Allocations at the constrained optimal allocation (monetary policy+optimal borrowing tax).

	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.