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Abstract

In this paper we highlight a new channel through which dollar fluctuations can become a self-fulfilling pro-cyclical force. We call this mechanism "Imperial Circle" as it makes the dollar the dominant macroeconomic variable in the context of the current international monetary system. At the core of it, there is a fundamental asymmetry between the shrinking exposure of the "real" U.S. economy to global developments versus the growing global role of the U.S. dollar. Dollar appreciation leads to a decline in global economic activity, which in turn benefits, in relative terms, the dollar itself, reinforcing the initial appreciation and its effects.

Key words: multi-country DSGE model, global supply chains, dollar currency pricing, trade spillovers

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1 Introduction

The role of the dollar in the context of the international monetary system has been examined and studied extensively in the recent and distant past. The objective of this research is to focus on the role of the dollar by combining several elements that characterize the structure of the international monetary system and the U.S. economy to highlight a channel through which the dollar exercises its power in the world economy to make it not only the dominant currency but the dominant macroeconomic variable (i.e., the Imperial Dollar, Soros (1984) and Turek (2020)).

There are two key asymmetries that are central to the mechanism we focus on. The first asymmetry arises from the global use of the dollar in the international monetary system along different dimensions that exceed the relative size of the U.S. economy within the global economy. The second asymmetry occurs as the U.S. economy has relatively limited exposure to developments in the world economy compared to its trading partners so that the dollar sensitivity to foreign development is smaller. Indeed, we emphasize how the dollar is a determinant variable in the global manufacturing cycle because of its dominance in trade invoicing (see, for example, Goldberg and Tille (2008b) and Gopinath (2016)) and its role in credit intensive global value chains (Bruno and Shin (2021)). A stronger dollar weakens global manufacturing trade and global manufacturing output through these channels. Given that the U.S. economy is much less exposed to the global manufacturing cycle and is relatively more service oriented, the dollar tends to benefit from global manufacturing weakness, reinforcing the initial strength and its effect. The combination of structural international and U.S. specific elements creates then a self fulfilling pro-cyclical force that gives rise to what we dub as Imperial Circle 2.0 (see, Turek (2020)).

To validate our analysis we build a three-country open economy model (Akinci et al. (2022)) in the tradition of Obstfeld and Rogoff (1995) and extend it to incorporate the key elements behind the Imperial Circle hypothesis. We interpret our multi-polar economy as representing the U.S., the Advanced Economy (AE) countries and Emerging Market (EM) economies. As in the Dominant Currency Paradigm (DCP) (Gopinath et al. (2020)), we assume that firms in the EM bloc set prices in the US dollar while we keep the assumption of producer currency pricing for the AE bloc.[1] In addition to labor, we allow for producers in all countries to use domestic and foreign intermediate inputs in the production process to capture part of the complexity of the integrated international production processes. To represent the idea of credit intensive global value chain, we assume that there is a working capital constraints at the level of intermediate inputs so that firms borrow in dollar units to finance advanced inputs payments. Finally, we allow for an asymmetric structure in terms of trade exposure of the different blocs by considering a model with traded and non-traded sectors in which we set the U.S. economy to be more biased towards the non-traded sector both in terms of consumption and production.

The focus of our rich but simple model is to study the transmission and amplification mechanism of the Dollar's Imperial Circle, rather than providing a full quantitative account given the many other simplifying assumptions that we embed in the framework. Indeed, to mimic the imperial circle

[1] See also Akinci and Queralto (2018) for the role of DCP in the spillovers of U.S. monetary policy shocks to emerging economies.

dynamic, we consider a cyclical tightening shock to monetary policy in the U.S. as a driver of the dollar appreciation and explore how that propagates into the world economy.

We show *four* key results: First, for a given monetary policy impulse, the dollar appreciates more under dollar pricing and credit intensive global value chains in EMs, as the U.S economy is more tilted towards the service sector, relative to the basic symmetric case with producer currency pricing and no working capital requirements. Second, for a given monetary policy impulse, the dollar appreciation has a bigger contractionary effect on EMs as tradeable production declines more than in the U.S. economy. Third, the effect on U.S. tradeable production is amplified under the Imperial Circle hypothesis. Fourth, the Dollar's Imperial Circle amplifies the effect of a dollar appreciation on global trade relative to the basic symmetric case.

Related literature

Our paper is related to several strands of literature. The central role of the dollar has been analyzed among others by Gourinchas et al. (2019), Rey (2020) and Gourinchas (2021). The common theme of these contributions is to highlight its hegemon position along different roles as an international currency. All these works describe how the dollar serves as a main currency in trade invoices (Goldberg and Tille (2008b) and Gopinath (2016)), as a dominant anchor (Ilzetzki et al. (2019)), and as a main reserve asset. Moreover, the dollar is dominant in terms of international debt issuance and cross border loans (Bertaut et al. (2021)). Carney (2019) also provides similar account and highlights the key asymmetry in the international monetary system between the growing role of the dollar and the diminishing weight of the U.S. economy. Finally, Bruno et al. (2018) emphasize the dollar role in the financing of working capital at the level of Global Value Chain.

Our analysis builds upon the insights of this strand of literature by focusing on the central role of the dollar in invoicing and financing for credit intense global value chain and in characterizing the asymmetric status of the International Monetary system. Along these lines we also stress the paradox of the U.S. economy that while becoming more integrated with the rest of the world is also less exposed to foreign development as the economy transforms towards a more service oriented economy.

Another strand of literature focuses on the spillovers of dollar fluctuations on the rest of the world. Miranda-Agrippino and Rey (2020) emphasize how U.S. monetary policy shocks induce comovements in the international financial variables that characterize the "Global Financial Cycle", a theme that is reinforced in Miranda-Agrippino et al. (2020) where they highlight the dichotomy with Chinese monetary policy that works mainly on the real side of the international monetary system. More recently, Obstfeld and Zhou (2022) focus on the dollar as a barometer of economic conditions in EMs. A similar focus with a different perspective is analyzed in Bruno and Shin (2021) that show how a stronger dollar impacts world trade through exports by affecting dollar credit conditions.

Our contribution with respect to this literature are two-fold: first, we stress the feedback effect of the dollar on the US economy itself by emphasizing the amplifying effect that the structure of the international monetary and the U.S. economy have on the dollar itself and the manufacturing sector in the U.S. economy. Secondly, we discuss the global macroeconomic implications of this interaction and its implicit constraints that impose on the conduct of global policies.

Finally our work builds upon the New Open Macroeconomic approach that has developed from the original contribution by Obstfeld and Rogoff (1995) and refined along several dimensions to capture more realistic features of the global economy, such as key international developments in currency invoicing, in global value chain structure and in international financial frictions.

In this paper, while discussing the financial side dimension of the Dollar Imperial Circle, in our model analysis we abstract from international financial spillovers to focus only on the "real" version of the Imperial Circle.

2 Background

Why Imperial Dollar?

The label Imperial Dollar goes back to Soros (1984). Back in 1984, he characterized the combination of economic policies of the Reagan administration as a form of economic imperialism that *allows to finance high budget deficits at the expense of debtor nations.*

In an article on the Financial Times (Soros (1984)), he developed his argument by referring to an irreconcilable policy objective: "*a desire to public spending while maintaining a strong military posture and reducing taxation. When government spending could not be cut sufficiently the deficit soared. Fortunately for Reagan, the budget deficit set in motion a self-reinforcing process which is beneficial for the U.S. Unfortunately for the debtor countries, what is a benign circle for the U.S. is a vicious circle for them.*"

High budget deficit leads to relatively higher real interest rates. Higher interest rates attract funds from the rest of the world. High budget deficit stimulates the economy and along with high interest rates that tends to keep the dollar strong.

The recovery, combined with a high exchange rate tends to increase imports and augments the trade deficit. Moreover, high trade deficit combined with a high exchange rate moderates inflation.

The U.S. enjoys the best of all possible worlds: strong economic growth, low inflation, budget deficit financed with an influx of foreign goods and foreign capital.

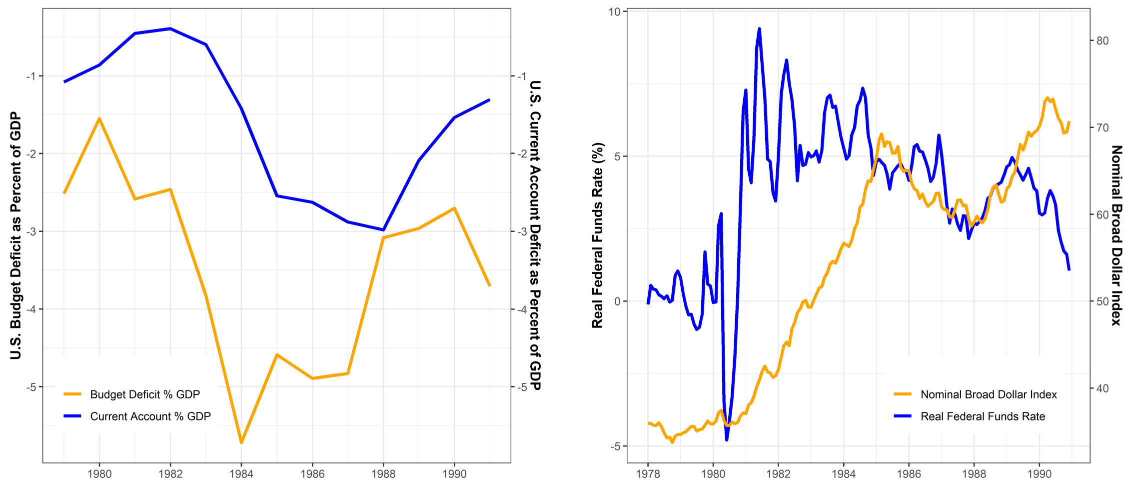
Soros (1984): I shall call this benign circle the "*Imperial Circle*".

We refer to the Imperial Circle *a la* Soros as **Imperial circle 1.0** in which a combination of high interest rate, fiscal deficits, and strong dollar reinforce each other. Figure 1 presents the evolution of the US budget deficit, current account and real interest rates along with trade weighted nominal and real exchange rate from late 1970s to late 1980s.

The Plaza Accord as the end of the Imperial Circle 1.0

From 1980 to 1985, the dollar had appreciated by about 50% against the Japanese yen, Deutsche Mark, French Franc and British Pound, the currencies of the next four biggest economies at the time. This caused considerable difficulties for the manufacturing sector in the U.S. Eventually the pressure for protectionism led the White house to start negotiating the Plaza accord. The devaluation of the dollar helped eventually to reduce its trade deficit mainly vis-a-vis Germany while it failed in the bilateral trade versus Japan.

Figure 1: US Budget Deficit, Current Account, Interest Rates, and Inflation



Notes: The US budget deficit as a percent of US GDP is from the US federal budget surplus/deficit data of the Office of Management and Budget (OMB). The US current account as a percent of US GDP data is from the BEA. We calculate the real federal funds rate using the federal funds effective rate from the Board of Governors and year-over-year percent change in US CPI inflation from the BLS. The nominal broad dollar index is from the Board of Governors (an increase means an appreciation of the dollar).

3 The New Imperial Circle (2.0)

We now describe another imperial circle that has been particularly pronounced in the aftermath of the global financial crisis due to structural factors and policy choices that have characterized the international monetary system (Turek (2020)).

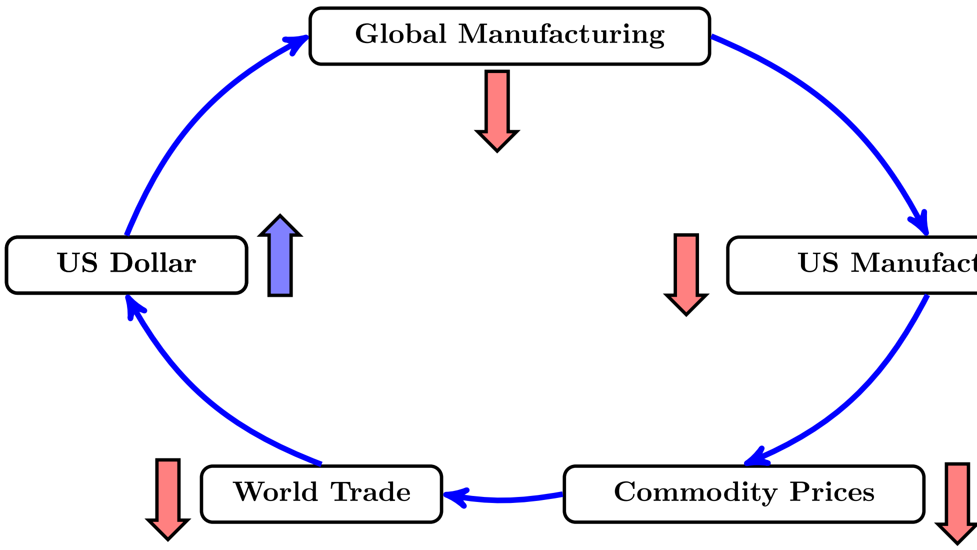
How does imperial circle 2.0 work? The New Imperial circle makes the dollar the dominant macroeconomic variable and creates a self-enforcing mechanism through which fluctuations in the dollar govern global macro developments that feeds back into dollar movements and eventually policy actions. As in the Imperial Circle 1.0, the dollar acts as a dominant macroeconomic variable but the details under which its role is validated are different. In the new Imperial Circle, the strength of the dollar translate into slowing global trade and global growth that makes the dollar outperforming as the US economy is less exposed to global trade reinforcing the initial strength of the dollar. Figure 2 highlights the more detailed mechanism through which the circle operates. Following a dollar appreciation, as manufacturing contracts globally and in the U.S., commodity prices and world trade decline feeding back into further dollar strength.

What are then the factors that create this dynamic? In the next subsections we describe the elements that characterize the new Imperial Circle hypothesis.

3.1 The Asymmetric International Monetary System

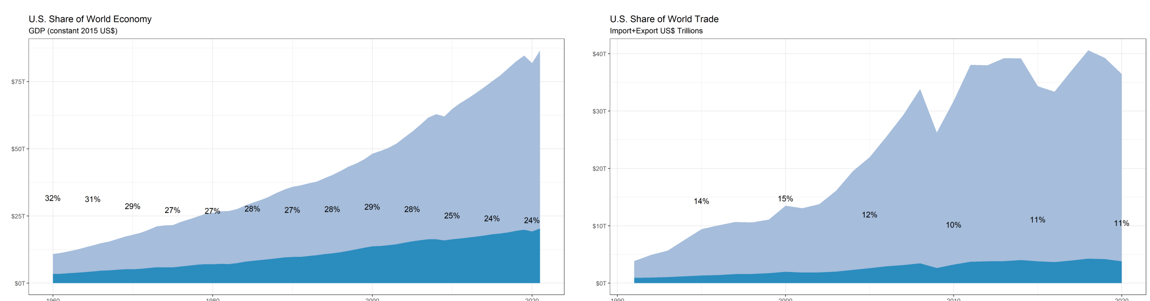
The key aspect behind the Imperial Circle is the asymmetric structure of the international monetary system and its functioning. As Carney (2019) notes there is a destabilizing asymmetry

Figure 2: The New Imperial Circle



at the core of the International Monetary and Financial System. The asymmetry relies on growing dominant role of the U.S. dollar while the U.S. economy is shrinking its importance both in terms of its weight as a share of global GDP and as a share of global trade (see left and right panels of Figure 3, respectively).

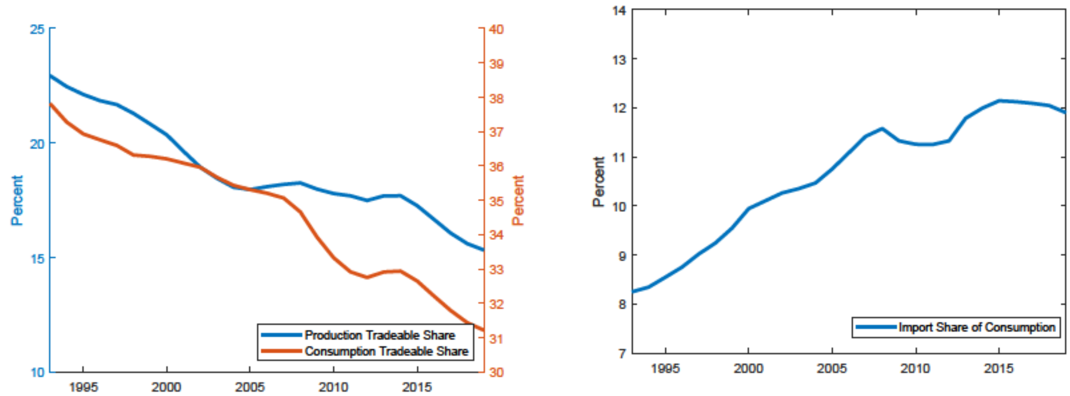
Figure 3: U.S. Share of World Economy and World Trade



Notes: U.S. share of world economy is calculated using World Bank national accounts data and OECD National Accounts data files. U.S. Share of world trade is calculated using World Integrated Trade Solution data.

While the real world economy is effectively multi-polar, the dollar acts as the hegemon currency within the International Monetary and Financial System. According to the latest IMF COFER data, the share of US dollars in total allocated global foreign exchange reserves is around 60 percent. Bertaut et al. (2021) document that 33 percent of marketable Treasury securities outstanding were held by foreign investors at the beginning of 2021. Besides its dominant role in trade invoicing (see below), the U.S. dollar is also the dominant currency in international banking. About 60 percent of international and foreign currency liabilities and claims are denominated in U.S. dollars (see Bertaut et al. (2021)). The dollar is dominant also as a global payment currency, holding a share of around 40

Figure 4: Trends in U.S. Openness



(a) Tradeable Share in Production and Consumption (b) U.S. Import Share of Consumption

Notes: The tradeable sector share in production is calculated using data from the Bureau of Economic Analysis and tradeable sector share in consumption is calculated from Bureau of Labor and Statistics. Import share of consumption is calculated using data from the Bureau of Economic Analysis.

percent, and dominant in foreign exchange turnover with a share of about 44 percent (ECB (2018)).

3.2 The Dichotomy of the "Real" US economy: More globalized but less exposed to foreign developments

While the US economy is becoming more globalized, its exposure to foreign real development is becoming smaller (Akinci et al. (2021). This dichotomy reflect mainly medium-run forces such as structural transformation (see Kehoe et al. (2018)) but could be also associated to structural shifts linked to the functioning of the international monetary system (Benigno et al. (2020)). We now briefly describe the empirical trends characterizing globalization process in the U.S. economy, focusing on the share of foreign goods in both final consumption goods and intermediate inputs.

Specially, we emphasize the following key findings:

Finding 1. Growth of the Non-Tradeable Sector: Using data from 1990 to 2019, we document that the importance of tradeable goods has decreased in the U.S. both from a production and consumption perspective. Figure 4a shows the 4-year moving average share of tradeable goods in U.S. production (blue line) and U.S. consumption (orange line) over the 1990-2019 period. Both production and consumption shares have decreased consistently since the 1990s, potentially suggesting that the role of non-tradeable sector in macro developments has become more relevant in understanding GDP fluctuations.

Finding 2. Growth of the Imported Consumption Share: For consumer expenditures on foreign goods, we calculate the 4-year moving average of the import share of total private consumption expenditure based the BEA data on categories of imports for the 1990-2019 period. As shown in 4b, the import share of U.S. personal consumption has increased from just above 8% to around 12% by 2019.

Finding 3. Imported Goods play a Role in Cross-Sectoral Input-Output Linkages: Another aspect of globalization that we incorporate in the model is the presence of global supply chains in the production process. Table 1 shows the non-tradeable and (home and foreign) tradeable intermediate input shares used in tradeable and non-tradeable production, respectively, using annual BEA input-output data over 1997-2019. Tradeable goods have been important as an input, consisting of 71 percent of tradeable good and 20 percent of non-tradeable good's total intermediate usage. Foreign intermediate goods constitute 13 percent of tradeable inputs in the tradeable sector, while they constitute only 1 percent of tradeable inputs in the non-tradeable sector (see, also Akinci et al. (2021)).

Table 1: Sectoral Intermediate Input Shares
(as a Percentage of Total Intermediate Usage)

	Definition	Average	Median
ν_{ntr}^{T}	Shr. of N inputs for T good	28.9	28.5
ν_{H}^{T}	Shr. of (home) T inputs for T good	53.1	53.1
ν_{F}^{T}	Shr. of (foreign) T inputs for T good	17.9	18.1
ν_{ntr}^{N}	Shr. of N inputs for N good	80.1	79.5
ν_{H}^{N}	Shr. of (home) T inputs for N good	15.1	15.6
ν_{F}^{N}	Shr. of (foreign) T inputs for N good	4.80	4.80

Note: Input-output coefficients are computed over the 1997-2019 period from Bureau of Economic Analysis data.

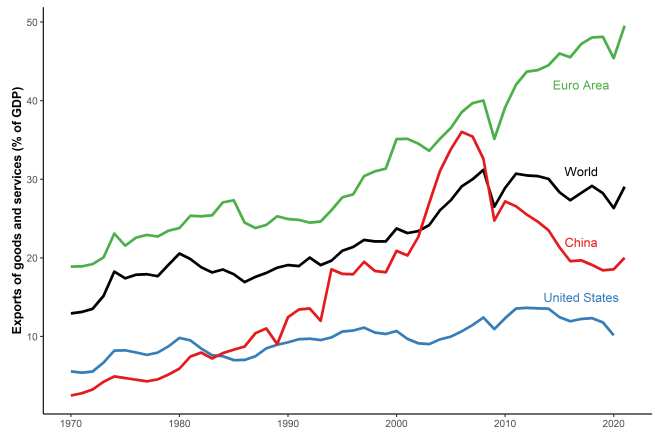
Finding 4. U.S. exports are relatively smaller: Finally, another interesting aspect of the U.S. economy relatively to other main blocs in the International Monetary System is its relatively smaller exposure in terms of exports. Figure 5 shows that the share of exports as a fraction of GDP for the U.S. economy is smaller compared to the Euro area (approaching 50 percent) and China (recently around 20 percent). This feature makes the U.S. economy less reliant on global trade developments as a source of growth so that its business cycle is less tied to the world economy's business cycle.

To summarize, we emphasize a dichotomy in the trend of the U.S. economy vis-a-vis the growing role of the dollar in the context of the international monetary system. On the one hand, the economy has become more globalized as the share of imports in economic activity has grown over time. On the other hand, the economy has also shifted towards the non-tradeable (service) sector, in terms of both consumption and production, thus potentially dampening the impact of increased import openness. While the hegemon role of the dollar has expanded, the *real* exposure of the US economy to the global economy has declined.

3.3 Structural Factors

We now discuss the key aspects behind the functioning of dollar imperial circle.

Figure 5: Exports of Goods and Services as a Share of GDP



Notes: Exports share of GDP is calculated by World Bank using World Bank national accounts data and OECD National Accounts data files.

3.3.1 Asset Shortage and Capital Flows

The first key element behind the Dollar's Imperial Circle is the direction of capital flows towards the U.S. economy as the main destination that has the capacity to absorb saving coming mainly from Asia. This element reflects the massive global asset shortage that is more pronounced in Asia and forces money into the U.S. For example, as emphasized by the IMF, the size of life insurers assets is more than 10 times the size of their respective domestic corporate bond market.

The asset shortage theme is also a by product of the policy choices from an official sector point of view. Benigno et al. (2020) note the build up of foreign exchange reserves by emerging countries and in particular East-Asian economies. In the period starting from 1980 to 2022, the average reserves to GDP ratio for East Asian economies rose from 14 percent to 52 percent. This large scale in foreign reserve accumulation is directed mainly towards U.S. dollar assets. Indeed, as documented in Bertaut et al. (2021), dollar assets are still about 60 percent of globally disclosed official foreign reserves. While declining from the early 2000s, the share of dollar foreign reserves still greatly exceed other currencies reserves, making the dollar the dominant reserve currency.

The global saving glut (Bernanke (2020)) is the expression of these structural forces coming from policy choices and economic factors leading to a structural demand for US assets as a supporting element in determining relative dollar strength.

3.3.2 Dollar Invoicing

The dominant role of the dollar as an invoicing currency (see the original contribution by Goldberg and Tille (2008a) in several recent studies of currency composition of global trade and international financial transactions. Gopinath (2015) and Boz et al. (2020) show that the share of exports invoiced in dollars exceed the export share to the U.S. Excluding dollar commodity exporting, the share of export invoiced in the U.S. dollar has been constantly well above 20 percent. Moreover, Bertaut et al. (2021) documents that over the period 1999-2019 the dollar accounted for 96 percent of trade invoicing in the Americas, 74 percent in the Asia-Pacific region and 79 percent in the rest of the world.

3.3.3 Credit Intensive Global Value Chain

Bruno and Shin (2021) emphasize the role of the dollar in dampening international trade by weighting on the operation of credit intensive global value chains. The logic brought forward by Bruno and Shin relies on the impact that the dollar has on the availability of dollar financing for working capital and the fact that the extensive use of working capital needs in supporting complex supply chain linkages. As such, movements in the dollar influences financial conditions and through that it has effects on international trade and the real economy.[2] In the narrow sense, their logic underscore the role of the dollar index as a determinant of Global Value Chain activity and more broadly their insight applies also to overall trade to the extent to which slowing of activity at the level of Global Value Chain translates into slowing international trade.[3] Figure 6 illustrates this link by using a measure of imbalance at the level of Global Value Chain that builds upon the New York Fed's GSCPI index (see Benigno et al. (2022)).[4]

4 What starts and what stops the Imperial Circle 2.0

We emphasize two forces that could lead to relative dollar strength and initiate the circle. One underlying structural force is given by the demand for U.S. assets as the U.S. economy is the main place that absorbs excess saving coming from the rest of the world. From a cyclical point of view, a relatively more aggressive monetary policy stance of the Federal Reserve can lead to a dollar appreciation or a negative asymmetric shock that hits the rest of the world (like, for example, the 2022-Energy shock that hits asymmetrically the world economy).

Once the strength of the dollar is initiated, the doom loop circle implies a decline in global manufacturing due to dollar invoicing and credit intensive global value chain. In particular, manufacturing where credit intensive global value chain are more pervasive will tend to suffer more. The contraction in global (ex-U.S.) manufacturing will spill back to US manufacturing due to production linkages and reduction in demand. This will also lead to a decline in commodity prices and world trade. As the U.S. economy is less exposed to global developments, the dollar will benefit in relative terms from a world decline reinforcing the circle.

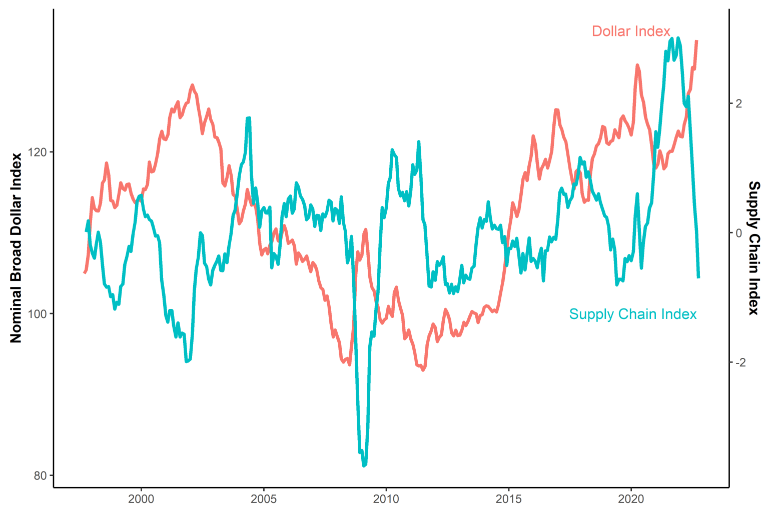
Figure 7 shows the relationship between the broad dollar index from 2001 up to 2019 and global manufacturing (ex U.S.) Purchasing Managers' (PMI) index and U.S. PMI. The figure suggest that

[2]In their analysis, they study the impact of dollar strength on the shipments of exporters that have financing needs building on the fact that dollar denominated credit is an important share of credit related activity according to data from SWIFT.

[3]To capture this link they look at the ratio of world trade over GDP as a proxy of Global Value Chain activity versus the dollar index (see Bruno and Shin (2012).

[4]The original GSCPI index filters out the a proxy for demand to measure the supply side of Global Supply Chain disruption. The version that we are using here abstract from this steps and arguably capture net pressures at the level of global supply chain.

Figure 6: Supply Chain Pressure Index and Dollar Index



Notes: Broad Dollar Index is taken from the Bank for International Settlements. Raw Supply Chain Index is created according to author's calculations using Bureau of Labor Statistics, Harper Petersen Holding GmbH, Baltic Exchange, IHS Markit, Institute for Supply Management, Haver Analytics, and Bloomberg L.P.

a broad nominal dollar appreciation is associated with a contraction in manufacturing activity. Similarly a dollar appreciation is negatively associated with commodity prices and world trade (as documented also by Bruno and Shin (2021) and Obstfeld and Zhou (2022)).

In Table 2 we report the negative year on year correlations of the dollar with global manufacturing, U.S. manufacturing, world trade and commodity prices. The table also confirms that the dollar appreciation is associated with a decline in global manufacturing/trade, and with a decline in commodity prices.

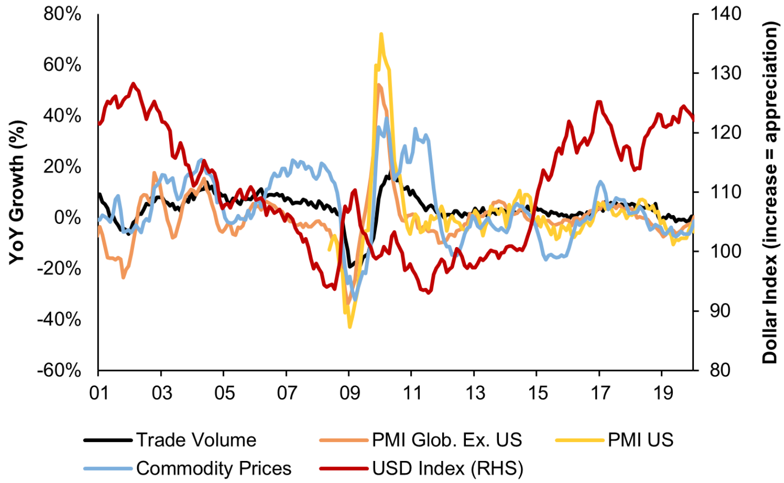
Table 2: Correlations: U.S. Dollar, Global Manufacturing/Trade, and Commodity Prices

Variable	2001 - 2019	2010 - 2019	2015 - 2019
PMI Glob. Ex. US YoY	-0.41	-0.38	-0.53
PMI US YoY	-0.51	-0.42	-0.62
Trade Volume YoY	-0.57	-0.48	-0.58
Commodity Price YoY	-0.80	-0.76	-0.77

4.1 An example: The 2018-2019 dollar circle

As an example of the dollar circle we can zoom in from the previous graphs in the period starting from the beginning of the tightening cycle of the Federal Reserve at the end of 2015 (Figure 8). The increase in the policy rate was combined with a reduction of the Fed's balance sheet. After the first initial increase in December 2015, the Fed Fund Rate was kept unchanged until November 2016 and constantly increased to reach the peak of 2.25-2.50 percent in December 2018. As we can see

Figure 7: U.S. Dollar, Global Manufacturing/Trade, and Commodity Prices: 2001-2019

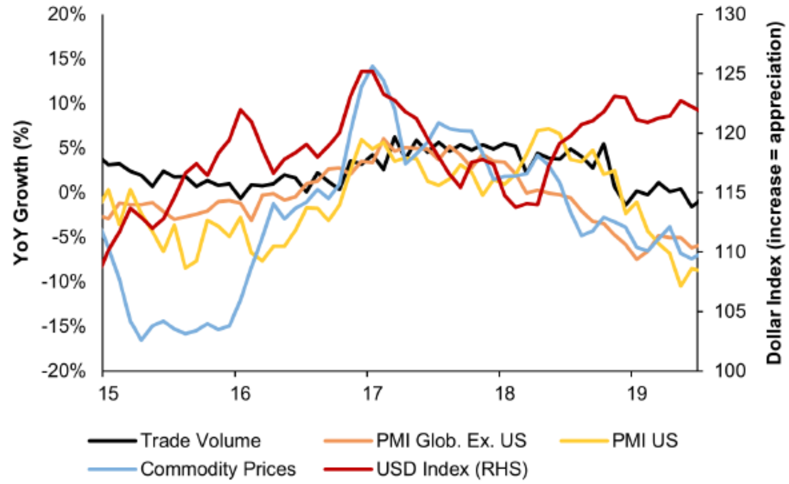


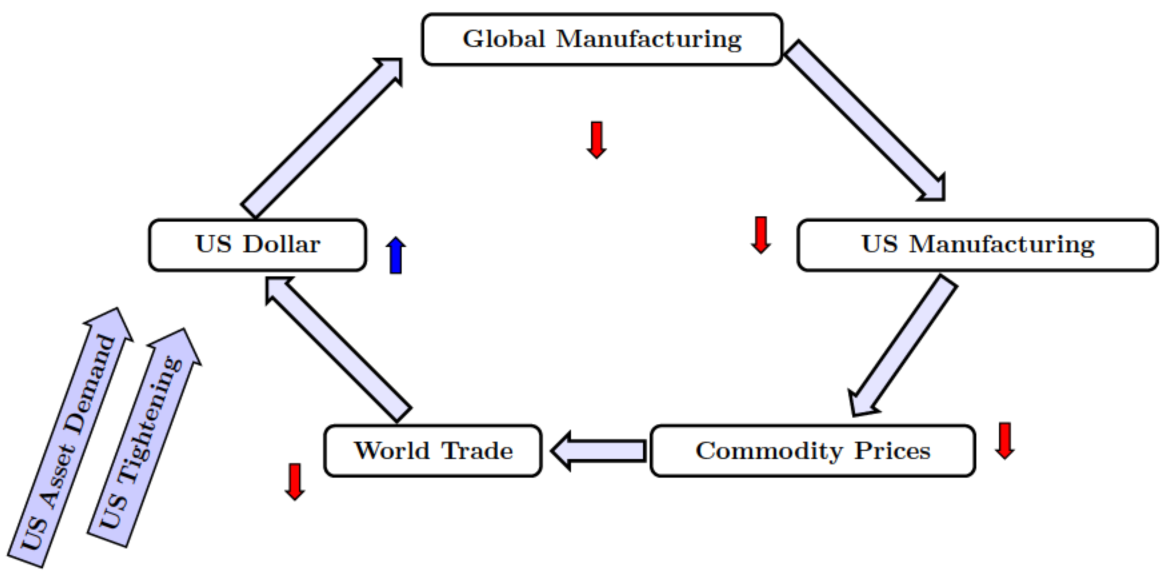
from the zoomed graph below the broad nominal dollar index initially appreciated till the beginning of 2017 to revert back its course during 2017 and restarting again its upward trend during 2018 accompanied by a decline in manufacturing activity globally and in the US economy and a decline in world trade and commodity prices.

4.2 What starts and what ends the Dollar's Circle

The brief narrative of the 2015-2019 tightening cycle provides also some insights on the forces that could start and limit/stop the dollar's circle (see Figure **??**). As discussed above demand of U.S. assets provide a support for the U.S. dollar from a structural point of view while monetary policy impulse in the U.S. is an important cyclical driver. Figure XX below provide a illustration of how these exogenous forces, lead to the beginning of a dollar circle.

Figure 8: U.S. Dollar, Global Manufacturing/Trade, and Commodity Prices: 2015-2019





The dimension of the dollar's circle that we have emphasized works mainly through the real side of the economy by affecting the manufacturing sector globally and internally. A counterbalance force in the pre-pandemic world has been Chinese growth and indeed instances in which the dollar has retraced are associated with an increase in Chinese credit impulse (our proxy for policy expansion in China).

A second force/element that can stop and contain the dollar circle runs through financial spillovers and spillback. We refer to this dimension as the Financial Side of the Imperial Dollar's Circle. Several authors have already documented how the dollar is central in driving the global financial cycle (Rey (2015)). In figure (9) we zoom in the period 2015-2019 and look our measure of financial conditions built at the NY Fed for the US economy, advanced economies except U.S., EMs and globally.

Figure 9: Dollar and Financial Conditions

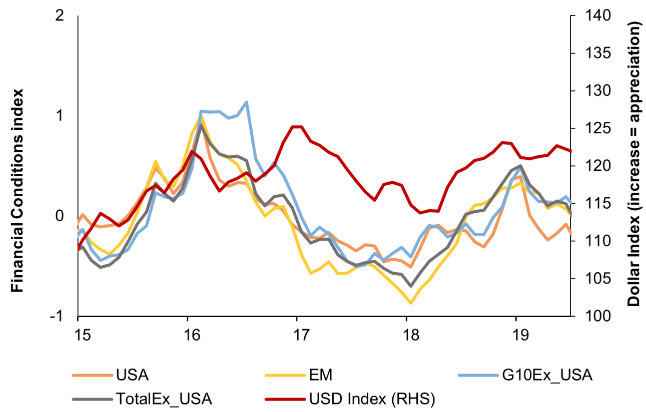
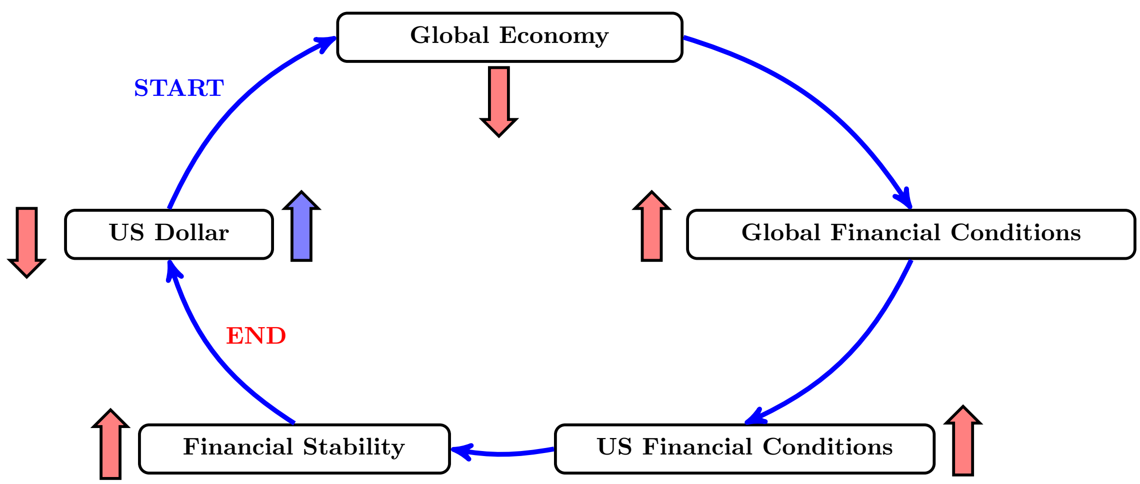


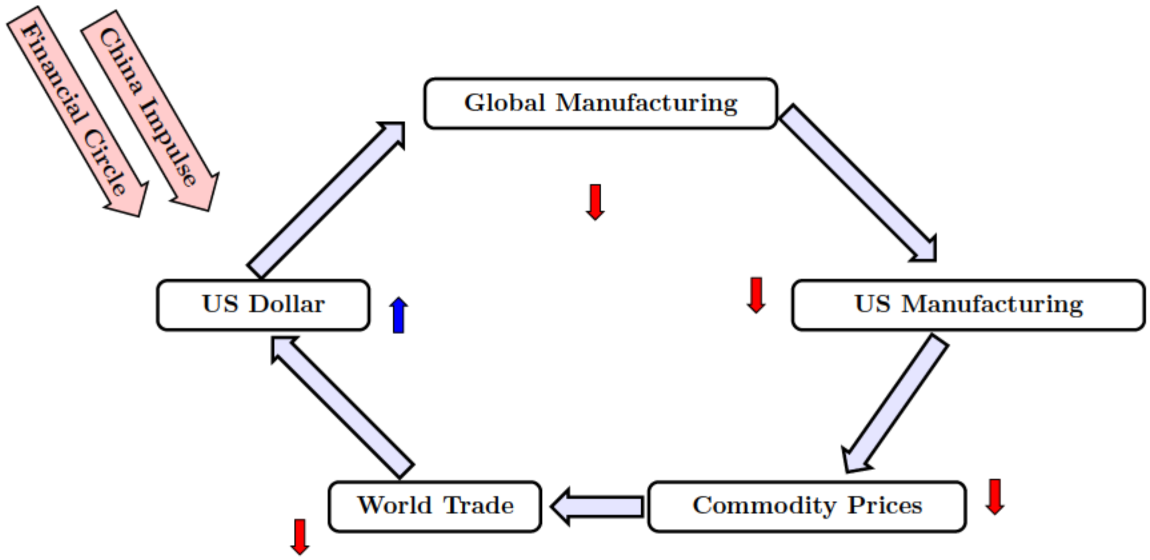
Figure 10: The Dollar Financial Circle



As the dollar appreciates from 2018, financial conditions both in the U.S. and abroad tightened (see, Figure 9). The global tightening of financial conditions eventually spilled back to US financial conditions limiting the monetary policy cycle and stopping the dollar appreciation (see, Figure 10).[5]

We again illustrate the interaction between these pull factors and the Dollar's Imperical Circle in the following figure XX

[5]In this paper we abstract, in our model, from the financial side dimension of the Imperial Dollar and we just provide the illustrative logic of our financial circle



Pre- and Post-pandemic Imperial Circle

Within the structural features that we have described above, we argue that the relevance of the imperial circle in terms of its impulse on the global economy depends on cyclical factors. The post pandemic economic environment is characterized by a significant shift in terms of fiscal policy especially in the U.S. and other AEs.

In the pre-pandemic economic cycle AEs were running primary surpluses, almost agnostic of the underlying economic conditions. This in a way reinforced the imperial dollar as an impulse. The reason being, as AEs were "short" of domestic aggregate demand, they became especially reliant on the tradeable goods sector as a source of growth. The tradeable goods sector is highly correlated to Chinese demand. In the previous cycle, the massive relevance of the Chinese credit cycle (China being the world's marginal trading partner) is a way to spur and export aggregate demand. The pre-pandemic cycle is indeed characterized by a strong correlation between the Chinese credit cycle and AE PMIs and nominal GDP readings. Because of this dynamic, the size of the imperial dollar's impulse was heightened. The dollar was less exposed to the Chinese credit cycle because the US economy is less exposed to global trade. Exports contribute less to U.S. growth compared to other AEs. This dynamic reinforced the imperial dollar's role as a pro-cyclical force. The same way that as the dollar strengthened, causing manufacturing to contract, and then strengthened because it was less exposed to manufacturing, also played out in reverse. However, given the Chinese credit impulse and goods demand as a percentage of GDP began a structural decline, this inverse of the imperial dollar played out less frequently.

Why has post Covid been different?

The imperial dollar is still relevant post Covid, however its impulse has become more muted. The reason for this change, in our view, has been the massive global fiscal effort in AEs and in the U.S., since the pandemic began in March of 2020. The reason is that with global fiscal expansion, AEs are less exposed to global trade. i.e., economies that typically 20-40% of GDP from exports now have larger cushions from fiscal stimulus.

One symptom of this is that, since the middle of 2021, the Chinese economy has weakened and the dollar has strengthened, and, despite the combination of these two factors, commodity prices are still high and manufacturing PMIs in AEs is still expanding. In the pre-pandemic cycle (2010s decade), this would not be the case as the combination of a strong dollar and weak China would have set off a procyclical loop of manufacturing weakness. So far in this cycle, AEs have been more resilient to the imperial dollar, and we think it is because of elevated levels of fiscal spending.

Overall, fiscal spending has made AEs more resilient to the imperial dollar but did not change it at a fundamental level. In our view, this cycle, the imperial dollar impulse may be lower and the level that the "doom loop" starts is higher, however the imperial dollar is still a very relevant and marginal global economic variable.

5 The Model

Our model is a multi-country New Keynesian model as in Corsetti and Pesenti (2001), Benigno and Benigno (2003), and Akinci and Queralto (2018), augmented with credit intensive global supply chains, as well as tradeable and non-tradeable goods sectors. We emphasize that a key feature of our global macroeconomic model is that there is trade in both final goods and intermediate goods sectors in an input output structure, consistent with evidence in Antràs (2005).

International financial markets are incomplete in the sense that households in each bloc can trade one period riskless international bond denominated in U.S. dollar. Further, in both tradeable and non-tradeable sectors there are working capital constraints in production funded by the intra-period borrowing from the international financial markets. For simplicity, capital is assumed to be fixed. Prices are sticky (*ala* Calvo (1983)). Monetary policy in each bloc follows standard Taylor rule in which policy rate reacts to deviations of inflation and total output from their respective long run values.

Section 5.1 outlines our multi-country model with Global Value Chain (GVC) in tradeable and non-tradeable goods with nominal rigidities, incomplete international financial markets, and working capital constraints, and DDCP. Section 6 describes the model calibration and presents the dynamic responses of our global model economy to a U.S. monetary policy shock.[6]

5.1 Sketch of the Model

The model consists of **3 countries**: Home (denoted H), Foreign (denoted F, and (*)) and Rest of the World (denoted W, and (**)). For empirical purposes U.S. is represented by the Home economy, while Emerging Market Economies (EM) by Foreign and Advanced Foreign Economies (AE) by Rest of the World.

The nominal exchange rate are denoted S^H_{Ft}, and S^H_{Wt}. This is expressed as the price of Foreign currency in units of home currency (i.e. if the Home country is the U.S. and the Foreign country is Japan, then S^H_{Ft} is dollars per yen and higher S^H_{Ft} implies depreciation of U.S. dollar vis-a-vis yen). Exchange rates between Foreign and World can be derived from these 2 exchange rates alone.

[6] Appendix B presents the complete list of equilibrium conditions characterizing the Global Macro Model.

5.1.1 Households and Consumption

Each country's consumption behavior is symmetric and so we write down Home economy equations as a representative. The representative households maximizes:

$$\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \left(\frac{\sigma}{\sigma-1} C_{t+j}^{\frac{\sigma-1}{\sigma}} - \frac{\chi_0}{1+\chi} L_{t+j}{}^{1+\chi} \right) \tag{1}$$

where C_t is the consumption bundle of the households and L_t the total hours of labor supplied.

Consumption bundle, C_t consists of tradable, C_t^T and non-tradable, C_t^N final goods such that:

$$C_t = \left[\omega_s^{\frac{1}{\rho_s}} \left(C_t^T\right)^{\frac{\rho_s - 1}{\rho_s}} + (1-\omega_s)^{\frac{1}{\rho_s}} \left(C_t^N\right)^{\frac{\rho_s - 1}{\rho_s}} \right]^{\frac{\rho_s}{\rho_s - 1}}$$

with the associated final consumption price:

$$P_{C,t} = \left[\omega_s \left(P_t^T\right)^{1-\rho_s} + (1-\omega_s) \left(P_t^N\right)^{1-\rho_s} \right]^{\frac{1}{1-\rho_s}}$$

where ω_s is the weight given to tradeable good relative to the non-tradeable good in final consumption bundle.

Consumption bundle for final tradeable good, C_t^T consists of all countries' tradable final goods and is given by:

$$C_t^T = \left[\nu_H^H{}^{\frac{1}{\rho_c}} C_{Ht}^{\frac{\rho_c - 1}{\rho_c}} + \nu_F^H{}^{\frac{1}{\rho_c}} C_{Ft}^{\frac{\rho_c - 1}{\rho_c}} + \nu_W^H{}^{\frac{1}{\rho_c}} C_{Wt}^{\frac{\rho_c - 1}{\rho_c}} \right]^{\frac{\rho_c}{\rho_c - 1}}$$

with the associated final tradable consumption price:

$$P_t^T = \left[\nu_H^H P_{Ht}^{1-\rho_c} + \nu_F^H P_{Ft}^{1-\rho_c} + \nu_W^H P_{Wt}^{1-\rho_c} \right]^{\frac{1}{1-\rho_c}}$$

where for $j = \{H, F, W\}$, ν_j^H is the weight given to country j's tradable good in the Home tradable consumption bundle.

We assume that both EM and AE countries can trade with the U.S. one period riskless international bond denominated in the U.S. dollars.

In all countries, W_t is the nominal wage across all sectors of production. For $i = \{T, N\}$, $\overline{K}^i$ is the fixed supply of capital with capital rents $R_{K,t}^i$ and Γ_t^i is the profits of firms, in sector i.

U.S. households face the budget constraint:

$$P_{C,t} C_t + B_{t+1} \leq R_t^n B_t + W_t L_t + R_{K,t}^T \overline{K}^T + R_{K,t}^N \overline{K}^N + \Gamma_t^T + \Gamma_t^N \tag{2}$$

where B_t is the nominal domestic bond with the U.S. nominal interest rate R_t^n.

Whereas EM and AE households face the budget constraint, respectively:

$$P_{C,t}^{*}C_t^{*}+\frac{B_{Ht}^{*}}{S_{Ft}^{H}R_{risk,ft}^{n}\phi_{Ht}^{*}}\leq\frac{B_{Ht-1}^{*}}{S_{Ft}^{H}}+W_t^{*}L_t^{*}+R_{K,t}^{T}{}^{*}\overline{K}^{T*}+R_{K,t}^{N}{}^{*}\overline{K}^{N*}+\Gamma_t^{T*}+\Gamma_t^{N*} \tag{3}$$

where B_{Ht}^{*} is the non-state contingent international bond in U.S. dollars, with the interest rate paid by EMs given by $R_{risk,ft}^{n}$. EM households do also face a premium for their borrowing of the U.S. bonds, denoted by ϕ_{Ht}^{*}, introduced primarily to induce stationarity in the model economy. [7]

One can show that optimality conditions in the model economy yields the following international risk sharing condition of U.S. with EMs:

$$\frac{\pi_{t+1}^{C}}{\Lambda_{t,t+1}}=\frac{\pi_{t+1}^{C}}{\Lambda_{t,t+1}^{*}}\frac{\mathcal{Q}_{Ft+1}^{H}}{\mathcal{Q}_{Ft}^{H}}\frac{1}{\phi_{Ht}^{*}} \tag{4}$$

where $\pi_{t+1}^{C}\equiv\frac{P_{C,t+1}}{P_{C,t}}$, $\Lambda_{t,t+1}\equiv\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\frac{1}{\sigma}}$, and $\Lambda_{t,t+1}^{*}\equiv\beta^{*}\left(\frac{C_{t+1}^{*}}{C_t^{*}}\right)^{-\frac{1}{\sigma}}$.

The AE households face a symmetric constraint and international risk sharing condition with the same properties as EMs.

5.1.2 Global Value Chain Production

In each country, final good producing sector $i=\{T,N\}$ has the Global Value Chain (GVC) production function:

$$Y^{i}=\overline{K}^{i\alpha}(Z_t^{i}L_t^{i})^{\gamma_p}\left(M_t^{i}\right)^{1-\alpha-\gamma_p} \tag{5}$$

where L_t^{i} is the labor allocation to sector i such that $\sum_i L_t^{i}=L_t$, and M_t^{i} is the intermediate goods bundle for sector i and is defined as:

$$M_t^{i}=\left[\nu_{pN}^{i}{}^{\frac{1}{\rho_m}}\left(M_{Nt}^{i}\right)^{\frac{\rho_m-1}{\rho_m}}+\nu_{pH}^{i}{}^{\frac{1}{\rho_m}}\left(M_{Ht}^{i}\right)^{\frac{\rho_m-1}{\rho_m}}+\nu_{pF}^{i}{}^{\frac{1}{\rho_m}}\left(M_{Ft}^{i}\right)^{\frac{\rho_m-1}{\rho_m}}+\nu_{pW}^{i}{}^{\frac{1}{\rho_m}}\left(M_{Wt}^{i}\right)^{\frac{\rho_m-1}{\rho_m}}\right]^{\frac{\rho_m}{\rho_m-1}}$$

with the associated price:

$$P_{Mt}^{i}=\left[\nu_{pN}^{i}\left(P_t^{N}\right)^{1-\rho_m}+\nu_{pH}^{i}\left(P_{Ht}\right)^{1-\rho_m}+\nu_{pF}^{i}\left(P_{Ft}\right)^{1-\rho_m}+\nu_{pW}^{i}\left(P_{Wt}\right)^{1-\rho_m}\right]^{\frac{1}{1-\rho_m}}$$

where for $k=\{N,H,F,W\}$, ν_{pk}^{i} is the weight given to intermediate good k in sector i.

Notice that the roundabout structure arises as intermediate goods face the same price as their respective final goods thus affecting the total demand needed for production as well as price setting of final goods. In other words, Y^{T} and M_H^{i} share the same price P_H and Y^{N} and M_N^{i} share the same price P_N.

[7] Note that the international borrowing rate faced by EMs is defined as $R_{risk,ft}^{n}=R_t^{n}$.

Dollar Borrowing - Working Capital

Final good producing non-U.S. firms use working capital loans to finance payments to labor and intermediate goods with loan from the US. For $i = \{T, N\}$, final good producing firms' non-capital payments are:

$$\Upsilon_t^i = P_{M,t}^i M_t^i + W_t L_t^i \tag{6}$$

Since production is available at the end of period t, firms have to borrow $\theta_w \Upsilon_t^i$ (the working capital) at the beginning of period t at the risk premium adjusted U.S. nominal interest rate $R_{risk,ft}^n$, this can be considered as the intra-temporal rate. The market for capital is frictionless, so at each period firms can make payments to the owners of capital at the end of the period when production is realized.

Such that in each sector the final good producing firms in EMs will maximize profits:

$$\Gamma_t^{T*} = P_{F,t}^* Y_t^{T*} - W_t^* L_t^{T*} - {R_{K,t}^T}^* \overline{K}^{T*} - {P_{M,t}^T}^* M_t^{T*} - (R_{risk,ft}^n - 1)\theta_w \Upsilon_t^{T*}$$
$$\Gamma_t^{N*} = P_t^{N*} Y_t^{N*} - W_t^* L_t^{N*} - {R_{K,t}^N}^* \overline{K}^{N*} - {P_{M,t}^N}^* M_t^{N*} - (R_{risk,ft}^n - 1)\theta_w \Upsilon_t^{N*}$$

where the last term represents the net interest payment on the fraction of the wage and intermediate good bill that is paid to the US.

Note: Since the loan is intra-temporal, the exchange rate term associated with the loan is 1.

Solving the firms' profit maximization problem, the nominal marginal cost of sectoral good i is defined as:

$$MC_t^{i*} = \left(\frac{W_t^*/Z_t^{i*}[1 + (R_{risk,ft}^n - 1)\theta_w]}{\gamma_p}\right)^{\gamma_p} \left(\frac{{R_{K,t}^i}^*}{\alpha}\right)^{\alpha} \left(\frac{{P_{Mt}^i}^*[1 + (R_{risk,ft}^n - 1)\theta_w]}{1 - \alpha - \gamma_p}\right)^{1-\alpha-\gamma_p} \tag{7}$$

Similarly for AEs where the associated price of Y_t^{T**} is P_{Wt}^{**}.

5.1.3 Sectoral Price Rigidity

This section describes the Calvo style price setting for tradeable and non-tradeable good firms. All steps follow symmetrically for Foreign and World countries.

For sector $i = \{T, N\}$, a continuum of mass unity of retail firms produce domestic sector i output. Final output Y_t^i is a CES composite of retailers' output:

$$Y_t^i = \left(\int_0^1 {Y_{lt}^i}^{\frac{1}{1+\theta_p}} dl\right)^{1+\theta_p} \tag{8}$$

where Y_{lt}^i is sector i output by retailer $l \in [0, 1]$. Let the price set by Home retailer l be P_{lt}^i[8]. The

[8]When $i = T$, P_t^i refers to the domestic production price of the tradable good P_{Ht} for the Home case. Similarly, P_{Ft}^* in Foreign and P_{Wt}^{**} in World tradable sector.

price level of domestic sector i final output is $P_t^i = \left(P\int_0^1 {P_{lt}^i}^{-\frac{1}{\theta_p}} dl\right)^{-\theta_p}$. Cost minimization by users of sector i final output yields the following demand function for firm l in sector i's output:

$$Y_{lt}^i = \left(\frac{P_{lt}^i}{P_t^i}\right)^{-\frac{1+\theta_p}{\theta_p}} Y_t^i \tag{9}$$

Domestic retail producer l in sector i employs the production function

$$Y_{lt}^i = {\overline{K}_{lt}^i}^{\alpha} (Z_{lt}^i L_{lt}^i)^{\gamma_p} \left(M_{lt}^i\right)^{1-\alpha-\gamma_p} \tag{10}$$

Firm l in sector i can reset its price with probability $1-\xi_p$, and otherwise must follow the indexation rule

$$P_{lt}^i = P_{lt-1}^i \pi_{t-1}^{\iota_p} \tag{11}$$

5.1.4 Dominant Currency Pricing

We assume that all EM exports (i.e. both to the U.S. and to AEs) are denominated in U.S. dollars (the dominant currency). This is the key structural asymmetry between EMs and AEs in the model and the novelty of the 3 country model.

The DCP pricing assumption is motivated by the invoicing evidence that most of international trade uses dominant currencies, especially the U.S. dollar (see Goldberg and Tille (2008b) and Gopinath et al. (2020)).

Under the DCP assumption, EM firms set export prices to both the U.S. and AEs in U.S. dollars. Whereas, U.S. and AE exports continue to use PCP as before. Now, EMs set one price in domestic currency and 2 other prices denominated in U.S. dollars. The U.S. dollar denominated export prices differ across U.S. and AEs based on the total demand for EM exports in each country and additionally by the exchange rate fluctuations between the U.S. and AEs because AEs convert U.S. dollar denominated EM export to AE prices. Simply, AE demand for EM exports can decline by AE depreciation against the dollar.

Each EM firm l sets a dollar export price $P_{Ft}(l)$ for U.S. and another dollar export price $P_{Ft}^W(l)$ for AEs, subject to Calvo price-setting friction. If EM firm l is not able to reset its export prices, then it follows the indexation rules: $P_{Ft}(j) = P_{Ft-1}(j)(\pi_{Ft-1})^{\iota_p}$ where $\pi_{Ft} \equiv P_{Ft}/P_{Ft-1}$ and $P_{Ft}^W(j) = P_{Ft-1}(j)(\pi_{Ft-1}^W)^{\iota_p}$ where $\pi_{Ft}^W \equiv P_{Ft}^W/P_{Ft-1}^W$. Finally, U.S. faces price P_{Ft} whereas AEs face price $P_F^{**} \equiv P_F^W/S_W^H$.

5.1.5 Market Clearing, Central Bank and BoP

Given international demand for final goods at the consumption and intermediate input levels the total demand in U.S. for the tradable good is defined as:

$$Y_t^T = C_{Ht} + M_{Ht}^T + M_{Ht}^N + \frac{n_F}{n_H}\left(C_{Ht}^* + {M_{Ht}^T}^* + {M_{Ht}^N}^*\right) + \frac{n_W}{n_H}\left(C_{Ht}^{**} + {M_{Ht}^T}^{**} + {M_{Ht}^N}^{**}\right) \tag{12}$$

where for $j = \{H, F, W\}$, n_j is the relative country size of country j such that $\sum_j n_j = 1$.

Since there is no trade on the consumption level, total demand of final non-tradeable good is (including intermediate input demands for domestic tradeable and non-tradeable production):

$$Y^N = C^N + M_N^N + M_N^T \tag{13}$$

Sectoral market clearing conditions can be similarly defined for other countries,

Each country implements a simple Taylor rule reacts to deviations of producer price inflation of the tradable sector.

$$R_t^n = \beta^{-1} {\pi_t}^{\gamma_\pi} \tag{14}$$

where $\pi_t \equiv P_{Ht}/P_{Ht-1}$, the change in price of the domestically produced tradable good. [9]

Balance of Payments (BoP) condition for EMs in nominal terms is given by:

$$\frac{1}{S_{Ft}^H}\left(B_{Ht-1}^* - \frac{B_{Ht}^*}{R_{risk,ft}^n \phi_{Ht}^*}\right) - (R_{risk,ft}^n - 1)\theta_w \left({P_{Mt}^T}^* {M_t^T}^* + {P_{Mt}^N}^* {M_t^N}^* + W_t^* L_t^*\right) =$$
$$P_{Ct}^* C_t^* + {P_{Mt}^T}^* {M_t^T}^* + {P_{Mt}^N}^* {M_t^N}^* - {P_{Ft}}^* {Y_t^T}^* - {P_t^N}^* {Y_t^N}^* \tag{15}$$

The BoP condition between U.S. and AEs can be derived similarly.

5.2 Calibration

We calibrate the Home bloc to the United States, take the Foreign and Rest of the World to represent the emerging and advanced countries, respectively, with strong trade and financial linkages to the United States. Our calibration is asymmetric with United States being relatively closed to trade. We report the trade openness parameter values in Table A.1. The remaining parameter values are reported in Table A.2.

The openness to trade at the final and intermediate good levels create the key parametric asymmetries of our model. Our calibration of trade openness is based on the OECD Inter-Country Input Output Tables. Within the tradable consumption bundle (i.e. at the final good level) the US is most closed to trade and EMs are most open to trade among the three blocs. Moreover, EM exports make up most of the trade at the final good level. At the production level (i.e. intermediate goods trade), the US is most open to trade and EMs are least open to trade among the three blocs. This stands in contrast to EMs being most open in the final good trade and is explained by EMs being the main global producers of intermediate goods.

Another key asymmetry across countries is the tradable share of consumption. As observed in Figure 4a tradable component of consumption has been decreasing over time making non-tradable goods a larger component of US consumption. To that end we let US households have the highest ratio of non-tradable consumption relative to tradable consumption $(1 - \omega_s)$ and EMs to have the lowest share among the three blocs.

[9] Non-US countries target deviations of consumer price inflation for their policy rule.

From the OECD Inter-Country Input Output Tables we observe that intermediate goods make up about 50% of production. To that end we let the labor (α) and capital and (γ_p) to take values 0.10 and 0.40 respectively.

We calibrate the discount factor across all countries, β, to be 0.9950, implying a steady state real interest rate of 2% per year. The intertemporal elasticity of substitution (σ) and the steady state price markup (θ_p) are set to their conventional values, 1 and 20 percent respectively. The remaining household and firm parameters are based on the estimates from Justiniano et al. (2010): the inverse Frisch elasticity of labor supply (χ) and parameters governing price rigidities (ξ_p, ι_p). The Taylor rule in all countries feature inertia with coefficient (γ_r) 0.82 following Justiniano et al. (2010).

The price elasticity between tradable consumption goods of domestic and foreign origin (ρ_c) is set to 1.01. Whereas the intermediate good price elasticity in production (ρ_m) and sectoral price elasticity between final tradable and non-tradable goods (ρ_s) is set to 0.66 and 0.44 respectively, to be complements. These parameters are consistent with values used in the literature in the calibration of open economy macroeconomic models (see, for example, Erceg et al. (2010), Akinci and Queralto (2018), Schmitt-Grohe and Uribe (2016), and the references therein).

Tables A.1 and A.2 list all the baseline parameter descriptions and values. Appendix B contains a complete description of the closed form model equilibrium conditions under DCP.

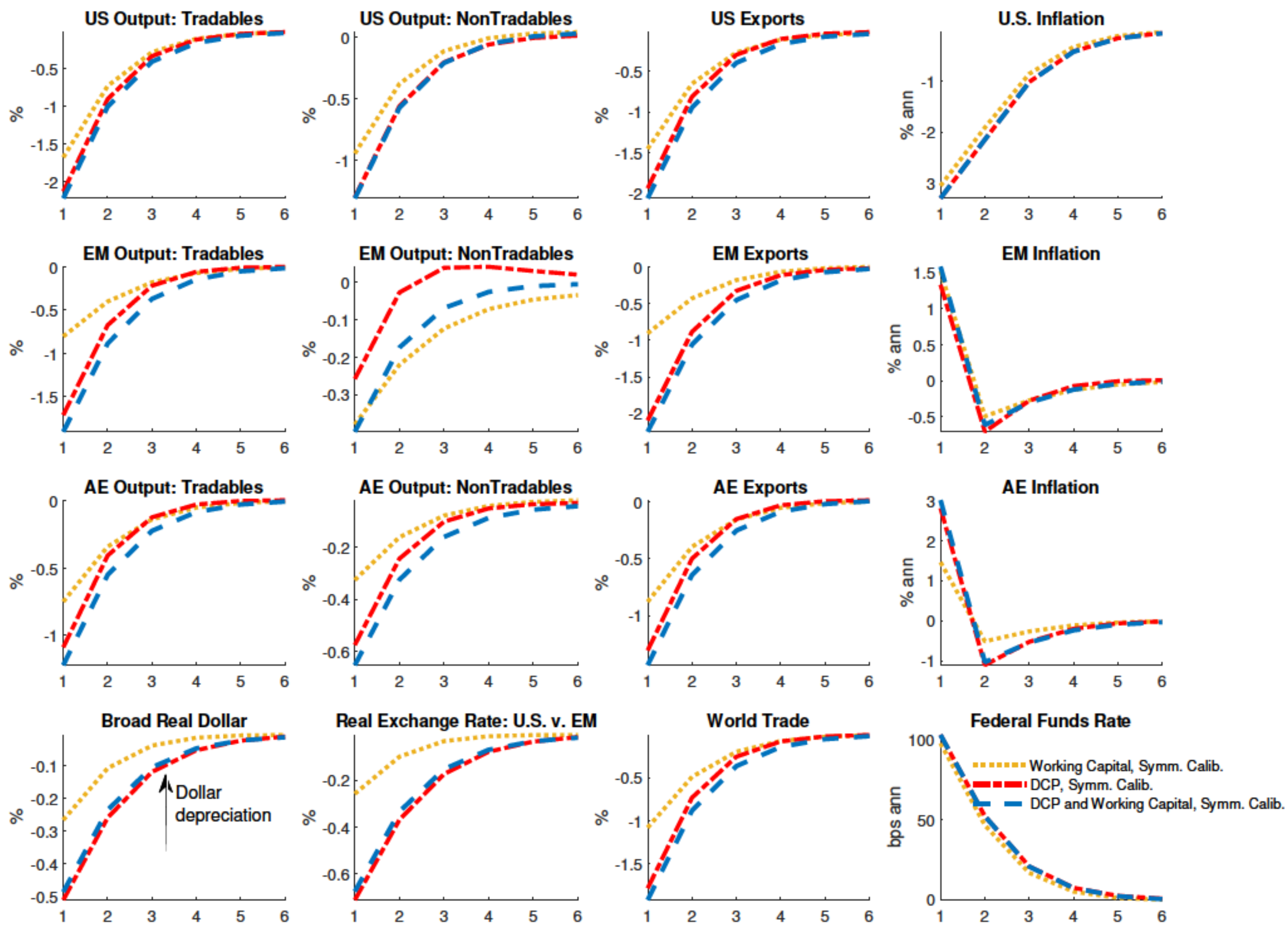
6 Global Effects of U.S. Monetary Policy Shock

We first explain the role of credit intensity of global supply chains and the role of dominant currency pricing for the transmission of U.S. monetary policy shocks. For that purpose we start our analysis with a symmetric calibration where each countries' size, trade openness (at both the intermediate and final goods level), and the share of tradable sectors are the same across all three blocs.

Figure 11 presents the domestic and cross-border effects of 100 basis points increase in the federal funds rate. The dotted yellow line displays the effects of the shock *only* with the presence of working capital frictions at the level of global supply chains, where exports from all countries are priced in the producer currency. The dashed-dotted red lines shows the effects of the shock *only* with the dominant currency pricing where we turn off the working capital frictions. Lastly, the dashed blue line illustrates the effects when the global economy faces both working capital frictions and dollar currency pricing for exports coming from the emerging market economies.

In the model without DCP (depicted by the yellow dashed line), a 100 basis points (annualized) increase in the Federal Funds Rate leads to a fall in U.S. output and U.S. inflation, as expected. Given the standard uncovered interest rate parity condition in the model, higher interest rates in the U.S. relative to the rest of the world (the latter is now shown in the figure), the broad real dollar index appreciates on impact and is expected to depreciate thereafter. The cross-border effects of the shock are governed by the relative strength of expenditure reducing and expenditure switching effects. Higher real interest rates in the U.S. cause demand for foreign goods to fall for both advanced countries and emerging market countries. The expenditure switching effect, on the other hand, works to stimulate AE and EM exports as these countries gain competitiveness against the U.S. due to a

Figure 11: U.S. Monetary Policy Shock, Symmetric Calibration



Note: The yellow dashed line shows the effect of a 100 basis points (annualized) rise in the Federal Funds Rate in the model with PCP and working capital constraints, the red dashed line shows it in the model with DCP without any working capital constraints, and the blue dashed line shows it in the model with DCP and working capital constraints. The trade openness, country size and sectoral consumption preference calibrations are symmetric across all countries to emphasize the structural asymmetries of our model rather than parametric asymmetries.

depreciation of their currencies.

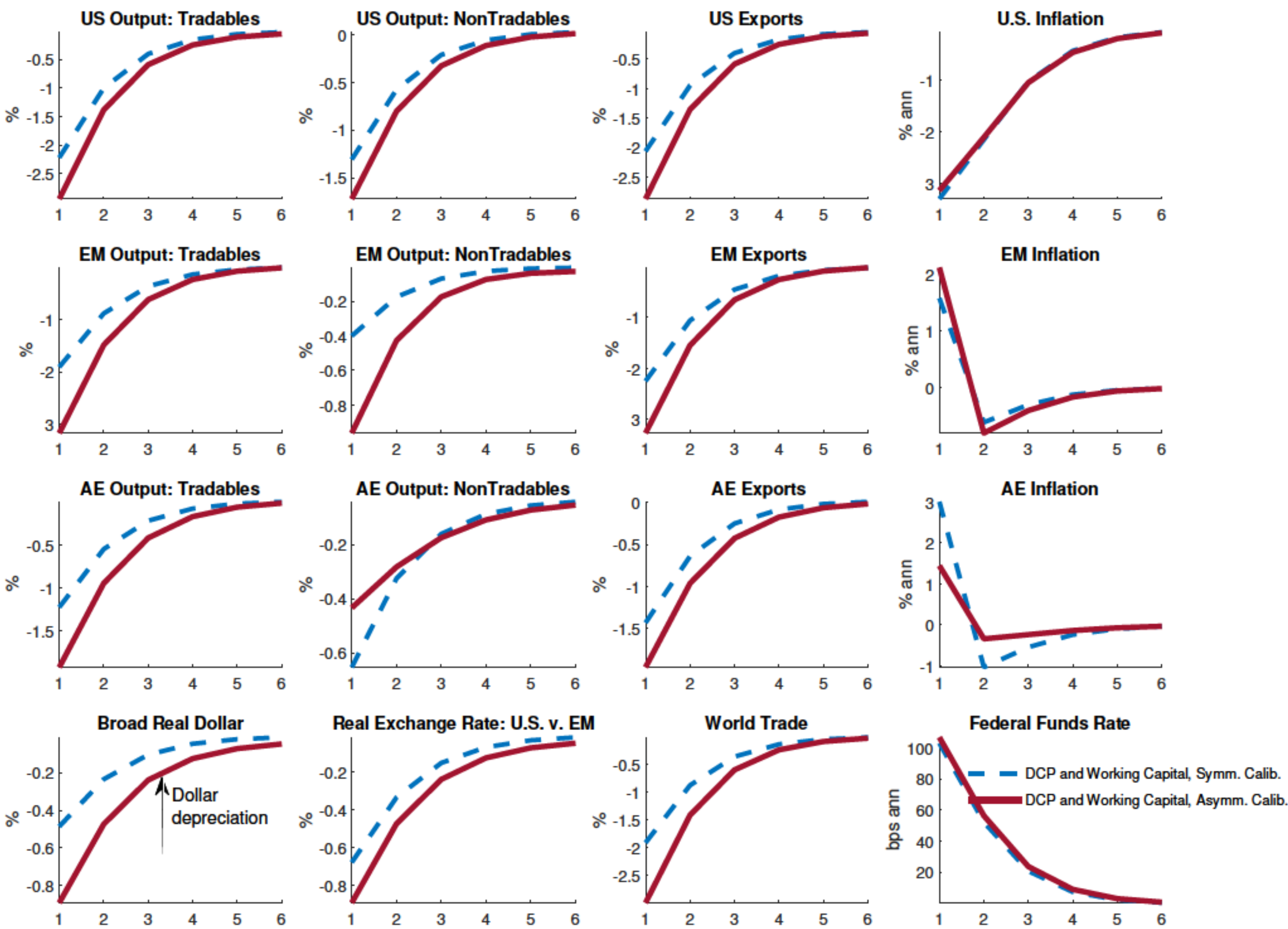
The final channel of cross-border transmission that our model features is the financial channel. An increase in the U.S. interest rates makes the financing cost of working capital loans higher, especially in those countries that rely heavily on financing the global supply chain activities via working capital loans. The combined effects of these three channels is negative, on net, for foreign output, which explains the decline in output in tradeable sectors in all the countries. One also needs to note that currency depreciation in foreign economies cause inflation to rise due to higher import prices as well as higher borrowing costs they face, which triggers an increase in the policy rate in these countries as well. As a result, we see a decline in output in both tradeable and nontradeable sectors in foreign economies, while US tradeable output falls roughly 50% more than non-tradeable output due to a fall in global trade.

Under the assumption of dollar invoicing of EM exports (as shown by dotted-dashed red line), EM output, especially in the tradeable sector, contracts more. It is because their exports fall a lot more with DCP compared with the PCP case, as the expenditure switching effect we highlighted above will largely be muted given the fact that their exports both to the U.S. and other advanced economies are priced in U.S. dollars and it is sticky (consistent with the empirical evidence in Gopinath et al. (2018)). Note that in our multi-country model AE's exports also fall more under DCP assumption compared with the PCP assumption in emerging economies, despite the fact that they continue to price their exports in domestic currency. It is because they face lower demand from both the U.S. and EMs for their goods as overall demand in these countries fall sharply. This finding highlights the richness of our 3 country model in accounting spillovers and spillbacks among countries. Lastly, the blue dashed line shows the effects of the 100 basis points increase in the federal funds rate when EM exports are priced in dollars, and the credit intensive global value chains face working capital frictions. We still keep our calibration to be symmetric. As expected, the presence of working capital frictions amplify the contraction of output in foreign economies, which then spillbacks to the U.S. economy as shown by slightly larger decline in U.S. tradeables. Nonetheless, the spillback to the U.S. economy under our symmetric calibration is relatively muted.

Figure 12 depicts the mechanism explained in Section 1 using our Global Macro Model that features DCP and Working Capital loans for the asymmetric calibration detailed in Section 5.2. The key feature of the asymmetric calibration, as explained above, is that the US is most closed to trade and EMs are most open to trade in final goods trade, while at the production level (i.e. intermediate goods trade), the US is most open to trade and EMs are least open to trade among the three blocs. Moreover, the share of non-tradable consumption relative to tradable consumption is highest in the U.S., while the EMs have the lowest share of non-tradable consumption among the three blocs. For comparison purposes, we reproduce the symmetric calibration in the figure (shown by dashed blue line). The dark red line shows the domestic and cross-border effects of U.S. monetary tightening in our global macro model with asymmetric calibration.

As shown, in a world in which asymmetries play an important role, the adverse effects of U.S. monetary tightening is much more severe in emerging economies. It is mainly due to the fact that the dollar appreciates more in this case, causing EMs to face higher import prices (and higher inflationary pressure) and higher working capital frictions, the former cause the EM central banks to tighten more to stabilize their inflation. Despite these adverse effects arising from depreciation of EM currencies on EM output, their export competitiveness are essentially unaffected because they price their exports in U.S. dollar. As a result, we see the output in the tradeable sector contracting sharply in EMs, as their exports collapse. Note that EMs are more exposed to trade relative to the US, explaining a much larger contraction in EM output relative to the U.S. in our global macro model. In other words, since the US economy is more closed to trade at the consumption level the spillbacks to US tradeable output are muted.

Figure 12: U.S. Monetary Policy Shock, Asymmetric Calibration



Note: The blue dashed line shows the effect of a 100 basis points (annualized) rise in the Federal Funds Rate in the model with DCP and working capital constraints in a symmetric calibration as in Figure 11, the purple solid line shows it for the model with DCP and working capital constraints with an asymmetric calibration explained in Section 5.2.

7 Conclusion

In this paper we propose a new channel through which dollar fluctuations can become a self-fulfilling pro cyclical force. We develop a multi-country DSGE model to illustrate key features of the global economy that contribute to the emergence of this mechanism that we call the Imperial Circle. As we discuss, at the core of it, there is a fundamental asymmetry between the shrinking exposure of the "real" U.S. economy to global developments versus the growing global role of the U.S. dollar. A dollar appreciation leads to a decline in global economic activity, which in turn benefits, in relative terms, the dollar itself, reinforcing the initial appreciation. The focus of our paper is positive and we abstract from normative considerations but it is easy to see how international monetary policy cooperation in such environment is challenging at best. The fact that in this paper we have focused mainly on the real side dimension of the Imperial Dollar reinforce our claim. Indeed, in our future research we plan to explore and study the interaction between the real and financial dimensions of the Dollar's Imperial Circle.

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Appendix

A Parameter Values

Table A.1: Openness Parameter Descriptions and Values

Parameter	Description	Estimate
Consumption		
λ_{cF}^{H}	EM and US tradable final good openness	1.90
λ_{cW}^{H}	AE and US tradable final good openness	0.01
λ_{cF}^{W}	EM and AE tradable final good openness	1.90
Tradeable		
λ_{pF}^{H}	EM and US intermediate good openness in tradable good production	1.50
λ_{pW}^{H}	AE and US intermediate good openness in tradable good production	0.50
λ_{pF}^{W}	EM and AE intermediate good openness in tradable good production	1.50
λ_{pH}^{H}	US domestic tradable intermediate good openness in tradable good production	0.20
λ_{pF}^{F}	EM domestic tradable intermediate good openness in tradable good production	0.25
λ_{pW}^{W}	AE domestic tradable intermediate good openness in tradable good production	0.20
Non-Tradeable		
λ_{pH}^{N}	US tradable intermediate good openness in US non-tradable good production	0.10
λ_{pF}^{N}	EM tradable intermediate good openness in US non-tradable good production	1.50
λ_{pW}^{N}	AE tradable intermediate good openness in US non-tradable good production	0.10
$\lambda_{pH}^{N^*}$	US tradable intermediate good openness in EM non-tradable good production	1.00
$\lambda_{pF}^{N^*}$	EM tradable intermediate good openness in EM non-tradable good production	0.50
$\lambda_{pW}^{N^*}$	AE tradable intermediate good openness in EM non-tradable good production	0.10
$\lambda_{pH}^{N^{**}}$	US tradable intermediate good openness in AE non-tradable good production	0.10
$\lambda_{pF}^{N^{**}}$	EM tradable intermediate good openness in AE non-tradable good production	1.00
$\lambda_{pW}^{N^{**}}$	AE tradable intermediate good openness in AE non-tradable good production	0.30

Note: The shares ν_{pj}^{i} for each country, where $j = \{N, H, F, W\}$ and $i = \{N, T\}$ are defined as $\nu_{pj}^{i} = n_i \lambda_{pj}^{i}$. Similarly for the consumption shares ν_{ck}^{z}, where $k = \{H, F, W\}$ and $z = \{H, F, W\}$ are defined as $\nu_{ck}^{z} = n_z \lambda_{ck}^{z}$. The term λ_j^i is defined as the common degree of openness between i and j, i.e. $\lambda_j^i = \lambda_i^j$, except for the non-tradable good production which cannot be common by nature.

Table A.2: Parameter Descriptions and Values

Parameter	Description	Value
α	output elasticity of capital	0.10
γ_p	output elasticity of labor	0.40
β	US consumer's discount rate	0.9950
β^*	EM consumer's discount rate	0.9950
β^{**}	AE consumer's discount rate	0.9950
χ	inverse labor supply elasticity	2.00
σ	inverse elasticity of substitution	1.00
γ^π	US response in Taylor rule to inflation	1.50
$\gamma^{\pi*}$	EM in Taylor rule to inflation	1.75
$\gamma^{\pi**}$	AE in Taylor rule to inflation	1.50
θ_w^*	EM working capital ratio	2.50
θ_w^{**}	AE working capital ratio	1.00
ν_H^*	US traded bond adjustment cost for EM	0.001
ν_H^{**}	US traded bond adjustment cost for AE	0.001
ω_s	sectoral bias for final tr consumption relative to US ntr good	0.05
ω_s^*	sectoral bias for final tr consumption relative to EM ntr good	0.46
ω_s^{**}	sectoral bias for final tr consumption relative to AE ntr good	0.20
ρ_c	final tradeable consumption price elasticity	1.01
ρ_m	intermediate tradeable production price elasticity	0.66
ρ_s	sectoral price elasticity	0.44
θ_p	net price markup	0.20
ξ_p	price stickiness	0.60
ι_p	price indexation	0.24
ρ_m	persistence of monetary shock	0.10
σ_m	standard deviation of monetary shock	0.01
ρ_z	persistence of technology shock	0.95
σ_z	standard deviation of technology shock	0.01
ρ_r	persistence of risk shock	0.70
σ_r	standard deviation of risk shock	0.01
ψ_r	correlation of risk shocks	0.00

B Full Set of Equilibrium Conditions

Home country equations:

$$C_t^{\frac{-1}{\sigma}} = \beta \mathbb{E}_t \left[C_{t+1}^{\frac{-1}{\sigma}} \frac{R_t^n}{\pi_{t+1}^C} \right] \tag{B.1}$$

$$w_t = \chi_o L_t^{\chi} C_t^{\frac{1}{\sigma}} \tag{B.2}$$

$$C_{Ht} = \nu_H^H \left(p_{HT,t}\right)^{-\rho_c} C_t^T \tag{B.3}$$

$$C_{Ft} = \nu_F^H \left(\frac{p_{Ft}}{p_{Tt}}\right)^{-\rho_c} C_t^T \tag{B.4}$$

$$C_{Wt} = \nu_W^H \left(\mathcal{T}_H^W p_{HT,t}\right)^{-\rho_c} C_t^T \tag{B.5}$$

$$C_t^T = \omega_s \left(p_{T,t}\right)^{-\rho_s} C_t \tag{B.6}$$

$$C_t^N = (1-\omega_s)\left(p_{N,t}\right)^{-\rho_s} C_t \tag{B.7}$$

$$M_N^T = \nu_{pN}^H \left(\frac{p_N p_{HM,t}}{p_{T,t} p_{HT,t}}\right)^{-\rho_m} M^T \tag{B.8}$$

$$M_H^T = \nu_{pH}^H \left(p_{HM,t}\right)^{-\rho_m} M^T \tag{B.9}$$

$$M_F^T = \nu_{pF}^H \left(\frac{p_{Ft}}{p_{Tt}} \frac{p_{HM,t}}{p_{HT,t}}\right)^{-\rho_m} M^T \tag{B.10}$$

$$M_W^T = \nu_{pW}^H \left(\mathcal{T}_H^W p_{HM,t}\right)^{-\rho_m} M^T \tag{B.11}$$

$$M_N^N = \nu_{pN}^N \left(p_{NM,t}\right)^{-\rho_m} M^N \tag{B.12}$$

$$M_H^N = \nu_{pH}^N \left(\frac{p_{T,t} p_{HT,t}}{p_{N,t}} p_{NM,t}\right)^{-\rho_m} M^N \tag{B.13}$$

$$M_F^N = \nu_{pF}^N \left(\frac{p_{Ft}}{p_{Nt}} p_{NM,t}\right)^{-\rho_m} M^N \tag{B.14}$$

$$M_W^N = \nu_{pW}^N \left(\frac{p_{T,t} p_{HT,t}}{p_{N,t}} \mathcal{T}_{H,t}^W p_{NM,t}\right)^{-\rho_m} M^N \tag{B.15}$$

$$p_{HT,t} = \left[\frac{1-\nu_F^H (p_{F,t}/p_{T,t})^{1-\rho_c}}{\nu_H^H + \nu_W^H (\mathcal{T}_H^W)^{1-\rho_c}}\right]^{\frac{1}{1-\rho_c}} \tag{B.16}$$

$$p_{N,t} = \left[\frac{1-\omega_s (p_T)^{1-\rho_s}}{1-\omega_s}\right]^{\frac{1}{1-\rho_s}} \tag{B.17}$$

$$p_{HM,t} = \left[\nu_{pN}^H \left(\frac{p_N}{p_{T,t} p_{HT,t}}\right)^{1-\rho_m} + \nu_{pH}^H + \nu_{pF}^H \left(\frac{p_{Ft}}{p_{Tt} p_{HT,t}}\right)^{1-\rho_m} + \nu_{pW}^H (\mathcal{T}_H^W)^{1-\rho_m}\right]^{-\frac{1}{1-\rho_m}} \tag{B.18}$$

$$p_{NM,t} = \left[\nu_{pN}^N + \nu_{pH}^N \left(\frac{p_{T,t} p_{HT,t}}{p_{N,t}}\right)^{1-\rho_m} + \nu_{pF}^N \left(\frac{p_{Ft}}{p_{Nt}}\right)^{1-\rho_m} + \nu_{pW}^N \left(\frac{p_{T,t} p_{HT,t}}{p_{N,t}} \mathcal{T}_{H,t}^W\right)^{1-\rho_m}\right]^{-\frac{1}{1-\rho_m}} \tag{B.19}$$

$$Y^T = \overline{K^T}^{\alpha} (Z_t^T L_t^T)^{\gamma_p} (M^T)^{1-\alpha-\gamma_p} \tag{B.20}$$

$$w_t = \frac{\gamma_p}{\alpha} \frac{\overline{K^T}}{L_t^T} r_{K,t}^T \tag{B.21}$$

$$p_{HT,t} p_{T,t} / p_{HM,t} = \frac{1-\alpha-\gamma_p}{\alpha} \frac{K^T}{M^T} r_K^T \tag{B.22}$$

$$mc_t^T = \left(\frac{w_t/Z_t^T}{\gamma_p}\right)^{\gamma_p}\left(\frac{r_{K,t}^T}{\alpha}\right)^{\alpha}\left(\frac{p_{HT,t}p_{T,t}/p_{HM,t}}{1-\alpha-\gamma_p}\right)^{1-\alpha-\gamma_p} \tag{B.23}$$

$$\pi_t{}^{-\frac{1}{\theta_p}} = (1-\xi_p)(\pi_t{}^o)^{-\frac{1}{\theta_p}} + \xi_p(\pi_{t-1})^{-\frac{\iota_p}{\theta_p}} \tag{B.24}$$

$$\pi_t{}^o = (1+\theta_p)\frac{x_{1T,t}}{x_{2T,t}}\pi_t \tag{B.25}$$

$$x_{1T,t} = \omega_s^{\frac{1}{\rho_s}} C_t^{\frac{1}{\rho_s}-\frac{1}{\sigma}} C_{T,t}^{-\frac{1}{\rho_s}} mc_t^T Y_t^T + \beta\xi_p \pi_t{}^{-\iota_p\frac{1+\theta_p}{\theta_p}} \mathbb{E}_t\left\{x_{1T,t+1}\pi_{t+1}{}^{\frac{1+\theta_p}{\theta_p}}\right\} \tag{B.26}$$

$$x_{2T,t} = \omega_s^{\frac{1}{\rho_s}} C_t^{\frac{1}{\rho_s}-\frac{1}{\sigma}} C_{T,t}^{-\frac{1}{\rho_s}} p_{HT,t}p_{T,t}Y_t^T + \beta\xi_p \pi_t{}^{\iota_p\left(1-\frac{1+\theta_p}{\theta_p}\right)} \mathbb{E}_t\left\{x_{2T,t+1}\pi_{t+1}{}^{\frac{1+\theta_p}{\theta_p}-1}\right\} \tag{B.27}$$

$$Y^N = \overline{K^N}^{\alpha}(Z_t^N L_t^N)^{\gamma_p}(M^N)^{1-\alpha-\gamma_p} \tag{B.28}$$

$$w_t = \frac{\gamma_p}{\alpha}\frac{\overline{K^N}}{L_t^N} r_{K,t}^N \tag{B.29}$$

$$p_{N,t}/p_{NM,t} = \frac{1-\alpha-\gamma_p}{\alpha}\frac{K^N}{M^N} r_K^N \tag{B.30}$$

$$mc^N = \left(\frac{w_t/Z_t^N}{\gamma_p}\right)^{\gamma_p}\left(\frac{r_{K,t}^N}{\alpha}\right)^{\alpha}\left(\frac{p_{N,t}/p_{NM,t}}{1-\alpha-\gamma_p}\right)^{1-\alpha-\gamma_p} \tag{B.31}$$

$$\pi_t^{N-\frac{1}{\theta_p}} = (1-\xi_p)(\pi_t^{N\,o})^{-\frac{1}{\theta_p}} + \xi_p(\pi_{t-1}^N)^{-\frac{\iota_p}{\theta_p}} \tag{B.32}$$

$$\pi_t^{N\,o} = (1+\theta_p)\frac{x_{1N,t}}{x_{2N,t}}\pi_t^N \tag{B.33}$$

$$x_{1N,t} = (1-\omega_s)^{\frac{1}{\rho_s}} C_t^{\frac{1}{\rho_s}-\frac{1}{\sigma}} C_{N,t}^{-\frac{1}{\rho_s}} mc_t^N Y_t^N + \beta\xi_p \pi_t^{N-\iota_p\frac{1+\theta_p}{\theta_p}} \mathbb{E}_t\left\{x_{1N,t+1}\pi_{t+1^N}{}^{\frac{1+\theta_p}{\theta_p}}\right\} \tag{B.34}$$

$$x_{2N,t} = (1-\omega_s)^{\frac{1}{\rho_s}} C_t^{\frac{1}{\rho_s}-\frac{1}{\sigma}} C_{N,t}^{-\frac{1}{\rho_s}} p_{N,t}Y_t^N + \beta\xi_p \pi_t^{N\,\iota_p\left(1-\frac{1+\theta_p}{\theta_p}\right)} \mathbb{E}_t\left\{x_{2N,t+1}\pi_{t+1}^N{}^{\frac{1+\theta_p}{\theta_p}-1}\right\} \tag{B.35}$$

$$\pi_t^C = \pi_t\frac{p_{HT,t-1}p_{T,t-1}}{p_{HT,t}p_{T,t}} \tag{B.36}$$

$$\pi_t^C = \pi_t^N\frac{p_{Nt-1}}{p_{N,t}} \tag{B.37}$$

$$\pi_t^C = \pi_{Ft}\frac{p_{Ft-1}}{p_{Ft}} \tag{B.38}$$

$$\pi_t^C = \pi_{Ft}^W\frac{p_{Ft-1}^W}{p_{Ft}^W} \tag{B.39}$$

$$Y_t^T = C_{Ht} + M_{Ht}^T + M_{Ht}^N + \frac{n_F}{n_H}\left(C_{Ht}^* + M_{Ht}^T{}^* + M_{Ht}^N{}^*\right) + \frac{n_W}{n_H}\left(C_{Ht}^{**} + M_{Ht}^T{}^{**} + M_{Ht}^N{}^{**}\right) \tag{B.40}$$

$$L = L^T + L^N \tag{B.41}$$

$$Y^N = C^N + M_N^N + M_N^T \tag{B.42}$$

$$R_t^n = \beta^{-1}\pi_t{}^{\gamma_\pi} \tag{B.43}$$

where $p_{HT,t} \equiv \frac{P_{H,t}}{P_t^T}$, $p_{HM,t} \equiv \frac{P_{H,t}}{P_{M,t}^T}$, $p_{NM,t} \equiv \frac{P_t^N}{P_{M,t}^N}$, $p_{N,t} \equiv \frac{P_t^N}{P_{C,t}}$, $p_{Ft} \equiv \frac{P_{Ft}}{P_{Ct}}$, $p_{Ft}^W \equiv \frac{P_{Ft}^W}{P_{Ct}}$, $\pi_t^C \equiv \frac{P_{C,t}}{P_{C,t-1}}$, $\pi_t \equiv \frac{P_{H,t}}{P_{H,t-1}}$, $\pi_t^N \equiv \frac{P_t^N}{P_{t-1}^N}$, $\pi_{Ft} \equiv \frac{P_{Ft}}{P_{Ft-1}}$, and $\pi_{Ft}^W \equiv \frac{P_{Ft}^W}{P_{Ft-1}^W}$.

Foreign country equations:

$$C_t^*{}^{\frac{-1}{\sigma}} = \beta^*\mathbb{E}_t\left[C_{t+1}^*{}^{\frac{-1}{\sigma}}\frac{R_t^{*n}}{\pi^*{}_{t+1}^C}\right] \tag{B.44}$$

$$
\begin{aligned}
w_t^* &= \chi_o L_t^{*\chi} C_t^{*\frac{1}{\sigma}} && \text{(B.45)}\\
C_{Ht}^* &= \nu_H^F \left(\mathcal{T}_F^H p_{FT,t}^*\right)^{-\rho_c} C_t^{T*} && \text{(B.46)}\\
C_{Ft}^* &= \nu_F^F \left(p_{FT,t}^*\right)^{-\rho_c} C_t^{T*} && \text{(B.47)}\\
C_{Wt}^* &= \nu_W^F \left(\mathcal{T}_F^W p_{FT,t}^*\right)^{-\rho_c} C_t^{T*} && \text{(B.48)}\\
C_t^{T*} &= \omega_s^* \left(p_{T,t}^*\right)^{-\rho_s} C_t^* && \text{(B.49)}\\
C_t^{N*} &= (1-\omega_s^*) \left(p_{N,t}^*\right)^{-\rho_s} C_t^* && \text{(B.50)}\\
M_N^{T*} &= \nu_{pN}^F \left(\frac{p_N^* p_{FM,t}^*}{p_{T,t}^* p_{FT,t}^*}\right)^{-\rho_m} M^{T*} && \text{(B.51)}\\
M_H^{T*} &= \nu_{pH}^F \left(\mathcal{T}_F^H p_{FM,t}^*\right)^{-\rho_m} M^{T*} && \text{(B.52)}\\
M_F^{T*} &= \nu_{pF}^F \left(p_{FM,t}^*\right)^{-\rho_m} M^{T*} && \text{(B.53)}\\
M_W^{T\,*} &= \nu_{pW}^F \left(\mathcal{T}_F^W p_{FM,t}^*\right)^{-\rho_m} M^{T*} && \text{(B.54)}\\
M_N^{N*} &= \nu_{pN}^{N*} \left(p_{NM,t}^*\right)^{-\rho_m} M^{N*} && \text{(B.55)}\\
M_H^{N*} &= \nu_{pH}^{N*} \left(\frac{p_{T,t}^* p_{FT,t}^*}{p_{N,t}^*} \mathcal{T}_F^H p_{NM,t}^*\right)^{-\rho_m} M^{N*} && \text{(B.56)}\\
M_F^{N*} &= \nu_{pF}^{N*} \left(\frac{p_{T,t}^* p_{FT,t}^*}{p_{N,t}^*} p_{NM,t}^*\right)^{-\rho_m} M^{N*} && \text{(B.57)}\\
M_W^{N*} &= \nu_{pW}^{N*} \left(\frac{p_{T,t}^* p_{FT,t}^*}{p_{N,t}^*} \mathcal{T}_F^W p_{NM,t}^*\right)^{-\rho_m} M^{N*} && \text{(B.58)}\\
p_{FT,t}^* &= \left[\nu_H^F \left(\mathcal{T}_F^H\right)^{1-\rho_c} + \nu_F^F + \nu_W^F \left(\mathcal{T}_F^W\right)^{1-\rho_c}\right]^{-\frac{1}{1-\rho_c}} && \text{(B.59)}\\
p_{N,t}^* &= \left[\frac{1-\omega_s^*(p_T^*)^{1-\rho_s}}{1-\omega_s^*}\right]^{\frac{1}{1-\rho_s}} && \text{(B.60)}\\
p_{FM,t}^* &= \left[\nu_{pN}^F \left(\frac{p_N^*}{p_{T,t}^* p_{FT,t}^*}\right)^{1-\rho_m} + \nu_{pH}^F \left(\mathcal{T}_F^H\right)^{1-\rho_m} + \nu_{pF}^F + \nu_{pW}^F \left(\mathcal{T}_F^W\right)^{1-\rho_m}\right]^{-\frac{1}{1-\rho_m}} && \text{(B.61)}\\
p_{NM,t}^* &= \left[\nu_{pN}^{N*} + \nu_{pH}^{N*} \left(\frac{p_{T,t}^* p_{FT,t}^*}{p_{N,t}^*} \mathcal{T}_F^H\right)^{1-\rho_m} + \nu_{pF}^{N*} \left(\frac{p_{T,t}^* p_{FT,t}^*}{p_{N,t}^*}\right) + \nu_{pW}^{N*} \left(\frac{p_{T,t}^* p_{FT,t}^*}{p_{N,t}^*} \mathcal{T}_F^W\right)^{1-\rho_m}\right]^{-\frac{1}{1-\rho_m}} && \text{(B.62)}\\
Y^{T*} &= \overline{K^{T*}}^{\alpha} (Z_t^{T*} L_t^{T*})^{\gamma_p} (M^{T*})^{1-\alpha-\gamma_p} && \text{(B.63)}\\
w^* &= \frac{\gamma_p}{\alpha} \frac{\overline{K}^{T*}}{L_t^{T*}} \frac{r_{K,t}^{T\ *}}{1+(R_{risk,ft}^n - 1)\theta_w} && \text{(B.64)}\\
p_{FT,t}^* p_{T,t}^* / p_{FM,t}^* &= \frac{1-\alpha-\gamma_p}{\alpha} \frac{\overline{K}^{T*}}{M_t^{T*}} \frac{r_{K,t}^{T\ *}}{1+(R_{risk,ft}^n - 1)\theta_w} && \text{(B.65)}\\
mc_t^{T*} &= \left(\frac{w_t^*/Z_t^{T*}[1+(R_{risk,ft}^n - 1)\theta_w]}{\gamma_p}\right)^{\gamma_p} \left(\frac{r_{K,t}^{T\ *}}{\alpha}\right)^{\alpha} \left(\frac{p_{FT,t}^* p_{T,t}^* / p_{FM,t}^* [1+(R_{risk,ft}^n - 1)\theta_w]}{1-\alpha-\gamma_p}\right)^{1-\alpha-\gamma_p} && \text{(B.66)}\\
\pi_t^{*-\frac{1}{\theta_p}} &= (1-\xi_p)(\pi_t^{*o})^{-\frac{1}{\theta_p}} + \xi_p (\pi_{t-1}^*)^{-\iota_p \frac{1}{\theta_p}} && \text{(B.67)}
\end{aligned}
$$

$$\pi_t^{*o} = (1+\theta_p)\frac{x_{1T,t}^*}{x_{2T,t}^*}\pi_t^* \tag{B.68}$$

$$x_{1T,t}^* = \omega_s^{*\frac{1}{\rho_s}} C_t^{*\frac{1}{\rho_s}-\frac{1}{\sigma}} C_{T,t}^{*\,-\frac{1}{\rho_s}} mc_t^{T*} Y_{Dt}^{T\,*} + \beta^*\xi_p \pi_t^{*\,-\iota_p\frac{1+\theta_p}{\theta_p}} \mathbb{E}_t\left\{(\pi_{t+1}^*)^{\frac{1+\theta_p}{\theta_p}} x_{1T,t+1}^*\right\} \tag{B.69}$$

$$x_{2T,t}^* = \omega_s^{*\frac{1}{\rho_s}} C_t^{*\frac{1}{\rho_s}-\frac{1}{\sigma}} C_{T,t}^{*\,-\frac{1}{\rho_s}} p_{FT,t}^* p_{T,t}^* Y_{Dt}^{T\,*} + \beta^*\xi_p \pi_t^{*\,\iota_p\left(1-\frac{1+\theta_p}{\theta_p}\right)} \mathbb{E}_t\left\{(\pi_{t+1}^*)^{\frac{1+\theta_p}{\theta_p}-1} x_{2T,t+1}^*\right\} \tag{B.70}$$

$$Y_D^{T*} = C_F^* + M_F^{T*} + M_F^{N*} \tag{B.71}$$

$$\pi_{Ft}^{-\frac{1}{\theta_p}} = (1-\xi_p)\pi_{Ft}^{o\,-\frac{1}{\theta_p}} + \xi_p(\pi_{Ft-1})^{-\iota_p\frac{1}{\theta_p}} \tag{B.72}$$

$$\pi_{Ft}^o = (1+\theta_p)\frac{z_{1t}}{z_{2t}}\pi_{Ft} \tag{B.73}$$

$$z_{1t} = \omega_s^{*\frac{1}{\rho_s}} C_t^{*\frac{1}{\rho_s}-\frac{1}{\sigma}} C_{T,t}^{*\,-\frac{1}{\rho_s}} N_t mc_{\ t}^{T*} + \beta^*\xi_p(\pi_{Ft})^{-\iota_p\frac{1+\theta_p}{\theta_p}} \mathbb{E}_t\left\{(\pi_{Ft+1})^{\frac{1+\theta_p}{\theta_p}} z_{1t+1}\right\} \tag{B.74}$$

$$z_{2t} = \omega_s^{*\frac{1}{\rho_s}} C_t^{*\frac{1}{\rho_s}-\frac{1}{\sigma}} C_{T,t}^{*\,-\frac{1}{\rho_s}} N_t \frac{p_{Ft}}{\mathcal{Q}_{Ft}^H} + \beta^*\xi_p(\pi_{Ft})^{\iota_p\left(1-\frac{1+\theta_p}{\theta_p}\right)} \mathbb{E}_t\left\{(\pi_{Ft+1})^{\frac{1+\theta_p}{\theta_p}-1} z_{2t+1}\right\} \tag{B.75}$$

$$N_t = C_{Ft} + M_{Ft}^T + M_{Ft}^N \tag{B.76}$$

$$\pi_{Ft}^{W\,-\frac{1}{\theta_p}} = (1-\xi_p)\pi_{Ft}^{Wo\,-\frac{1}{\theta_p}} + \xi_p(\pi_{Ft-1}^W)^{-\iota_p\frac{1}{\theta_p}} \tag{B.77}$$

$$\pi_{Ft}^{Wo} = (1+\theta_p)\frac{z_{1t}^W}{z_{2t}^W}\pi_{Ft}^W \tag{B.78}$$

$$z_{1t}^W = \omega_s^{*\frac{1}{\rho_s}} C_t^{*\frac{1}{\rho_s}-\frac{1}{\sigma}} C_{T,t}^{*\,-\frac{1}{\rho_s}} N_t^W mc_{\ t}^{T*} + \beta^*\xi_p(\pi_{Ft}^W)^{-\iota_p\frac{1+\theta_p}{\theta_p}} \mathbb{E}_t\left\{(\pi_{Ft+1}^W)^{\frac{1+\theta_p}{\theta_p}} z_{1t+1}^W\right\} \tag{B.79}$$

$$z_{2t}^W = \omega_s^{*\frac{1}{\rho_s}} C_t^{*\frac{1}{\rho_s}-\frac{1}{\sigma}} C_{T,t}^{*\,-\frac{1}{\rho_s}} N_t^W \frac{p_{Ft}^W}{\mathcal{Q}_{Ft}^H} + \beta^*\xi_p(\pi_{Ft}^W)^{\iota_p\left(1-\frac{1+\theta_p}{\theta_p}\right)} \mathbb{E}_t\left\{(\pi_{Ft+1}^W)^{\frac{1+\theta_p}{\theta_p}-1} z_{2t+1}^W\right\} \tag{B.80}$$

$$N_t^W = C_{Ft}^{**} + M_{Ft}^{T\,**} + M_{Ft}^{N\,**} \tag{B.81}$$

$$Y^{N*} = \overline{K^{N*}}^{\alpha}(Z_t^* L_t^{N*})^{\gamma_p}(M^{N*})^{1-\alpha-\gamma_p} \tag{B.82}$$

$$w^* = \frac{\gamma_p}{\alpha}\frac{\overline{K}^{N*}}{L_t^{N*}}\frac{r_{K,t}^{N\ *}}{1+(R_{risk,ft}^n-1)\theta_w} \tag{B.83}$$

$$p_{N,t}^*/p_{NM,t}^* = \frac{1-\alpha-\gamma_p}{\alpha}\frac{\overline{K}^{N*}}{M_t^{N*}}\frac{r_{K,t}^{N\ *}}{1+(R_{risk,ft}^n-1)\theta_w} \tag{B.84}$$

$$mc_t^{N*} = \left(\frac{w_t^*/Z_t^{N*}[1+(R_{risk,ft}^n-1)\theta_w]}{\gamma_p}\right)^{\gamma_p}\left(\frac{r_{K,t}^{N\ *}}{\alpha}\right)^{\alpha}\left(\frac{p_{N,t}^*/p_{NM,t}^*[1+(R_{risk,ft}^n-1)\theta_w]}{1-\alpha-\gamma_p}\right)^{1-\alpha-\gamma_p} \tag{B.85}$$

$$\pi_t^{N*-\frac{1}{\theta_p}} = (1-\xi_p)(\pi_t^{N*o})^{-\frac{1}{\theta_p}} + \xi_p(\pi_{t-1}^{N\ *})^{-\frac{\iota_p}{\theta_p}} \tag{B.86}$$

$$\pi_t^{N*o} = (1+\theta_p)\frac{x_{1N,t}^*}{x_{2N,t}^*}\pi_t^{N*} \tag{B.87}$$

$$x_{1N,t}^* = (1-\omega_s^*)^{\frac{1}{\rho_s}} C_t^{*\frac{1}{\rho_s}-\frac{1}{\sigma}} C_{N,t}^{*\,-\frac{1}{\rho_s}} mc_t^{N*} Y_t^{N*} + \beta^*\xi_p \pi_t^{N*-\iota_p\frac{1+\theta_p}{\theta_p}} \mathbb{E}_t\left\{x_{1N,t+1}^* \pi_{t+1^N}^{\ \ *\frac{1+\theta_p}{\theta_p}}\right\} \tag{B.88}$$

$$x_{2N,t}^* = (1-\omega_s^*)^{\frac{1}{\rho_s}} C_t^{*\frac{1}{\rho_s}-\frac{1}{\sigma}} C_{N,t}^{*\,-\frac{1}{\rho_s}} p_{N,t}^* Y_t^{N*} + \beta^*\xi_p \pi_t^{N*\iota_p\left(1-\frac{1+\theta_p}{\theta_p}\right)} \mathbb{E}_t\left\{x_{2N,t+1}^* \pi_{t+1}^{N\ *\frac{1+\theta_p}{\theta_p}-1}\right\} \tag{B.89}$$

$$\pi_t^{*C} = \pi_t^*\frac{p_{FT,t-1}^* p_{T,t-1}^*}{p_{FT,t}^* p_{T,t}^*} \tag{B.90}$$

$$\pi_t^{*C} = \pi_t^{N*}\frac{p^*_{Nt-1}}{p^*_{N,t}} \tag{B.91}$$

$$Y^{T*} = C^*_{Ft} + M^{T\,*}_{Ft} + M^{N\,*}_{Ft} + \frac{n_H}{n_F}\left(C_{Ft} + M^T_{Ft} + M^N_{Ft}\right) + \frac{n_W}{n_F}\left(C^{**}_{Ft} + M^{T\,**}_{Ft} + M^{N\,**}_{Ft}\right) \tag{B.92}$$

$$L^* = L^{T*} + L^{N*} \tag{B.93}$$

$$Y^{N*} = C^{N*} + M^{N*}_N + M^{T*}_N \tag{B.94}$$

$$R^{*n}_t = \beta^{*-1}\pi_t^{C^*\gamma_\pi} \tag{B.95}$$

where $p^*_{FT,t} \equiv \frac{P^*_{F,t}}{P_t^{T*}}$, $p^*_{FM,t} \equiv \frac{P_{F,t}{}^*}{P^T_{M,t}{}^*}$, $p^*_{NM,t} \equiv \frac{P_t^{N*}}{P^N_{M,t}{}^*}$, $p^*_{N,t} \equiv \frac{P_t^{N*}}{P^*_{C,t}}$, $\pi_t^{C*} \equiv \frac{P^*_{C,t}}{P^*_{C,t-1}}$, $\pi^*_t \equiv \frac{P^*_{F,t}}{P^*_{F,t-1}}$, and $\pi_t^{N*} \equiv \frac{P_t^{N*}}{P^N_{t-1}{}^*}$.

'World' country equations:

$$C_t^{**\frac{-1}{\sigma}} = \beta^{**}\mathbb{E}_t\left[C_{t+1}^{**\frac{-1}{\sigma}}\frac{R_t^{**n}}{\pi^{**C}_{t+1}}\right] \quad \text{(B.9}$$

$$w^{**}_t = \chi_o L_t^{**\chi} C_t^{**\frac{1}{\sigma}} \quad \text{(B.9}$$

$$C^{**}_{Ht} = \nu^W_H\left(\frac{1}{\mathcal{T}^W_H}p^{**}_{WT,t}\right)^{-\rho_c} C_t^{T**} \quad \text{(B.9}$$

$$C^{**}_{Ft} = \nu^W_F\left(\frac{p^W_F}{p_{T**}}\frac{1}{\mathcal{Q}^H_W}\right)^{-\rho_c} C_t^{T**} \quad \text{(B.9}$$

$$C^{**}_{Wt} = \nu^W_W\left(p^{**}_{WT,t}\right)^{-\rho_c} C_t^{T**} \quad \text{(B.10}$$

$$C_t^{T**} = \omega^{**}_s\left(p^{**}_{T,t}\right)^{-\rho_s} C^{**}_t \quad \text{(B.10}$$

$$C_t^{N**} = \left(1-\omega^{**}_s\right)\left(p^{**}_{N,t}\right)^{-\rho_s} C^{**}_t \quad \text{(B.10}$$

$$M^{T**}_N = \nu^W_{pN}\left(\frac{p^{**}_N p^{**}_{WM,t}}{p^{**}_{T,t}p^{**}_{WT,t}}\right)^{-\rho_m} M^{T**} \quad \text{(B.10}$$

$$M^{T**}_H = \nu^W_{pH}\left(\frac{1}{\mathcal{T}^W_H}p^{**}_{WM,t}\right)^{-\rho_m} M^{T**} \quad \text{(B.10}$$

$$M^{T**}_F = \nu^W_{pF}\left(\frac{p^W_{Ft}}{\mathcal{Q}^H_{Wt}}\frac{p^{**}_{WM}}{p^{**}_{WT,t}p^{**}_{T,t}}\right)^{-\rho_m} M^{T**} \quad \text{(B.10}$$

$$M^{T\,**}_W = \nu^W_{pW}\left(p^{**}_{WM,t}\right)^{-\rho_m} M^{T**} \quad \text{(B.10}$$

$$M^{N**}_N = \nu^{N**}_{pN}\left(p^{**}_{NM,t}\right)^{-\rho_m} M^{N**} \quad \text{(B.10}$$

$$M^{N**}_H = \nu^{N**}_{pH}\left(\frac{p^{**}_{T,t}p^{**}_{WT,t}}{p^{**}_{N,t}}\frac{p^{**}_{NM,t}}{\mathcal{T}^W_{H,t}}\right)^{-\rho_m} M^{N**} \quad \text{(B.10}$$

$$M^{N**}_F = \nu^{N**}_{pF}\left(\frac{p^W_{Ft}}{\mathcal{Q}^H_{Wt}}\frac{p^{**}_{NM,t}}{p^{**}_{N,t}}\right)^{-\rho_m} M^{N**} \quad \text{(B.10}$$

$$M^{N**}_W = \nu^{N**}_{pW}\left(\frac{p^{**}_{T,t}p^{**}_{WT,t}}{p^{**}_{N,t}}p^{**}_{NM,t}\right)^{-\rho_m} M^{N**} \quad \text{(B.11}$$

$$p^{**}_{WT,t} = \left[\frac{1-\nu_F^W\left(\frac{p_F^W}{p_{T^{**}}}\frac{1}{\mathcal{Q}_W^H}\right)^{1-\rho_c}}{\nu_H^W\left(\frac{1}{\mathcal{T}_H^W}\right)^{1-\rho_c}+\nu_W^W} \right]^{\frac{1}{1-\rho_c}} \qquad \text{(B.11}$$

$$p^{**}_{N,t} = \left[\frac{1-\omega_s^{**}(p_T^{**})^{1-\rho_s}}{1-\omega_s^{**}} \right]^{\frac{1}{1-\rho_s}} \qquad \text{(B.11}$$

$$p^{**}_{WM,t} = \left[\nu_{pN}^W\left(\frac{p_N^{**}}{p^{**}_{T,t}p^{**}_{WT,t}}\right)^{1-\rho_m} + \nu_{pH}^W\left(\frac{1}{\mathcal{T}^W_{Ht}}\right)^{1-\rho_m} + \nu_{pF}^W\left(\frac{p^W_{Ft}}{\mathcal{Q}^H_{Wt}p^{**}_{WT,t}p^{**}_{T,t}}\right)^{1-\rho_m} + \nu^W_{pW} \right]^{-\frac{1}{1-\rho_m}} \qquad \text{(B.11}$$

$$p^{**}_{NM,t} = \left[\nu_{pN}^{N^{**}} + \nu_{pH}^{N^{**}}\left(\frac{p^{**}_{T,t}p^{**}_{WT,t}}{p^{**}_{N,t}\mathcal{T}^W_{H,t}}\right)^{1-\rho_m} + \nu_{pF}^{N^{**}}\left(\frac{p^W_{Ft}}{\mathcal{Q}^H_{Wt}p^{**}_{N,t}}\right)^{1-\rho_m} + \nu_{pW}^{N^{**}}\left(\frac{p^{**}_{T,t}p^{**}_{WT,t}}{p^{**}_{N,t}}\right)^{1-\rho_m} \right]^{-\frac{1}{1-\rho_m}} \qquad \text{(B.11}$$

$$Y^{T^{**}} = \overline{K^{T^{**}}}^{\alpha}(Z_t^{T^{**}}L_t^{T^{**}})^{\gamma_p}(M^{T^{**}})^{1-\alpha-\gamma_p} \qquad \text{(B.11}$$

$$w^{**} = \frac{\gamma_p}{\alpha}\frac{\overline{K}^{T^{**}}}{L_t^{T^{**}}}\frac{r_{K,t}^{T\ \ **}}{1+(R^n_{risk,wt}-1)\theta_w} \qquad \text{(B.11}$$

$$p^{**}_{WT,t}p^{**}_{T,t}/p^{**}_{WM,t} = \frac{1-\alpha-\gamma_p}{\alpha}\frac{\overline{K}^{T^{**}}}{M_t^{T^{**}}}\frac{r_{K,t}^{T\ \ **}}{1+(R^n_{risk,wt}-1)\theta_w} \qquad \text{(B.11}$$

$$mc_t^{T^{**}} = \left(\frac{w_t^{**}/Z_t^{T^{**}}[1+(R^n_{risk,wt}-1)\theta_w]}{\gamma_p}\right)^{\gamma_p}\left(\frac{r_{K,t}^{T\ \ **}}{\alpha}\right)^{\alpha}\left(\frac{p^{**}_{WT,t}p^{**}_{T,t}/p^{**}_{WM,t}[1+(R^n_{risk,wt}-1)\theta_w]}{1-\alpha-\gamma_p}\right)^{1-\alpha-} \qquad \text{(B.11}$$

$$\pi_t^{**-\frac{1}{\theta_p}} = (1-\xi_p)(\pi_t^{*o})^{-\frac{1}{\theta_p}} + \xi_p(\pi^*_{t-1})^{-\frac{\iota_p}{\theta_p}} \qquad \text{(B.11}$$

$$\pi_t^{**o} = (1+\theta_p)\frac{x^{**}_{1T,t}}{x^{**}_{2T,t}}\pi_t^{**} \qquad \text{(B.12}$$

$$x^{**}_{1T,t} = \omega_s^{**\frac{1}{\rho_s}}C_t^{**\frac{1}{\rho_s}-\frac{1}{\sigma}}C_{T,t}^{**-\frac{1}{\rho_s}}mc_t^{T^{**}}Y_t^{T^{**}} + \beta^{**}\xi_p\pi_t^{**-\iota_p\frac{1+\theta_p}{\theta_p}}\mathbb{E}_t\left\{x^{**}_{1T,t+1}\pi_{t+1}^{**\frac{1+\theta_p}{\theta_p}}\right\} \qquad \text{(B.12}$$

$$x^{**}_{2T,t} = \omega_s^{**\frac{1}{\rho_s}}C_t^{**\frac{1}{\rho_s}-\frac{1}{\sigma}}C_{T,t}^{**-\frac{1}{\rho_s}}p^{**}_{WT,t}p^{**}_{T,t}Y_t^{T^{**}} + \beta^{*}\xi_p\pi_t^{**\iota_p\left(1-\frac{1+\theta_p}{\theta_p}\right)}\mathbb{E}_t\left\{x^{**}_{2T,t+1}\pi_{t+1}^{**\frac{1+\theta_p}{\theta_p}-1}\right\} \qquad \text{(B.12}$$

$$Y^{N^{**}} = \overline{K^{N^{**}}}^{\alpha}(Z_t^{**}L_t^{N^{**}})^{\gamma_p}(M^{N^{**}})^{1-\alpha-\gamma_p} \qquad \text{(B.12}$$

$$w^{**} = \frac{\gamma_p}{\alpha}\frac{\overline{K}^{N^{**}}}{L_t^{N^{**}}}\frac{r_{K,t}^{N\ \ **}}{1+(R^n_{risk,wt}-1)\theta_w} \qquad \text{(B.12}$$

$$p^{**}_{N,t}/p^{**}_{NM,t} = \frac{1-\alpha-\gamma_p}{\alpha}\frac{\overline{K}^{N^{**}}}{M_t^{N^{**}}}\frac{r_{K,t}^{N\ \ **}}{1+(R^n_{risk,wt}-1)\theta_w} \qquad \text{(B.12}$$

$$mc_t^{N^{**}} = \left(\frac{w_t^{**}/Z_t^{N^{**}}[1+(R^n_{risk,wt}-1)\theta_w]}{\gamma_p}\right)^{\gamma_p}\left(\frac{r_{K,t}^{N\ \ **}}{\alpha}\right)^{\alpha}\left(\frac{p^{**}_{N,t}/p^{**}_{NM,t}[1+(R^n_{risk,wt}-1)\theta_w]}{1-\alpha-\gamma_p}\right)^{1-\alpha-\gamma_p} \qquad \text{(B.12}$$

$$\pi_t^{N^{**}-\frac{1}{\theta_p}} = (1-\xi_p)(\pi_t^{N^{**}o})^{-\frac{1}{\theta_p}} + \xi_p(\pi_{t-1}^{N\ \ **})^{-\frac{\iota_p}{\theta_p}} \qquad \text{(B.12}$$

$$\pi_t^{N^{**}o} = (1+\theta_p)\frac{x^{**}_{1N,t}}{x^{**}_{2N,t}}\pi_t^{N^{**}} \qquad \text{(B.12}$$

$$x^{**}_{1N,t} = (1-\omega_s^{**})^{\frac{1}{\rho_s}}C_t^{**\frac{1}{\rho_s}-\frac{1}{\sigma}}C_{N,t}^{**-\frac{1}{\rho_s}}mc_t^{N^{**}}Y_t^{N^{**}} + \beta^{**}\xi_p\pi_t^{N^{**}-\iota_p\frac{1+\theta_p}{\theta_p}}\mathbb{E}_t\left\{x^{**}_{1N,t+1}\pi_{t+1^N}^{\ \ **\frac{1+\theta_p}{\theta_p}}\right\} \qquad \text{(B.12}$$

$$x^{**}_{2N,t} = (1-\omega_s^{**})^{\frac{1}{\rho_s}}C_t^{**\frac{1}{\rho_s}-\frac{1}{\sigma}}C_{N,t}^{**-\frac{1}{\rho_s}}p^{**}_{N,t}Y_t^{N^{**}} + \beta^{**}\xi_p\pi_t^{N^{**}\iota_p\left(1-\frac{1+\theta_p}{\theta_p}\right)}\mathbb{E}_t\left\{x^{**}_{2N,t+1}\pi_{t+1}^{N\ \ **\frac{1+\theta_p}{\theta_p}-1}\right\} \qquad \text{(B.13}$$

$$\pi_t^{**C} = \pi_t^{**} \frac{p_{WT,t-1}^{**} p_{T,t-1}^{**}}{p_{WT,t}^{**} p_{T,t}^{**}} \quad \text{(B.13}$$

$$\pi_t^{**C} = \pi_t^{N**} \frac{p_{Nt-1}^{**}}{p_{N,t}^{**}} \quad \text{(B.13}$$

$$Y_t^{T**} = C_{Wt}^{**} + M_{Wt}^{T\ **} + M_{Wt}^{N\ **} + \frac{n_H}{n_W} \left(C_{Wt} + M_{Wt}^T + M_{Wt}^N\right) + \frac{n_F}{n_W} \left(C_{Wt}^* + M_{Wt}^{T\ *} + M_{Wt}^{N\ *}\right) \quad \text{(B.13}$$

$$L^{**} = L^{T**} + L^{N**} \quad \text{(B.13}$$

$$Y^{N**} = C^{N**} + M_N^{N**} + M_N^{T**} \quad \text{(B.13}$$

$$R_t^{**n} = \beta^{**-1} \pi_t^{C**\gamma_\pi} \quad \text{(B.13}$$

where $p_{WT,t}^{**} \equiv \frac{P_{W,t}^{**}}{P_t^{T**}}$, $p_{WM,t}^{T\ \ **} \equiv \frac{P_{W,t}^{\ **}}{P_{M,t}^{T\ \ **}}$, $p_{NM,t}^{T\ \ **} \equiv \frac{P_t^{N**}}{P_{M,t}^{N\ \ **}}$, $p_{N,t}^{**} \equiv \frac{P_t^{N**}}{P_{C,t}^{**}}$, $\pi_t^{C**} \equiv \frac{P_{C,t}^{**}}{P_{C,t-1}^{**}}$, $\pi_t^{**} \equiv \frac{P_{W,t}^{**}}{P_{W,t-1}^{**}}$, and $\pi_t^{N**} \equiv \frac{P_t^{N**}}{P_{t-1}^{N\ \ **}}$.

Equations Common to all countries :

$$\mathcal{Q}_F^H = \frac{1}{\mathcal{T}_F^H} \frac{p_{HT} p_T}{p_{FT}^* p_T^*} \quad \text{(B.137)}$$

$$\mathcal{Q}_{Wt}^H = \mathcal{T}_{Ht}^W \frac{p_{HT,t} p_{T,t}}{p_{WT,t}^{**} p_{T,t}^{**}} \quad \text{(B.138)}$$

$$\mathcal{T}_F^W = \frac{\mathcal{Q}_W^H}{\mathcal{Q}_F^H} \frac{p_{WT}^{**} p_T^{**}}{p_{FT}^* p_T^*} \quad \text{(B.139)}$$

$$\Lambda_{t,t+1} \frac{1}{\pi_{t+1}^C} = \Lambda_{t,t+1}^* \frac{\mathcal{Q}_{Ft}^H}{\mathcal{Q}_{Ft+1}^H} \frac{1}{\pi_{t+1}^C} \phi_{Ht}^* \quad \text{(B.140)}$$

$$\Lambda_{t,t+1} \frac{1}{\pi_{t+1}^C} = \Lambda_{t,t+1}^{**} \frac{\mathcal{Q}_{Wt}^H}{\mathcal{Q}_{Wt+1}^H} \frac{1}{\pi_{t+1}^C} \phi_{Ht}^{**} \quad \text{(B.141)}$$

$$p_{FT,t}^* p_{T,t}^* \left[\mathcal{T}_F^H (C_{Ht}^* + M_{Ht}^{T\ *} + M_{Ht}^{N\ *}) + \mathcal{T}_F^W (C_{Wt}^* + M_{Wt}^{T\ *} + M_{Wt}^{N\ *})\right] - \frac{1}{\mathcal{Q}_F^H} \left(\frac{n_H}{n_F} p_{Ft} N_t + \frac{n_W}{n_F} p_{Ft}^W N_t^W\right) =$$
$$\frac{1}{\mathcal{Q}_{Ft}^H} \left(\frac{B_{t-1}^*}{\pi_t^C} - \frac{B_t^*}{R_{risk,ft}^n \phi_{Ht}^*}\right) - (R_{risk,ft}^n - 1)\theta_w \left(\frac{p_{FT,t}^* p_{T,t}^*}{p_{FM,t}^*} M_t^{T*} + \frac{p_{N,t}^*}{p_{NM,t}^*} M_t^{N*} + w_t^* L_t^*\right) \quad \text{(B.142)}$$

$$p_{WT}^{**} p_T^{**} \left[\frac{1}{\mathcal{T}_H^W} (C_{Ht}^{**} + M_{Ht}^{T\ **} + M_{Ht}^{N\ **}) - \frac{n_H}{n_W} (C_{Wt} + M_{Wt}^T + M_{Wt}^N) - \frac{n_F}{n_W} (C_{Wt}^* + M_{Wt}^{T\ *} + M_{Wt}^{N\ *})\right] + \frac{p_F^W}{\mathcal{Q}_W^H} N_t^W =$$
$$\frac{1}{\mathcal{Q}_{Wt}^H} \left(\frac{B_{t-1}^{**}}{\pi_t^C} - \frac{B_t^{**}}{R_{risk,wt}^n \phi_{Ht}^{**}}\right) - (R_{risk,wt}^n - 1)\theta_w \left(\frac{p_{WT,t}^{**} p_{T,t}^{**}}{p_{WM,t}^{**}} M_t^{T**} + \frac{p_{N,t}^{**}}{p_{NM,t}^{**}} M_t^{N**} + w_t^{**} L_t^{**}\right) \quad \text{(B.143)}$$

where $\Lambda_{t,t+1} \equiv \beta \left(\frac{C_{t+1}}{C_t}\right)^{-\frac{1}{\sigma}}$, $\Lambda_{t,t+1}^* \equiv \beta^* \left(\frac{C_{t+1}^*}{C_t^*}\right)^{-\frac{1}{\sigma}}$, $\Lambda_{t,t+1}^{**} \equiv \beta^{**} \left(\frac{C_{t+1}^{**}}{C_t^{**}}\right)^{-\frac{1}{\sigma}}$, $\phi_{H,t}^* = exp\left(-\nu_H^* \frac{B_t^*}{\mathcal{Q}_{Ft}^H Y_t{}^*}\right)$, $\phi_{H,t}^{**} = exp\left(-\nu_H^{**} \frac{B_t^{**}}{\mathcal{Q}_{Wt}^H Y_t{}^{**}}\right)$, $R_{risk,ft}^n = R_t^n + \epsilon_{ft}$, $R_{risk,wt}^n = R_t^n + \epsilon_{wt}$, and $\mathcal{Q}_{Ft}^H \equiv \frac{S_{Ft}^H P_{C,t}^*}{P_{C,t}}$, $\mathcal{Q}_{Wt}^H \equiv \frac{S_{Wt}^H P_{C,t}^{**}}{P_{C,t}}$, $\mathcal{T}_{Ft}^H \equiv \frac{P_{Ht}^*}{P_{Ft}^*}$, $\mathcal{T}_F^W \equiv \frac{P_W^*}{P_F^*}$, $\mathcal{T}_{Wt}^H \equiv \frac{P_{Wt}}{P_{Ht}} \equiv \frac{P_{Wt}^{**}}{P_{Ht}^{**}}$, $B_t^* = \frac{B_{Ht}^*}{P_{C,t}}$, and $B_t^{**} = \frac{B_{Ht}^{**}}{P_{C,t}}$.

List of Variables (143): C_t, C_t^*, C_t^{**}, C_t^T, C_t^{T*}, C_t^{T**}, C_t^N, C_t^{N*}, C_t^{N**}, $C_{H,t}$, $C_{H,t}^*$, $C_{H,t}^{**}$, $C_{F,t}$, $C_{F,t}^*$, $C_{F,t}^{**}$, $C_{W,t}$, $C_{W,t}^*$, $C_{W,t}^{**}$, M_t^T, M_t^{T*}, M_t^{T**}, M_t^N, M_t^{N*}, M_t^{N**}, $M_{N,t}^T$, $M_{N,t}^{T\ *}$, $M_{N,t}^{T\ **}$, $M_{H,t}^T$, $M_{H,t}^{T\ *}$, $M_{H,t}^{T\ **}$, $M_{F,t}^T$, $M_{F,t}^{T\ *}$, $M_{F,t}^{T\ **}$, $M_{W,t}^T$, $M_{W,t}^{T\ *}$, $M_{W,t}^{T\ **}$, $M_{N,t}^N$, $M_{N,t}^{N\ *}$, $M_{N,t}^{N\ **}$, $M_{H,t}^N$, $M_{H,t}^{N\ *}$,

${M_{H,t}^{N}}^{**}$, $M_{F,t}^{N}$, ${M_{F,t}^{N}}^{*}$, ${M_{F,t}^{N}}^{**}$, $M_{W,t}^{N}$, ${M_{W,t}^{N}}^{*}$, ${M_{W,t}^{N}}^{**}$, Y_t^T, Y_t^{T*}, Y_t^{T**}, Y_t^N, Y_t^{N*}, Y_t^{N**}, ${Y_{D,t}^{T}}^{*}$, N_t, N_t^W, L_t, L_t^*, L_t^{**}, L_t^T, L_t^{T*}, L_t^{T**}, L_t^N, L_t^{N*}, L_t^{N**}, w_t, w_t^*, w_t^{**}, $r_{K,t}^T$, ${r_{K,t}^T}^*$, ${r_{K,t}^T}^{**}$, $r_{K,t}^N$, ${r_{K,t}^N}^*$, ${r_{K,t}^N}^{**}$, mc_t^T, mc_t^{T*}, mc_t^{T**}, mc_t^N, mc_t^{N*}, mc_t^{N**}, $p_{HT,t}$, $p_{FT,t}^*$, $p_{WT,t}^{**}$, $p_{HM,t}$, $p_{FM,t}^*$, $p_{WM,t}^{**}$, $p_{NM,t}$, $p_{NM,t}^*$, $p_{NM,t}^{**}$, $p_{T,t}$, $p_{T,t}^*$, $p_{T,t}^{**}$, $p_{N,t}$, $p_{N,t}^*$, $p_{N,t}^{**}$, $p_{F,t}$, $p_{F,t}^W$, R_t^n, R_t^{n*}, R_t^{n**}, π_t^C, π_t^{C*}, π_t^{C**}, π_t, ${\pi_t}^*$, ${\pi_t}^{**}$, π_t^N, π_t^{N*}, π_t^{N**}, $\pi_{F,t}$, $\pi_{F,t}^W$ π_t^0, π_t^{0*}, π_t^{0**}, ${\pi^N}_t^0$, ${\pi^N}_t^{0*}$, ${\pi^N}_t^{0**}$, $\pi_{F,t}^0$, $\pi_{F,t}^{0W}$, $x_{1T,t}$, $x_{1T,t}^*$, $x_{1T,t}^{**}$, $x_{1N,t}$, $x_{1N,t}^*$, $x_{1N,t}^{**}$, $z_{1,t}$, $z_{1,t}^W$, $x_{2T,t}$, $x_{2T,t}^*$, $x_{2T,t}^{**}$, $x_{2N,t}$, $x_{2N,t}^*$, $x_{2N,t}^{**}$, $z_{2,t}$, $z_{2,t}^W$, $\mathcal{T}_{tF}^H$, $\mathcal{T}_{tF}^W$, $\mathcal{T}_{tH}^W$, $\mathcal{Q}_{Ft}^H$, $\mathcal{Q}_{Wt}^H$, B_t^*, B_t^{**}.