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Should Europe continue to fund U.S. federal debt?

Paola Subacchi* and Paul van den Noord**

Abstract

Against a backdrop of heightened international trade tensions and a possible decoupling of leading economies it may be time to examine the economic validity of countries maintaining large foreign exchange reserves denominated in the US dollar. Specifically, in this paper we assess to what extent Europe should follow in the footsteps of China to trim its US dollar reserves invested in US Federal debt. Using a three-country dynamic general equilibrium model built around stylized representations of the United States, the euro area and China, we find that a cutback of foreign investments in US federal debt would make economic sense, but that a collapse of the dollar's dominant position within the international monetary system is unlikely, unless China prioritises geo-strategic goals over economic rationales.

Keywords: Reserve Currencies, Exorbitant Privilege, Triffin Dilemma, Fiscal Policy, Public Debt, Safe Assets, Confidence Crises

JEL Classification: E32, E63, F33, F42

* Sciences Po Chair in Sovereign Debt and Finance, Department of Economics and Paris School of International Affairs, paola.subacchi@sciencespo.fr.

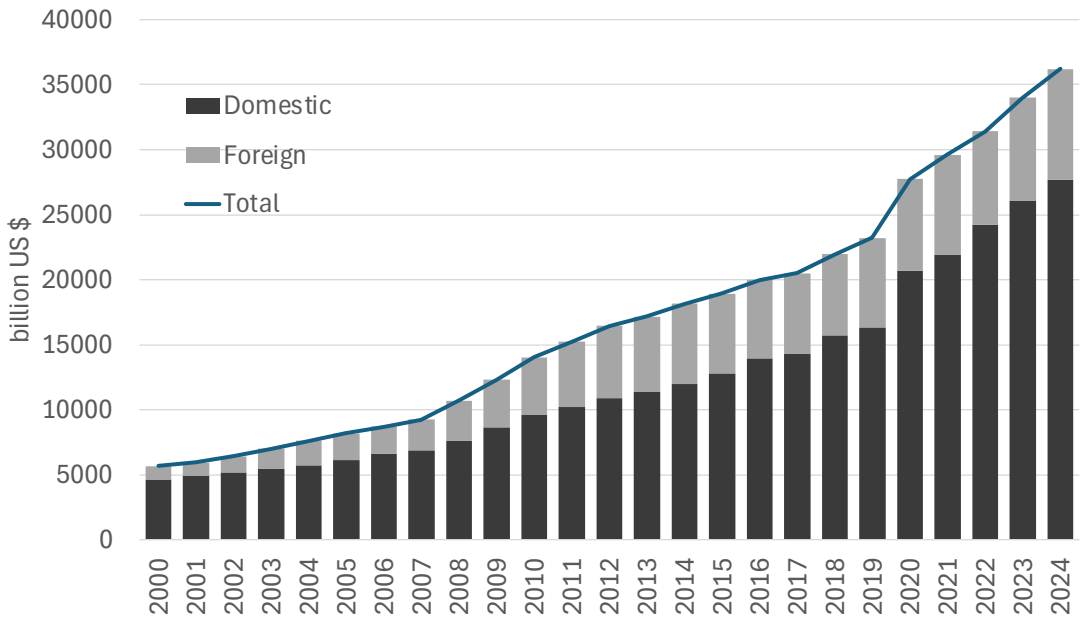
** Amsterdam School of Economics and ACES, Amsterdam Center for European Studies, p.j.vandennoord@uva.nl.

1 Introduction

The US dollar has been at the core of the international monetary system since WW2, serving as the unit of account and medium of exchange through which most international trade is invoiced and settled. Being the anchor of the global financial system central banks have held dollars as official reserves while firms engaged in international trade have held dollars to settle their trade transactions. The US Treasury in turn has provided liquid and safe financial assets in which the rest of the world could invest its US dollar reserves.

For almost half a century, large economies – Japan, Germany and more recently China – have run major trade surpluses with the United States, leading to the accumulation of large international dollar reserves, mainly invested in US treasury bonds (Eichengreen 2011). As a result, around one-third of US Treasury debt (now amounting to over 120% of US GDP) is effectively funded by foreign creditors (Figure 1), although this share is somewhat lower if also State and Local debt in the United States is taken into account.

Figure 1: Foreign and domestic holdings of US Federal debt

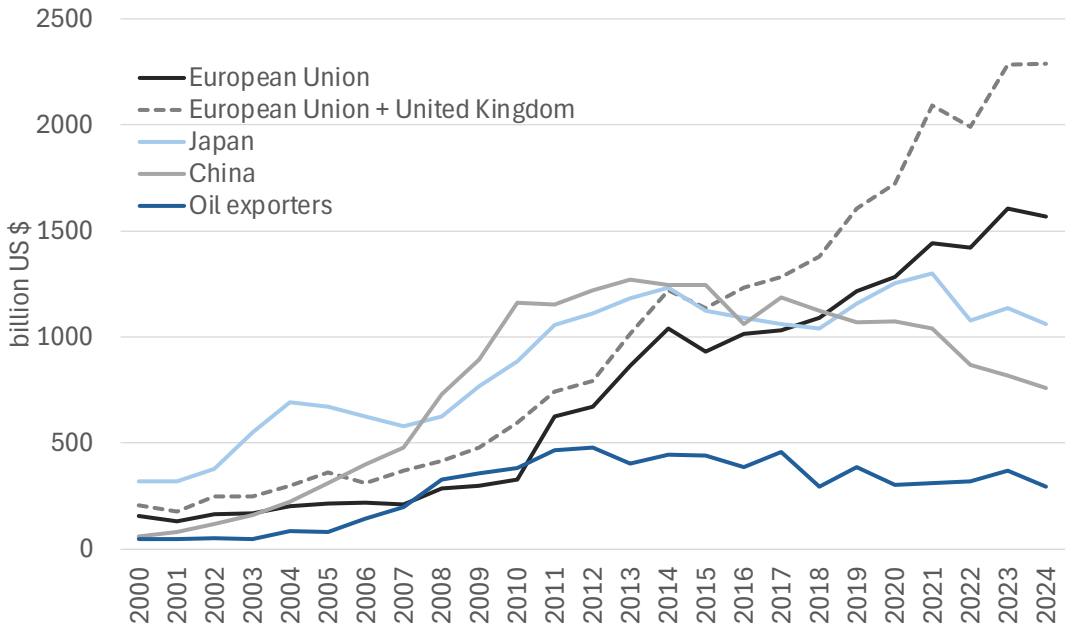


Source: Board of Governors of the Federal Reserve System.

Initially, Japan was the largest investor in US Federal debt, but, as depicted in Figure 2, in the course of the first decade of this millennium China has surpassed Japan as the largest holder of such debt (Arslan and Cantú 2019). More recently, weak returns on US debt following the global financial crisis and zero-bound interest rates, along with, more recently, geopolitical considerations, have prompted China to gradually reduce its holding of US sovereign debt (Eichengreen 2023, Li 2024). Some have argued that this could help explain the comparatively high level

of US yields at present (Ahmed and Rebucci 2025). The investment in US Federal debt by oil exporters – very important in the 1970s and 1980s – has stalled so far this millennium.

Figure 2: Foreign holdings of US Federal debt by country or jurisdiction

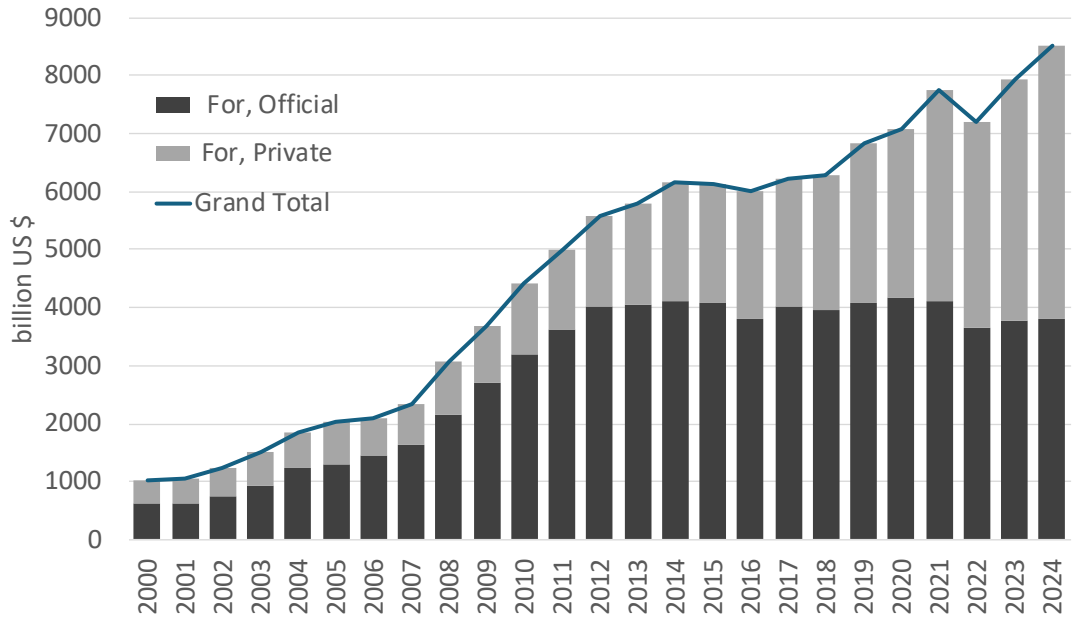


Source: US Department of the Treasury. The jurisdictions included in this figure are the five largest investors in US Federal debt.

As shown in Figure 2, however, countries in the European Union along with the United Kingdom have largely picked up the slack, which explains why the total amount of foreign investments in US Federal debt has in fact increased over this period. The bulk of this increased demand of US Treasuries by EU and UK investors is private, presumably attracted by the higher yield.[1] Indeed, as indicated in Figure 3, basically all of the increase in foreign holdings of US Federal debt is attributable to private investors. Even so, there has also been a shift in the geographical distribution of official foreign exchange reserves away from China to Europe over the past decade or so – with Chinese holdings falling from $3.9 trillion to $3.4 trillion over the period 2013-2023 and European holdings (including the UK) rising from $1.3 trillion to $2 trillion over the same period (Figure 4).

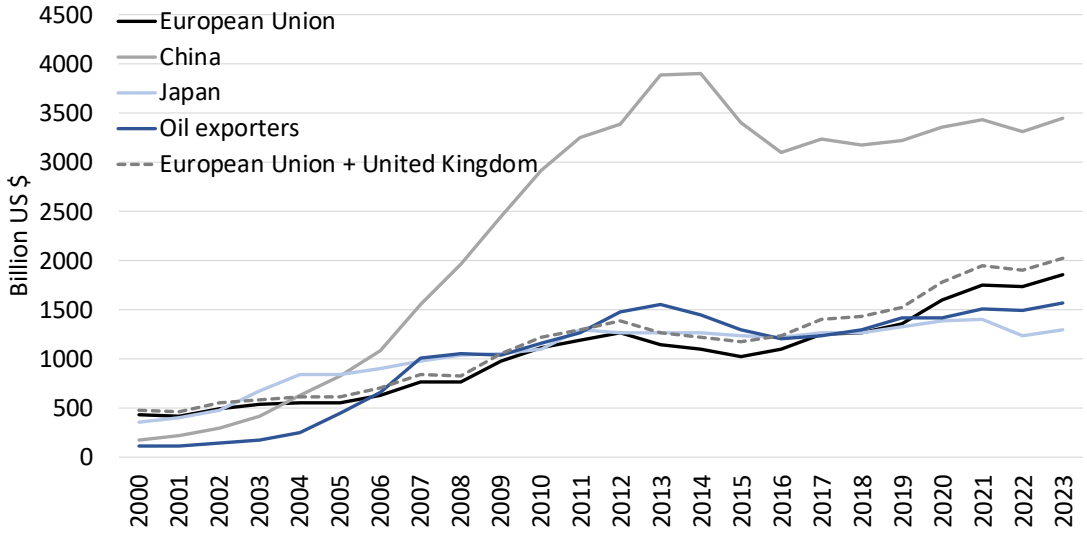
[1] The bulk of the holdings of US several debt in Europe are reported by its main financial centres, i.e. the United Kingdom, Ireland, Luxembourg and Belgium (where SWIFT and Euroclear are established). Since the investors may not be the ultimate owners it makes little sense to provide a breakdown by country.

Figure 3: Official and private foreign holdings of US Federal debt



Source: US Department of the Treasury.

Figure 4: Official foreign exchange reserves by country or jurisdiction



Source: World Bank.

With heightened international trade tensions triggered by the new US Administration in office since January 2025, it is the appropriate time to examine the economic validity of countries holding such large amounts of foreign exchange reserves invested in US Federal debt, in particular of countries in the European Union. Specifically, in this paper we assess to what extent the official and private sectors in Europe should follow in the footsteps of China to trim their US dollar reserves invested in US Federal debt, as a measure of risk mitigation. Holding the

US debt is increasingly risky due to the Trump administration trade and fiscal policies and their impact on the value of the dollar and on debt sustainability. In addition, holders of dollar assets face the risk of sanctions and other hostile measures.

In this paper we address the question of whether the US can continue to benefit from issuing the key reserve currency and expand its external indebtedness at favourable terms, tapping into the savings of other countries that use its currency to settle international trade, when their holdings of US sovereign debt are cut in response to trade disputes. Looking at the opportunity cost of holding the US debt, we examine scenarios where creditor countries holding of US sovereign debt cut back in the built-up and assess the impact of structural reductions of dollar reserve assets across the world.

The paper is organised as follows. Section 2 looks at the historical backdrop and reviews the main inferences by the literature. Section 3 discusses the basic features of our model, with the full model included in the Annex. Section 4 looks at the numerical results and Section 5 concludes.

2 Stylised developments and the literature

The role of the US dollar as the world's dominant reserve currency led to a burgeoning literature. In the 1960s it focused mostly on the "Triffin dilemma", arguing that the dollar's peg to gold – the hallmark of the Bretton Woods system – would be unsustainable as the amount of dollars circulating across the globe got out of whack with the inelastic supply of gold.

This prediction turned out to be correct, yet the also predicted demise of the dollar's dominance proved wrong. The literature explains this from the network properties of the US dollar and the safe-asset properties of US Federal debt and how these have continued to support the US-dollar's dominance. However, concerns have been growing about the sustainability of US Federal debt and how this could trigger a run on the US dollar. A new literature is now emerging in response to the ambitions of the "Global South" to "dedollarize" as part of a wider agenda to weaken US global hegemony.

2.1 Bretton Woods and the Triffin dilemma

Issuing the global reserve currency conferred on the United States an "exorbitant privilege", as France's Finance Minister and future President Valery Giscard d'Estaing lamented in 1965. Robert Triffin (Triffin, 1960) explained this privilege as the ability to finance a current account deficit at cheaper rates than the rest of the world. This feature has continued during most of the fifty years that have followed the end of Bretton Woods in 1971.

Triffin predicted that the growing foreign demand for US dollars from the rest of the world would eventually erode this confidence and force a devaluation of the dollar. When in the 1960s the demand for dollar reserves began to outstrip the United States' fixed holdings of gold, Triffin's dilemma started to bite. The United States would be forced to either continue to provide dollars to the rest of the world via its current account deficit or curtail the deficit but then jeopardize the provision of international liquidity.

After devaluing the dollar against gold in 1971, the Nixon administration suspended convertibility and let the dollar float, unilaterally putting an end to the Bretton Woods system.[2] However, despite the collapse of Bretton Woods, confidence in the dollar remained unchallenged. The dollar remained at the core of the international monetary system, allowing the United States to finance its current account deficit at lower rates than the rest of the world, borrow at low interest rates and invest in higher yielding risky assets in the rest of the world (Subacchi and Vines, 2023; Gourinchas and Rey, 2016).

2.2 Network effects and the demand for safe assets

The continued role of the US dollar in the international financial system after the collapse of Bretton Woods, and the benefits that come with, led to a burgeoning literature (e.g. Gourinchas and Rey, 2007b; Caballero, Farhi, and Gourinchas, 2008; Caballero and Krishnamurthy, 2009; Canzoneri et al, 2013; Maggiori, 2017; He, Krishnamurthy, and Milbradt, 2018; Gopinath and Stein, 2018; Krishnamurthy and Lustig, 2019; Choi, Kirpalani, and Perez, 2022; Mukhin, 2022).

A first strand of this literature relates the dollar's continued dominance to its use in international trade as a unit of account and means of payment (Goldberg and Tille, 2008, Goldberg, 2010, Gopinath, 2016). Gopinath and Stein (2018, 2021) argue that the use of a currency for trade invoicing creates incentives for firms to hold liquid funds and issue liabilities in that currency, and for governments to hold their foreign exchange reserves is that currency.

Farhi and Maggiori (2018) show that historically, holding a dominant position as a reserve currency has often been linked to widespread use of that currency for pricing goods and other contracts. As a result, the more goods are priced in a given reserve currency, the safer debt denominated in that currency becomes. This is because any nominal devaluation of the reserve currency results in a reduction in the real value of the debt from the perspective of the issuing country.

[2] This marked the beginning of an international "non-system" (Corden, 1994).

A second strand of this literature focused on the role of the United States as 'world banker'. Gourinchas and Rey (2007a) explain that by being long in risky foreign assets and short in risk-free liquid dollar liabilities the United States plays the role of world banker.[3] This literature considers the unique advantage of US corporate borrowers to borrow in their domestic currency when they raise capital from foreigners (Caballero et al., 2008; Mendoza et al., 2009; Gourinchas et al., 2011; He et al., 2019; Maggiori, 2017; Farhi and Maggiori, 2018).

The mismatch between the US external assets and external liabilities has resulted in a significant deterioration of the US net foreign asset position (Milesi-Ferretti, 2021; Atkeson et al, 2023). Even so, the United States has earned massive excess returns on its gross foreign asset position. As a result, compared to other countries, the United States experiences a smoother process of external adjustment i.e., the economic mechanisms through which deficit or surplus countries satisfy their intertemporal budget constraints (Gourinchas and Rey, 2007b; Gourinchas, Rey, and Govillot, 2011; Maggiori, 2017).

The quasi-monopolistic position that derives from the role of the dollar in international portfolios and in international transactions has allowed the United States to expand its external balance sheet and build large gross cross-border positions and long position in risky securities on the back of the US foreign direct investment (FDI) and equity (Gourinchas and Rey, 2007a, 2014). This has allowed the dollar to maintain a central place in the international monetary and financial system albeit the US GDP's relative loss of weight vis-a-vis the overall world economy.

Many scholars have pointed out that the safe-haven properties of the US dollar and the associated demand for US government bonds add a fiscal dimension of the "privilege" (Cheng and Zhang, 2011; Bassetto and Cui, 2018; Schuknecht, 2018; Blanchard, 2019; Furman and Summers, 2020; Mehrotra and Sergeyev, 2021; Mian, Straub, and Sufi, 2021; Brunnermeier, Merkel, and Sannikov, 2022; Reis, 2021; Chen et al, 2023).

Some refer in this context to the United States as the *monetary hegemon* (Canzonieri et al., 2013; Farhi and Maggiori, 2018). Foreign demand for the monetary hegemon's debt allows this debt to be higher than otherwise would be without affecting the

[3] Thus the monetary hegemon receives a transfer of wealth – the "exorbitant privilege" – as compensation for risk. The monetary hegemon, however, can influence the terms of the compensation via its supply of reserves (Farhi and Maggiori, 2018:11).

country's fiscal space.[4] In a recent paper (Subacchi and Van den Noord, 2023) we found empirical evidence that a reserve currency country can carry a more expansionary fiscal policy at times of crisis, because assets denominated in that currency will be shielded from short-term capital outflows when expansionary fiscal measures are deemed unsustainable.[5]

Farhi and Maggiori (2018) have explored the question of whether there is a limit to the higher-than-otherwise-would-be-the-case debt of the monetary hegemon. Drawing on Despres et al (1966), they have suggested a new version of the Triffin dilemma where the monetary hegemon needs to expand its debt in order to meet the international demand for safe assets. In doing so, however, it undermines foreign investors' confidence in its ability to repay its debt and avoid a currency devaluation.

Eventually – and this is the intrinsic fragility of being the "world banker" – the rest of the world would stop buying the monetary hegemon's debt, triggering a debt crisis (Farhi and Maggiori, 2018). Thus, the monetary hegemon would not be able to issue debt indefinitely because the asymmetry inherent in this system generates financial fragilities that can ultimately lead to the system's break-up.

2.3 The role of China and the "Global South"

Gourinchas and Rey (2007*a*,*b*) have documented that the US activities as a world banker are today performed on a much grander scale than when originally debated in the 1960s. This is mainly due to China's significant demand for US securities. Between 1995 and 2023 this resulted in approximately US$ 2.8 trillion added to China's reserves, now totalling around US$ 3.5 trillion (see Figure 4).[6]

During this period, the accumulation of FX reserves moved in sync with the widening of China's current account surplus, particularly in the years between 2002

[4] Debt management, including debt servicing costs, usually constrain a country's fiscal space through restrictive fiscal measures.

[5] This is what happened, for instance, in September 2022 when the UK Prime Minister Liz Truss unveiled a 'mini budget' with GBP45 billion of unfunded tax cuts, resulting in financial instability and the intervention of the Bank of England to backstop the gilt market.

[6] Authors' calculation based on IMF Balance of Payments and International Investment Position. McKinnon (2009, 2012) argues that this accumulation is the result of the Chinese monetary authorities' policy to directly intermediate China's saving surplus that otherwise cannot be easily traded through conventional banking and financial channels due to constraints on capital movements.

and 2012. Strong dollar asset accumulation[7] is also reflected in China's international investment position. Here total assets grew from US$1.2 trillion in 2005 to US$9.5 trillion in 2023[8], driven by FX reserves, direct investment and debt instruments.

China's FX reserves peaked in 2014 at US$3.8 tr. In the second half of 2015 and in 2016 the Chinese monetary authorities intervened to support the renminbi after the introduction of a managed float exchange rate in August 2015 (Subacchi, 2017). These interventions required approximately US$830 bn and dented the FX reserves. In the meantime, the current account surplus narrowed from a 9.2% of GDP peak in 2009, while reserves stabilised at around US$3.1 tn.

Arguably China's opening up and the consequent strong output growth – and exports – coupled with constrained capital movements and a currency with limited international use have resulted in a strong demand for dollar government securities. This has allowed the continuous accumulation of the US external debt despite repeated warnings against a possible sudden loss of confidence in the dollar and the triggering of a Triffin-like event (Obstfeld and Rogoff, 2001, 2007).

Central banks – and the PBoC is unlikely to be an exception – rebalance their reserve portfolios in response to perceived exchange rate risks and changes in the returns on the securities in which they invest or which they forgo. For China, the higher opportunity cost of holding US Treasuries in FX reserves emerged after the global financial crisis, with the Federal Reserve holding interest rates at around zero. As a result, the Chinese monetary authorities were faced with the dilemma of how to diversify their dollar-denominated assets away from the US Treasuries. During the period of 2009-2022, China's dollar assets were rebalanced towards direct investments and loans so as to achieve better returns. Only recently, since February 2022, the US 10-year government bonds have been more competitive than their Chinese equivalent, with a differential of approximately 230 basis points.

Geopolitical considerations also affect the demand for safe assets issued by the monetary hegemon. China is seen to challenge the monetary hegemon for monetary – and geopolitical – leadership, thus acting as a *monetary rival*. If the currency of the monetary rival becomes a competing reserve currency, this could in principle lead to the instability of the international monetary system when a rival appears as

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[7] Conventionally, flows and stocks in the Balance of Payments and International Investment Position Statistics dataset are reported in dollars. Given the prominence of the dollar in settling and invoicing international trade and China's trade balance surplus, the assumption here is that most of China's international assets, including the FX reserves, are denominated in dollars.

[8] Latest available figures, IMF, Balance of Payments and International Investment Position Statistics, https://data.imf.org/en/Data-Explorer?datasetUrn=IMF.STA:BOP_AGG(9.0.1)

described in Nurkse (1944). As argued by Li (2024), de-dollarization efforts are indeed mounting, even if this does not necessarily mean the dollar's demise is imminent. Yet it does seem to reflect a drive led by China and more largely the "Global South" towards a multipolar international order.

2.4 Initiatives under the Trump Administration

Despite its inherent imbalances, the system described above – underpinning the post-1971 monetary and financial system – has been 'sticky' owing to multilateral cooperation and the willingness of the United States to support it as lender of last resort. This may be explained by the fact that the United States has derived significant benefits from this system, including the availability of fiscal space and the possibility to use its control of the world's main reserve asset strategically.

In recent years, however, the balance between these benefits and its perceived cost has shifted in the United States, which has become less willing to underwrite international financial (and economic) stability, as well as international security, at the expense of an overvalued currency. With the second Trump administration, which revolves around nationalism and protectionism and a growing disregard for institutions and the rule of law, the United States has shifted from being a reluctant leader to a disruptive one. This shift is evident, for example, in the imposition of punitive tariffs, which are most disruptive for western countries (O'Neiland and Huesa 2025, York 2025). These tariffs are used in part as negotiation tactics, but they also aim to offset the loss in competitiveness associated with the strong dollar on the back of global demand for safe dollar assets.

Tariffs alone, however, cannot curb the US trade deficit as the demand for dollar assets is relatively inelastic. This has led to calls on the Administration to force creditor countries to restrain their dollar reserves and accept poorer terms for their holdings of US Federal debt -- dubbed the "Mar-a-Lago Accord" with a nod to the Plaza and Louvre Accords of the 1980s (Miran, 2024). Exactly how creditor countries could be forced into such restraint is as yet unclear, but it would not be farfetched to assume that the United States could use its leverage as a military superpower.

What happens when US policies thus become a source of disruption for the dollar itself? The world is no stranger to the spillover effects of the US domestic policies on the dollar from – after all, the dollar is "our currency, but your problem". Unitl now, however, these spillovers have occurred within a multilateral framework of cooperation, that implies willingness to extend the financial safety net. This may no longer be the case. As the US Treasury Secretary Scott Bessent, put it, "a grand global economic reordering" may be on the horizon. Does this mean that the dollar will be used as a tool of coercion and to repay the United States for the public goods they have provided to the rest of the world as suggested by Miran (2024)?

In view of the above, one may legitimately ask whether the global economy is headed for a sustained period of fragmentation among major economic blocks and what this might imply for the development of US-dollar denominated FX reserves and the associated demand for US Federal debt. Specifically, we examine whether Europe should follow in China's footsteps by curtailing its demand for dollar assets on economic grounds –regardless of political pressure from the United States. If so, this would strengthen Europe's position at a prospective negotiation table. This brings us to our analytical framework.

3 The model

3.1 Basic assumptions

We set up a three-country model in which international trade is settled in the currency supplied by the "monetary hegemon". The two other countries accumulate foreign exchange reserves that they reinvest in sovereign debt issued by the monetary hegemon, as this debt is considered safe and liquid. These two countries therefore serve as the monetary hegemon's foreign creditors. The two creditor countries differ in that one of them allows private investors to invest in sovereign debt issued by the monetary hegemon alongside the official sector, whereas the other country prohibits private investors to do so.

We distinguish just two periods in the model, the "short run" and the "longer run", denoted as 'period 0' and 'period 1'. The two-period approach has the advantage that it is relatively easy to secure the no-Ponzi-game condition (all assets and liability positions unwind without default at the end of period 1). Moreover, we keep the model 'real' in the sense that there is no explicit role for monetary policy to determine the overall price level. This implies that movements in the real exchange rates are not broken down into movements in the nominal exchange rate and the inflation rate. Owing to its relative simplicity, we are able to solve the model numerically without having to resort to log-linear approximations. [9]

We assume that the representative household in each country chooses an intertemporal mix of consumption that maximizes utility over the two periods (intertemporal equilibrium). Moreover, in each country the representative

[9] We acknowledge that numerous extensions of the model could be envisaged. Aside from an explicit role for monetary policy, these might include allowing the supply of goods to vary due to trade-offs between labour and leisure, introducing nominal rigidities that lead to disequilibria in supply and demand, a distinction between tradable and non-tradable goods, or the possibility of cross-holdings of financial assets. We will leave this for future research.

household chooses the optimal mix of consumption goods produced at home and produced in the other two countries (intra-temporal equilibrium). There is a bias towards goods produced at home (home bias), but households do not *a priori* discriminate between consumption goods provided by one foreign country or the other (though they do adjust their basket of imported goods in response to changes in relative prices).

The real interest rate is the key adjustment variable to establish intertemporal equilibrium, i.e the optimal mix between consumption in the short and in the longer run. The real exchange rates (or the terms of trade) play this role for the establishment of intratemporal equilibrium, i.e. the optimal mix of consumption of home-produced and imported goods, while respecting the balance of payment constraint that the current account and capital account positions must match.

The accumulation of reserve currency assets by the private sector in the country where this is allowed is a function of the opportunity cost of holding these reserves relative to their "convenience yield". The opportunity cost consists of the spread between the risk-adjusted yields on domestic sovereign debt and the monetary hegemon's sovereign debt and the expected exchange rate loss on reserve assets. This exchange rate loss is likely to occur because in the longer run (period 1) the monetary hegemon needs to run a trade surplus to finance the repayment of its foreign debt.

The build-up of official reserves by the two creditor countries is treated as exogenous. Yet the official investors debt in the two creditor countries face opportunity cost on their holdings of the monetary hegemon's sovereign as well. While these are assumed to have no automatic feedback effect on these investments, we consider it nonetheless important to compute this opportunity cost. Specifically, we want to be able to assess the economic validity of the build-up of foreign exchange reserves and the associated investments in the monetary hegemon's sovereign debt by the official sectors.

We assume that while the monetary hegemon, which provides the global reserve currency by way of a public good, is not committed to maintain the stability of the reserve currency or to restrain the issuance of sovereign debt to secure its sustainability.[10] For the two creditor countries the tradeoff is then between the advantages of using the reserve currency for international transactions and the risk-adjusted opportunity cost of holding reserve assets. These assets are typically risk-free because they depend on the monetary hegemon's fiscal sustainability, which –

[10] Farhi and Maggiori (2018: 5-6) trace the scarcity of reserve assets to commitment problems. For example, under full commitment the monetary hegemon chooses to issue risk-free debt and commits not to devalue in a disaster.

as we have argued in Subacchi and van den Noord (2023) – is underpinned by the global demand for the monetary hegemon's debt.[11] Thus the fiscal dimension of the "exorbitant privilege" is closely intertwined with the international demand for the reserve currency.[12]

Farhi and Maggiori (2018) and Triffin at al. (1966) consider this equilibrium to be fragile and easily disrupted. However, despite repeated warnings against a possible sudden loss of confidence in the dollar and the triggering of a Triffin-like event (Obstfeld and Rogoff, 2001, 2007), the US external debt has continued to accumulate. Accordingly, we would argue that, in a quasi-monopolistic situation where liquid and safe assets are provided by the monetary hegemon, and alternatives are limited, confidence can diminish as debt accumulates, yields and exchange rates adjusts and therefore the opportunity cost of holding this debt falls. In this situation where confidence falls the monetary hegemon can continue to marginally issue debt without triggering a confidence crisis.

The assumption that the monetary hegemon must run a trade surplus in the longer run (period 1) to repay its external debt built up in period 0 is fundamental. This contrasts with the 'optimistic' view that the monetary hegemon could continue to run trade deficits forever, as embedded both in more complex models with an infinite time horizon (e.g. Felbermayr et al 2023) and in static one-period models (Cheng and Zhang 2011, 2012). Hence our approach is more in line with the 'pessimistic' view that the 'global imbalance' would need to unwind at some stage, as argued by for instance Blanchard, Giavazzi, & Sa (2005).

3.2 Intratemporal equilibrium

The monetary hegemon, the 'conventional' foreign creditor and the 'emerging' foreign creditor, are denoted as *H*, *F* and *E*. Moreover, symbols without an asterisk, with one asterisk and with two asterisks always refer to country *H*, *F* or *E*, respectively). The demand for home produced and imported consumption goods in

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[11] We use the term fiscal capacity/fiscal space in a deliberately unusual manner compared with the existing literature. Cohen (2015: 22) talks about the enhanced policy autonomy created for the issuer of a reserve currency which faces looser constraints of external-payments imbalances.

[12] By contrast, much of the existing literature defines fiscal capacity/space as the maximum amount of public debt relative to GDP that a country can sustain without triggering an adverse reaction, including higher interest rates, on the part of those who lend to it (Blanchard, 2022, 2019, Kose et all, 2017; Bi, 2012 and Bi et al., 2016). Accordingly, the US has large fiscal capacity and large capacity for reserves issuance because of its size and and its institutional framework, and not because of international demand for dollar assets.

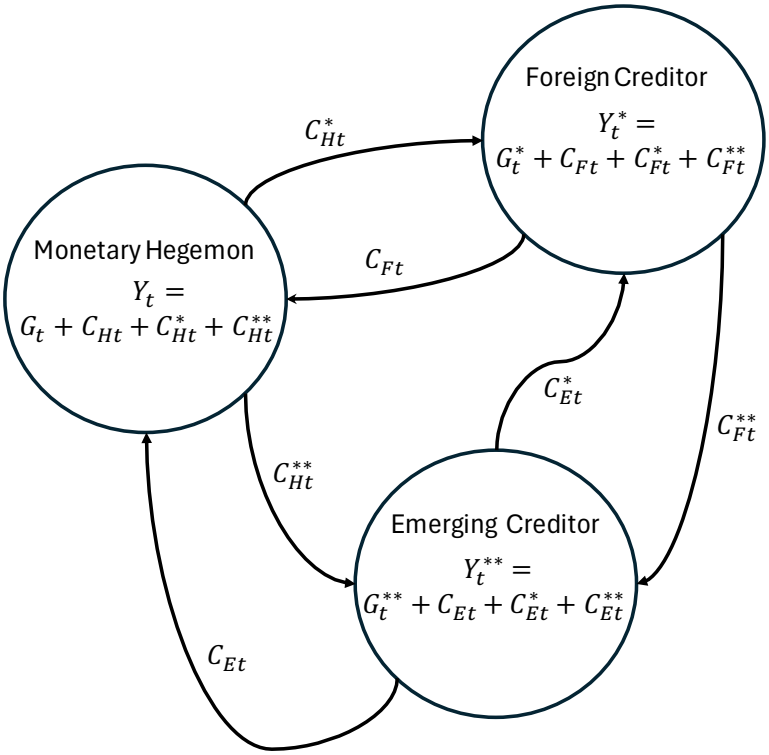
each country is determined by utility-maximization, using the following utility functions:

$$C_t = \eta C_{Ht}^{\alpha}\left(\sqrt{C_{Ft}C_{Et}}\right)^{1-\alpha} \qquad C_t^* = \eta {C_{Ft}^*}^{\alpha}\left(\sqrt{C_{Ht}^*C_{Et}^*}\right)^{1-\alpha}$$

$$C_t^{**} = \eta {C_{Et}^{**}}^{\alpha}\left(\sqrt{C_{Ht}^{**}C_{Ft}^{**}}\right)^{1-\alpha} \qquad \eta = \alpha^{-\alpha}\left[\frac{1}{2}(1-\alpha)\right]^{-(1-\alpha)} \qquad (1)$$

with the aggregate consumption volumes in countries *H*, *F* and *E* denoted as C_t, C_t^* and C_t^{**}, and C_{jt}, C_{jt}^* and C_{jt}^{**} denoting the consumption of goods produced in countries $j = H, F, E$. Note that the parameter $0 \leq \alpha \leq 1$ reflects the *degree of home bias*; if it is equal to 1 all goods consumed are produced at home and if it is 0 all goods consumed at home are imported.

Figure 5: Output and international trade flows



Source: Diagram by the authors

As illustrated in Figure 5, output in each country, denoted Y_t, Y_t^* and Y_t^{**} is allocated to government spending G_t, G_t^* and G_t^{**}, respectively, domestic consumption home-produced goods C_{Ht}, C_{Ft}^* and C_{Et}^{**}, and the exports of consumption goods to the trading partners. Intra-temporal equilibrium for the monetary hegemon then requires that $Y_t = G_t + C_{Ht} + C_{Ht}^* + C_{Ht}^{**}$, where C_{Ht}^* and C_{Ht}^{**} denote the exports of consumption goods to countries *F* and *E*, respectively. Similarly so for the other two countries, it must hold that $Y_t^* = G_t^* + C_{Ft} + C_{Ft}^* + C_{Ft}^{**}$ and $Y_t^{**} = G_t^{**} + C_{Et} + C_{Et}^* + C_{Et}^{**}$. Moreover, the budget identities that nominal aggregate consumption must be equal to the sum of the nominal consumption of each type of good, in each country,

must also be satisfied, i.e. $C_t P_t = P_{Ht}C_{Ht} + P_{Ft}C_{Ft} + P_{Et}C_{Et}$, $P_t^* C_t^* = P_{Ft}^* C_{Ft}^* + P_{Ht}^* C_{Ht}^* + P_{Et}^* C_{Et}^*$ and $P_t^{**} C_t^{**} = P_{Ft}^{**} C_{Ft}^{**} + P_{Ht}^{**} C_{Ht}^{**} + P_{Et}^{**} C_{Et}^{**}$, where P_{Ht}, P_{Ft}, P_{Et} and P_t denote the prices of goods and the aggregate price level in the home country, and P_{Ht}^*, P_{Ft}^*, P_{Et}^* and P_t^* and P_{Ht}^{**}, P_{Ft}^{**}, P_{Et}^{**} and P_t^{**} denote their equivalents in the conventional and emerging creditor countries, respectively. Note that the aggregate price indices in the three countries are defined as $P_t = P_{Ht}^{\alpha}\left(\sqrt{P_{Ft}P_{Et}}\right)^{1-\alpha}$, $P_t^* = P_{Ft}^{*\,\alpha}\left(\sqrt{P_{Ht}^* P_{Et}^*}\right)^{1-\alpha}$ and $P_t^{**} = P_{Et}^{**\alpha}\left(\sqrt{P_{Ht}^{**}P_{Ft}^{**}}\right)^{1-\alpha}$.

Optimizing the consumption basket in each country subject to the above intra-temporal equilibrium conditions, yields the following set of aggregate demand equations:

$$
\begin{aligned}
Y_t &= G_t + \alpha S_t^{*-\frac{1-\alpha}{2}} S_t^{**-\frac{1-\alpha}{2}} C_t + \tfrac{1}{2}(1-\alpha)\left[S_t^{*-\alpha} S_t^{**-\frac{1-\alpha}{2}} C_t^* + S_t^{**-\alpha} S_t^{*-\frac{1-\alpha}{2}} C_t^{**}\right] \\
Y_t^* &= G_t^* + \alpha S_t^{*1-\alpha} S_t^{**-\frac{1-\alpha}{2}} C_t^* + \tfrac{1}{2}(1-\alpha)\left[S_t^{*\frac{1+\alpha}{2}} S_t^{**-\frac{1-\alpha}{2}} C_t + S_t^{**-\alpha} S_t^{*\frac{1+\alpha}{2}} C_t^{**}\right] \\
Y_t^{**} &= G_t^{**} + \alpha S_t^{**1-\alpha} S_t^{*-\frac{1-\alpha}{2}} C_t^{**} + \tfrac{1}{2}(1-\alpha)\left[S_t^{*-\frac{1-\alpha}{2}} S_t^{**\frac{1+\alpha}{2}} C_t + S_t^{*-\alpha} S_t^{**\frac{1+\alpha}{2}} C_t^*\right] \quad (2)
\end{aligned}
$$

where $S_t^* = P_{Ht}/P_{Ft} = P_{Ht}^*/P_{Ft}^* = P_{Ht}^{**}/P_{Ft}^{**}$ and $S_t^{**} = P_{Ht}/P_{Et} = P_{Ht}^*/P_{Et}^* = P_{Ht}^{**}/P_{Et}^{**}$ denote the terms of trade of the hegemon vis-à-vis its two trading partners, defined as the relative price levels of goods produced in country *H* relative to those produced in country *F* and *E*, respectively, denominated in the same currency. As the "Law of One Price" is assumed to hold, the relative prices for each pair of goods are the same for all countries. Moreover, as explained in the Annex, the real exchange rates of the monetary hegemon vis-à-vis its two trading partners, are equal to $S_t^{*(3\alpha-1)/2}$ and $S_t^{**(3\alpha-1)/2}$, respectively.

The system (2) contains six equations (three for each of the two periods 0 and 1) with ten dependent variables C_0, C_0^*, C_0^{**}, C_1, C_1^*, C_1^{**}, S_0^*, S_0^*, S_1^{**} and S_1^{**} (we assume real endowment output Y_t, Y_t^* and Y_t^{**} and government spending G_t, G_t^* and G_t^{**} to be exogenous). Therefore, when the terms of trade S_t^* and S_t^{**} are known, the aggregate consumption volumes C_t, C_t^* and C_t^{**}, in each country are also known (the analytical solution is derived in the Annex).

3.3 Intertemporal equilibrium

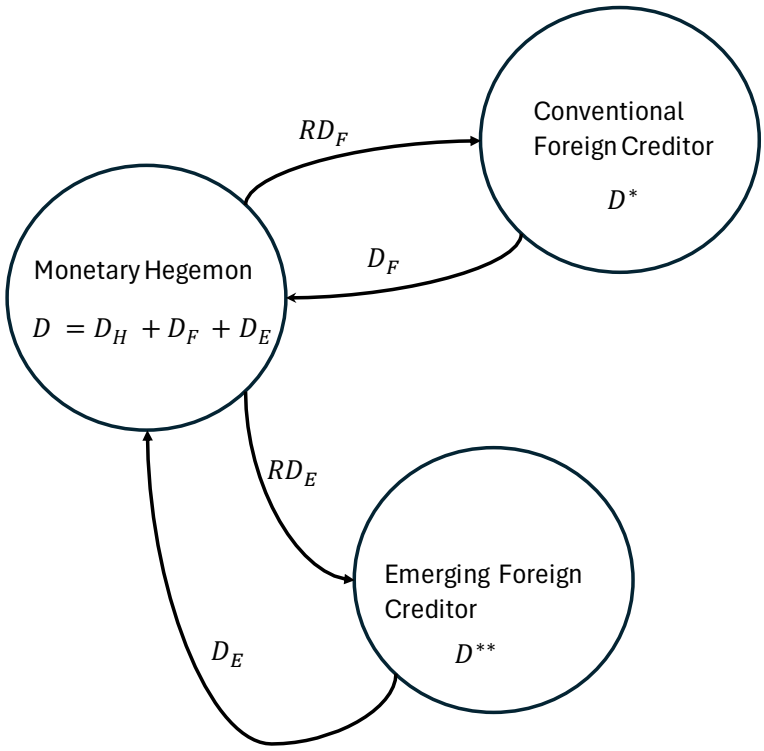
We assume that the representative household in each country maximises its utility by adjusting the mix of present and future consumption, with the latter discounted to reflect a natural preference of present over future consumption (pure time preference). We adopt two-period CRRA utility functions, which ensure that the law of diminishing marginal utility of present and future consumption applies; in formal terms:

$$U = \sum_{t=0,1} \beta^t \frac{C_t^{1-\sigma}}{1-\sigma} \qquad U^* = \sum_{t=0,1} \beta^t \frac{C_t^{*1-\sigma}}{1-\sigma} \qquad U^{**} = \sum_{t=0,1} \beta^t \frac{C_t^{**1-\sigma}}{1-\sigma} \qquad (3)$$

where and with β denotes the discount factor and σ the elasticity of intra-temporal substitution (both assumed to be identical across countries).

Inter-temporal equilibrium requires that the representative household in each country allocates real income across periods 0 and 1 in line with these preferences, subject to the intertemporal budget constraint that in period 0 consumption must be equal to disposable income less savings and that in period 1 consumption must be equal to disposable income plus the gross return on these savings.

Figure 6: Sovereign debt and international capital flows



Source: Diagram by the authors

The first order conditions for maximum utility, subject to the appropriate dynamic budget constraints, implies that the gross real interest rates in each country are determined by the usual Euler equations:

$$R = \frac{1}{\beta}\left(\frac{C_1}{C_0}\right)^{\sigma} \qquad R^* = \frac{1}{\beta}\left(\frac{C_1^*}{C_0^*}\right)^{\sigma} \qquad R^{**} = \frac{1}{\beta}\left(\frac{C_1^{**}}{C_0^{**}}\right)^{\sigma} \qquad (4)$$

where R, R^* and R^{**} denote the real gross rates of return on sovereign debt in each of the three countries.

The representative household in country H is assumed to invest its savings in period 0 exclusively in real domestic sovereign debt D_H. Total real debt issued by

the government in period 0, denoted as D, is partly financed by these domestic savings, with the remainder financed by countries *F* and *E*, denoted as D_F and D_E, respectively. This is illustrated by the diagram in Figure 6, which also shows that the real gross return on household savings in period 1 are equal to RD_F and RD_E, respectively. Sovereign debt issued by countries *F* and *E*, denoted as D^* and D^{**}, are entirely financed at home.

The supply of sovereign bonds by the monetary hegemon (the 'safe asset') and the demand for it by countries *F* and *E* need to balance (equilibrium in international capital markets). The mechanism to achieve this equilibrium relies on the adjustment of the terms of trade S_t^* and S_t^{**} (or real exchange rate) of the monetary hegemon against its trading partners. Therefore, assuming that government spending in each country is given such that $G_0 = G$, $G_0^* = G^*$, $G_0^{**} = G^{**}$ are exogenous and $G_1 = G_1^* = G_1^{**} = 0$, the terms of trade variables in the system S_0^*, S_0^{**}, S_1^* and S_1^{**} can be solved from the balance of payment constraints for periods 0 and 1. In fact there are six balance of payment constraints (three countries × two periods), but owing to Walras' Law one pair of constraints is redundant (we have chosen this to be the pair of constraints for country *F*). The remaining four reduced-form balance of payments constraints read:

$$D_F + D_E = C_0 - S_0^{*\frac{1-\alpha}{2}} S_0^{**\frac{1-\alpha}{2}} (Y_0 - G), \qquad R(D_F + D_E) = S_1^{*\frac{1-\alpha}{2}} S_1^{**\frac{1-\alpha}{2}} Y_1 - C_1,$$

$$S_0^{**\frac{3\alpha-1}{2}} D_E = S_0^{*\frac{1-\alpha}{2}} S_0^{**-(1-\alpha)} (Y_0^{**} - G^{**}) - C_0^{**}$$

$$S_1^{**\frac{3\alpha-1}{2}} RD_E = C_1^{**} - S_1^{*\frac{1-\alpha}{2}} S_1^{**-(1-\alpha)} Y_1^{**} \qquad (5)$$

where D_F and D_E denote the investment in the hegemon's sovereign debt by countries *F* and *E*. The first two equations refer to the monetary hegemon, with on the right-hand sides the real trade balances (a deficit in period 0 and a surplus in period 1) and on the left-hand sides their financing. The last two equations refer to country *E*, with again on right-hand sides the trade surplus in period 0 and the trade deficit in period 1, and on the left-hand sides their financing.

Note that the terms $S_0^{**(3\alpha-1)/2}$ and $S_1^{**(3\alpha-1)/2}$ are the real exchange rates of the monetary hegemon against country *E* in each period, necessary to convert the latter's investment in the monetary hegemon's debt, and its gross return in period 1, into *E*'s currency. The upshot of these relationships is that when global demand for reserve assets outstrips the monetary hegemon's capacity to issue safe debt, the hegemon's real exchange rate must appreciate in period 0. Conversely, if the gross return on this debt outstrips the hegemon's trade surplus in period 1 its exchange rate must depreciate in that period.

If D_F and D_E are taken as given, the sets of equations (2), (4) and (5) comprise a system of thirteen equations which can be solved for the thirteen dependent variables C_0, C_0^*, C_0^{**}, C_1, C_1^*, C_1^{**}, S_0^*, S_0^*, S_1^{**}, S_1^{**}, R, R^* and R^{**}.

3.4 The opportunity cost of foreign reserves and the budget

The main reason why we distinguish two creditor countries instead of just one is that we want to include what we consider the two archetypes of foreign creditors in our model: one with an open capital account where private investors are free to hold any amount of reserve currency they consider necessary (the conventional creditor), and one with a closed capital account where foreign exchange reserves are the exclusive realm of the sovereign (the emerging creditor).

The accumulation of foreign exchange reserves by the official sector of each creditor country, denoted as X^* and X^{**} respectively for each country, may serve a variety of goals, including achieving a targeted level for the exchange rate against the reserve currency or the relative stability of that exchange rate (given that the currency issued by H is used to invoice and settle trade among the three countries), or to selfinsure against foreign exchange crises in the event of limitations to the accesss to international backstops such as swap arrangements and official loans. However, we do not assume a fixed policy rule for each country but instead treat the official demand for reserve assets as exogenous.

The accumulation of reserve assets in each country has fiscal consequences which are included in the model as follows. We assume that the public sectors in each country spend a real amount G , G^* and G^{**} in period 0, respectively. Additionally, the governments of the two creditor countries accumulate reserve assets X^* and X^{**} respectively. As a result, the budget identities for period 0 read:

$$D = G \qquad D^* = G^* + S_0^{*\frac{3\alpha-1}{2}} X^* \qquad D^{**} = G^{**} + S_0^{**\frac{3\alpha-1}{2}} X^{**} \tag{6}$$

where the real exchange rates of the monetary hegemon against countries E and F, $S_0^{*(3\alpha-1)/2}$ and $S_0^{**(3\alpha-1)/2}$, convert the investment in the monetary hegemon's debt into local currency. Note that there is no tax levied in period 0, hence D, D^* and D^{**} correspond to the budget deficit in period 0.

Each government levies a (net) tax in period 1, denoted as T, T^* and T^{**} , to finance the repayment of debt, as reflected in the sovereign budget identities for period 1:

$$T = RD \qquad T^* = R^*D^* - S_1^{*\frac{3\alpha-1}{2}} RX^* \qquad T^{**} = R^{**}D^{**} - S_1^{**\frac{3\alpha-1}{2}} RX^{**} \tag{7}$$

We assume that private investors in country E are prohibited to hold foreign exchange reserves such that $D_E = X^{**}$. By contrast, private investors in the conventional creditor country F set a target $\overline{(D_F - X^*)}$ for the reserve assets they want to hold over and above the official reserves. This gives rise to a cost minimization problem, with the real cost to be minimized consisting of the opportunity cost of holding these assets and the cost of missing the target. The first-order condition for a minimum reads:

$$D_F = X^* + \overline{(D_F - X^*)}\left[1 - \gamma\left(\frac{R^*}{\chi^*} S_0^{*\frac{3\alpha-1}{2}} - \frac{R}{\chi} S_1^{*\frac{3\alpha-1}{2}}\right)\right]. \tag{8}$$

where γ is the weight attached to the opportunity cost relative to the total cost of holding reserve assets and $\chi \geq 1$ and $\chi^* \geq 1$ are risk adjustment factors, which are equal to 1 plus the expected variance of the return on these assets, hence in the absence of risk $\chi = \chi^* = 1$. This may refer to liquidity risk (less liquid assets portray more volatility) or default risk. In the latter case we might expect the risk to increase if the budget outlook deteriorates, so if either sovereign debt or the required tax take increase. However, in our model we treat risk as exogenous.

Even if we treat official investments in the reserve asset as exogenous, we are able to compute how the variables R, R^*, R^{**}, S_0^*, S_1^* S_0^{**} and S_1^{**} affect the opportunity cost of official holdings of the reserve asset for each creditor country, which read:

$$\frac{R^*}{\chi^*} S_0^{*\frac{3\alpha-1}{2}} - \frac{R}{\chi} S_1^{*\frac{3\alpha-1}{2}} \qquad \frac{R^{**}}{\chi^{**}} S_0^{**\frac{3\alpha-1}{2}} - \frac{R}{\chi} S_1^{**\frac{3\alpha-1}{2}} \qquad (9)$$

The marginal opportunity cost of holding reserve assets issued by the monetary hegemon thus correspond to the spread between the domestic real interest rate (R^* or R^{**} depending on the country) and the exchange rate adjusted real interest rate R of the monetary hegemon. In symmetric equilibrium (see below) $S_t^* = S_t^{**} = 1$ and $R = R^* = R^{**}$, hence according to (9) the marginal opportunity cost of holding the monetary hegemon's sovereign debt are nil in both creditor countries. So, clearly, if there consists a convenience yield on holding this debt, the incentives for countries E and F to hold H's sovereign debt, thus moving from symmetric equilibrium, are potentially strong.

3.5 Calibration and symmetric equilibrium

The parameters in the system are calibrated as follows. First, the elasticity of intertemporal substitution σ is fixed at 0.5 in line with findings in a survey of 169 published studies reported by Havranek et al (2013). In line with the convention for computable general equilibrium models and in accordance with findings from studies by Meyer (2013) and Yao et al (2012) we fix the discount factor β at 0.99. For convenience we fix the degree of home bias α at $\frac{2}{3}$ since this leaves us with the attractive property that $(3\alpha - 1)/2 = \frac{1}{2}$ and hence that the real exchange rate of the reserve currency against the other two currencies is equal to $\sqrt{S_t^*}$ and $\sqrt{S_t^{**}}$. The weight of the opportunity cost in the demand function for the hegemon's sovereign debt by private investors γ is fixed at 1, implying equal weights of the real cost of missing the target for $D_F - X^*$ and the opportunity cost of achieving the target. We will assume in our baseline that the risk factors $\chi = \chi^* = \chi^{**} = 1$. For real endowments we assume that $Y_t = Y_t^* = Y_t^{**} = 1$.

To solve the model for symmetric equilibrium, government expenditure in the baseline G, G^* and G^{**} are fixed at 0.025, which means that each country runs a budget deficit of 2½ % of output. Moreover, we assume that the sovereigns of

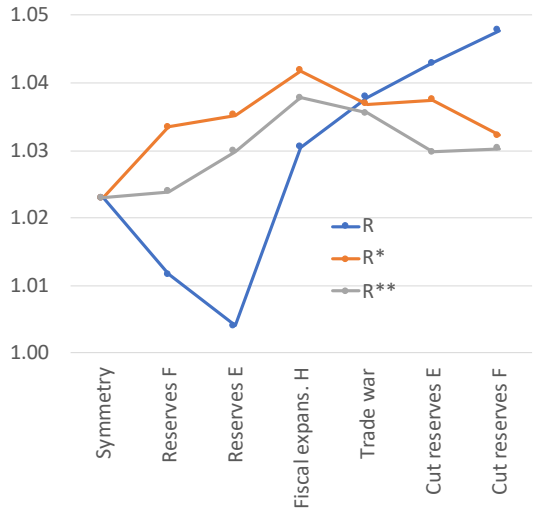
countries do not accumulate foreign exchange reserves, i.e. $X^* = X^{**} = 0$, and that also the private sector in country F targets zero foreign exchange reserves such that $\overline{(D_F - X^*)} = 0$. This yields as a solution that $R = R^* = R^{**} = 1.023$, $S_0^* = S_0^* = S_1^{**} = S_1^{**} = 1$, $T = T^* = T^{**} = 0.0256$, $D = D^* = D^{**} = 0.025$, $C_0 = C_0^* = C_0^{**} = 0.975$, $C_1 = C_1^* = C_1^{**} = 1$ and $D_F = D_E = 0$. We use this symmetric equilibrium as the starting point for our scenario analysis in the next section.

4 Scenario analysis

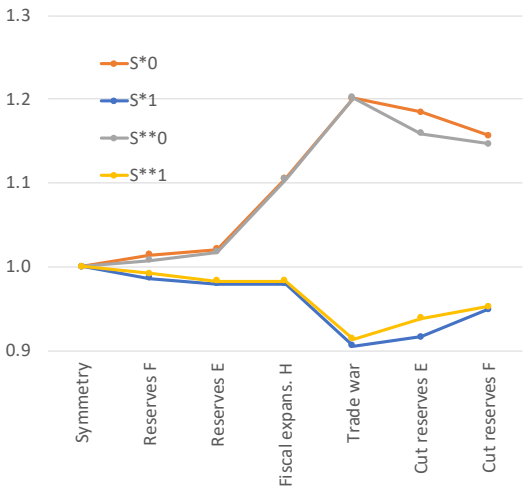
Now that we have established a symmetric equilibrium, we use the model to generate two sets of scenarios. In the first scenario – which we call 'exorbitant privilege' – we assume that first the conventional creditor country *F* builds up reserve assets, next the emerging creditor country *E* does so and, finally, the monetary hegemon *H* 'consumes' the fiscal space thus created via a fiscal expansion. In the second set of scenarios – dubbed 'trade war and de-dollarization' – we assume that international trade contracts radically and that in response first the emerging creditor country E and subsequently the conventional creditor F downsize their holdings of reserve assets. The numerical results are summarized in Figure 7 with a full report provided in the Annex.

Figure 7: Scenario analysis

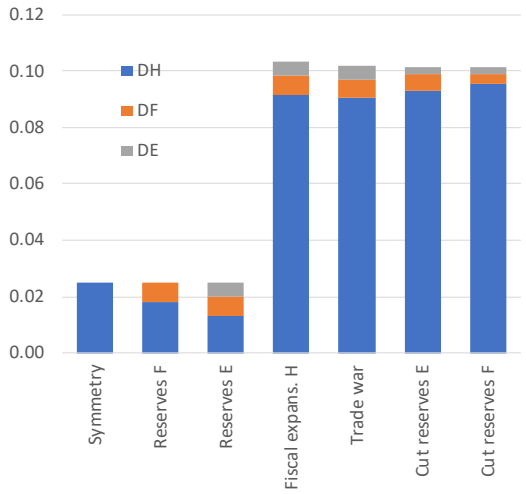
A. Gross real interest rates



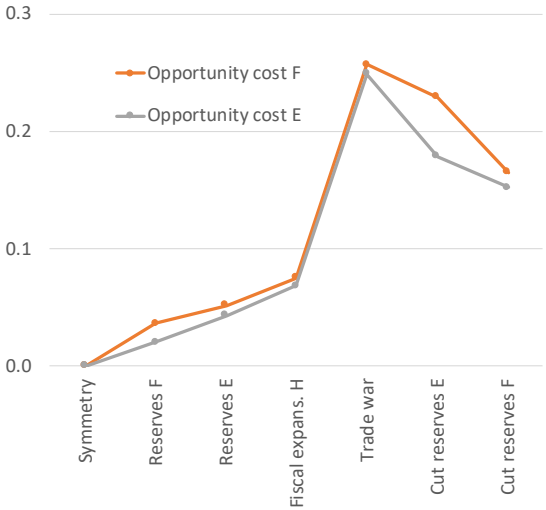
B. Terms of trade



C. Composition of sovereign debt of the 'monetary hegemon', by holder



D. Opportunity cost of sovereign debt of the 'monetary hegemon', by holder



Source: Annex

4.1 'Exorbitant privilege'

First we construct a scenario in which the sovereign of the conventional creditor country F purchases one-fifth of the monetary hegemon's sovereign debt, such that $X^* = 0.005$, while private investors set a target for their holdings of debt over and above the official holdings of the same amount, such that $\overline{(D_F - X^*)} = 0.005$. As shown in Panel A of Figure 6, the gross real yield on this debt falls from 1.023 to

1.012, meaning that the net real yield virtually halves from 2.3% to 1.2%, in line with the 'exorbitant privilege' hypothesis. By contrast, country *F*'s real yield increases by 1 percentage point as it needs to tap into domestic savings to finance the investment in reserve assets.

As shown in Panel B, the terms of trade of the monetary hegemon against the conventional creditor increases by 1.5% in period 0 but falls by 1.4% in period 1 – both relative to symmetric equilibrium. This means that the longer term outlook for the real exchange rate of the monetary hegemon weakens, due to the repayment of foreign debt in period 1. This is reflected in the increase in the opportunity cost for country *F* of holding H's debt (Panel D).

While we observe similar developments for country *E*, these are less stark. This changes when, additionally, we assume the sovereign of that country to purchase one-fifth of *H*'s debt as well, such that $X^{**} = 0.005$. As also shown in Figure 6, in this scenario the real yield on *H*'s debt approaches zero (0.4%) while the terms of trade strengthens further in period 0 but also weakens further in period 1. The opportunity cost of holding this debt increases for both creditor countries.

In a third scenario we assume that the sovereign of country *H* collects some of the benefits stemming from the 'exorbitant privilege' by raising its budget deficit in period 0, from 2.5% to 10% of aggregate output, such that $G = 0.100$. As shown in Figure 6, country *H*'s real yield increases from 0.4% to 3.1%, broadly in line with empirical observations. Meanwhile its terms of trade (and hence the real exchange rate) strengthen in period 0, though it weakens in period 1 due to the larger debt repayment of foreign debt. As a result, the opportunity cost of holding *H*'s debt increases further, despite the higher yield.

To sum up, buoyant demand for reserve assets by creditor countries leads to an increase in the real interest rate spreads of the latter against the hegemon and a stronger short-term but weaker long-run outlook for the real exchange rate of the reserve currency. However, when the hegemon collects the 'exorbitant privilege' benefits, by running a loose fiscal policy, these spreads shrink while the hegemon's real exchange rate strengthens further in the short run (but not in the long run). The real interest rate on debt issued by the monetary hegemon increases little as the exchange rates bear the brunt of the adjustment. As a result, the opportunity cost of holding reserve assets rises further.

4.2 'Trade war and de-dollarization'

We take the last-mentioned scenario as our baseline against which to assess the impact of a trade war and, subsequently, a cut in the demand for reserve assets by the other two economies. We treat these changes as 'exogenous shocks' in our analysis, though in reality such occurrences may reflect pre-set reaction functions that we leave, however, unspecified.

In the first – 'trade war' – sub-scenario we assume that the degree of home bias in international trade embedded in the intra-termporal utility functions increases by adopting a value of the relevant parameter $\alpha = 0.9$ in stead of $\alpha = 0.667$, see the system of equations (1). This implies that the amount of international trade shrinks relative to global output while more consumption is domestic. We apply this change to all three countries, implying that all three decouple to some extent. The results are again depicted in Figure 6.

Since we have not adjusted the official demand for reserve assets X^* and X^{**} nor the target for reserve assets in the private sector of country F, $\overline{D_F - X^*}$, the exchange rates (and terms of trade) must adjust to secure equilibrium in the balance of payments. This is indeed what the model outcomes indicate, with the terms of trade of the monetary hegemon strengthening in the short run to absorb the excess demand for its debt but weakening in the long run when its foreign debt is repaid. The real yield on this debt is found to move only little in this scenario as the exchange rate bears the brunt of the adjustment. As a result, the opportunity cost of holding the hegemon's sovereign debt increases sharply for both creditor countries in this scenario.

In view of the above results the question can be legitimately asked whether these are sustainable, and the answer is likely no. If the opportunity cost of holding assets denominated in the reserve currency become very high, it makes sense for creditor countries to dispose some of it. Note that this is true even disregarding the possibility of creditor countries restraining their holdings by way of retaliation against the hegemon's trade policy or (other) geopolitical issues.

In a first 'de-dollarization' scenario we assume that the sovereign of the emerging creditor country halves its holdings of reserve assets $X^{**} = 0.0025$ from 0.005 and in a second scenario that (public and private) investors in the conventional creditor country follow suit, with $X^* = 0.0025$ and $\overline{(D_F - X^*)} = 0.0025$, halving also from a baseline value of 0.005.

In each scenario the real yield on reserve assets increases sharply as the monetary hegemon needs to tap into its domestic savings to a greater extent. In the first scenario the terms of trade (and real exchange rate) of the emerging creditor appreciates in the short run, with that of the conventional creditor catching up in the second scenario. In the long run their real exchange rates weaken as the receipt of debt repayments is smaller. As a result in both scenarios the opportunity cost of holding reserve assets recovers a bit and a complete wipe-out becomes less likely.

5 Conclusions

The replacement of the dollar convertibility under the Bretton Woods system with a system of floating exchange rates from the outset considerably mitigated the risk of

a ‘run on the dollar’, but this may not last forever. While the Triffin dilemma is no longer applicable – having removed the mismatch between the fixed value of the monetary anchor, i.e. gold, and the demand for dollar – the issue of dollar stability has not gone away. Dollar-holders remain highly concerned with its stability to minimise the risk of capital losses on their holdings.

Recently, geopolitical tensions, coupled with the aggressive trade policy of the Trump administration, have introduced new risks for dollar-holders – especially sovereign holders – as their dollar assets can become target of retaliation or coercion. These concerns arise against the backdrop of China actively promoting the use of its currency in international trade and finance and reducing its exposure to the dollar.

The key question, therefore, is whether dollar holders, notably in Europe, will continue to maintain their dollar positions or reduce their exposure in lockstep with China, in response to a reduction in global trade. In our paper we show that the rationale of holding less reserves in that case is compelling because the opportunity cost of holding US sovereign debt would increase. However, a slowdown in the accumulation of US sovereign debt also reduces the opportunity cost of holding such debt.

Our model simulations suggest that cutbacks in the build-up of creditor countries positions of the monetary hegemon’s sovereign debt lowers its opportunity cost relative to the associated convenience yield. More importantly, if China initiates a further reduction in its holdings and triggers a response from European countries to also cut back, the fall in opportunity cost would be even larger. This, in turn, could lead China to adopt a smaller move or to refrain from moving in the first place.

This outcome would be even more pronounced if the marginal convenience yield of holding reserves were to increase as a result of the cutbacks. Such an outcome is highly probable given that there is only one reserve currency in this system. A reduction in its availability would necessarily increase the marginal convenience yield as there is no other currency that could take over its role. Hence, a collapse of the dollar’s dominant position within the international monetary system is unlikely, unless China prioritises geo-strategic goals over economic rationales. A related concern is that with the new Administration in office the United States appears to give more precedence to geopolitical brinkmanship over economic rationales than in the past. Against this backdrop, European countries would be wise to reassess the validity of their dollar exposures.

Annex – The full model

Aside from the 'monetary hegemon' which represents the United States, we distinguish two other players: an 'emerging creditor' which represents China and a 'conventional creditor' which represents other major creditors (we do not make a further distinction between emerging economies or advanced economies among this group). Hence we distinguish three countries, which includes the 'home country' (the monetary hegemon or H), the 'conventional creditor country' (F) and the 'emerging creditor country (E).

A.1 Intra-temporal allocation

Households in each country consume a basket of home-produced goods and foreign-produced goods, each at their own price. The law of one price applies, ensuring that the relative price of one good against the other is identical in all three countries.

Households in each country maximise utility which depends on consumption of home goods and foreign goods based on the nested Cobb-Douglas utility functions:

$$C_t = \eta C_{Ht}^{\alpha}\left(\sqrt{C_{Ft}C_{Et}}\right)^{1-\alpha}, \qquad C_t^* = \eta {C_{Ft}^*}^{\alpha}\left(\sqrt{C_{Ht}^*C_{Et}^*}\right)^{1-\alpha},$$
$$C_t^{**} = \eta C_{Et}^{**\alpha}\left(\sqrt{C_{Ht}^{**}C_{Ft}^{**}}\right)^{1-\alpha}, \qquad \eta = \alpha^{-\alpha}\left[\tfrac{1}{2}(1-\alpha)\right]^{-(1-\alpha)}, \qquad (A.1)$$

where aggregate consumption in the home, foreign and emerging country are denoted as C_t, C_t^* and C_t^{**}, while C_{Ht}, C_{Ft} and C_{Et} are real consumption of goods produced in the home, foreign and emerging countries in the home country, and C_{Ht}^*, C_{Ft}^* and C_{Et}^* and C_{Ht}^{**}, C_{Ft}^{**} and $C_{Et}^{**}$are their equivalents for the foreign and emerging country.

Real aggregate consumption in each country is maximized subject to the conditions:

$$C_tP_t = P_{Ht}C_{Ht} + P_{Ft}C_{Ft} + P_{Et}C_{Et}, \quad P_t^*C_t^* = P_{Ft}^*C_{Ft}^* + P_{Ht}^*C_{Ht}^* + P_{Et}^*C_{Et}^*,$$
$$P_t^{**}C_t^{**} = P_{Ft}^{**}C_{Ft}^{**} + P_{Ht}^{**}C_{Ht}^{**} + P_{Et}^{**}C_{Et}^{**}, \qquad (A.2)$$

with P_{Ht}, P_{Ft}, P_{Et} and P_t denoting the prices of goods in the home country, and P_{Ht}^*, P_{Ft}^*, P_{Et}^* and P_t^* and P_{Ht}^{**}, P_{Ft}^{**}, P_{Et}^{**} and P_t^{**} denoting their equivalents in the foreign and emerging country.

The aggregate price levels in the three countries are:

$$P_t = P_{Ht}^{\alpha}\left(\sqrt{P_{Ft}P_{Et}}\right)^{1-\alpha}, P_t^* = {P_{Ft}^*}^{\alpha}\left(\sqrt{P_{Ht}^*P_{Et}^*}\right)^{1-\alpha}, P_t^{**} = P_{Et}^{**\alpha}\left(\sqrt{P_{Ht}^{**}P_{Ft}^{**}}\right)^{1-\alpha} \qquad (A.3)$$

Owing to the law of one price, after conversion at the nominal exchange each good sell at the same price in both countries, i.e.:

$$e_t^* = \frac{P_{Ht}^*}{P_{Ht}} = \frac{P_{Ft}^*}{P_{Ft}} = \frac{P_{Et}^*}{P_{Et}}, \qquad e_t^{**} = \frac{P_{Ht}^{**}}{P_{Ht}} = \frac{P_{Ft}^{**}}{P_{Ft}} = \frac{P_{Et}^{**}}{P_{Et}}, \qquad (A.4)$$

where e_t^* is the exchange rate of the foreign currency per unit of the reserve currency and e_t^{**} is the equivalent for the exchange rate of the currency of the emerging country. The terms of trade are defined as:

$$S_t^* = \frac{P_{Ht}}{P_{Ft}} = \frac{P_{Ht}^*}{P_{Ft}^*} = \frac{P_{Ht}^{**}}{P_{Ft}^{**}}, \qquad S_t^{**} = \frac{P_{Ht}}{P_{Et}} = \frac{P_{Ht}^*}{P_{Et}^*} = \frac{P_{Ht}^{**}}{P_{Et}^{**}}, \tag{A.5}$$

From (A.3), (A.4) and (A.5) follows for the real exchange rates $e_t^* \cdot P_t/P_t^*$ and $e_t^{**} \cdot P_t/P_t^{**}$ that:

$$e_t^* \frac{P_t}{P_t^*} = \sqrt{S_t^*}^{3\alpha-1}, \qquad e_t^{**} \frac{P_t}{P_t^{**}} = \sqrt{S_t^{**}}^{3\alpha-1}. \tag{A.6}$$

Maximising real aggregate consumption (A.1) subject to (A.2), (A.3), (A.4) and (A.5) yields the following demand equations for the home country:

$$C_{Ht} = \alpha S_t^{*-\frac{1-\alpha}{2}} S_t^{**-\frac{1-\alpha}{2}} C_t, \qquad C_{Ft} = \frac{1}{2}(1-\alpha) S_t^{*\frac{1+\alpha}{2}} S_t^{**-\frac{1-\alpha}{2}} C_t,$$
$$C_{Et} = \frac{1}{2}(1-\alpha) S_t^{*-\frac{1-\alpha}{2}} S_t^{**\frac{1+\alpha}{2}} C_t, \tag{A.7}$$

the conventional creditor country:

$$C_{Ft}^* = \alpha S_t^{*1-\alpha} S_t^{**-\frac{1-\alpha}{2}} C_t^*, \qquad C_{Ht}^* = \frac{1}{2}(1-\alpha) S_t^{*-\alpha} S_t^{**-\frac{1-\alpha}{2}} C_t^*,$$
$$C_{Et}^* = \frac{1}{2}(1-\alpha) S_t^{*-\alpha} S_t^{**\frac{1+\alpha}{2}} C_t^*, \tag{A.8}$$

and the emerging creditor country:

$$C_{Et}^{**} = \alpha S_t^{**1-\alpha} S_t^{*-\frac{1-\alpha}{2}} C_t^{**}, \qquad C_{Ht}^{**} = \frac{1}{2}(1-\alpha) S_t^{**-\alpha} S_t^{*-\frac{1-\alpha}{2}} C_t^{**},$$
$$C_{Ft}^{**} = \frac{1}{2}(1-\alpha) S_t^{**-\alpha} S_t^{*\frac{1+\alpha}{2}} C_t^{**}. \tag{A.9}$$

We assume that in each country the government consumes an amount G_t, G_t^* and G_t^{**} consisting solely of home-produced goods (the government is not engaged in international trade). With Y_t, Y_t^* and Y_t^{**} denoting the given production endowments in each country and period, the market clearing conditions read:

$$Y_t = G_t + C_{Ht} + C_{Ht}^* + C_{Ht}^{**},$$
$$Y_t^* = G_t^* + C_{Ft} + C_{Ft}^* + C_{Ft}^{**}, \quad Y_t^{**} = G_t^{**} + C_{Et} + C_{Et}^* + C_{Et}^{**} \ . \tag{A.10}$$

Combining these conditions with the demand equations (A.7-9) yields for each country and period:

$$Y_t = G_t + \alpha S_t^{*-\frac{1-\alpha}{2}} S_t^{**-\frac{1-\alpha}{2}} C_t + \frac{1}{2}(1-\alpha)\left[S_t^{*-\alpha} S_t^{**-\frac{1-\alpha}{2}} C_t^* + S_t^{**-\alpha} S_t^{*-\frac{1-\alpha}{2}} C_t^{**}\right],$$
$$Y_t^* = G_t^* + \alpha S_t^{*1-\alpha} S_t^{**-\frac{1-\alpha}{2}} C_t^* + \frac{1}{2}(1-\alpha)\left[S_t^{*\frac{1+\alpha}{2}} S_t^{**-\frac{1-\alpha}{2}} C_t + S_t^{**-\alpha} S_t^{*\frac{1+\alpha}{2}} C_t^{**}\right],$$
$$Y_t^{**} = G_t^{**} + \alpha S_t^{**1-\alpha} S_t^{*-\frac{1-\alpha}{2}} C_t^{**} + \frac{1}{2}(1-\alpha)\left[S_t^{*-\frac{1-\alpha}{2}} S_t^{**\frac{1+\alpha}{2}} C_t + S_t^{*-\alpha} S_t^{**\frac{1+\alpha}{2}} C_t^*\right] \tag{A.11}$$

From this we solve aggregate consumption C_t, C_t^* and C_t^{**} in each country and period. First we derive the determinant of this system:

$$\Delta = \begin{vmatrix} \alpha & \frac{1}{2}(1-\alpha) & \frac{1}{2}(1-\alpha) \\ \frac{1}{2}(1-\alpha) & \alpha & \frac{1}{2}(1-\alpha) \\ \frac{1}{2}(1-\alpha) & \frac{1}{2}(1-\alpha) & \alpha \end{vmatrix} = \alpha^3 + \frac{1}{4}(1-\alpha)^3 - \frac{3}{4}(1-\alpha)^2\alpha. \qquad (A.12)$$

Note that if we choose for instance $\alpha = \frac{2}{3}$ then $\Delta = \frac{1}{4}$. Next we derive:

$$\begin{aligned} C_t = \frac{1}{\Delta}\Big[\alpha^2 - \tfrac{1}{4}(1-\alpha)^2\Big] S_t^{*\frac{1-\alpha}{2}} S_t^{**\frac{1-\alpha}{2}} (Y_t - G_t) \\ - \frac{1}{\Delta}(1-\alpha)\Big[\alpha - \tfrac{1}{2}(1-\alpha)\Big]\Big[\tfrac{1}{2} S_t^{*-\frac{1+\alpha}{2}} S_t^{**\frac{1-\alpha}{2}} (Y_t^* - G_t^*) \\ + \tfrac{1}{2} S_t^{*\frac{1-\alpha}{2}} S_t^{**-\frac{1+\alpha}{2}} (Y_t^{**} - G_t^{**})\Big] \end{aligned}$$

$$\begin{aligned} C_t^* = \frac{1}{\Delta}\Big[\alpha^2 - \tfrac{1}{4}(1-\alpha)^2\Big] S_t^{*-(1-\alpha)} S_t^{**\frac{1-\alpha}{2}} (Y_t^* - G_t^*) \\ - \frac{1}{\Delta}(1-\alpha)\Big[\alpha - \tfrac{1}{2}(1-\alpha)\Big]\Big[\tfrac{1}{2} S_t^{*\alpha} S_t^{**\frac{1-\alpha}{2}} (Y_t - G_t) \\ + \tfrac{1}{2} S_t^{*\alpha} S_t^{**-\frac{1+\alpha}{2}} (Y_t^{**} - G_t^{**})\Big], \end{aligned}$$

$$\begin{aligned} C_t^{**} = \frac{1}{\Delta}\Big[\alpha^2 - \tfrac{1}{4}(1-\alpha)^2\Big] S_t^{*\frac{1-\alpha}{2}} S_t^{**-(1-\alpha)} (Y_t^{**} - G_t^{**}) \\ - \frac{1}{\Delta}(1-\alpha)\Big[\alpha - \tfrac{1}{2}(1-\alpha)\Big]\Big[\tfrac{1}{2} S_t^{*\frac{1-\alpha}{2}} S_t^{**\alpha} (Y_t - G_t) \\ + \tfrac{1}{2} S_t^{*-\frac{1+\alpha}{2}} S_t^{**\alpha} (Y_t^* - G_t^*)\Big] \qquad (A.13) \end{aligned}$$

Note that if $S_t^* = S_t^{**} = 1$ and $\alpha = \frac{2}{3}$ then $C_t = 1\frac{2}{3}(Y_t - G_t) - \frac{1}{3}(Y_t^* - G_t^*) - \frac{1}{3}Y_t^{**}$, $C_t^* = 1\frac{2}{3}(Y_t^* - G_t^*) - \frac{1}{3}(Y_t^{**} - G_t^{**}) - \frac{1}{3}(Y_t - G_t)$, and $C_t^{**} = 1\frac{2}{3}(Y_t^{**} - G_t^{**}) - \frac{1}{3}(Y_t^* - G_t^*) - \frac{1}{3}(Y_t - G_t)$. If endowment incomes and government expenditures Y_t, Y_t^* and Y_t^{**} and G_t, G_t^* and G_t^{**} are given and the terms of trade S_t^* and S_t^{**} are known, then aggregate consumption C_t, C_t^* and $C_t^{**}$are determined as well.

A.2 Intertemporal allocation -- the monetary hegemon

In period 0 the monetary hegemon's sovereign raises real debt D to fund a real income transfer G. In period 1 it raises a real tax T, which is used to repay the real debt D at a gross real rate of interest R. This implies that $G_0 = G$ and $G_1 = 0$. In formal terms the period 0 and period 1 budget indentities then read:

$$G\frac{P_{H0}}{P_0} = D, \qquad RD = T\,. \qquad (A.14)$$

Households in this country face the following budget identities for period 0 and period 1:

$$\frac{P_{H0}}{P_0} Y_0 = C_0 + D_H, \qquad \frac{P_{H1}}{P_1} Y_1 + RD_H - T = C_1 \qquad (A.15)$$

Replacing the real prices in $(A.14)$ and $(A.15)$ by expressions of the terms of trade using $(A.3)$ and $(A.5)$ yields:

$$S_0^{*\frac{1-\alpha}{2}} S_0^{**\frac{1-\alpha}{2}} G = D, \qquad S_0^{*\frac{1-\alpha}{2}} S_0^{**\frac{1-\alpha}{2}} Y_0 = C_0 + D_H, \qquad S_1^{*\frac{1-\alpha}{2}} S_1^{**\frac{1-\alpha}{2}} Y_1 + RD_H - T = C_1 \qquad (A.16)$$

Household maximize expected utility subject to the budget constraints (A.13) based on the intertemporal mix of consumption:

$$U = \sum_{t=0,1} \beta^t \frac{C_t^{1-\sigma}}{1-\sigma} \qquad (A.17)$$

where $1/\beta$ is the pure rate of time preference. This yields the usual Euler equation:

$$R = \frac{1}{\beta}\left(\frac{C_1}{C_0}\right)^{\sigma}. \qquad (A.18)$$

While households invest D_H in sovereign debt, the remainder of this debt is exported, hence:

$$D_H = D - D_F - D_E \ . \qquad (A.19)$$

Combining this with the household budget constraints $(A.16)$ and the government budget constraints $(A.14)$ yields:

$$D_F + D_E = C_0 - S_0^{*\frac{1-\alpha}{2}} S_0^{**\frac{1-\alpha}{2}} (Y_0 - G), \qquad R(D_F + D_E) = S_1^{*\frac{1-\alpha}{2}} S_1^{**\frac{1-\alpha}{2}} Y_1 - C_1 \qquad (A.20)$$

where the right-hand side of the first equation represents the real current account deficit position of the home country in period 0 and the right-hand side of the second equation represents the current account surplus position of the home country in period 1. Re-arranging these relationships yields equations for the terms of trade S_0^* and S_1^*:

$$S_0^* = S_0^{**-1}\left(\frac{C_0 - D_F - D_E}{Y_0 - G}\right)^{\frac{2}{1-\alpha}}, \qquad S_1^* = S_1^{**-1}\left[\frac{C_1 + R(D_F + D_E)}{Y_1}\right]^{\frac{2}{1-\alpha}}. \qquad (A.21)$$

A.3 Intertemporal allocation -- the 'conventional' creditor country

The sovereign of the foreign country issues debt to fund an income transfer to households, akin to the sovereign of the monetary hegemon. Additionally, however, in period 0 the foreign invests in sovereign debt issued by the monetary hegemon by a real amount X^*, which serves as its official international reserves. As a result, the budget identities for the foreign sovereign read:

$$S_0^{*\frac{3\alpha-1}{2}} X^* + \frac{P_{F0}^*}{P_0^*} G^* = D^*, \qquad R^* D^* = S_1^{*\frac{3\alpha-1}{2}} R X^* + T^*, \qquad (A.22)$$

The first identity says that in period 0 the foreign sovereign raises real debt D^* to finance the purchase of hegemon country real sovereign debt X^* at a real exchange rate as dfined in $(B.6)$ and real government expenditure G^*. The second identity says

that the foreign sovereign in period 1 repays real domestic debt D^* with real interest R^* funded by the gross real yield on its foreign investments and real tax receipts T^*. Note that the investment in real sovereign foreign debt X^* is financed by domestic debt and therefore fully sterilized (there are no monetary consequences).

The household income identities for the foreign country read:

$$\frac{P_{F0}^*}{P_0^*}Y_0^* = C_0^* + S_0^{*\frac{3\alpha-1}{2}}(D_F - X^*) + D^*,$$

$$\frac{P_{F1}^*}{P_1^*}Y_1^* + S_1^{*\frac{3\alpha-1}{2}}R(D_F - X^*) + R^*D^* - T^* = \ C_1^*. \qquad (A.23)$$

Incorporating (A.3) and (A.5) in (A.22) and (A.23) yields:

$$S_0^{*\frac{3\alpha-1}{2}}X^* + S_0^{*-(1-\alpha)}S_0^{**\frac{1-\alpha}{2}}G^* = \ D^*,$$

$$S_0^{*-(1-\alpha)}S_0^{**\frac{1-\alpha}{2}}Y_0^* = C_0^* + S_0^{*\frac{3\alpha-1}{2}}(D_F - X^*) + D^*,$$

$$S_1^{*-(1-\alpha)}S_1^{**\frac{1-\alpha}{2}}Y_1^* + S_1^{*\frac{3\alpha-1}{2}}R(D_F - X^*) + R^*D^* - T^* = \ C_1^*. \quad (A.24)$$

The utility function for the foreign country is similar to that for the home country and reads:

$$U^* = \sum_{t=0,1} \beta^{*t}\frac{C_t^{*1-\sigma^*}}{1-\sigma^*}, \qquad (A.25)$$

where $1/\beta^*$ is again the pure rate of time preference.

Maximising utility subject to (A.25) subject to (A.24) yields the Euler equation:

$$R^* = \frac{1}{\beta^*}\left(\frac{C_1^*}{C_0^*}\right)^{\sigma^*}, \qquad (A.26)$$

where a $1/\beta^*$ is again the pure rate of time preference, which we allow to differ across the two countries.

Combining the accounting identities (A.22) and (A.24) for the sovereign and households with (A.2) yields the balance of payments identities:

$$S_0^{*-(1-\alpha)}S_0^{**\frac{1-\alpha}{2}}(Y_0^* - G^*) - C_0^* = S_0^{*\frac{3\alpha-1}{2}}D_F,$$

$$S_1^{*-(1-\alpha)}S_1^{**\frac{1-\alpha}{2}}Y_1^* + S_1^{*\frac{3\alpha-1}{2}}RD_F = C_1^*. \qquad (A.27)$$

We assume that foreign investors in the conventional creditor country want to hold the hegemon's sovereign debt for international transaction purposes and as a safe and liquid store of value. Investors are assumed to set a target for the hegemon's sovereign debt they want to hold as part of their portfolio policy while considering the risk-adjusted opportunity cost of holding this debt. This gives rise to a cost

minimization problem, with the real cost to be minimized consisting of the opportunity cost and the cost of missing the target. In formal terms:

$$\min_{D_F - X^*} \frac{\frac{1}{2}\left[(D_F - X^*) - \overline{(D_F - X^*)}\right]^2}{\overline{(D_F - X^*)}} + \gamma\left(\frac{R^*}{\chi^*} - \frac{e_1^*}{e_0^*}\frac{P_1}{P_0}\frac{P_0^*}{P_1^*}\frac{R}{\chi}\right)\frac{P_0 e_0^*}{P_0^*}(D_F - X^*), \quad (A.28)$$

where the quadratic term is the cost of missing the target $\overline{D_F - X}$, and the other term is the real opportunity cost of holding the hegemon's sovereign debt, with χ and χ^* denoting the risk associated with holding hegemon and foreign country sovereign debt, respectively.

The first-order condition for a minimum, making use of (A.6), reads:

$$D_F = \overline{(D_F - X^*)} + X^* - \gamma\overline{(D_F - X^*)}\left(\frac{R^*}{\chi^*}S_0^{*\frac{3\alpha-1}{2}} - \frac{R}{\chi}S_1^{*\frac{3\alpha-1}{2}}\right). \quad (A.29)$$

This result indicates that the spread between the real yield on domestic debt R^* and that on debt issued by the hegemon R, corrected for exchange rate effects and default risk, will exert a negative impact on the amount of investment in the hegemon's sovereign debt. We will assume that $D_F - X^*$ cannot be negative.

For the risk terms χ and χ^* we assume that these grow exponentially when level of taxation in period 1 exceeds a threshold $\bar{T}$ or $\bar{T}^*$, so:

$$\chi = \begin{cases} 1, & T \le \bar{T} \\ exp[\delta(T - \bar{T})], & T > \bar{T} \end{cases}, \qquad \chi^* = \begin{cases} 1, & T^* \le \bar{T}^* \\ exp[\delta(T^* - \bar{T}^*)], & T^* > \bar{T}^* \end{cases}. \quad (A.30)$$

Note that this country's sovereign faces the same opportunity cost as the private sector. However, since it is assumed that X^* is exogenous, there is no feedback effect from the opportunity cost onto the investment in foreign exchange reserves by the sovereign.

A.4 Intertemporal allocation -- the 'emerging' creditor country

Akin to the foreign country the sovereign of the emerging country issues debt to fund an income transfer to households and investments in sovereign debt issued by the monetary hegemon, which serves as its official international reserves. As a result, the budget identities for the second foreign sovereign read:

$$S_0^{**\frac{3\alpha-1}{2}}X^{**} + \frac{P_{E0}^{**}}{P_0^{**}}G^{**} = D^{**}, \qquad R^{**}D^{**} = S_1^{**\frac{3\alpha-1}{2}}RX^{**} + T^{**}. \quad (A.31)$$

We will assume that the emerging country has capital controls, meaning that only the sovereign is permitted to invest in the hegemon's debt, hence:

$$D_E = X^{**}. \quad (A.32)$$

The household income identities for the emerging country then read:

$$\frac{P_{E0}^{**}}{P_0^{**}}Y_0^{**} = C_0^{**} + D^{**}, \qquad \frac{P_{E1}^{**}}{P_1^{**}}Y_1^{**} - T^{**} + R^{**}D^{**} = C_1^{**}. \quad (A.33)$$

Incorporating (A.3) and (A.5) in (A.31) and (A.33) yields:

$$S_0^{**\frac{3\alpha-1}{2}} X^{**} + S_1^{*\frac{1-\alpha}{2}} S_1^{**-(1-\alpha)} G^{**} = D^{**}, \qquad S_0^{*\frac{1-\alpha}{2}} S_0^{**-(1-\alpha)} Y_0^{**} = C_0^{**} + D^{**},$$
$$S_1^{*\frac{1-\alpha}{2}} S_1^{**-(1-\alpha)} Y_1^{**} - T^{**} + R^{**} D^{**} = C_1^{**}. \qquad (A.34)$$

The utility function reads:

$$U^{**} = \sum_{t=0,1} \beta^{**t} \frac{C_t^{**1-\sigma^{**}}}{1-\sigma^{**}} \ . \qquad (A.35)$$

Utility maximization subject to the income identities A*B*.9) yields the usual Euler equation:

$$R^{**} = \frac{1}{\beta^{**}} \left(\frac{C_1^{**}}{C_0^{**}} \right)^{\sigma^{**}} , \qquad (A.36)$$

We derive the balance of payments identity by combining the household and government budget identities:

$$S_0^{*\frac{1-\alpha}{2}} S_0^{**-(1-\alpha)} (Y_0^{**} - G^{**}) - C_0^{**} = S_0^{**\frac{3\alpha-1}{2}} X^{**},$$
$$S_1^{*\frac{1-\alpha}{2}} S_1^{**-(1-\alpha)} Y_1^{**} + S_1^{**\frac{3\alpha-1}{2}} R X^{**} = C_1^{**}. \qquad (A.37)$$

A.5 Reduced forms

The model comprises 28 endogenous variables χ, χ^*, S_0^*, S_1^*, S_0^{**}, S_1^{**}, R, R^*, R^*, C_0, C_1, C_0^*, C_1^*, C_0^{**}, C_1^{**}, $e_0^* \cdot P_0/P_0^*$, $e_1^{**} \cdot P_1/P_1^{**}$, $e_0^{**} \cdot P_0/P_0^{**}$, $e_1^* \cdot P_1/P_1^*$, D, D^*, D^{**} T, T^*, T^{**}, D_F, D_E and D_H along with twelve exogenous variables Y_0, Y_1, Y_0^*, Y_1^*, Y_0^{**}, Y_1^{**}, X^*, X^{**} $\overline{D_F - X^*}$, G, G^* and G^{**}. After elimination of redundancies the system also consists of 28 equations: the six budget identities for the two sovereigns (*A*.14), (*A*.22) and (*A*.31), the four balance of payment identities (*A*.21) and (*A*.37), the six conditions for intra-temporal equilibrium (*A*.13), the four identities for the real exchange rates A*B*.6), the three Euler equations (*A*.18), (*A*.26) and (*A*.34), the three equations for the demand for the hegemon's sovereign debt at home (*A*.19) and abroad (*A*.29) and (*A*.32), and the two default risk equations (A.30). After some rearrangement and removal of redundancies the model reads:

$$D = S_0^{*\frac{1-\alpha}{2}} S_0^{**\frac{1-\alpha}{2}} G, \qquad T = RD \ , \qquad (A.14)$$

$$D^* = S_0^{*\frac{3\alpha-1}{2}} X^* + S_0^{*-(1-\alpha)} S_0^{**\frac{1-\alpha}{2}} G^*, \qquad T^* = R^* D^* - S_1^{*\frac{3\alpha-1}{2}} R X^*, \qquad (A.22)$$

$$D^{**} = S_0^{**\frac{3\alpha-1}{2}} X^{**} + S_1^{*\frac{1-\alpha}{2}} S_1^{**-(1-\alpha)} G^{**}, \quad T^{**} = R^{**} D^{**} - S_1^{**\frac{3\alpha-1}{2}} R X^{**}, \quad (A.31)$$

$$S_0^{*-(1-\alpha)} S_0^{**\frac{1-\alpha}{2}} (Y_0^* - G^*) - C_0^* = S_0^{*\frac{3\alpha-1}{2}} D_F,$$
$$S_1^{*-(1-\alpha)} S_1^{**\frac{1-\alpha}{2}} Y_1^* + S_1^{*\frac{3\alpha-1}{2}} R D_F = C_1^*. \quad (A.27)$$

$$S_0^* = S_0^{**-1} \left(\frac{C_0 - D_F - D_E}{Y_0 - G} \right)^{\frac{2}{1-\alpha}}, \qquad S_1^* = S_1^{**-1} \left[\frac{C_1 + R(D_F + D_E)}{Y_1} \right]^{\frac{2}{1-\alpha}}. \qquad (A.21)$$

$$S_0^{*\frac{1-\alpha}{2}} S_0^{**-(1-\alpha)}(Y_0^{**} - G^{**}) - C_0^{**} = S_0^{**\frac{3\alpha-1}{2}} X^{**},$$
$$S_1^{*\frac{1-\alpha}{2}} S_1^{**-(1-\alpha)} Y_1^{**} + S_1^{**\frac{3\alpha-1}{2}} R X^{**} = C_1^{**}. \qquad (A.37)$$

$$C_0 = \frac{1}{\Delta}\left[\alpha^2 - \tfrac{1}{4}(1-\alpha)^2\right] S_0^{*\frac{1-\alpha}{2}} S_0^{**\frac{1-\alpha}{2}}(Y_0 - G)$$
$$- \frac{1}{\Delta}(1-\alpha)\left[\alpha - \tfrac{1}{2}(1-\alpha)\right]\left[\tfrac{1}{2} S_0^{*-\frac{1+\alpha}{2}} S_0^{**\frac{1-\alpha}{2}}(Y_0^{*} - G^{*})\right.$$
$$\left. + \tfrac{1}{2} S_0^{*\frac{1-\alpha}{2}} S_0^{**-\frac{1+\alpha}{2}}(Y_0^{**} - G^{**})\right]$$

$$C_0^{*} = \frac{1}{\Delta}\left[\alpha^2 - \tfrac{1}{4}(1-\alpha)^2\right] S_0^{*-(1-\alpha)} S_0^{**\frac{1-\alpha}{2}}(Y_0^{*} - G^{*})$$
$$- \frac{1}{\Delta}(1-\alpha)\left[\alpha - \tfrac{1}{2}(1-\alpha)\right]\left[\tfrac{1}{2} S_0^{*\alpha} S_0^{**\frac{1-\alpha}{2}}(Y_0 - G)\right.$$
$$\left. + \tfrac{1}{2} S_0^{*\alpha} S_0^{**-\frac{1+\alpha}{2}}(Y_0^{**} - G^{**})\right],$$

$$C_0^{**} = \frac{1}{\Delta}\left[\alpha^2 - \tfrac{1}{4}(1-\alpha)^2\right] S_0^{*\frac{1-\alpha}{2}} S_0^{**-(1-\alpha)}(Y_0^{**} - G^{**})$$
$$- \frac{1}{\Delta}(1-\alpha)\left[\alpha - \tfrac{1}{2}(1-\alpha)\right]\left[\tfrac{1}{2} S_0^{*\frac{1-\alpha}{2}} S_0^{**\alpha}(Y_0 - G)\right.$$
$$\left. + \tfrac{1}{2} S_0^{*-\frac{1+\alpha}{2}} S_0^{**\alpha}(Y_0^{*} - G^{*})\right],$$

$$C_1 = \frac{1}{\Delta}\left[\alpha^2 - \tfrac{1}{4}(1-\alpha)^2\right] S_1^{*\frac{1-\alpha}{2}} S_1^{**\frac{1-\alpha}{2}} Y_1$$
$$- \frac{1}{\Delta}(1-\alpha)\left[\alpha - \tfrac{1}{2}(1-\alpha)\right]\left[\tfrac{1}{2} S_1^{*-\frac{1+\alpha}{2}} S_1^{**\frac{1-\alpha}{2}} Y_1^{*} + \tfrac{1}{2} S_1^{*\frac{1-\alpha}{2}} S_1^{**-\frac{1+\alpha}{2}} Y_1^{**}\right]$$

$$C_1^{*} = \frac{1}{\Delta}\left[\alpha^2 - \tfrac{1}{4}(1-\alpha)^2\right] S_1^{*-(1-\alpha)} S_1^{**\frac{1-\alpha}{2}} Y_1^{*}$$
$$- \frac{1}{\Delta}(1-\alpha)\left[\alpha - \tfrac{1}{2}(1-\alpha)\right]\left[\tfrac{1}{2} S_1^{*\alpha} S_1^{**\frac{1-\alpha}{2}} Y_1 + \tfrac{1}{2} S_1^{*\alpha} S_1^{**-\frac{1+\alpha}{2}} Y_1^{**}\right],$$

$$C_1^{**} = \frac{1}{\Delta}\left[\alpha^2 - \tfrac{1}{4}(1-\alpha)^2\right] S_1^{*\frac{1-\alpha}{2}} S_1^{**-(1-\alpha)} Y_1^{**}$$
$$- \frac{1}{\Delta}(1-\alpha)\left[\alpha - \tfrac{1}{2}(1-\alpha)\right]\left[\tfrac{1}{2} S_1^{*\frac{1-\alpha}{2}} S_1^{**\alpha} Y_1 + \tfrac{1}{2} S_1^{*-\frac{1+\alpha}{2}} S_1^{**\alpha} Y_1^{*}\right] \quad (A.13)$$

$$e_0^{*} \frac{P_0}{P_0^{*}} = S_0^{*\frac{3\alpha-1}{2}}, \qquad e_0^{**} \frac{P_0}{P_0^{**}} = S_0^{**\frac{3\alpha-1}{2}}.$$
$$e_1^{*} \frac{P_1}{P_1^{*}} = S_1^{*\frac{3\alpha-1}{2}}, \qquad e_1^{**} \frac{P_1}{P_1^{**}} = S_1^{**\frac{3\alpha-1}{2}}. \qquad (A.6)$$

$$R = \frac{1}{\beta}\left(\frac{C_1}{C_0}\right)^{\sigma}, (B.18), \quad R^{*} = \frac{1}{\beta^{*}}\left(\frac{C_1^{*}}{C_0^{*}}\right)^{\sigma^{*}}, (B.26), \quad R^{**} = \frac{1}{\beta^{**}}\left(\frac{C_1^{*}}{C_0^{**}}\right)^{\sigma^{**}} \quad (A.33)$$

$$D_H = D - D_F - D_E \qquad (A.19)$$

$$D_F = \overline{(D_F - X^{*})} + X^{*} - \gamma\overline{(D_F - X^{*})}\left(\frac{R^{*}}{\chi^{*}} S_0^{*\frac{3\alpha-1}{2}} - \frac{R}{\chi} S_1^{*\frac{3\alpha-1}{2}}\right). \qquad (A.29)$$

$$\chi = \begin{cases} 1, & T \le \bar{T} \\ exp[\delta(T - \bar{T})], & T > \bar{T} \end{cases}, \qquad \chi^{*} = \begin{cases} 1, & T^{*} \le \bar{T}^{*} \\ exp[\delta(T^{*} - \bar{T}^{*})], & T^{*} > \bar{T}^{*} \end{cases}. \quad (A.30)$$

$$D_E = X^{**}. \qquad (A.38)$$

It is convenient, however, to treat the terms of trade S_0^{**} and S_1^{**} as exogenous and X^{**} as an endogenous variable. We rewrite (A.37) accordingly as:

$$X^{**} = \frac{S_0^{*\frac{1-\alpha}{2}} S_0^{**-(1-\alpha)}(Y_0^{**} - G^{**}) - C_0^{**}}{S_0^{**\frac{3\alpha-1}{2}}}, \quad X^{**} = \frac{C_1^{**} - S_1^{*\frac{1-\alpha}{2}} S_1^{**-(1-\alpha)} Y_1^{**}}{S_1^{**\frac{3\alpha-1}{2}} R}. \quad (A.37)$$

In the simulations we set a target for X^{**} and then use (A.37) to back out the terms of trade S_0^{**} and S_1^{**} consistent with this target.

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