THE PARADOX OF GLOBAL THRIFT

2018

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Documentos de Trabajo
N.º 1845

BANCO DE ESPAÑA
Eurosistema

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Documentos de Trabajo. N.º 1845

2018

ISSN: 1579-8666 (on line)

Abstract

This paper describes a *paradox of global thrift.* Consider a world in which interest rates are low and monetary policy is constrained by the zero lower bound. Now imagine that governments implement prudential financial and fiscal policies to stabilize the economy. We show that these policies, while effective from the perspective of individual countries, might backfire if applied on a global scale. In fact, prudential policies generate a rise in the global supply of savings and a drop in global aggregate demand. Weaker global aggregate demand depresses output in countries at the zero lower bound. Due to this effect, non-cooperative financial and fiscal policies might lead to a fall in global output and welfare.

Keywords: liquidity traps, zero lower bound, capital flows, fiscal policies, macroprudential policies, current account policies, aggregate demand externalities, international cooperation.

JEL classification: E32, E44, E52, F41, F42.

Resumen

Este artículo describe una *paradox of global thrift*. Se considera un mundo en el que las tasas de interés son bajas y la política monetaria está limitada por el límite inferior cero. Se imagina que los Gobiernos implementan políticas financieras y fiscales prudenciales para estabilizar la economía. Mostramos que estas políticas, si bien son efectivas desde la perspectiva de los países individuales, podrían ser contraproducentes si se aplican a escala global. De hecho, las políticas prudenciales generan un aumento en la oferta global de ahorros y una caída en la demanda agregada global. Una demanda agregada global más débil deprime la producción en los países que se sitúan en el límite inferior cero. Debido a este efecto, las políticas financieras y fiscales no cooperativas podrían llevar a una caída en la producción y el bienestar global.

Palabras clave: trampas de liquidez, límite inferior cero, flujos de capital, políticas fiscales, políticas macroprudenciales, cuenta corriente, externalidades de la demanda agregada, cooperación internacional.

Códigos JEL: E32, E44, E52, F41, F42.

1 Introduction

The current state of the global economy is characterized by exceptionally low nominal interest rates. In recent years, indeed, policy rates have hit the zero lower bound in most advanced countries (Figure 1, left panel). Against this background a consensus is emerging suggesting that monetary policy, which is expected to be frequently constrained by the zero lower bound in the foreseeable future, should be complemented with prudential financial and fiscal policies. Limiting private and public debt accumulation during booms, the argument goes, will help stabilize the economy, respectively by reducing the risk of financial crises and by creating space for fiscal interventions during busts. According to this view, governments should employ prudential financial and fiscal policies as macroeconomic stabilization tools when the zero lower bound constrains monetary policy.[1]

But what happens if prudential policies are implemented on a global scale? In this paper we show that, as a result, the world can fall prey of a *paradox of global thrift*. In a financially integrated world, in fact, the implementation of prudential financial and fiscal policies increases the global supply of savings. If the demand for savings does not perfectly adjust, the result is a drop in global aggregate demand. In turn, weaker global aggregate demand depresses output in countries whose monetary policy is constrained by the zero lower bound. Due to this effect prudential policies might completely backfire and, paradoxically, lead to a fall in global output and welfare.

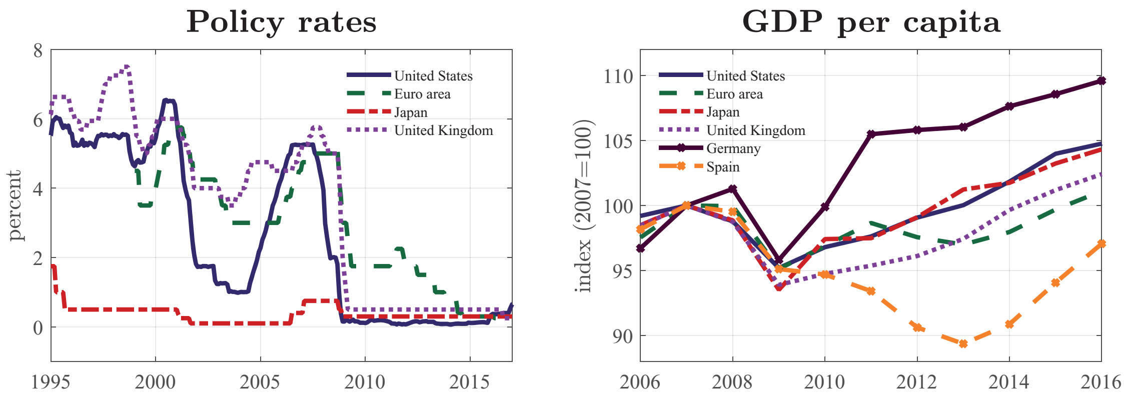
To formalize this insight we develop a tractable framework of a financially integrated world, in which equilibrium interest rates are low and monetary policy is occasionally constrained by the zero lower bound. We study a world composed of a continuum of small open economies. Countries are hit by uninsurable idiosyncratic shocks. Because of this feature, there is heterogeneity in the demand and supply of savings across countries, and foreign borrowing and lending emerge naturally.

Due to the presence of nominal rigidities monetary policy plays an active role in stabilizing the economy. For instance, when a country experiences a fall in aggregate demand the central bank has to lower the policy rate to keep the economy at full employment. The zero lower bound, however, might prevent monetary policy from fully offsetting the impact of negative demand shocks on output. When this happens the country enters a recessionary liquidity trap. Importantly, if global rates are sufficiently low the world itself can be stuck in a *global liquidity trap*. This is a situation in which a significant fraction of the world economy experiences a liquidity trap with unemployment.

Our global liquidity trap has two key features. First, because of the presence of idiosyncratic shocks, during a global liquidity trap not all countries need to be constrained by the zero lower bound and experience a recession. Moreover, even among those countries stuck in a liquidity trap there is asymmetry in terms of the severity of the recession. The model thus captures situations such as the asymmetric recovery that has characterized advanced countries in the aftermath of

[1] These arguments have been formalized in two seminal papers by Farhi and Werning (2016) and Korinek and Simsek (2016). In this literature, which we describe in detail later on, the need for government intervention arises due to an aggregate demand externality, caused by the fact that atomistic agents do not internalize the impact of their financial decisions on aggregate spending and income.

Figure 1: Policy rates and real gross domestic product per capita. Note: the left panel shows the exceptionally low interest rates characterizing the post-2008 period. The right panel highlights the relatively fast recoveries from the 2009 recession experienced by the US and Japan, and the slow recovery in the Euro area and in the United Kingdom. The figure also shows the heterogeneity between fast-recovering core Euro area countries, captured by Germany, and the stagnation experienced by peripheral Euro area countries, captured by Spain. See Appendix K for data sources.



the 2008 financial crisis (Figure 1, right panel). Second, a global liquidity trap is a persistent event, which is expected to last for a long time.[2] Hence, during a global liquidity trap countries experiencing a boom in the present anticipate that they might fall into a recessionary liquidity trap in the future.[3]

Throughout the paper we contrast two different policy regimes. The first policy regime is a laissez-faire benchmark. In the second regime benevolent, but domestically-oriented, governments actively intervene to influence private agents' financial decisions by means of financial or fiscal policies. While these policies can take a variety of forms, their common trait is that they affect the country's current account. Hence, we refer to them as *current account policies*.

We start by showing that during a global liquidity trap governments have an incentive to intervene on the current account for prudential reasons. This is due to the same domestic aggregate demand externality described by Farhi and Werning (2016) and Korinek and Simsek (2016). That is, governments perceive that private agents overborrow in times of robust economic performance, because they do not internalize the fact that increasing savings in good times leads to higher aggregate demand and employment in the event of a future liquidity trap. Hence, governments in booming countries implement financial and fiscal policies to increase national savings and to improve the country's current account.

The fundamental insight of the paper is that these policy interventions might trigger a paradox of global thrift, which is essentially an international and policy-induced version of Keynes' paradox of thrift (Keynes, 1933). By stimulating national savings and current account surpluses, governments in countries undergoing a period of robust economic performance increase the global supply

[2] Though making predictions about the future is of course a challenging task, this feature of the model is consistent with the empirical analysis performed by Gourinchas and Rey (2017), suggesting that global rates are likely to remain low for a long time.

[3] Our global liquidity trap is then in line with the notion of secular stagnation as described by Hansen (1939) and Summers (2016). Both authors, in fact, refer to a state of secular stagnation as a long-lasting period characterized by low global interest rates, and by countries undergoing frequent liquidity traps, followed by fragile recoveries.

of savings, depressing aggregate demand around the world. But central banks in countries stuck in a liquidity trap cannot respond to the drop in global demand by lowering their policy rate. As a consequence, the implementation of prudential current account policies by booming countries aggravates the recession in countries experiencing a liquidity trap.[4] This effect, which can be interpreted as an international aggregate demand externality, can be so strong so that well-intended prudential policy interventions might end up exacerbating the global liquidity trap rather than mitigating it.

This result sounds a note of caution on the use of prudential policies as stabilization tools during periods of weak global aggregate demand. More precisely, in our framework it is the lack of international cooperation that can give rise to a paradox of global thrift. Key to our results, indeed, is the fact that governments in booming countries do not take into account the negative international demand externalities that policies fostering national savings and current account surpluses impose on countries stuck in a liquidity trap. Our analysis, which resonates with the logic of Keynes' Plan of 1941, thus suggests that when global aggregate demand is scarce international cooperation is needed, to ensure that current account interventions by booming countries do not impart excessive negative spillovers on the rest of the world.[5]

Related literature. This paper is related to three literatures. First, the paper contributes to the emerging literature on secular stagnation in open economies (Caballero et al., 2015; Eggertsson et al., 2016). As in this literature, we study a world trapped in a global liquidity trap. This is a persistent state of affairs in which global rates are low and monetary policy is frequently constrained by the zero lower bound. Both Caballero et al. (2015) and Eggertsson et al. (2016) study two-country overlapping generations models, in which interest rates are low because of a global shortage of safe assets.[6] Compared to these two papers, a distinctive feature of our framework is that the shortage of safe assets driving down global rates emerges from the presence of financial frictions that limits agents' ability to insure against idiosyncratic country-specific shocks. This allows us to study prudential policies, which neither Caballero et al. (2015) nor Eggertsson et al. (2016) consider, that is policy interventions that governments implement during booms to mitigate future liquidity traps.

Second, our paper is related to the work of Farhi and Werning (2016) and Korinek and Simsek (2016), who develop theories of macroprudential policy interventions based on aggregate demand externalities. In particular, these papers study optimal financial market interventions in closed or small open economies in which monetary policy is constrained by zero lower bound.[7] One of the key insights of this literature is that benevolent governments should implement prudential

[4]Our model thus formalizes the view that the large current account surpluses that some countries, most notably Germany, have run in the aftermath of the 2008 financial crisis might have slowed down significantly the recovery in the rest of the world (Bernanke, 2015; IMF, 2014; Krugman, 2013).

[5]Chapter 4 of Eichengreen (2008) and chapter 7 of Temin and Vines (2014) are two excellent sources on Keynes' Plan of 1941. In a nutshell, Keynes envisaged the need for international rules to contain excessive current account surpluses by booming countries, on the ground that these surpluses would depress global demand.

[6]Instead, Corsetti et al. (2018) study secular stagnation in a single small open economy.

[7]In turn, these papers build upon Eggertsson and Krugman (2012) and Guerrieri and Lorenzoni (2017), who show that in closed economies negative financial shocks can trigger an episode of deleveraging and give rise to a recessionary liquidity trap. Benigno and Romei (2014) and Fornaro (2018), instead, study deleveraging and liquidity traps in open economies.

financial and fiscal policies when they foresee that the zero lower bound will bind in the future.[8] We contribute to this literature by showing that, under certain conditions, in a financially integrated world prudential policies can backfire and give rise to a paradox of global thrift. Our results thus suggest that international cooperation is needed in order to fully exploit the stabilization benefits of prudential policies.

Third, our paper is related to the vast literature on international policy cooperation. For instance, Obstfeld and Rogoff (2002) and Benigno and Benigno (2003, 2006) study international monetary policy cooperation in models with nominal rigidities. In these frameworks, the gains from cooperation arise because individual countries have an incentive to manipulate their terms of trade at the expenses of the rest of the world. In our model, terms of trade are constant and independent of government policy, and hence terms of trade externalities are absent. Acharya and Bengui (2018) show that there are gains from international cooperation in the design of capital control policies during a temporary liquidity trap. Their focus is on capital control policies that governments implement in order to manipulate the exchange rate during a liquidity trap.[9] Instead, we consider ex-ante prudential policies, that is policies that governments implement to foster national savings and current account surpluses during booms, in order to mitigate future liquidity traps. Sergeyev (2016) studies optimal monetary and financial policy in a monetary union, and shows that gains from international cooperation arise because individual countries do not internalize the impact of liquidity creation by the domestic banking sector on the rest of the world. In his framework aggregate demand and pecuniary externalities interact, and fixed exchange rates constitute the fundamental constraint on monetary policy. Instead, in our model public interventions in the financial markets are purely driven by the presence of aggregate demand externalities, and our main result is that these policies can exacerbate the inefficiencies due to the zero lower bound constraint on monetary policy.

The rest of the paper is composed by five sections. Section 2 presents a simple baseline framework of an imperfectly financially integrated world with nominal rigidities. In Section 3 we characterize the laissez-faire equilibrium, and derive conditions under which the world ends up being stuck in a global liquidity trap. We then introduce, in Section 4, current account policies and describe the paradox of global thrift. In Section 5 we extend the baseline model in several directions. Section 6 concludes.

2 Baseline model

In this section we present the baseline model that we use in our analysis of the global implications of current account policies.[10] The model has two key elements. First, due to frictions on the credit markets agents cannot perfectly insure against shocks, giving rise to fluctuations in aggregate demand. Second, the presence of nominal rigidities and of the zero lower bound constraint on

[8]Farhi and Werning (2012, 2014, 2017) and Schmitt-Grohé and Uribe (2016) study optimal financial market interventions when the constraint on monetary policy is due to fixed exchange rates.

[9]The use of capital controls to manipulate the exchange rate during a liquidity trap is also discussed in Korinek (2017).

monetary policy implies that drops in aggregate demand can generate involuntary unemployment.

In order to deliver transparently the key message of the paper, our baseline model is kept voluntarily stylized. In Section 5 below we present several extensions that allow for a variety of features ignored in the baseline model.

2.1 Households

We consider a world composed of a continuum of measure one of small open economies indexed by $i \in [0,1]$. Each economy can be thought of as a country. Time is discrete and indexed by $t \in \{0,1,...\}$. Since the presence of risk is not crucial for our results, in our baseline model there is perfect foresight. We introduce uncertainty later on in Section 5.3.

Each country is populated by a continuum of measure one of identical infinitely-lived households. The lifetime utility of the representative household in a generic country i is

$$\sum_{t=0}^{\infty} \beta^t \log(C_{i,t}), \tag{1}$$

where $C_{i,t}$ denotes consumption and $0 < \beta < 1$ is the subjective discount factor. Consumption is a Cobb-Douglas aggregate of a tradable good $C_{i,t}^T$ and a non-tradable good $C_{i,t}^N$, so that $C_{i,t} = (C_{i,t}^T)^{\omega}(C_{i,t}^N)^{1-\omega}$ where $0 < \omega < 1$.

Each household is endowed with one unit of labor. There is no disutility from working, and so households supply inelastically their unit of labor on the labor market. However, due to the presence of nominal wage rigidities to be described below, a household might be able to sell only $L_{i,t} < 1$ units of labor. Hence, when $L_{i,t} = 1$ the economy operates at full employment, while when $L_{i,t} < 1$ there is involuntary unemployment and the economy operates below capacity.

Households can trade in one-period real and nominal bonds. Real bonds are denominated in units of the tradable consumption good and pay the gross interest rate R_t. The interest rate on real bonds is common across countries, and R_t can be interpreted as the *world interest rate*. Nominal bonds are denominated in units of the domestic currency and pay the gross nominal interest rate $R_{i,t}^n$. $R_{i,t}^n$ is the interest rate controlled by the central bank, and thus can be thought of as the domestic policy rate.[11]

The household budget constraint in terms of the domestic currency is

$$P_{i,t}^T C_{i,t}^T + P_{i,t}^N C_{i,t}^N + P_{i,t}^T B_{i,t+1} + B_{i,t+1}^n = W_{i,t} L_{i,t} + P_{i,t}^T Y_{i,t}^T + P_{i,t}^T R_{t-1} B_{i,t} + R_{i,t-1}^n B_{i,t}^n. \tag{2}$$

The left-hand side of this expression represents the household's expenditure. $P_{i,t}^T$ and $P_{i,t}^N$ denote respectively the price of a unit of tradable and non-tradable good in terms of country i currency. Hence, $P_{i,t}^T C_{i,t}^T + P_{i,t}^N C_{i,t}^N$ is the total nominal expenditure in consumption. $B_{i,t+1}$ and $B_{i,t+1}^n$ denote

[10] Our framework builds on work by Schmitt-Grohé and Uribe (2016). However, their focus is on a single small open economy, while here we consider a multi-country world in which the world interest rate is endogenously determined. Moreover, in Schmitt-Grohé and Uribe (2016) monetary policy is constrained by participation in a fixed exchange rate regime. In our model, instead, monetary policy is constrained by the zero lower bound on the policy rate.

[11] Alternatively, we could allow households to trade nominal bonds denominated in foreign currencies. Given the structure of the economy, and in particular the fact that we are focusing on perfect-foresight equilibria, allowing households to trade foreign nominal bonds would not affect the equilibrium allocation of the model.

respectively the purchase of real and nominal bonds made by the household at time t. If $B_{i,t+1} < 0$ or $B^n_{i,t+1} < 0$ the household is holding a debt.

The right-hand side captures the household's income. $W_{i,t}$ denotes the nominal wage, and hence $W_{i,t}L_{i,t}$ is the household's labor income. Labor is immobile across countries and so wages are country-specific. $Y^T_{i,t}$ is an endowment of tradable goods received by the household. Changes in $Y^T_{i,t}$ can be interpreted as movements in the quantity of tradable goods available in the economy, or as shocks to the country's terms of trade. $P^T_{i,t}R_{t-1}B_{i,t}$ and $R^n_{i,t-1}B^n_{i,t}$ represent the gross returns on investment in bonds made at time $t-1$.

There is a limit to the amount of debt that a household can take. In particular, the end-of-period bond position has to satisfy

$$B_{i,t+1} + \frac{B^n_{i,t+1}}{P^T_{i,t}} \geq -\kappa_{i,t}, \tag{3}$$

where $\kappa_{i,t} \geq 0$. In words, the maximum amount of debt that a household can take is equal to $\kappa_{i,t}$ units of tradable goods.

The household's optimization problem consists in choosing a sequence $\{C^T_{i,t}, C^N_{i,t}, B_{i,t+1}, B^n_{i,t+1}\}_t$ to maximize lifetime utility (1), subject to the budget constraint (2) and the borrowing limit (3), taking initial wealth $P^T_0 R_{-1}B_{i,0} + R^n_{i,-1}B^n_{i,0}$, a sequence for income $\{W_{i,t}L_{i,t} + P^T_{i,t}Y^T_{i,t}\}_t$, and prices $\{R_t, R^n_{i,t}, P^T_{i,t}, P^N_{i,t}\}_t$ as given. The household's first-order conditions can be written as

$$\frac{\omega}{C^T_{i,t}} = R_t \frac{\beta\omega}{C^T_{i,t+1}} + \mu_{i,t} \tag{4}$$

$$\frac{\omega}{C^T_{i,t}} = \frac{R^n_{i,t}P^T_{i,t}}{P^T_{i,t+1}} \frac{\beta\omega}{C^T_{i,t+1}} + \mu_{i,t} \tag{5}$$

$$B_{i,t+1} + \frac{B^n_{i,t+1}}{P^T_{i,t}} \geq -\kappa_{i,t} \quad \text{with equality if} \quad \mu_{i,t} > 0 \tag{6}$$

$$C^N_{i,t} = \frac{1-\omega}{\omega} \frac{P^T_{i,t}}{P^N_{i,t}} C^T_{i,t}, \tag{7}$$

where $\mu_{i,t}$ is the nonnegative Lagrange multiplier associated with the borrowing constraint. Equations (4) and (5) are the Euler equations for, respectively, real and nominal bonds. Equation (6) is the complementary slackness condition associated with the borrowing constraint. Equation (7) determines the optimal allocation of consumption expenditure between tradable and non-tradable goods. Naturally, demand for non-tradables is decreasing in their relative price $P^N_{i,t}/P^T_{i,t}$. Moreover, demand for non-tradables is increasing in $C^T_{i,t}$, due to households' desire to consume a balanced basket between tradable and non-tradable goods.

2.2 Exchange rates, interest rates and aggregate demand

In our model, monetary policy affects the real economy through its impact on households' expenditure on non-tradable goods. Before moving on, it is then useful to illustrate the channels through which the policy rate and the world interest rate affect demand for non-tradables.

Let us start by establishing a link between demand for non-tradable goods and the exchange rate. Since the law of one price holds for the tradable good we have that[12]

$$P_{i,t}^T = S_{i,t} P_t^T, \tag{8}$$

where $P_t^T \equiv \exp\left(\int_0^1 \log P_{j,t}^T dj\right)$ is the average world price of tradables, while $S_{i,t}$ is the effective nominal exchange rate of country i, defined so that an increase in $S_{i,t}$ corresponds to a nominal depreciation.

To gain intuition let us now keep $P_{i,t}^N$ and P_t^T constant, so that the nominal and the real exchange rate move together. Then equations (7) and (8) jointly imply that an exchange rate depreciation increases demand for non-tradable goods. Intuitively, when the exchange rate depreciates the relative price of non-tradables falls, inducing households to switch expenditure away from tradable goods and toward non-tradable goods.

We now relate the exchange rate to the policy and the world interest rates. Combining (4) and (5) gives a no arbitrage condition between real and nominal bonds

$$R_{i,t}^n = R_t \frac{P_{i,t+1}^T}{P_{i,t}^T}. \tag{9}$$

This is a standard uncovered interest parity condition, equating the nominal interest rate to the real interest rate multiplied by expected inflation. Since real bonds are denominated in units of the tradable good, the relevant inflation rate is tradable price inflation. Combining this expression with (8) gives

$$R_{i,t}^n = R_t \frac{S_{i,t+1}}{S_{i,t}} \frac{P_{t+1}^T}{P_t^T}.$$

Taking everything else as given, this expression implies that a drop in $R_{i,t}^n$ produces a rise in $S_{i,t}$. In words, a fall in the policy rate leads to an exchange rate depreciation, which induces households to switch expenditure out of tradable goods and toward non-tradables. Through this channel, a cut in the policy rate boosts demand for non-tradable goods. Conversely, a fall in the world interest rate R_t generates an exchange rate appreciation which, due to its expenditure switching effect, depresses demand for non-tradables.

To capture these effects more compactly, it is useful to combine (7) and (9) into a single aggregate demand (AD) equation

$$C_{i,t}^N = \frac{R_t \pi_{i,t+1}}{R_{i,t}^n} \frac{C_{i,t}^T}{C_{i,t+1}^T} C_{i,t+1}^N, \tag{AD}$$

where $\pi_{i,t} \equiv P_{i,t}^N / P_{i,t-1}^N$. This expression is essentially an open-economy version of the New Keynesian aggregate demand block. As in the standard closed-economy New Keynesian model, demand

[12]To derive this expression, consider that by the law of one price it must be that $P_{i,t}^T = S_{i,t}^j P_{j,t}^T$. for any i and j, where $S_{i,t}^j$ is defined as the nominal exchange rate between country i's and j's currencies, that is the units of country i's currency needed to buy one unit of country j's currency. Taking logs and integrating across j gives $P_{i,t}^T = S_{i,t} P_t^T$, where $S_{i,t} \equiv \exp\left(\int_0^1 \log S_{i,t}^j dj\right)$ and $P_t^T \equiv \exp\left(\int_0^1 \log P_{j,t}^T dj\right)$.

for non-tradable consumption is decreasing in the real interest rate $R^n_{i,t}/\pi_{i,t+1}$ and increasing in future non-tradable consumption $C^N_{i,t+1}$. In addition, changes in the consumption of tradable goods act as demand shifters. As already explained, a higher current consumption of tradable goods increases the current demand for non-tradables. Instead, a higher future consumption of tradables induces households to postpone their non-tradable consumption, thus depressing current demand for non-tradable goods. Finally, due to the expenditure switching effect just discussed, a lower world interest rate is associated with lower demand for non-tradable consumption.

2.3 Firms and nominal rigidities

Non-traded output $Y^N_{i,t}$ is produced by a large number of competitive firms. Labor is the only factor of production, and the production function is $Y^N_{i,t} = L_{i,t}$. Profits are given by $P^N_{i,t}Y^N_{i,t} - W_{i,t}L_{i,t}$, and the zero profit condition implies that in equilibrium $P^N_{i,t} = W_{i,t}$.

We introduce nominal rigidities by assuming, in the spirit of Akerlof et al. (1996), that nominal wages are subject to the downward rigidity constraint

$$W_{i,t} \geq \gamma W_{i,t-1},$$

where $\gamma > 0$. This formulation captures in a simple way the presence of frictions to the downward adjustment of nominal wages, which might prevent the labor market from clearing. In fact, equilibrium on the labor market is captured by the condition

$$L_{i,t} \leq 1, \quad W_{i,t} \geq \gamma W_{i,t-1} \quad \text{with complementary slackness.} \tag{10}$$

This condition implies that unemployment arises only if the constraint on wage adjustment binds.

2.4 Monetary policy and inflation

We describe monetary policy in terms of targeting rules. In particular, we consider central banks that target inflation of the domestically-produced good. More formally, the objective of the central bank is to set $\pi_{i,t} = \bar{\pi}$, where $\bar{\pi}$ is the central bank's inflation target. Throughout the paper we focus on the case $\bar{\pi} > \gamma$, so that when the inflation target is attained the economy operates at full employment (i.e. $\pi_{i,t} = \bar{\pi}$ implies $L_{i,t} = 1$). Hence, monetary policy faces no conflict between stabilizing inflation and attaining full employment, thus mimicking the divine coincidence typical of the baseline New Keynesian model (Blanchard and Galí, 2007).[13]

[13]Since only the non-tradable good is produced, we are in practice assuming that the central bank follows a policy of producer price inflation targeting. This is a common assumption in the open economy monetary literature. Another option is to consider a central bank that targets consumer price inflation. We have experimented with this possibility, and found that the results are robust to this alternative monetary policy target. The analysis is available upon request.

The central bank runs monetary policy by setting the nominal interest rate $R^n_{i,t}$, subject to the zero lower bound constraint $R^n_{i,t} \geq 1$.[14] Monetary policy can then be captured by the following monetary policy (MP) rule[15]

$$R^n_{i,t} = \begin{cases} \geq 1 & \text{if } Y^N_{i,t} = 1, \pi_{i,t} = \bar{\pi} \\ = 1 & \text{if } Y^N_{i,t} < 1, \pi_{i,t} = \gamma, \end{cases} \tag{MP}$$

where we have used (10) and the equilibrium relationships $W_{i,t} = P^N_{i,t}$ and $L_{i,t} = Y^N_{i,t}$. The (MP) equation captures the fact that unemployment ($Y^N_{i,t} < 1$) arises only if the central bank is constrained by the zero lower bound ($R^n_{i,t} = 1$). As we show in Appendix D, this policy is also constrained efficient as long as the central bank operates under discretion, and faces an arbitrarily small cost from deviating from its inflation target.[16]

In what follows we will focus on the limit $\gamma \to \bar{\pi}$. This corresponds to an extremely flat Phillips curve, such that deviations of economic activity from full employment do not generate significant drops in inflation below target. While this assumption is by no mean crucial for our results, it allows to streamline the exposition and simplifies the derivation of some of the results that follow.

2.5 Market clearing and definition of competitive equilibrium

Since households inside a country are identical, we can interpret equilibrium quantities as either household or country specific. For instance, the end-of-period net foreign asset position of country i is equal to the end-of-period holdings of bonds of the representative household, $NFA_{i,t} = B_{i,t+1} + B^n_{i,t+1}/P^T_{i,t}$. In our baseline model, which features perfect foresight, the composition of the net foreign asset position between real and nominal bonds is not uniquely pinned down in equilibrium. Throughout, we resolve this indeterminacy by focusing on equilibria in which nominal bonds are in zero net supply, so that

$$B^n_{i,t} = 0, \tag{11}$$

for all i and t. This implies that the net foreign asset position of a country is exactly equal to its investment in real bonds, i.e. $NFA_{i,t} = B_{i,t+1}$.

Market clearing for the non-tradable consumption good requires that in every country consumption is equal to production

$$C^N_{i,t} = Y^N_{i,t}. \tag{12}$$

[14] We provide in Appendix C some possible microfoundations for this constraint. In practice, the lower bound on the nominal interest rate is likely to be slightly negative. In this paper, with a slight abuse of language, we will refer the the lower bound on $R^n_{i,t}$ as the zero lower bound. It should be clear, though, that conceptually it makes no difference between a small positive or a small negative lower bound.

[15] One could think of the central bank as setting $R^n_{i,t}$ according to the rule

$$R^n_{i,t} = \max\left(\bar{R}^n_{i,t}\left(\frac{\pi_{i,t}}{\bar{\pi}}\right)^{\phi_\pi}, 1\right),$$

where $\bar{R}^n_{i,t}$ is the value of $R^n_{i,t}$ consistent with $\pi_{i,t} = \bar{\pi}$. In the baseline model we focus on the limit $\phi_\pi \to \infty$. This means that the inflation target can be missed only if the zero lower bound constraint binds.

[16] Deviating from the inflation target could be costly for the central bank due to institutional reasons, capturing the price stability mandate characterizing central banks in most advanced countries. Alternatively one could assume, as in the standard New Keynesian model, that deviations of inflation from target are costly because they distort relative prices.

Instead, market clearing for the tradable consumption good requires

$$C_{i,t}^{T} = Y_{i,t}^{T} + R_{t-1}B_{i,t} - B_{i,t+1}. \tag{13}$$

This expression can be rearranged to obtain the law of motion for the stock of net foreign assets owned by country i, i.e. the current account

$$NFA_{i,t} - NFA_{i,t-1} = CA_{i,t} = Y_{i,t}^{T} - C_{i,t}^{T} + B_{i,t}\left(R_{t-1} - 1\right).$$

As usual, the current account is given by the sum of net exports, $Y_{i,t}^{T} - C_{i,t}^{T}$, and net interest payments on the stock of net foreign assets owned by the country at the start of the period, $B_{i,t}(R_{t-1} - 1)$.

Finally, in every period the world consumption of the tradable good has to be equal to world production, $\int_0^1 C_{i,t}^{T}\,\mathrm{d}i = \int_0^1 Y_{i,t}^{T}\,\mathrm{d}i$. This equilibrium condition implies that bonds are in zero net supply at the world level

$$\int_0^1 B_{i,t+1}\,\mathrm{d}i = 0. \tag{14}$$

We are now ready to define a competitive equilibrium.

Definition 1 ***Competitive equilibrium.*** *A competitive equilibrium is a path of real allocations* $\{C_{i,t}^{T}, C_{i,t}^{N}, Y_{i,t}^{N}, B_{i,t+1}, B_{i,t+1}^{n}, \mu_{i,t}\}_{i,t}$*, policy rates* $\{R_{i,t}^{n}\}_{i,t}$ *and world interest rate* $\{R_t\}_t$*, satisfying* $(4), (6), (11), (12), (13), (14)$*,* (AD) *and* (MP) *given a path of endowments* $\{Y_{i,t}^{T}\}_{i,t}$*, a path for the borrowing limits* $\{\kappa_{i,t}\}_{i,t}$*, and initial conditions* $\{R_{-1}B_{i,0}\}_i$*.*

2.6 Some useful simplifying assumptions

We now make some simplifying assumptions that allow us to solve analytically the baseline model. We will discuss how our results are affected by relaxing these assumptions in Section 5.

We consider a world in which the global supply of saving instruments is limited, and in which borrowing constraints are tight. The simplest way to formalize this idea is to focus on a zero liquidity economy, in the spirit of Werning (2015). We thus assume that $\kappa_{i,t} = 0$ for all i and t, so that households cannot take any debt. This situation can be thought of as a limiting case of extreme scarcity in liquidity, with very limited borrowing and small asset values. Later on, in Section 5, we will relax this assumption and introduce positive amounts of liquidity.

We also focus on a specific process for the tradable endowment. Following Woodford (1990), we consider a case in which there are two possible realizations of the tradable endowment: high (Y_h^T) and low ($Y_l^T < Y_h^T$). We assume that half of the countries receives Y_h^T in even periods and Y_l^T in odd periods. Symmetrically, the other half receives Y_l^T during even periods and Y_h^T during odd periods. From now on, we will say that a country with $Y_{i,t}^T = Y_h^T$ is in the high state, while a country with $Y_{i,t}^T = Y_l^T$ is in the low state. As we will see, this endowment process generates in a tractable way asymmetric business cycles across countries.

Finally, we study stationary equilibria in which the world interest rate and the net foreign asset distribution are constant. We will thus assume that the initial asset position satisfies $B_{i,0} = 0$ for every country i.[17] Moreover, we focus on minimum state space Markov equilibria, in which all the countries with the same tradable endowment behave symmetrically. Hence, with a slight abuse of notation, we will sometime omit the i subscripts, and denote with a h (l) subscript variables pertaining to countries in the high (low) state.

3 Equilibrium under laissez faire

In this section we characterize the equilibrium under laissez faire. This will serve as a benchmark against which to contrast the equilibrium with government intervention through fiscal and financial policy. We start by solving for the path of tradable consumption and deriving the equilibrium world interest rate. We then turn to the market for non-tradable goods.

3.1 Tradable consumption and world interest rate

Solving for the path of tradable consumption is straightforward. Intuitively, households seek to smooth tradable consumption by borrowing in the low-endowment state and saving in the high-endowment state. But savers in high-state countries can only save by lending to borrowers in low-state countries, and borrowing is ruled out. Hence, in equilibrium the allocation of tradable consumption corresponds to the financial autarky one, so that every country consumes exactly its endowment of tradable goods ($C_{i,t}^T = Y_{i,t}^T$ for all i and t).

Since the borrowing constraint binds in low-state countries, the equilibrium world interest rate adjusts to ensure that countries in the high state do not want to save. This happens when[18]

$$R \leq R^{lf} \equiv \frac{Y_l^T}{\beta Y_h^T}. \tag{15}$$

Any interest rate below R^{lf} ensures that the international credit market clearing condition (14) holds. As a consequence, the equilibrium world interest rate is potentially not uniquely pinned down. However, as highlighted by Werning (2015), interest rates strictly below R^{lf} are not robust to the introduction of small amounts of liquidity. In fact, with positive but vanishing levels of liquidity high-state countries must have positive savings. This implies that the Euler equation (4) in high-state countries must hold with equality, requiring $R = R^{lf}$. We adopt this equilibrium refinement throughout the paper.

Expression (15) relates the world interest rate to the fundamentals of the economy. Naturally, a higher discount factor β leads to a higher demand for bonds by saving countries, and thus to a lower world interest rate.[19] Moreover, the world interest rate is decreasing in Y_h^T/Y_l^T, because a

[17] We briefly discuss transitional dynamics in Appendix E.

[18] This expression is obtained by combining the Euler equation (4) characterizing households in high-state countries, with the equilibrium relations $C_{h,t}^T = Y_h^T$ and $C_{h,t+1}^T = Y_l^T$.

[19] The demand for bonds by countries in the high state B_h is given by

$$B_h = \max\left\{\frac{\beta}{1+\beta}\left(Y_h^T - \frac{Y_l^T}{\beta R}\right), 0\right\}.$$

To derive this expression we have combined the Euler equation (4) with the resource constraint (13) and the equilibrium condition $B_l = 0$.

higher volatility of the endowment process increases the desire to save to smooth consumption for countries in the high state. We collect these results in the following lemma.

Lemma 1 ***Tradable market equilibrium under laissez faire.*** *In a laissez-faire equilibrium with vanishing liquidity* $C^T_{i,t} = Y^T_{i,t}$ *and* $R = R^{lf} \equiv Y^T_l/(\beta Y^T_h)$.

3.2 Non-tradable consumption and output

We now turn to the market for non-tradable goods. Equilibrium on this market is reached at the intersection of the (AD) and (MP) equations, which we rewrite here for convenience[20]

$$Y^N_{i,t} = \frac{R\bar{\pi}}{R^n_{i,t}} \frac{C^T_{i,t}}{C^T_{i,t+1}} Y^N_{i,t+1} \tag{AD}$$

$$R^n_{i,t} = \begin{cases} \geq 1 & \text{if } Y^N_{i,t} = 1 \\ = 1 & \text{if } Y^N_{i,t} < 1, \end{cases} \tag{MP}$$

where we have imposed the equilibrium condition $C^N_{i,t} = Y^N_{i,t}$.

The key observation is that when aggregate demand is sufficiently weak monetary policy ends up being constrained by the zero lower bound ($R^n_{i,t} = 1$), and the economy experiences a liquidity trap with output below potential ($Y^N_{i,t} < 1$). Combining the (AD) and (MP) equations and using $R = R^{lf}$ and $C^T_{i,t} = Y^T_{i,t}$, one can see that a liquidity trap occurs if

$$R^{lf}\bar{\pi}\frac{Y^T_{i,t}}{Y^T_{i,t+1}} Y^N_{i,t+1} < 1. \tag{16}$$

Notice that, since $Y^T_h > Y^T_l$, the zero lower bound is more likely to bind in the low state compared to the high state. Intuitively, changes in tradable consumption act as demand shifters. When a country transitions from the high to the low state the associated drop in tradable consumption gives rise to a fall in aggregate demand for non-tradable goods.

Throughout the paper we focus on equilibria in which liquidity traps can happen, but they have finite duration.[21] Given our focus on two-period stationary equilibria, this is the case if fundamentals are such that liquidity traps can arise only when a country is in the low state. We thus make the following assumption.

Assumption 1 *The parameters* β, Y^T_l, Y^T_h *and* $\bar{\pi}$ *are such that* $R^{lf}\bar{\pi} > 1$.

Assumption 1 guarantees that in the laissez faire equilibrium the zero lower bound does not bind in the high state, so that $R^n_h > 1$ and $Y^N_h = 1$, where we have removed time subscripts to simplify notation. We provide a discussion of the case $R^{lf}\bar{\pi} \leq 1$ in Appendix F.

[20] Recall that we are focusing on the limit $\gamma \to \bar{\pi}$.

[21] This is the case considered traditionally by the literature on liquidity traps (Krugman, 1998; Eggertsson and Woodford, 2003; Werning, 2011), as well as by the literature on macroprudential policies and aggregate demand externalities (Farhi and Werning, 2016; Korinek and Simsek, 2016). See Caballero et al. (2015) and Eggertsson et al. (2016) for open-economy models in which permanent liquidity traps are possible.

Turning to the low state, there are two possible scenarios to consider. First, if aggregate demand is sufficiently strong low-state countries operate at full employment ($Y_l^N = 1$). This happens if[22]

$$R^{lf} \geq R^* \equiv (\bar{\pi}\beta)^{-\frac{1}{2}}. \tag{17}$$

Otherwise, if $R^{lf} < R^*$, in low-state countries the zero lower bound binds ($R_l^n = 1$) and production of non-tradable goods is

$$Y_l^N = (R^{lf}/R^*)^2 < 1. \tag{18}$$

The following proposition summarizes these results.[23]

Proposition 1 ***Non-tradable market equilibrium under laissez faire.*** *In a laissez-faire equilibrium with vanishing liquidity if $R^{lf} \geq R^* \equiv (\bar{\pi}\beta)^{-1/2}$ then $Y_h^N = Y_l^N = 1$, otherwise $Y_h^N = 1$ and $Y_l^N = (R^{lf}/R^*)^2 < 1$.*

Proposition 1 highlights the crucial role that the world interest rate plays in determining global output of non-tradable goods. In fact, if $R^{lf} \geq R^*$ every country in the world operates at potential. Otherwise the zero lower bound binds in low-state countries and world output is below potential. Moreover, if $R^{lf} < R^*$, drops in the world interest rate are associated with falls in global output.

Depending on fundamentals, the equilibrium interest rate R^{lf} might be greater or smaller than R^*.[24] We think of the case $R^{lf} < R^*$ as capturing a world stuck in a global liquidity trap. In such a world, global aggregate demand is weak and countries hit by negative shocks experience liquidity traps with unemployment. Interestingly, this state of affair can persist for an arbitrarily long period of time. In this sense, the model captures in a simple way the salient features of a world undergoing a period of secular stagnation, in which interest rates are low and liquidity traps frequent (Summers, 2016).

4 Current account policies and the paradox of global thrift

Since there is no disutility from working, unemployment in our model is inefficient. Hence, governments have an incentive to implement policies that limit the incidence of liquidity traps on employment and output. For instance, a large literature has emphasized how raising expected inflation can mitigate the inefficiencies due to the zero lower bound. However, a robust conclusion of this literature is that, in presence of inflation costs, circumventing the zero lower bound by raising inflation expectations is not an option when the central bank lacks commitment (Eggertsson and Woodford, 2003).[25]

[22] To obtain this condition, combine (15) holding with equality and (16).

[23] Using these equilibrium conditions and equation (7), one can also recover the behavior of tradable price inflation. For instance, it is easy to see that in a stationary equilibrium the average world price of tradables evolves according to

$$\frac{P_t^T}{P_{t-1}^T} = \exp\left(\int_0^1 \log P_{i,t}^T di - \int_0^1 \log P_{i,t-1}^T di\right) = \bar{\pi},$$

where we have used (7) and the fact that $P_{i,t}^N/P_{i,t-1}^N = \{\bar{\pi}, \gamma\}$ in every country i and the assumption $\gamma \rightarrow \bar{\pi}$. In words, on average the prices of tradable and non-tradable goods grow at the same rate.

[24] Precisely, $R^{lf} < R^*$ if $\bar{\pi} < \beta(Y_h^T/Y_l^T)^2$, otherwise $R^{lf} \geq R^*$.

[25] We extend this insight to our model in Appendix D.

In this paper we take a different route and consider the role of policies that affect agents' saving and borrowing decisions, such as fiscal or financial policies, in stabilizing aggregate demand and employment. While these policies can take a variety of forms, their common trait is that they influence national savings and, in financially-open economies, the country's current account. Hence, we refer to them as *current account policies*.

We implement the notion of current account policies by endowing governments with the power to choose directly their country's net foreign asset position and the path of tradable consumption, as long as these do not violate the resource constraint (13) and the borrowing limit (3). Crucially, even in presence of current account policies the market for non-tradable goods clears competitively, and hence the (AD) and (MP) equations enter the government problem as implementability constraints.[26] In fact, as we will see, in our model a role for current account policies emerges precisely because the government internalizes the impact of agents' saving decisions on the non-tradable goods market.

4.1 The national planning problem

How does a government optimally intervene on the current account? We address this question by taking the perspective of a national planner that designs current account policies to maximize domestic households' welfare.[27] Importantly, the national planner does not internalize the impact of its decisions on the rest of the world. Hence, the planning allocation that we consider corresponds to the non-cooperative optimal current account policy.

As it turns out, the planning allocation might differ depending on whether the planner operates under commitment or discretion. In the interest of brevity, for most of the paper we will restrict attention to planners that lack commitment. We make this choice because, as we will see, the planning allocation under discretion captures particularly well the spirit of the prudential policies studied by Farhi and Werning (2016) and Korinek and Simsek (2016). However, in Section 5.1 we show that our main results hold true even when national planners operate under commitment.

Formally, we focus on Markov-stationary policy rules that are functions of the payoff-relevant state variables $(B_{i,t}, Y_{i,t}^T)$ only. Since the planner operates under discretion, it chooses its policy rules in any given period taking as given the policy rules associated with future planner's decisions. A Markov-perfect equilibrium is then characterized by a fixed point in these policy rules. Intuitively, at this fixed point the current planner does not have an incentive to deviate from future planners' policy rules, so that these rules are time consistent. In what follows, we define $\mathcal{B}(B_{i,t}, Y_{i,t}^T)$ as the policy rule for bond holdings of future planners, while $\{\mathcal{C}^T(B_{i,t}, Y_{i,t}^T), \mathcal{Y}_N(B_{i,t}, Y_{i,t}^T)\}$ are the functions that return the values of the corresponding variables associated with the planners' policy rules.

[26] Notice that to derive that (AD) equation we have used the no arbitrage condition between real and nominal bonds. Hence, we are effectively assuming that governments cannot influence households' decision on how to allocate their savings between the two bonds. This assumption captures a world with a high degree of capital mobility, in which it is difficult for governments to discriminate, for instance through capital controls, between domestic and foreign assets. This feature of the model resonates with the fact that capital controls have essentially been absent in advanced economies since the early 1990s (Ilzetzki et al., 2017).

[27] Later on, in Section 4.2, we show that a government can implement the planning allocation as part of a competitive equilibrium using some simple fiscal or financial policy instruments.

The problem of the national planner in a generic country i can be represented as

$$V(B_{i,t}, Y^T_{i,t}) = \max_{C^T_{i,t}, Y^N_{i,t}, B_{i,t+1}} \omega \log C^T_{i,t} + (1-\omega) \log Y^N_{i,t} + \beta V(B_{i,t+1}, Y^T_{i,t+1}) \tag{19}$$

subject to

$$C^T_{i,t} = Y^T_{i,t} - B_{i,t+1} + RB_{i,t} \tag{20}$$

$$B_{i,t+1} \geq -\kappa_{i,t} \tag{21}$$

$$Y^N_{i,t} \leq 1 \tag{22}$$

$$Y^N_{i,t} \leq C^T_{i,t} R \bar{\pi} \frac{\mathcal{Y}^N(B_{i,t+1}, Y^T_{i,t+1})}{\mathcal{C}^T(B_{i,t+1}, Y^T_{i,t+1})}. \tag{23}$$

The resource constraints are captured by (20) and (22). (21) implies that the government is subject to the same borrowing constraint imposed by the markets on individual households.[28] Instead, constraint (23), which is obtained by combining the (AD) and (MP) equations, encapsulates the requirement that production of non-tradable goods is constrained by private sector's demand. The functions $\mathcal{C}^T(B_{i,t+1}, Y^T_{i,t+1})$ and $\mathcal{Y}^N(B_{i,t+1}, Y^T_{i,t+1})$ determine respectively consumption of tradable goods and production of non-tradable goods in period $t+1$ as a function of the country's stock of net foreign assets $(B_{i,t+1})$ and the endowment of tradables $(Y^T_{i,t+1})$ at the beginning of next period. Since the current planner cannot make credible commitments about its future actions, these variables are not into its direct control. However, the current planner can still influence these quantities through its choice of net foreign assets. In what follows, we focus on equilibria in which these functions are differentiable. Moreover, we will restrict attention to equilibria in which $\mathcal{C}^T(B_{i,t+1}, Y_{i,t+1})$ is non-decreasing in $B_{i,t+1}$, that is in which tradable consumption is non-decreasing in start-of-period wealth. We make this mild assumption to simplify some of the proofs.

Notice that, since each country is infinitesimally small, the domestic planner takes the world interest rate R as given. This feature of the planning problem synthesizes the lack of international coordination in the design of current account policies.

The first order conditions of the planning problem can be written as

$$\bar{\lambda}_{i,t} = \frac{\omega}{C^T_{i,t}} + \bar{\upsilon}_{i,t} \frac{Y^N_{i,t}}{C^T_{i,t}} \tag{24}$$

$$\frac{1-\omega}{Y^N_{i,t}} = \bar{\nu}_{i,t} + \bar{\upsilon}_{i,t} \tag{25}$$

$$\bar{\lambda}_{i,t} = \beta R \bar{\lambda}_{i,t+1} + \bar{\mu}_{i,t} + \bar{\upsilon}_{i,t} Y^N_{i,t} \left[\frac{\mathcal{Y}^N_B(B_{i,t+1}, Y^T_{i,t+1})}{\mathcal{Y}^N(B_{i,t+1}, Y^T_{i,t+1})} - \frac{\mathcal{C}^T_B(B_{i,t+1}, Y^T_{i,t+1})}{\mathcal{C}^T(B_{i,t+1}, Y^T_{i,t+1})} \right] \tag{26}$$

$$B_{i,t+1} \geq -\kappa_{i,t} \quad \text{with equality if} \quad \bar{\mu}_{i,t} > 0 \tag{27}$$

$$Y^N_{i,t} \leq 1 \quad \text{with equality if} \quad \bar{\nu}_{i,t} > 0 \tag{28}$$

[28] To write this constraint we have used the equilibrium condition $B^n_{i,t+1} = 0$. It is straightforward to show that allowing the government to set $B^n_{i,t+1}$ optimally would not change any of the results.

$$Y_{i,t}^N \leq C_{i,t}^T R\bar{\pi}\frac{\mathcal{Y}^N(B_{i,t+1},Y_{i,t+1}^T)}{\mathcal{C}^T(B_{i,t+1},Y_{i,t+1}^T)} \quad \text{with equality if} \quad \bar{\upsilon}_{i,t} > 0, \tag{29}$$

where $\bar{\lambda}_{i,t}, \bar{\mu}_{i,t}, \bar{\nu}_{i,t}, \bar{\upsilon}_{i,t}$ denote respectively the nonnegative Lagrange multipliers on constraints (20), (21), (22) and (23), while $\mathcal{Y}_B^N(B_{i,t+1},Y_{i,t+1}^T)$ and $\mathcal{C}_B^T(B_{i,t+1},Y_{i,t+1}^T)$ are the partial derivatives of $\mathcal{Y}^N(B_{i,t+1},Y_{i,t+1}^T)$ and $\mathcal{C}^T(B_{i,t+1},Y_{i,t+1}^T)$ with respect to $B_{i,t+1}$.

It is useful to combine (24) and (26) to obtain

$$\begin{aligned}\frac{1}{C_{i,t}^T}\left(\omega + \bar{\upsilon}_{i,t}Y_{i,t}^N\right) = \frac{\beta R}{C_{i,t+1}^T}\left(\omega + \bar{\upsilon}_{i,t+1}Y_{i,t+1}^N\right) + \bar{\mu}_{i,t} \\ + \bar{\upsilon}_{i,t}Y_{i,t}^N\left[\frac{\mathcal{Y}_B^N(B_{i,t+1},Y_{i,t+1}^T)}{\mathcal{Y}^N(B_{i,t+1},Y_{i,t+1}^T)} - \frac{\mathcal{C}_B^T(B_{i,t+1},Y_{i,t+1}^T)}{\mathcal{C}^T(B_{i,t+1},Y_{i,t+1}^T)}\right].\end{aligned} \tag{30}$$

This is the planner's Euler equation. Comparing this expression with the households' Euler equation (4), it is easy to see that the marginal benefit from a rise in $C_{i,t}^T$ perceived by the planner differs from households' whenever $\bar{\upsilon}_{i,t} > 0$ in any period t, that is when the zero lower bound constraint binds. This happens because, contrary to atomistic households, the planner internalizes the impact that financial decisions have on output when the central bank is constrained by the zero lower bound.

We are now ready to define an equilibrium with current account policies.

Definition 2 ***Equilibrium with current account policies.*** *An equilibrium with current account policies is a path of real allocations* $\{C_{i,t}^T, Y_{i,t}^N, B_{i,t+1}, \bar{\mu}_{i,t}, \bar{\nu}_{i,t}, \bar{\upsilon}_{i,t}\}_{i,t}$ *and world interest rate* $\{R_t\}_t$*, satisfying* (14), (20), (25), (27), (28), (29) *and* (30) *given a path of endowments* $\{Y_{i,t}^T\}_{i,t}$*, a path for the borrowing limits* $\{\kappa_{i,t}\}_{i,t}$*, and initial conditions* $\{R_{-1}B_{i,0}\}_i$*. Moreover, the functions* $\mathcal{C}^T(B_{i,t+1},Y_{i,t+1}^T)$ *and* $\mathcal{Y}^N(B_{i,t+1},Y_{i,t+1}^T)$ *have to be consistent with the national planners' decision rules.*

4.2 Current account policies in a small open economy

Under the simplifying assumptions stated in Section 2.6, it is possible to solve analytically for the equilibrium with current account policies. We start by taking the perspective of a single small open economy, and characterize the solution to the national planning problem as a function of the world interest rate.

Proposition 2 ***National planner allocation.*** *Suppose that* $1/\bar{\pi} < R < 1/\beta$*. Define* $\bar{R}^* \equiv (\omega/(\bar{\pi}\beta))^{1/2}$*. A stationary solution to the national planning problem satisfies* $B_l = 0$ *and* $B_h = \max\{\mathcal{B}_h^p(R), 0\}$*, where the function* $\mathcal{B}_h^p(R)$ *is defined by*

$$\mathcal{B}_h^p(R) = \begin{cases} \frac{\beta}{\omega+\beta}\left(Y_h^T - \frac{\omega Y_l^T}{\beta R}\right) & \text{if } R < \bar{R}^* \\ \frac{Y_h^T - R\bar{\pi}Y_l^T}{1+R^2\bar{\pi}} & \text{if } \bar{R}^* \leq R < R^* \\ \frac{\beta}{1+\beta}\left(Y_h^T - \frac{Y_l^T}{\beta R}\right) & \text{if } R^* \leq R. \end{cases} \tag{31}$$

Moreover, $\bar{\mu}_h > 0$ if $\mathcal{B}^p_h(R) < 0$, otherwise $\bar{\mu}_h = 0$. Finally, $Y^N_h = 1$ and $Y^N_l = \min\{1, R\bar{\pi}(Y^T_l + RB_h)/(Y^T_h - B_h)\}$.

Proof. See Appendix B.2.

Corollary 3 *Consider a small open economy facing the world interest rate R^{lf}. If $R^{lf} < R^*$ the national planner allocation features higher Y^N_l, B_h and welfare compared to laissez faire, otherwise the two allocations coincide.*

Proof. See Appendix B.3.

Corollary 3, which considers a scenario in which the world interest rate is at its equilibrium value under laissez faire, provides two results. First, if $R^{lf} \geq R^*$, so that the zero lower bound never binds, the planner chooses the same path for tradable consumption and bonds that households would choose under laissez faire. This result highlights the fact that in our simple model there are no incentives for the domestic government to intervene on the current account if monetary policy is not constrained by the zero lower bound.

Second, if the zero lower bound binds when the economy is in the low state ($R^{lf} < R^*$), the government intervenes to increase the current account surplus while the economy is in the high state. To understand the logic behind this result, consider a case in which the economy operates below potential in the low state, so that[29]

$$Y^N_l = R^{lf}\bar{\pi}C^T_l/C^T_h < 1. \tag{32}$$

Now imagine that the government implements a policy that leads to an increase in B_h, and thus in the country's current account surplus while the economy is booming. Households now enter the low state with higher wealth and, since they are borrowing constrained, this leads to a rise in C^T_l. But the rise in C^T_l also boosts demand for non-tradables in the low state.[30] In turn, since the central bank is constrained by the zero lower bound, higher demand for non-tradables leads to higher output and employment. Hence, holding constant the world interest rate, current account interventions lead to higher output of non-tradable goods in the low state.

Moreover, again holding constant the world interest rate, current account policies have a positive impact on welfare. As in Farhi and Werning (2016) and Korinek and Simsek (2016), this result is due to the presence of an aggregate demand externality. Atomistic households, indeed, take aggregate demand and employment as given, and do not internalize the impact of tradable consumption decisions on aggregate demand and production of non-tradable goods. Interestingly, the current account interventions implemented by the government to correct these externalities have a prudential flavor. In fact, the government intervenes to increase national savings and the current account surplus in the high state, when the economy is booming, to mitigate the drop in

[29]To derive this expression we have used the fact that Proposition 2 implies $Y^N_h = 1$.

[30]In a stationary equilibrium there is also a second effect. Indeed, the rise in B_h lowers C^T_h, i.e. tradable consumption in the high state. This effect also contributes to the rise in demand for non-tradables when the economy is in the low state. See Section 5.1 for further discussion on this point.

employment associated with future liquidity traps occurring when the economy transitions toward the low state.

Before moving on, it is useful to spend some words on the instruments that a government needs to decentralize the planning allocation. One possibility is to allow the government to impose a borrowing limit tighter than the market one. Under this financial policy, (3) is replaced by

$$B_{i,t+1} + \frac{B^n_{i,t+1}}{P^T_{i,t}} \geq -\min\left\{0, \kappa^g_{i,t}\right\},$$

where $\kappa^g_{i,t}$ is the borrowing limit set by the government. The government can implement the planning allocation characterized in Proposition 2 as part of a competitive equilibrium by setting $\kappa^g_h = -\max\{\mathcal{B}^p_h(R), 0\} \leq 0$ and $\kappa^g_l = 0$. Intuitively, to decentralize the planning allocation with financial policy the government should tighten households' access to credit when the economy is in the high state.

Alternatively, the planning allocation could be decentralized using fiscal policy. Consider a case in which the government can levy lump-sum taxes on households $T_{i,t}$, to be paid with tradable goods, and use the proceeds to purchase foreign bonds. The government budget constraint is $B^g_{i,t+1} = T_{i,t} + R_{t-1}B^g_{i,t}$, where $B^g_{i,t}$ denotes the stock of foreign bonds held by the government at the start of period t.[31] Under these assumptions, equation (13) is replaced by

$$C^T_{i,t} = Y^T_{i,t} + R_{t-1}\left(B_{i,t} + B^g_{i,t}\right) - \left(B_{i,t+1} + B^g_{i,t+1}\right).$$

The planning allocation characterized in Proposition 2 can be implemented as part of a competitive equilibrium with fiscal policy by setting $B^g_h = \max\{\mathcal{B}^p_h(R), 0\}$ and $B^g_l = 0$. In words, the government accumulates foreign assets while the economy is booming, and rebates them to households when the economy is in a liquidity trap. This simple form of fiscal policy is effective because the presence of the borrowing limit prevents households from undoing asset accumulation by the government through increases in private borrowing.

Taking stock, the government can use simple forms of financial and fiscal policy to implement the planning allocation. In particular, in our model a government can attain an increase in the country's current account surplus either by tightening financial regulation or through a rise in the fiscal surplus. Hence, prudential financial and fiscal policies are the natural counterpart of the current account policy outlined in Proposition 2.

In this section, we have essentially extended the insights from the literature on aggregate demand externalities and prudential policy interventions to our setting (Farhi and Werning, 2016; Korinek and Simsek, 2016). In particular, we have shown that governments have an incentive to implement prudential current account policies to complement monetary policy, when the monetary authority is constrained by the zero lower bound. As in Farhi and Werning (2016), when implemented by a single small open economy current account policies lead to higher average output and welfare. While this point is well understood, little is known about what happens when current

[31] To prevent governments from circumventing the private borrowing limit, we also assume that governments cannot sell bonds to foreign agents, i.e. $B^g_{i,t+1} \geq 0$.

account policies are implemented by a significantly large group of countries. We tackle this issue next.

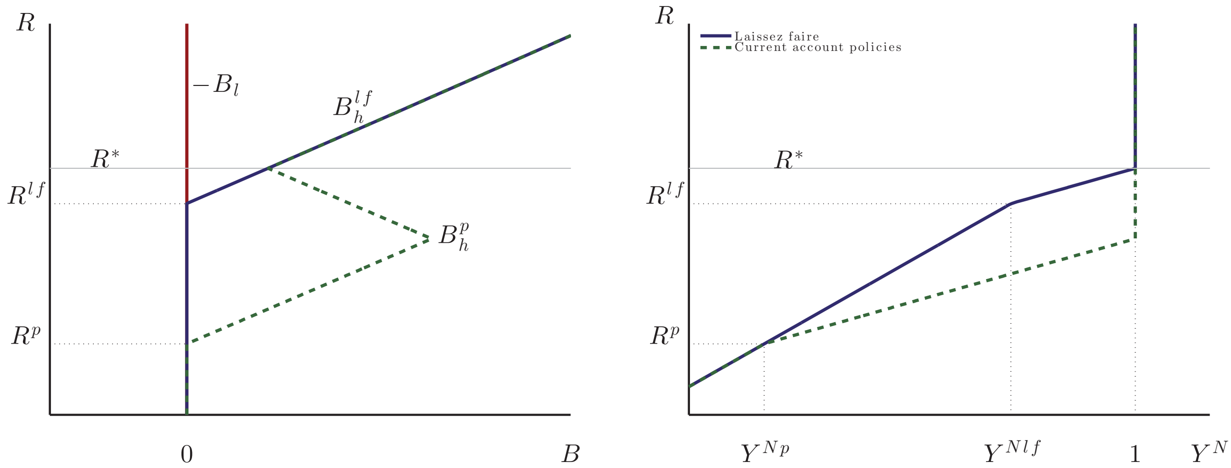
4.3 Global equilibrium with current account policies

We now characterize the global equilibrium when all the countries implement the current account policy described in Proposition 2. We show that, once general equilibrium effects are taken into account, government interventions on the international credit markets can backfire by exacerbating the global liquidity trap and give rise to a paradox of global thrift.

Given our focus on a zero liquidity economy, in a global equilibrium all the countries must hold zero bonds. It follows that, just as in the laissez-faire equilibrium, the allocation of tradable consumption corresponds to the autarky one ($C_l^T = Y_l^T$ and $C_h^T = Y_h^T$). Hence, when current account policies are implemented on a global scale governments' efforts to alter the path of tradable consumption are ineffective.

This does not, however, mean that current account policies do not have any impact. Indeed, the following proposition provides a striking result: current account interventions exacerbate the global liquidity trap, and have a negative effect on global output and welfare.

Figure 2: Impact of current account policies during a global liquidity trap.



Proposition 3 ***Global equilibrium with current account policies.*** *Suppose that $R^{lf} < R^*$ and $\omega R^{lf}\bar{\pi} > 1$. Then in a vanishing-liquidity equilibrium with current account policies $R = R^p \equiv \omega R^{lf}$. Moreover, for every country output and welfare are lower in the equilibrium with current account policies compared to the laissez-faire one.*

Proof. See Appendix B.4.

Perhaps the best way to gain intuition about this result is through a diagram. The left panel of Figure 2 displays the demand for bonds by countries in the high state (B_h) and supply of bonds by countries in the low state ($-B_l$), as a function of the world interest rate (R). The dashed line B_h^p corresponds to the demand for bonds when governments intervene on the international credit markets, while the solid line B_h^{lf} displays the demand for bonds under laissez faire. Notice that for $R^p < R < R^*$ the demand for bonds under current account policy is higher than under laissez faire. Indeed, this is the range of R for which governments in high-state countries intervene to increase the current account surplus.[32] The supply of bonds, instead, does not depend on whether governments intervene. In fact, in both cases countries in the low state end up being borrowing constrained, and the supply of bonds is $-B_l = 0$.

The equilibrium world interest rate is found at the intersection of the B_h and $-B_l$ schedules, corresponding to a kink in the B_h schedule.[33] The diagram shows that $R^p < R^{lf}$, meaning that the equilibrium with current account interventions features a lower world interest rate compared to the laissez-faire one. To understand this result, consider a world with no current account interventions. Now imagine that governments in countries in the high state start intervening to increase their current account surpluses. This generates an increase in the global demand for bonds. But world bonds supply is fixed because countries in the low state are borrowing constrained. To restore equilibrium the world interest rate has to fall, so as to bring back the demand for bonds to its equilibrium value of zero.

The right panel of Figure 2 shows how world output of non-tradable goods (Y^N) adjusts following the implementation of current account policies. The solid line shows global output as a function of the world interest rate under laissez faire, while the dashed line displays world output when current account policies are implemented. Holding constant R, the implementation of current account policies increases global output by shifting tradable consumption and aggregate demand from the high to the low state (see Corollary 3). In equilibrium, however, current account policies cannot alter the path of tradable consumption and their only effect is to produce a drop in the world interest rate. In turn, a lower world rate depresses demand for non-tradable consumption across the whole world. Due to the zero lower bound constraint, central banks in low-state countries cannot respond to the drop in aggregate demand by reducing the policy rate. Through this channel, current account interventions in booming high-state countries exacerbate the recession in low-state countries stuck in a liquidity trap.[34] As a result of these negative international aggregate demand externalities, the implementation of current account policies produces a drop in global output and welfare.[35]

This is the essence of the *paradox of global thrift*, as well as the key insight of the paper. Due to their general equilibrium impact on the world interest rate and global aggregate demand,

[32] The non-monotonicity of B_h^p arises for the following reason. According to Proposition 2, when $\bar{R}^* \leq R < R^*$ the national planners choose a value of B_h such that Y_l^N is exactly equal to 1. In words, governments intervene to increase the current account during booms so that the economy operates at full employment during busts. But a lower world interest rate implies that a country need to save more while in the high state to keep the economy at full employment in the low state. Hence, for $\bar{R}^* \leq R < R^*$ the demand for bonds by countries in the high state is decreasing in R. Once R gets too low, precisely for $R < \bar{R}^*$, it becomes too costly for the government to increase B_h so as to always keep the economy at full employment. In this case, the standard logic applies and demand for bonds becomes increasing in the world interest rate.

[33] All the other intersections between the B_h and B_l curves correspond to cases in which all the countries are borrowing constrained. As explained above, these equilibria are not robust to the introduction of small amounts of liquidity, and we thus disregard them.

[34] As in the case of laissez faire, we focus on equilibria in which liquidity traps are temporary, and so high-state economies operate at full employment. This is guaranteed by condition $\omega R^{lf}\bar{\pi} > 1$. See Appendix F for a discussion on why we need this condition to hold in equilibrium.

[35] To see why welfare is lower with current account policy compared to laissez faire, consider that both policy regimes are characterized by the same equilibrium path of tradable consumption. It follows that the impact of current account interventions on welfare is fully captured by the drop in output and consumption of non-tradable goods.

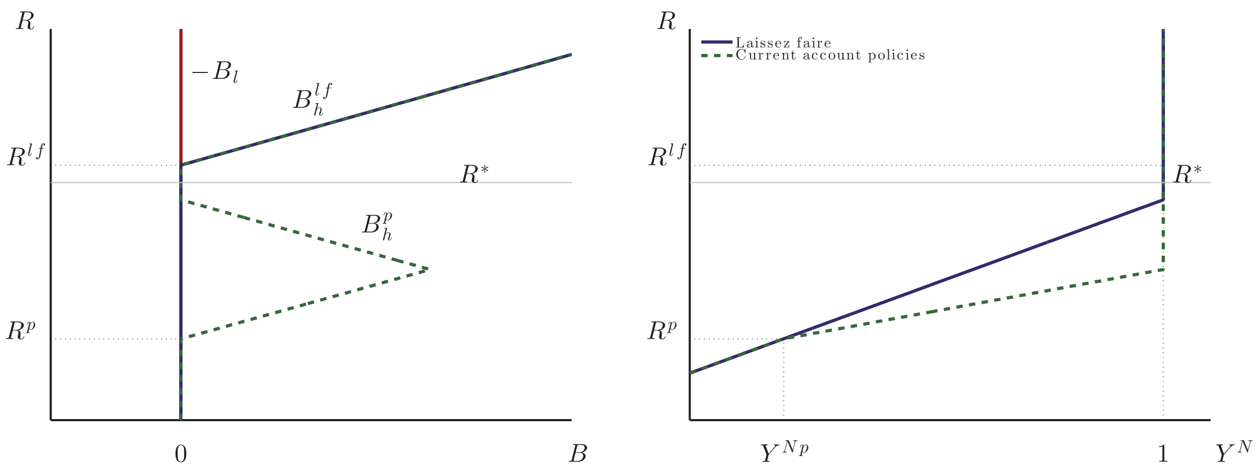
prudential current account policies aiming at mitigating the output and welfare losses associated with liquidity traps might end up exacerbating them.

4.4 Multiple equilibria with current account policies

We now consider the impact of current account interventions when fundamentals are such that $R^{lf} \geq R^*$. This corresponds to a case in which, under laissez faire, the world interest rate is sufficiently high so that the zero lower bound never binds.

Proposition 4 ***Multiple equilibria with current account policies.*** *Suppose that $R^{lf} \geq R^*$. Then there exists a vanishing-liquidity equilibrium with current account policies with $R = R^{lf}$. This equilibrium is isomorphic to the laissez-faire one. However, if $\omega R^{lf} < R^*$ and $\omega R^{lf}\bar{\pi} > 1$, there exists at least another equilibrium with current account policies associated with a world interest rate $R = R^p \equiv \omega R^{lf}$. This equilibrium features lower output and welfare than the laissez-faire one.*

Figure 3: Multiple equilibria under current account policies.



Proof. See Appendix B.5.

One might be tempted to conclude that if $R^{lf} \geq R^*$ then governments will not intervene on the international credit markets, and the equilibrium with current account policies will coincide with the laissez-faire one. Indeed, Proposition 4 states that this is a possibility. However, Proposition 4 also states that there might be other equilibria, characterized by current account interventions and associated with global liquidity traps. Hence, the fact that fundamentals are sufficiently good to rule out a global liquidity trap under laissez faire does not exclude the possibility of a global liquidity trap when governments intervene on the current account. This result is illustrated by Figure 3, which shows that multiple intersections between the B_h^p and $-B_l$ curves are possible.

To gain intuition about this result, consider that governments' actions depend on their expectations about the future path of the world interest rate. This happens because the zero lower bound binds only if the world interest rate is sufficiently low. For instance, consider a case in which governments expect that the world interest rate will never fall below R^*. In this case, governments expect that the zero lower bound will never bind and hence do not intervene. Since we are focusing on the case $R^{lf} \geq R^*$, in absence of policy interventions the zero lower bound will indeed never bind, confirming the initial expectations. But now think of a case in which governments anticipate that the world interest rate will always be below R^*, so that the zero lower bound is expected to bind in low-state countries. Then governments in high-state countries will start intervening on the current account in an attempt to reduce future unemployment. These interventions will increase the global supply of savings above its value under laissez faire, putting downward pressure on the world interest rate. If $\omega R^{lf} < R^*$ holds, the resulting drop in the interest rate is sufficiently large so that $R < R^*$, validating governments' initial expectations. Thus, expectations of a future global liquidity trap might generate a global liquidity trap in the present.

We have seen that in our baseline model current account interventions, while being desirable from the point of view of a single country, lead to perverse outcomes once their general equilibrium effects are taken into account. First, current account policies implemented during a global liquidity

global liquidity traps purely driven by pessimistic expectations. Since all these general equilibrium effects are mediated by the world interest rate, which national governments take as given, the perverse effects associated with current account policies are not internalized by governments.[36] Our results thus suggest that international cooperation is needed during a global liquidity trap, in order to limit the negative international aggregate demand externalities arising from unilateral current account interventions. Otherwise, self-oriented interventions on the current account might backfire by triggering a paradox of global thrift.

5 Extensions

So far we have drawn insights based on an admittedly stylized model. While the simplicity of our baseline model is useful to derive intuition, it is interesting to know whether and how our results would apply to richer settings. In this section we extend the model in several directions, and discuss the conditions under which a paradox of global thrift is more likely to occur.

5.1 Current account policies under commitment

As our baseline case, we considered national planners that operate under discretion. In this section we endow planners with the ability to commit.[37] Our key finding is that the logic of the paradox of global thrift applies even in this case.

In the interest of space, in this section we sketch the solution to the planning problem under commitment. We provide a formal description in Appendix G. Under commitment, the planner's Euler equation (30) is replaced by

[36] One might wonder what would happen in a framework in which countries are large enough, so that governments take into account the impact of their policy decisions on the world interest rate. Though a formal analysis of this case is beyond the scope of this paper, we conjecture that our key results would survive in this alternative setting. In our model, in fact, prudential current account policies backfire because governments in booming countries do not internalize the impact of their current account interventions on welfare in countries experiencing a recession. Hence, the logic behind our results should survive, as long as one considers self-oriented national governments that ignore the impact of their policy decisions on welfare in the rest of the world.

[37] To be clear, we consider what happens when current account policies are designed under commitment, holding constant the monetary policy rule. We make this choice because there is a large literature describing how the ability to commit affects optimal monetary policy around liquidity trap episodes.

$$\frac{1}{C_{i,t}^T}\left(\omega + \bar{\upsilon}_{i,t} Y_{i,t}^N - \bar{\upsilon}_{i,t-1}\frac{Y_{i,t-1}^N}{\beta}\right) = \frac{\beta R}{C_{i,t+1}^T}\left(\omega + \bar{\upsilon}_{i,t+1} Y_{i,t+1}^N - \bar{\upsilon}_{i,t}\frac{Y_{i,t}^N}{\beta}\right) + \bar{\mu}_{i,t}.$$

Here the policy intervention has a flavor of forward guidance, captured by the terms $\bar{\upsilon}_{i,t-1}Y_{i,t-1}^N/(\beta C_{i,t}^T)$ and $\bar{\upsilon}_{i,t}Y_{i,t+1}^N/(\beta C_{i,t+1}^T)$. Through these terms, the planner internalizes the fact that lowering tradable consumption in the future sustains aggregate demand in the present.

To see this point more clearly, consider a case in which the zero lower bound does not bind in the present and is never expected to bind in the future ($\bar{\upsilon}_{i,t} = 0$ for $t \geq 0$), but it was binding in period $t-1$ ($\bar{\upsilon}_{i,t-1} > 0$). The planner Euler equation now reduces to

$$\frac{1}{C_{i,t}^T}\left(\omega - \bar{\upsilon}_{i,t-1}\frac{Y_{i,t-1}^N}{\beta}\right) = \frac{\beta R \omega}{C_{i,t+1}^T}.$$

Comparing this expression with (30), one can see that the term $\bar{\upsilon}_{i,t-1}Y_{i,t-1}^N/(C_{i,t}^T\beta)$ creates a wedge between the solutions to the planning problem under discretion and commitment.

Intuitively, when the zero lower bound constraint binds, the planner has an incentive to promise future current account interventions that will lower future tradable consumption. If households believe this promise, the prospect of low future tradable consumption induces them to front-load consumption of non-tradable goods. This form of forward guidance sustains aggregate demand and output during the liquidity trap. This promise, however, is not credible if the government operates under discretion. That is why the term $\bar{\upsilon}_{i,t-1}Y_{i,t-1}^N/(C_{i,t}^T\beta)$, which encapsulates the impact of past promises on current government policy, is absent from the discretionary planner Euler equation (30).

In terms of our two-period stationary equilibria, this result implies that a planner that operates under commitment has an even stronger incentive to suppress households' tradable consumption during booms. In fact, a lower C_h^T not only increases output during future liquidity traps, through the precautionary channel described in Section 4.2. In addition, under commitment planners reduce tradable consumption during booms to fulfill the promises made during past liquidity traps, because of the forward guidance channel explained above.

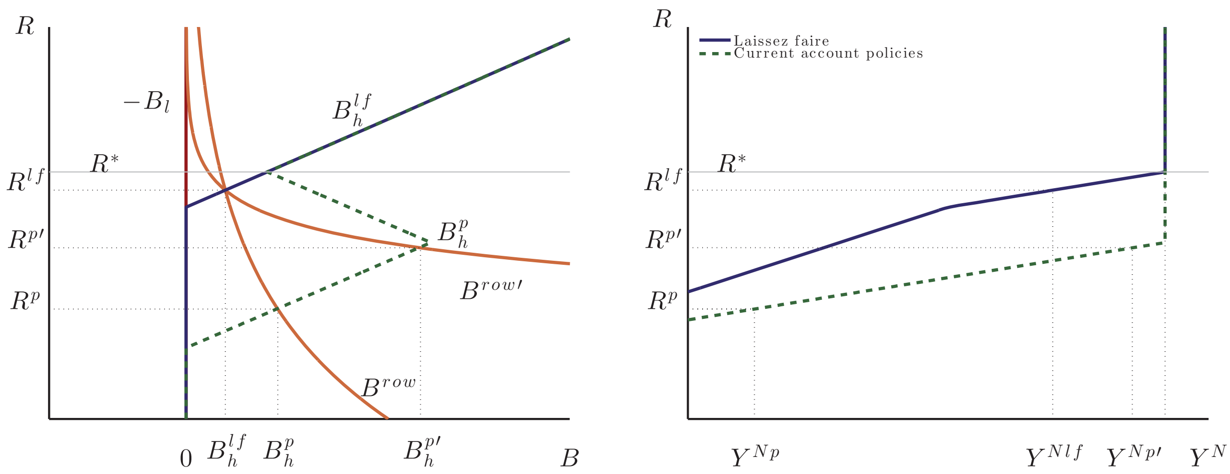
Hence, when the zero lower bound binds in the low state, current account interventions under commitment foster national savings during booms even more than under discretion. But, in a zero liquidity economy, current account policies cannot alter the equilibrium path of tradable consumption. It follows that current account policies produce an even larger drop in the equilibrium world interest rate and global output compared to the case of discretion. The conclusion is that governments' ability to commit when designing current account policies does not free them from the logic of the paradox of global thrift.

5.2 Positive liquidity

Our baseline model features zero liquidity. While useful for illustrative purposes, this assumption is admittedly unrealistic. It is then natural to investigate the impact of prudential policies in a world with positive liquidity supply, in which current account policies can affect equilibrium savings. To anticipate, our main results are that with positive liquidity current account policies have an ambiguous impact on world output, and that a paradox of global thrift is likely to arise when the elasticity of liquidity supply with respect to the world interest rate is low. In this case, in fact, prudential policies trigger a large drop in the world interest rate, while failing to increase significantly savings by booming countries.

There are many ways to introduce positive liquidity. The simplest option is to open up our model economies to trade in financial assets with agents from the rest of the world. We thus replace

Figure 4: Impact of current account policies with positive liquidity.



the world bond market clearing condition (14) with

$$\int_0^1 B_{i,t+1}\,\mathrm{d}i = B_{t+1}^{row},$$

where B_{t+1}^{row} denotes the bonds supply by the rest of the world. We also assume that

$$B_{t+1}^{row} = \frac{\bar{B}}{2}\left(\frac{\bar{R}}{R_t}\right)^{\phi},$$

with $\bar{B} > 0$, $\bar{R} > 0$ and $\phi > 1$. In words, the supply of bonds by agents from the rest of the world is decreasing in the world interest rate.

As in the case of zero liquidity, we consider stationary equilibria satisfying the assumptions stated in Section 2.6. Moreover, we are interested in studying equilibria in which liquidity is scarce enough so that the borrowing constraint binds in low-state countries. This is the case if

$$\bar{B}\bar{R}^{\phi} < \frac{(Y_h^T - Y_l^T)\beta^{1-\phi}}{1+\beta},$$

which we assume from now on.

We are now ready to solve for the equilibrium on the international credit markets. Since the borrowing constraint binds in low-state countries $B_l = 0$. Hence, in equilibrium the world interest rate adjusts so that $B_h/2 = B^{row}$. Moreover, both under laissez faire and with current account policies, the demand for bonds by countries in the high-state B_h is identical to the one derived in the zero liquidity economy. We can thus employ the same graphical apparatus developed in Section 4.3. In fact, as shown in Figure 4, the only difference is the presence of the downward-sloped B^{row} curve.

As drawn in Figure 4, the laissez-faire equilibrium corresponds to a global liquidity trap. Current account policies, just as in the case of zero liquidity, end up lowering the world interest rate because they increase the global saving supply. Different from the case of zero liquidity, however, here current account policies have an impact on equilibrium savings and consumption of tradables. In fact, tradable consumption is now given by

$$C_h^T = Y_h^T - \bar{B}\left(\frac{\bar{R}}{R}\right)^{\phi}$$

$$C_l^T = Y_l^T + \bar{B}R^{1-\phi}\bar{R}^{\phi}.$$

Hence, recalling that $\phi > 1$, a drop in the world interest rate induces a reallocation of tradable consumption from the high to the low state. This is possible because, as the world interest rate falls, rest-of-the-world agents expand their bond supply and allow high state countries to increase their equilibrium savings.

Tracing the output response to the implementation of current account policies is more difficult. Recall that output in the low state is given by $Y_l^N = \bar{\pi} R C_l^T / C_h^T$. The fall in the interest rate triggered by current account policies has thus two contrasting effects on output. On the one hand, a lower world rate has a direct negative impact on production of non-tradables. On the other hand, the resulting reallocation of tradable consumption from the high to the low state increases aggregate demand and output. In general, it is difficult to obtain analytic results about which effect will prevail.

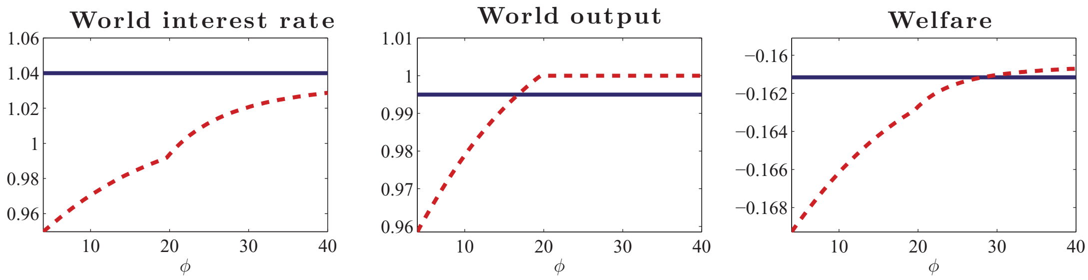
Luckily, it is possible to work out an insightful special case analytically. Let us assume that the endowment is received only by countries in the high state ($Y_l^T = 0$). We then have the following results.

Proposition 5 ***Global equilibrium with current account policies and positive liquidity.*** *Suppose that* $Y_l^T = 0$, $((\omega/\beta + 1)\bar{B}/Y_h^T)^{1/\phi}\bar{R}\bar{\pi} > 1$ *and that under laissez faire the world is stuck in global liquidity trap. Then if* $\phi < \phi^*$, *for every country output and welfare are lower in the equilibrium with current account policies compared to the laissez-faire one.* ϕ^* *is such that* $\omega^{\phi^*/2} = (\omega + \beta)/(1 + \beta)$.

Proof. See Appendix B.6.

Proposition 5 states that the impact that current account policies have on output and welfare crucially depends on the elasticity of liquidity supply to the world interest rate, which is increasing in the parameter ϕ. To understand this result consider that, as shown in Figure 4, a lower ϕ is associated with a larger drop in the world rate following the implementation of current account policies . At the same time, for a given drop in the world rate, the lower ϕ the less current account policies expand equilibrium savings by booming countries. It then follows naturally that if the liquidity supply is sufficiently inelastic, precisely if $\phi < \phi^*$, then current account policies induce a drop in output and welfare.[38]

Figure 5: Impact of current account policies with positive liquidity. Note: laissez faire (solid lines) and current account policies (dashed lines).



To demonstrate that this result does not restrict itself to the case $Y_l^T = 0$, we turn to a numerical example. Figure 5 displays the equilibrium world interest rate, world output and welfare under laissez faire (solid lines) and current account policies (dashed lines), as a function of ϕ.[39] The main message is that, in line with the illustrative case $Y_l^T = 0$, lower values of ϕ make it more likely that current account policies generate a drop in output and welfare.

To conclude this section, we want to clarify that introducing an ad-hoc supply of bonds from the rest of the world is akin to bring noise traders into the model. For this reason, the welfare results presented in this section need to be taken with a grain of salt. However, the logic of our results do not rest on this particular formulation of liquidity supply. To make this point, in Appendix *H* we consider a model in which liquidity is provided by investment in physical capital. While the analysis is more involved, the key results are unchanged. That is, also in the economy with physical capital current account policies are more likely to lower output and welfare if the elasticity of liquidity supply with respect to the world interest rate is low. The only wrinkle is that in the model with capital this elasticity is determined by the technological factors shaping the production function.

5.3 Extended model and numerical analysis

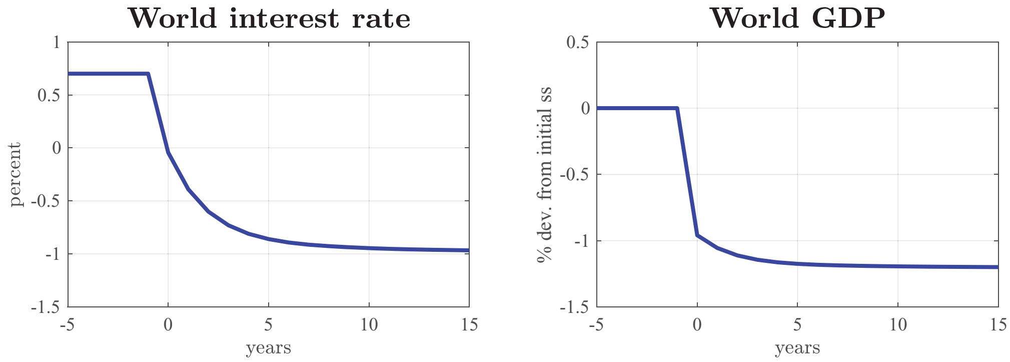
In this section, we consider an extended version of the model and perform a simple calibration exercise. To be clear, the objective of this exercise is not to provide a careful quantitative evaluation of the framework, or to replicate any particular historical event. Rather, our aim is to show that

[38]Notice the parallel with the results in Section 4. There we showed that current account policies have a positive impact on output and welfare if implemented by a single small open economy. This corresponds to the case of an infinitely elastic supply of liquidity ($\phi \to +\infty$). The global equilibrium of the zero liquidity economy, instead, can be thought as a case in which the supply of liquidity is infinitely inelastic ($\phi = 0$).

[39]To construct the figure we set $Y_h^T = 1$, $Y_l^T = .8$, $\beta = .8$, $\omega = .9$, $\bar{\pi} = 1.14$ and $\bar{B} = 0.01$. For every value of ϕ considered we adjust $\bar{R}$ to keep the equilibrium under laissez faire constant. Of course, this parametrization is purely illustrative and not meant to be realistic. In particular, we have set the share of tradable goods in consumption ω to an unrealistically high value. Setting ω to a realistic value, in fact, would lead to an extremely large impact of current account policies on the world interest rate. This is due to the fact that our simple model lacks many factors, such as the disutility that households derive from working or uncertainty about the occurrence of a liquidity trap in the future, that affect governments' incentives to intervene on the current account. In Section 5.3 we show, using a richer framework, that our results do not depend on setting ω to an unrealistically high value.

our key results do not depend on the simplifying assumptions characterizing the baseline model. In the interest of space, we present a detailed description of the model and the results in Appendix I. Here we just sketch the main insights delivered by this exercise.

Figure 6: Transition toward steady state with current account policies. Note: the procedure used to construct this figure is explained in Appendix I.



For our numerical exercise, we enrich the baseline model along three dimensions. First, we consider more general households' preferences, that take into account households' disutility from working. Second, we relax the no-borrowing assumption, and allow countries to take positive amounts of debt. Third, we introduce uncertainty, in the form of idiosyncratic tradable endowment and financial shocks. Financial shocks are modeled as stochastic variations in the households' borrowing limit. The model does not admit an analytic solution, so we explore its properties using numerical simulations.

A key aspect of the model is that liquidity traps tend to occur in countries that have accumulated a large stock of debt. This happens because highly indebted households end up being borrowing constrained after a tightening in their country's borrowing limit. Once their borrowing constraint binds, households cut spending on consumption, giving rise to a liquidity trap and a recession. In this respect, the model shares many similarities with theories in which liquidity traps are triggered by episodes of deleveraging (Eggertsson and Krugman, 2012; Guerrieri and Lorenzoni, 2017).

When given the option to intervene on the current account, governments implement policies that limit debt accumulation in order to mitigate the impact of future liquidity traps on output. Interestingly, interventions by governments tend to happen mostly in countries that are experiencing abundant access to credit, and have already accumulated a sizable stock of external debt. These are the countries, in fact, that are mostly exposed to the risk of a recession in the event of a negative financial shock.

As in the baseline model, current account interventions lead to an increase in the global supply of savings and an associated drop in the world interest rate. If the fall in the interest rate is large enough a paradox of global thrift will ensue. That is, world output might be lower in the equilibrium with current account policies compared to laissez faire. As an example, Figure 6 shows the dynamics triggered by a permanent shift from laissez faire to current account policies under our baseline calibration. During the transition to the final steady state the world interest rate drops by 150 basis points and global output falls by more than 1%. To clarify, because our model is highly stylized we interpret these quantitative results as being only suggestive. Still, the model points toward the possibility of significant output losses associated with the paradox of global thrift.

5.4 Global recessions

In our baseline model, we have abstracted from aggregate shocks. In reality, business cycles are partly correlated across countries, and global shocks, as in the case of the 2008 financial crisis, can give rise to world-wide recessions. In this section we introduce a global shock in our model, and briefly study its implications for current account policies. Our main result is that the current account interventions implemented by governments in the expectation of a future global recession might depress interest rates and output ex ante.

To keep the analysis simple, we will assume the following timing. In the initial period ($t = 0$) agents anticipate that a global shock will hit the economy in the future. In period 1, indeed, a global shock materializes and pushes the whole world into a recession. Period 0 should thus be interpreted as the run-up to a global crisis. The global shock is a one-time event, and no further aggregate shocks are expected from period 2 on.

There are a variety of shocks that could generate a world-wide recession. Perhaps the simplest option, in line with much of the literature on liquidity traps, is to introduce fluctuations in the households' discount factor.[40] Let β_t denote the discount factor applied by households between periods t and $t+1$. All the countries share the same discount factor, hence the absence of the i subscript. We will consider a scenario in which β_t satisfies $\beta_t = \beta_h$ in $t = 1$ and $\beta_t = \beta < \beta_h$ in any other period t. In words, in period 1 agents become more patient and increase their supply of savings. As we will see, the associated drop in global demand gives rise to a world-wide recession.

In order to illustrate our point it is convenient to assume that households experience disutility from working.[41] We thus modify the period utility function to

$$U\left(C_{i,t}^T, C_{i,t}^N, L_{i,t}\right) = \omega \log C_{i,t}^T + (1-\omega)\log C_{i,t}^N - \chi L_{i,t},$$

where $\chi > 0$. Under the normalization $\chi = 1 - \omega$, it is easy to check that when the constraint on wage adjustment does not bind non-tradable output is equal to 1. Hence, it is still the case that when $Y_{i,t}^N = 1$ the economy operates at full employment, while when $Y_{i,t}^N < 1$ the economy is experiencing involuntary unemployment and a negative output gap.

The rest of the model is identical to the one considered in Sections 3 and 4. In particular, we keep on assuming that the central bank follows the policy rule MP. In fact, it is possible to prove that this is the policy that a central bank operating under discretion would adopt. Moreover, in

[40]For instance, liquidity traps are triggered by discount factor shocks in the seminal papers by Krugman (1998) and Eggertsson and Woodford (2003). The results would be similar if the global liquidity trap was triggered by a fall in inflation expectations, in the spirit of Schmitt-Grohé and Uribe (2017), or in expected productivity growth, as in Benigno and Fornaro (2018). In Section 5.5, instead, we consider world-wide recessions triggered by shocks originating in the domestic credit markets.

[41]It turns out that in the case of an inelastic labor supply current account policies depress the interest rate in period 0, but the effect is not sufficiently strong to generate a recession (see Appendix B.7).

order to derive analytic insights, we consider a zero liquidity economy in which no borrowing is allowed and no source of outside liquidity is available.

We start by briefly deriving the equilibrium under laissez faire. As discussed in Section 3, low-state countries always end up being borrowing constrained. The equilibrium world interest rate thus adjusts so that desired savings by high-state countries are exactly zero. This happens if

$$R_t^{lf} = \frac{Y_l^T}{\beta_t Y_h^T}, \tag{33}$$

which is just a straightforward generalization of equation (15). According to this expression, the increase in households' desire to save in period 1 drives down the world interest rate.

Turning to output, we will assume that conditions are such that every country always operates at full employment, except for period 1, in which every country experiences a recession. In Appendix B.7 we show that this happens if $\bar{\pi} \leq \beta_h \leq (\bar{\pi} Y_l^T / Y_h^T)^2 / \beta$. Intuitively, the rise in the discount factor is large enough to push all the countries in a recession in period 1, but not so large so as to generate a recession in period 0.

To sum up, the world starts in period 0 at full employment. In period 1 the rise in households' desire to save pushes global rates down, and the whole world into a recession. From period 2 on the world enters a steady state in which all countries operate at full employment.

We now turn to the impact of current account policies. We are interested in studying prudential policies that governments implement in anticipation of a future global crisis. We instead abstract from policy interventions that governments might carry out during the crisis itself.[42] Following Farhi and Werning (2016) and Korinek and Simsek (2016), we will thus endow governments with the ability to choose their country's net foreign asset position at the end of period 0 ($B_{i,1}$), and assume that they cannot interfere thereafter.

The following proposition summarizes the key insight of this exercise.

Proposition 6 ***Current account policies in the run-up to a global crisis.*** *Suppose that $\bar{\pi} \leq \beta_h \leq (\bar{\pi} Y_l^T / Y_h^T)^2 / \beta$ and that $\beta_h > \tilde{\beta}_h$ (see Appendix B.7 for $\tilde{\beta}_h$). Then in a vanishing-liquidity equilibrium with current account policies global output and the world interest rate in period 0 are lower than under laissez faire. From $t = 1$ on the two allocations coincide.*

Proof. See Appendix B.7.

Proposition 6 states that current account interventions in the run up to the global crisis might generate a recession ex ante. The reason is simple. In period 0, governments attempt to boost national savings, in order to sustain aggregate demand and output during the future world recession. These interventions, however, depress the world interest rate in the present. If this effect is sufficiently strong, precisely if $\beta_h > \tilde{\beta}_h$, the result is a recession in period 0.

The proposition also states that current account policies fail to boost output during the world recession happening in period 1. This result is specific to zero liquidity economies, because with zero liquidity current account policies cannot alter equilibrium savings. With positive liquidity,

[42]See Caballero et al. (2015) and Eggertsson et al. (2016) for analyses of policy interventions during a liquidity trap affecting the whole world.

instead, current account interventions would produce a rise in savings in period 0, which would mitigate the global recession in period 1. Still, as long as the supply of liquidity is not perfectly elastic with respect to the world interest rate, in order for this to happen R_0 has to fall. If the drop in R_0 is large enough, a recession in period 0 occurs.

The general insight is then that prudential current account policies can help sustain output during a global crisis. However, this might come at the cost of lower output in the run-up to the crisis itself. Importantly, individual governments do not internalize this cost, because when designing current account interventions governments take the world interest rate as given. This result points toward the need to coordinate internationally the prudential current account interventions that governments might want to take in anticipation of a future global crisis.

5.5 International spillovers with symmetric countries

The focus of our paper is on a world characterized by international asymmetries. Yet, it is natural to wonder whether coordination problems in the design of current account policies would disappear if countries were to be identical. One might perhaps guess that the interests of identical countries would be aligned, making international cooperation superfluous. It turns out that matters are more complicated than that. In fact, even in absence of heterogeneity across countries prudential current account policies might produce substantial international spillovers. Moreover, depending on the exact scenario these spillovers might be contractionary or expansionary.

We make this point in Appendix J by mean of two examples.[43] In these examples countries are symmetric, but agents within each country are heterogeneous. Moreover, in both examples a global liquidity trap occurs because a fraction of the households ends up being borrowing constrained. The associated drop in global aggregate demand produces a world-wide recession.

In the example discussed in Appendix $J.2$, households are ex-ante identical. In period 1 households are hit by idiosyncratic shocks to their endowment of tradable goods.[44] Households receiving a negative shock end up being borrowing constrained. The subsequent drop in demand for consumption produces a global recession.

Against this background, governments perceive that prudential current account policies that increase national savings ex ante, i.e. in period 0, sustain output during the liquidity trap in period 1. The reason is that an increase in national savings in period 0 leads to higher wealth owned by households at the start of period 1. Households, especially those who end up being borrowing constrained, react to the rise in wealth by increasing spending. In turn, higher spending sustains output during the liquidity trap occurring in period 1.

Unconstrained agents, however, will want to save part of the increase in wealth. If all the countries increase national savings ex ante, therefore, the global supply of savings during the liquidity trap rises. In equilibrium, the rise in the global supply of savings pushes down the world interest rate. In turn, the fall in the world interest rate drives down aggregate demand and output throughout the world. This effect is not internalized by governments, which ignore the impact of

[43] A full analysis of the spillovers arising in presence of symmetric countries and domestic heterogeneity is interesting, but complex and beyond the scope of this paper.

[44] For instance, one can think about a case in which households experience idiosyncratic shocks to their labor income, perhaps because some sectors of the economy are experiencing a downturn.

their actions on the rest of the world. In this scenario prudential current account policies thus generate contractionary spillovers toward the rest of the world.

The example presented in Appendix $J.3$ illustrates the case of expansionary international spillovers, and it is inspired by the deleveraging scenarios studied by Farhi and Werning (2016) and Korinek and Simsek (2016). In this example there is no outside liquidity. Borrowers, which represent one half of the population, enter period 1 with some pre-existing debt. These debts are fully owed to savers. In period 1 a tightening in the borrowing limit curtails borrowers' access to credit. This generates a drop in spending by borrowers and a global recession.

In this setting, governments perceive that they can mitigate the output loss during the recession by limiting the debt taken by borrowers in period 0. The rationale is that borrowers will then enter period 1 with higher wealth, and use the wealth increase to spend more. Once this policy is implemented on a global scale, however, the fall in borrowers' debt is matched by a drop in the assets held by savers. Savers will then enter period 1 with lower wealth. The associated drop in the global supply of savings leads to a rise in the world interest rate during the liquidity trap, generating expansionary spillovers across countries. In this example, therefore, prudential interventions by governments aiming at reducing ex-ante debt produce positive international aggregate demand externalities.

These two examples suggest that in a setting with symmetric countries and domestic heterogeneity prudential policies can generate complex international spillovers. Our, rather tentative, conclusion is then that international coordination in the design of prudential policies is desirable also when countries are symmetric. More research, however, is needed to understand the exact form that this coordination should take.

6 Conclusion

In this paper we have shown that during a global liquidity trap governments have an incentive to complement monetary policy with prudential financial and fiscal policies. These policy interventions increase national savings and improve the current account in good times, in order to sustain aggregate demand and employment in the event of a future liquidity trap. The key insight of the paper is that, however, prudential policies might backfire if implemented on a global scale. The reason is that prudential policies increase the global supply of savings and depress global demand. In turn, the drop in global demand exacerbates the output and welfare losses due to the zero lower bound constraint on monetary policy. This effect, which we refer to as the *paradox of global thrift*, might be so strong so that both global output and welfare end up being reduced by the implementation of well-intended prudential policies.

These results suggest that during global liquidity traps international cooperation is needed in order to exploit the stabilization properties of prudential policies. Thus, a natural next step in this research program is to evaluate the macroeconomic impact of different forms of international cooperation. Ideally, one would want to derive the optimal cooperative policy. While this task is feasible in the stylized model of Section 2, matters become much more complicated once the framework is extended along the dimensions described in Section 5. For this reason, we have left the characterization of the optimal cooperative policy to future research. Alternatively, one could study simpler forms of international cooperation. For instance, in his 1941 plan Keynes proposed to discourage the emergence of excessively large current account surpluses by imposing simple taxes on capital outflows. We believe that our framework represents a useful starting point for future research aiming at evaluating this and other forms of international cooperation during global liquidity traps.

Appendix (for online publication)

A Additional lemmas

Lemma 2 *Suppose that the market for non-tradable goods clears competitively, so that the (AD) and (MP) equations hold, and that the world interest rate* R *and the inflation target* $\bar{\pi}$ *satisfy* $R\bar{\pi} > 1$*. Then there cannot be a stationary equilibrium with* $R^n_{i,t} = 1$ *for all* t*. Moreover if* $C^T_h \geq C^T_l$ *then* $R^n_h > 1$*.*

Proof. To prove the first part of the lemma, consider that in a stationary equilibrium the (AD) equation in the low and high state can be written as

$$Y^N_h = \frac{R\bar{\pi}}{R^n_h}\frac{C^T_h}{C^T_l}Y^N_l \tag{A.1}$$

$$Y^N_l = \frac{R\bar{\pi}}{R^n_l}\frac{C^T_l}{C^T_h}Y^N_h. \tag{A.2}$$

Combining these two expressions gives

$$R^n_h R^n_l = (R\bar{\pi})^2 > 1. \tag{A.3}$$

Since $R^n_{i,t} \geq 1$ then $\max\left\{R^N_h, R^N_l\right\} > 1$.

We now prove that if $C^T_h \geq C^T_l$ then $R^n_h > 1$. Suppose that this is not the case and $R^n_h = 1$. We have just proved that if $R^h_h = 1$ then $R^n_l > 1$, and so $Y^N_l = 1$. We can thus write the (AD) equation in the high state as

$$Y^N_h = R\bar{\pi}C^T_h/C^T_l. \tag{A.4}$$

$R\bar{\pi} > 1$ and $C^T_h \geq C^T_l$ imply that the right-hand side is larger than one. Since $Y^N_h \leq 1$, we have found a contradiction. So $C^T_h \geq C^T_l$ implies $R^n_h > 1$.

B Proofs

B.1 Proof of Proposition 1

Proposition 1 ***Non-tradable market equilibrium under laissez faire.*** *In a laissez-faire equilibrium with vanishing liquidity if* $R^{lf} \geq R^* \equiv (\bar{\pi}\beta)^{-1/2}$ *then* $Y^N_h = Y^N_l = 1$ *, otherwise* $Y^N_h = 1$ *and* $Y^N_l = (R^{lf}/R^*)^2 < 1$*.*

Proof. Since we are considering a stationary equilibrium satisfying $R\bar{\pi} > 1$ and $C^T_h > C^T_l$, Lemma 2 applies and so $R^n_h > 1$. By the (MP) equation then $Y^N_h = 1$. The (AD) equation in the low state can then be written as

$$Y^N_l = \frac{R\bar{\pi}}{R^n_l}\frac{C^T_l}{C^T_h} = \frac{R^{lf}\bar{\pi}}{R^n_l}\frac{Y^T_l}{Y^T_h},$$

where the second equality makes use of the equilibrium relationships $R = R^{lf}$, $C_h^T = Y_h^T$ and $C_l^T = Y_l^T$. Define $R^* \equiv (\bar{\pi}\beta)^{-1/2}$. Combining the expression above with (15) and (MP), gives that if $R^{lf} \geq R^*$, then $Y_l^N = 1$ and $R_l^n \geq 1$, otherwise $R_l^n = 1$ and $Y_l^N = (R^{lf}/R^*)^2 < 1$.

B.2 Proof of Proposition 2

Proposition 2 ***National planner allocation.*** *Suppose that $1/\bar{\pi} < R < 1/\beta$. Define $\bar{R}^* \equiv (\omega/(\bar{\pi}\beta))^{1/2}$. A stationary solution to the national planning problem satisfies $B_l = 0$ and $B_h = \max\{\mathcal{B}_h^p(R), 0\}$, where the function $\mathcal{B}_h^p(R)$ is defined by*

$$\mathcal{B}_h^p(R) = \begin{cases} \frac{\beta}{\omega+\beta}\left(Y_h^T - \frac{\omega Y_l^T}{\beta R}\right) & \text{if } R < \bar{R}^* \\ \frac{Y_h^T - R\bar{\pi}Y_l^T}{1+R^2\bar{\pi}} & \text{if } \bar{R}^* \leq R < R^* \\ \frac{\beta}{1+\beta}\left(Y_h^T - \frac{Y_l^T}{\beta R}\right) & \text{if } R^* \leq R. \end{cases} \tag{B.1}$$

Moreover, $\bar{\mu}_h > 0$ if $\mathcal{B}_h^p(R) < 0$, otherwise $\bar{\mu}_h = 0$. Finally, $Y_h^N = 1$ and $Y_l^N = \min\{1, R\bar{\pi}(Y_l^T + RB_h)/(Y_h^T - B_h)\}$.

Proof. We break down the proof in several steps. We start by proving the the zero lower bound does not bind in the high state, and then we show that the borrowing constraint binds in the low state.

1. Zero lower bound does not bind in high state ($\bar{\upsilon}_h = 0, Y_h^N = 1$). Suppose that $\bar{\upsilon}_h > 0$ and $R_h^n = 1$. Since Lemma 2 applies then $R_l^n > 1$, $Y_l^N = 1$ and $C_l^T > C_h^T$. But $C_l^T > C_h^T$ only if $B_h > 0$ and so if $\bar{\mu}_h = 0$. We can then write the Euler equation (30) in the high state as

$$\frac{\omega + \bar{\upsilon}_h Y_h^N}{C_h^T} = \beta R \frac{\omega}{C_l^T} - \bar{\upsilon}_h Y_h^N \frac{\partial C_l^T/\partial B_h}{C_l^T}. \tag{B.2}$$

Since $\beta R < 1$ and $\partial C_l^T/\partial B_h \geq 0$, this expression implies $C_l^T < C_h^T$. We have thus reached a contradiction and proved that $\bar{\upsilon}_h = 0$ and $Y_h^N = 1$.

2. Borrowing constraint binds in low state ($\bar{\mu}_l > 0$). Suppose instead that $\bar{\mu}_l = 0$. Thus, considering that $Y_h^N = 1$ and $\bar{\upsilon}_h = 0$, the Euler equation (30) in the low state implies

$$\frac{\omega + \bar{\upsilon}_l Y_l^N}{C_l^T} = \beta R \frac{\omega}{C_h^T} - \bar{\upsilon}_l Y_l^N \frac{\partial C_h^T/\partial B_l}{C_h^T}. \tag{B.3}$$

Since $\beta R < 1$ and $\partial C_h^T/\partial B_l \geq 0$, the following condition needs to hold $C_h^T < C_l^T$. Since $Y_h^T > Y_l^T$ and $B_l \geq 0$, this is possible only if $B_h > 0$ and so if $\bar{\mu}_h = 0$. Then the Euler equation (30) in the high state is

$$\frac{\omega}{C_h^T} = \beta R \frac{\omega + \bar{\upsilon}_l Y_l^N}{C_l^T}. \tag{B.4}$$

By combining (B.3) and (B.4), and using $\partial C_h^T/\partial B_l \geq 0$, we obtain $\beta R \geq 1$. This contradicts the condition $\beta R < 1$. Thus, it must be that $\bar{\mu}_l > 0$.

We now derive the function $\mathcal{B}_h^p(R)$. This function captures the planner's demand for bonds in the high state (B_h) when the borrowing constraint does not bind $\bar{\mu}_h = 0$.

3. $\mathcal{B}_h^p(R)$ **for** $R \geq R^*$**.** We start by showing that if $\bar{\mu}_h = 0$ then $\bar{v}_l = 0$. Suppose instead that $\bar{v}_l > 0$. Since $\bar{v}_h = 0$, we can write (30) as

$$\frac{\omega}{C_h^T} = \frac{\beta R}{C_l^T}\left(\omega + \bar{v}_l Y_l^N\right). \tag{B.5}$$

It must then be that $C_l^T / C_h^T > \beta R$. Using the (AD) in the low state we can then write

$$Y_l^N = \bar{\pi} R C_l^T / C_h^T > \bar{\pi}\beta R^2. \tag{B.6}$$

Since $Y_l^N \leq 1$, the expression above implies $\bar{\pi}\beta R^2 < 1$. Since we are focusing on the case $R \geq R^*$ we have found a contradiction and proved that $\bar{v}_l = 0$.

Hence, (B.5) implies that $\beta R C_h^T = C_l^T$. Using the resource constraint it is then easy to show that if $\bar{\mu}_h = 0$ then

$$B_h = \frac{\beta}{1+\beta}\left(Y_h^T - \frac{Y_l^T}{\beta R}\right).$$

4. $\mathcal{B}_h^p(R)$ **for** $R^* > R \geq \bar{R}^*$**.** Using the same logic of step 3 above, it is easy to check that if $R < R^*$ and $\bar{\mu}_h = 0$ then $\bar{v}_l > 0$. We start by showing that for $R^* > R \geq \bar{R}^*$ if $\bar{\mu}_h = 0$ then the economy operates at full employment in the low state ($Y_l^N = 1$). We can write (30) in the high state as

$$\frac{\omega}{C_h^T} = \frac{\beta R}{C_l^T}(\omega + \bar{v}_l Y_l^N) = \frac{\beta R}{C_l^T}(1 - \bar{\nu}_l), \tag{B.7}$$

where the second equality makes use of $Y_l^N = 1$ and (25). Moreover, since $\bar{v}_l > 0$ the (AD) equation in the low state implies

$$1 = R\bar{\pi} C_l^T / C_h^T. \tag{B.8}$$

Combining $(B.7)$ and $(B.8)$ gives

$$1 = \frac{\bar{\pi}\beta R^2 (1 - \bar{\nu}_l)}{\omega}. \tag{B.9}$$

Since we are free to set $\bar{\nu}_l$ to any non-negative number, the expression above implies that a sufficient condition for $Y_l^N = 1$ to be a solution is that $R \geq (\omega/(\bar{\pi}\beta))^{1/2} \equiv \bar{R}^*$. We have thus proved that if $R^* > R \geq \bar{R}^*$ and $\bar{\mu}_h = 0$ then $\mathrm{Y}_l^N = 1$.

To solve for B_h, again assuming $\bar{\mu}_h = 0$, we can use $(B.8)$, $C_h^T = Y_h^T - B_h$ and $C_l^T = Y_l^T + RB_h$ to write

$$B_h = \frac{Y_h^T - R\bar{\pi} Y_l^T}{1 + R^2\bar{\pi}}. \tag{B.10}$$

5. $\mathcal{B}_h^p(R)$ **for** $R < \bar{R}^*$**.** Suppose that the equilibrium is such that $\bar{\mu}_h = 0$. From the logic above we know that $\bar{v}_l > 0$ and $Y_l^N < 1$. We set $\bar{\nu}_l = 0$ and we use (25) to obtain $\bar{v}_l = (1 - \omega)/Y_l^N$. Plugging this condition in the Euler equation for the high state gives

$$\frac{C_l^T}{C_h^T} = \frac{\beta R}{\omega}. \tag{B.11}$$

By combining the expression above with (??) we can write

$$Y_l^N = \bar{\pi}\frac{\beta R^2}{\omega} < 1. \tag{B.12}$$

To solve for B_h, again assuming that $\bar{\mu}_h = 0$, we use $C_h^T = \beta R C_l^T/\omega$, $C_h^T = Y_h^T - B_h$ and $C_l^T = Y_l^T + RB_h$ to write

$$B_h = \frac{\beta}{\omega+\beta}\left(Y_h^T - \frac{\omega Y_l^T}{\beta R}\right). \tag{B.13}$$

6. Solution to the planning problem. We have showed that $B_l = 0$ and $B_h = \max\left\{\mathcal{B}_h^p(R), 0\right\}$. Moreover, we have proved that $Y_h^N = 1$. Using $C_h^T = Y_h^T - B_h$ and $C_l^T = Y_l^T + RB_h$ we can then write output in the low state as $Y_l^N = \min\left\{1, R\bar{\pi}(Y_l^T + RB_h)/(Y_h^T - B_h)\right\}$.

B.3 Proof of Corollary 3

Corollary 4 *Consider a small open economy facing the world interest rate R^{lf}. If $R^{lf} < R^*$ the national planner allocation features higher Y_l^N, B_h and welfare compared to laissez faire, otherwise the two allocations coincide.*

Proof. Since $1/\bar{\pi} < R^{lf} < 1/\beta$ Proposition 2 applies. It is then straightforward to check that if $R^{lf} \geq R^*$ the two allocations coincide (and feature $Y_l^N = 1$ and $B_h = 0$), while if $R^{lf} < R^*$ then the planning allocation features higher Y_l^N and B_h compared to laissez faire.

We are left to prove that if $R^{lf} < R^*$ the planning allocation features higher welfare compared to laissez faire. For households living in a country in the high-endowment state, the expected lifetime utility associated to $(C_h^T, C_l^T, Y_h^N, Y_l^N)$ is

$$\mathcal{W} = \frac{1}{1-\beta^2}\left(\omega \log C_h^T + (1-\omega)\log Y_h^N + \beta\left(\omega \log C_l^T + (1-\omega)\log Y_l^N\right)\right) \tag{B.14}$$

Let us start from the laissez-faire case. Since $R = R^{lf}$, the Euler equation for high-state countries holds with equality, meaning that $C_l^T/C_h^T = \beta R^{lf}$. Moreover, the resource constraint for tradable goods (13) and $B_l = 0$ imply

$$C_h^T + \frac{C_l^T}{R^{lf}} = Y_h^T + \frac{Y_l^T}{R^{lf}}. \tag{B.15}$$

We thus have that

$$C_h^T = \frac{1}{1+\beta}\left(Y_h^T + \frac{Y_l^T}{R^{lf}}\right) \tag{B.16}$$

$$C_l^T = \frac{\beta R}{1+\beta}\left(Y_h^T + \frac{Y_l^T}{R^{lf}}\right). \tag{B.17}$$

Finally, $Y_h^N = 1$ and, since $R^{lf} < R^*$,$Y_l^N = R^{lf}\bar{\pi}C_l^T/C_h^T = (R^{lf})^2\bar{\pi}\beta < 1$. We can then write the expected lifetime utility under laissez faire as

$$\mathcal{W}^{lf} = \frac{1}{1-\beta^2}\left(\omega\log\left(\frac{1}{1+\beta}\right) + \beta\left(\omega\log\left(\frac{\beta R^{lf}}{1+\beta}\right) + (1-\omega)\log\left((R^{lf})^2\bar{\pi}\beta\right)\right) + (1+\beta)\omega\log\left(Y_h^T + \frac{Y_l^T}{R^{lf}}\right)\right). \tag{B.18}$$

Turning to the planning allocation, start by considering the case $R^{lf} < \bar{R}^*$. Then $C_l^T/C_h^T = \beta R^{lf}/\omega$ and so

$$C_h^T = \frac{\omega}{\omega+\beta}\left(Y_h^T + \frac{Y_l^T}{R^{lf}}\right) \tag{B.19}$$

$$C_l^T = \frac{\beta R^{lf}}{\omega+\beta}\left(Y_h^T + \frac{Y_l^T}{R^{lf}}\right). \tag{B.20}$$

Moreover $Y_h^N = 1$ and, since $R^{lf} < \bar{R}^*$ then $Y_l^N = R^{lf}\bar{\pi}C_l^T/C_h^T = (R^{lf})^2\bar{\pi}\beta/\omega$.We can then write the expected lifetime utility under the planning allocation as

$$\mathcal{W}^p = \frac{1}{1-\beta^2}\left(\omega\log\left(\frac{\omega}{\omega+\beta}\right) + \beta\left(\omega\log\left(\frac{\beta R^{lf}}{\omega+\beta}\right) + (1-\omega)\log\left((R^{lf})^2\bar{\pi}\beta/\omega\right)\right) + (1+\beta)\omega\log\left(Y_h^T + \frac{Y_l^T}{R^{lf}}\right)\right) \tag{B.21}$$

After some algebra, the difference in welfare between the planning and the laissez-faire allocations can be written as

$$\mathcal{W}^p - \mathcal{W}^{lf} = \frac{1}{1-\beta^2}\left(\omega(1+\beta)\left(\log(1+\beta) - \log(\omega+\beta)\right) + (\omega - \beta(1-\omega))\log\omega\right) \equiv \mathcal{F}(\omega). \tag{B.22}$$

We now show that the function $\mathcal{F}(\omega)$ satisfies $\mathcal{F}(\omega) > 0$ for $0 < \omega < 1$. First consider that $\mathcal{F}(1) = 0$. Moreover, differentiating $(B.22)$ with respect to ω and rearranging the resulting expression, we have that

$$\mathcal{F}'(\omega) = \frac{1}{1-\beta^2}\left((1+\beta)\left(\log\left(\frac{\omega(1+\beta)}{\omega+\beta}\right)\right) - \frac{\beta^2(1-\omega)}{\omega(\omega+\beta)}\right). \tag{B.23}$$

This expression implies that $\mathcal{F}'(\omega) < 0$ for $0 < \omega < 1$. It must then be that $\mathcal{F}(\omega) > 0$ for $0 < \omega < 1$. We have thus proved that the planning allocation attains higher welfare compared to the laissez faire one.

To conclude the proof, we turn to the case $\bar{R}^* \leq R^{lf} < R^*$. In this case the planning allocation features $Y_h^N = 1$ and $Y_l^N = R^{lf}\bar{\pi}C_l^T/C_h^T = 1$. Since $C_l^T/C_h^T = 1/(R^{lf}\bar{\pi})$ we have

$$C_h^T = \frac{\bar{\pi}(R^{lf})^2}{1+\bar{\pi}(R^{lf})^2}\left(Y_h^T + \frac{Y_l^T}{R^{lf}}\right) \tag{B.24}$$

$$C_l^T = \frac{R^{lf}}{1+\bar{\pi}(R^{lf})^2}\left(Y_h^T + \frac{Y_l^T}{R^{lf}}\right). \tag{B.25}$$

After a few steps of algebra, and defining $x \equiv (R^{lf})^2\bar{\pi}$, we can then write

$$\mathcal{W}^p - \mathcal{W}^{lf} = \frac{1}{1-\beta^2}\left(\omega(1+\beta)\log\left(\frac{x(1+\beta)}{1+x}\right) - \beta\log(\beta x)\right) \equiv \mathcal{G}(x). \tag{B.26}$$

Now notice that $\omega/\beta < x < 1/\beta$ and $\mathcal{G}(1/\beta) = 0$. Now differentiating the function $\mathcal{G}(x)$ gives

$$\mathcal{G}'(x) = \omega(1+\beta)\left(\frac{1}{x} - \frac{1}{1+x}\right) - \frac{\beta}{x}. \tag{B.27}$$

Using the fact that $x \geq \omega/\beta$ and $\omega < 1$ one can then check that $\mathcal{G}'(x) < 0$ for $\omega/\beta < x < 1/\beta$. It must then be that $\mathcal{G}(x) > 0$ for $\omega/\beta < x < 1/\beta$. We have thus completed the proof by showing that the planning allocation attains higher welfare compared to laissez faire when $\bar{R}^* \leq R^{lf} < R^*$.[45]

B.4 Proof of Proposition 3

Proposition 3 ***Global equilibrium with current account policies.*** *Suppose that $R^{lf} < R^*$ and $\omega R^{lf}\bar{\pi} > 1$. Then in a vanishing-liquidity equilibrium with current account policies $R = R^p \equiv \omega R^{lf}$. Moreover, for every country output and welfare are lower in the equilibrium with current account policies compared to the laissez-faire one.*

Proof. In a vanishing-liquidity equilibrium with current account policies it must be that $\mathcal{B}_h^p(R) = 0$ (so that $B_h = 0$ and $\bar{\mu}_h = 0$). We now show that if $R^{lf} < R^*$ then there exist a unique equilibrium world interest rate $R = R^p = \omega R^{lf}$.

We will consider ranges of R for which $R\bar{\pi} > 1$, so that Proposition 2 applies.[46] Clearly $R \geq R^*$ can't be a solution. In fact, for $R \geq R^*$ the demand for bonds by national planners coincide with the one under laissez faire, and so $\mathcal{B}_h^p(R) > 0$. Moreover, $\bar{R}^* \leq R < R^*$ can't be a solution either. Consider that $\mathcal{B}_h^p(R^*) > 0$, and that over the range $\bar{R}^* \leq R^p < R^*$ we have $\mathcal{B}_h^{p'}(R) > 0$. This implies that there can't be a $\bar{R}^* \leq R < R^*$ such that $\mathcal{B}_h^p(R) = 0$. The equilibrium interest rate must then satisfy $R < \bar{R}^*$. But, from Proposition 2, in this range $\mathcal{B}_h^p(R) = 0$ only if $R = R^p \equiv \omega R^{lf}$. We then have that the equilibrium world interest rate is $R^p < R^{lf}$.

We now show that Y_l^N and welfare are lower with current account interventions compared to laissez faire. Independently of whether governments intervene on the credit markets $C_l^T = Y_l^T, C_h^T = Y_h^T$ and $Y_h^N = 1$. Moreover, we can write non-tradable output in the low state as

$$Y_l^N = \min\left(R\bar{\pi}Y_l^T/Y_h^T, 1\right).$$

Since $R^p < R^{lf}$ it immediately follows that Y_l^N is lower in the equilibrium with current account policy than in the laissez-faire equilibrium. Since the impact on welfare of credit market interventions is fully determined by Y_l^N, it follows that also welfare is lower in the equilibrium with current account policy than in the laissez-faire equilibrium

B.5 Proof of Proposition 4

Proposition 4 ***Multiple equilibria with current account policies.*** *Suppose that $R^{lf} \geq R^*$. Then there exists a vanishing-liquidity equilibrium with current account policies with $R = R^{lf}$. This equilibrium is isomorphic to the laissez-faire one. However, if $\omega R^{lf} < R^*$ and $\omega R^{lf}\bar{\pi} > 1$, there exists at least another equilibrium with current account policies associated with a world interest rate $R = R^p \equiv \omega R^{lf}$. This equilibrium features lower output and welfare than the laissez-faire one.*

[45] Following the same steps, it is easy to show that the same welfare result applies to countries in the low state.

[46] By assumption, this condition holds for $R \geq R^p$. For completeness, if $R < R^p$ it might be that $R\bar{\pi} < 1$. But in this case, as we discuss in Appendix F, an equilibrium does not exist.

Proof. In an equilibrium with vanishing liquidity it must be that $\mathcal{B}_h^p(R) = 0$ (so that $B_h = 0$ and $\bar{\mu}_h = 0$). Notice that $R = R^{lf}$ is an equilibrium. This is the case because for $R^{lf} \geq R^*$ Proposition 2 implies that the demand for bonds with current account interventions and under laissez faire coincide. If $R^p \equiv \omega R^{lf} \geq R^*$, this is the unique solution, because the demand for bonds are independent of current account interventions for any value of R. Now assume that $R^p < R^*$. Since by assumption $R^p\bar{\pi} > 1$, the results in Proposition 2 apply. Then there exists a second solution $R = R^p$, because $\mathcal{B}_h^p(R^p) = 0$. Moreover, since $R^p < R^*$ this second solution corresponds to a global liquidity trap. The welfare statement can be proved following the steps in the proof to Proposition 4.

B.6 Proof of Proposition 5

Proposition 5 ***Global equilibrium with current account policies and positive liquidity.*** *Suppose that $Y_l^T = 0$, $((\omega/\beta + 1)\bar{B}/Y_h^T)^{1/\phi}\bar{R}\bar{\pi} > 1$ and that under laissez faire the world is stuck in global liquidity trap. Then if $\phi < \phi^*$, for every country output and welfare are lower in the equilibrium with current account policies compared to the laissez-faire one. ϕ^* is such that $\omega^{\phi^*/2} = (\omega + \beta)/(1 + \beta)$.*

Proof. We start by showing that if $\phi < \phi^*$ then $Y_l^{Nlf} > Y_l^{Np}$. To solve for Y_l^{Nlf}, consider that in a laissez faire equilibrium $\beta R C_h^T = C_l^T$. Using $C_h^T = Y_h^T - 2B^{row}$ and $C_l^T = 2RB^{row}$ gives

$$R^{lf} = \left(\frac{1+\beta}{\beta}\frac{\bar{B}}{Y_h^T}\right)^{\frac{1}{\phi}} \bar{R}.$$

Since $\bar{\pi}R^{lf} > 1$ and $C_h^T > C_l^T$ Lemma 2 implies $Y_h^{Nlf} = 1$. Output in the low state is then given by $Y_l^{Nlf} = \bar{\pi}R^{lf}C_l^T/C_h^T = \bar{\pi}\beta(R^{lf})^2$.

Turning to the equilibrium with current account policies, let us guess and verify that if $\phi < \phi^*$ then $Y_l^{Np} < 1$. Following the steps outlined in the proof to Proposition **??**, one finds that in the equilibrium with current account policies $\beta R C_h^T = \omega C_l^T$, while the equilibrium world rate is

$$R^p = \left(\frac{\omega+\beta}{\beta}\frac{\bar{B}}{Y_h^T}\right)^{\frac{1}{\phi}} \bar{R}.$$

Since $\bar{\pi}R^p > 1$ and $C_h^T > C_l^T$ then $Y_h^{Np} = 1$. Output in the low state is then given by $Y_l^{Np} = \bar{\pi}R^pC_l^T/C_h^T = \bar{\pi}\beta(R^p)^2/\omega$.

We thus have that $Y_l^{Nlf} > Y_l^{Np}$ if and only if

$$\omega^{\frac{\phi}{2}} > \frac{\omega+\beta}{1+\beta},$$

which holds if $\phi < \phi^*$. Since by assumption $Y_l^{Nlf} < 1$ then we have verified our guess $Y_l^{Np} < 1$.

Concerning welfare, since if $\phi < \phi^*$ then $Y_l^{Np} < Y_l^{Nlf}$, it is sufficient to show that the utility associated with tradable consumption is lower in the equilibrium with current account policies compared to laissez faire. Following the steps in the proof to Corollary 3 one finds that this is the case if

$$\log \frac{\omega}{\omega+\beta} + \beta \log \frac{R^p}{\omega+\beta} - \log \frac{1}{1+\beta} + \beta \log \frac{R^{lf}}{1+\beta} < 0.$$

Since $R^p < R^{lf}$, the inequality above holds if

$$(1+\beta)\log\left(\frac{1+\beta}{\omega+\beta}\right) + \log \omega < 0.$$

The left-hand side of this inequality is equal to zero for $\omega = 1$, and it is easy to check that it is increasing in ω for $0 < \omega < 1$. Hence, the inequality above holds for $0 < \omega < 1$. We have thus proved that welfare is lower when current account policies are implemented.

B.7 Proof of Proposition 6

Proposition 6 ***Current account policies in the run-up to a global crisis.*** *Suppose that $\bar{\pi} \leq \beta_h \leq (\bar{\pi} Y_l^T / Y_h^T)^2/\beta$ and that $\beta_h > \tilde{\beta}_h$. Then in a vanishing-liquidity equilibrium with current account policies global output and the world interest rate in period 0 are lower than under laissez faire. From $t = 1$ on the two allocations coincide.*

Proof. Allocation under laissez faire. We start by deriving the allocation under laissez faire. Consumption of tradable goods follows the autarky path $C_{i,t}^T = Y_{i,t}^T$ and the equilibrium world interest rate is given by (33).

From period 2 on the economy enters a steady state in which the world interest rate is equal to $R^{lf} = Y_l^T/(\beta Y_h^T)$. We now guess and verify that in this steady state all the countries operate at full employment. Imagine that $Y_{i,t+1}^N = 1$ for all i and $t \geq 2$. We can then write

$$Y_{h,t}^N = \min\left(R^{lf}\bar{\pi}\frac{Y_h^T}{Y_l^T}, 1\right) \tag{B.28}$$

$$Y_{l,t}^N = \left(R^{lf}\bar{\pi}\frac{Y_l^T}{Y_h^T}, 1\right), \tag{B.29}$$

for $t \geq 2$. It follows that if $\bar{\pi}/\beta(Y_l^T/Y_h^T)^2 > 1$ then $Y_{h,t}^N = Y_{l,t}^N = 1$ for $t \geq 2$. But this is the case under our assumption $\bar{\pi} \leq \beta_h \leq (\bar{\pi} Y_l^T/Y_h^T)^2/\beta$. This verifies our initial guess and proves that the world operates at full employment from period $t = 2$ on.

We now turn to period 1. Using $R_1^{lf} = Y_l^T/(\beta_h Y_h^T)$ and $Y_{h,2}^N = Y_{l,2}^N = 1$, one finds that

$$Y_{h,1}^N = \min\left(\frac{\bar{\pi}}{\beta_h}, 1\right) \tag{B.30}$$

$$Y_{l,1}^N = \left(\frac{\bar{\pi}}{\beta_h}\left(\frac{Y_l^T}{Y_h^T}\right)^2, 1\right), \tag{B.31}$$

Our assumption $\bar{\pi} < \beta_h$ then implies that every country operates below full employment in period 1.

Finally, using $R_0^{lf} = Y_l^T/(\beta Y_h^T)$ and the expressions for $Y_{h,1}^N$ and $Y_{l,1}^N$ derived above, one finds that in period 0 output is given by

$$Y_{h,0}^N = Y_{l,0}^N = \min\left(\frac{\bar{\pi}^2}{\beta\beta_h}\left(\frac{Y_l^T}{Y_h^T}\right)^2, 1\right). \tag{B.32}$$

Condition $\beta_h \leq (\bar{\pi}Y_l^T/Y_h^T)^2/\beta$ then implies that $Y_{h,0}^N = Y_{l,0}^N = 1$.

Allocation with current account policies. We start by solving the planning problem in a country that is in the high state in period 0. We are interested in deriving conditions under which output is below potential in periods 0 and 1. Hence, will focus on allocations such that $Y_{h,0}^N < 1$ and $Y_{l,1}^N < 1$. We will also restrict attention to allocations in which the borrowing constraint binds in period 1, but not in period 0. This will be anyway the case in equilibrium. The planning problem can then be stated as

$$\max_{C_{h,0}^T, C_{l,1}^T, Y_{h,0}^N, Y_{l,1}^N, B_{h,1}} \omega \log C_{h,0}^T + (1-\omega)\left(\log Y_{h,0}^N - Y_{h,0}^N\right) + \beta\left(\omega \log C_{l,1}^T + (1-\omega)\left(\log Y_{l,1}^N - Y_{l,1}^N\right)\right), \tag{B.33}$$

subject to

$$C_{h,0}^T = Y_h^T - B_{h,1} \tag{B.34}$$

$$C_{l,1}^T = Y_l^T + R_0 B_{h,1} \tag{B.35}$$

$$Y_{h,0}^N = R_0 \bar{\pi} \frac{C_{h,0}^T}{C_{l,1}^T} Y_{l,1}^N \tag{B.36}$$

$$Y_{l,1}^N = R_1 \bar{\pi} \frac{C_{l,1}^T}{C_{h,2}^T}. \tag{B.37}$$

Notice that, since the borrowing constraint binds in period 1, the period 0 planner cannot affect the allocation from $t = 2$ on (and hence takes $C_{h,2}^T$ as given).

The solution to this planning problem can be summarized with the planner's Euler equation[47]

$$\frac{\omega + (1-\omega)(1 - Y_{h,0}^N)}{C_{h,0}^T} = \frac{\beta R_0 \left(\omega + (1-\omega)(1 - Y_{l,1}^N)\right)}{C_{l,1}^T}. \tag{B.38}$$

Notice that as long as $Y_{h,0}^N < 1$ or $Y_{l,1}^N < 1$ this Euler equation diverges from the households' one. As in the baseline model, the planner wants to alter the path of tradable consumption whenever the economy operates below full employment. In particular, the term $(1-\omega)(1 - Y_{l,1}^N)$ captures the planner's incentive to increase national savings in period 0 when the zero lower bound binds in period 1.

[47] Without disutility from labor, instead, were the zero lower bound to bind in periods 0 and 1 the planner Euler equation would coincide with the households' one (and hence in equilibrium current account policies would never depress R_0 enough to trigger a recession in period 0). To understand why this happens, consider that the planner perceives that increasing savings in period 0 is beneficial because it increases output in period 1. But the planner also perceives that this comes at the cost of lower output and utility in period 0. Without disutility from working, these two effects exactly cancel out. In presence of disutility from working, instead, as long as the output gap is larger in period 1 ($Y_{l,1}^N < Y_{h,0}^N$) the first effect prevails, pushing the planner to save more than what households would do.

Similarly, the solution to the planning problem in a country which is in the low state in period 0 is captured by the Euler equation

$$\frac{\omega + (1-\omega)(1-Y_{l,0}^N)}{C_{l,0}^T} = \frac{\beta R_0 \left(\omega + (1-\omega)(1-Y_{h,1}^N)\right)}{C_{h,1}^T} + \bar{\mu}_{l,0}. \tag{B.39}$$

Here we take explicitly into account the fact that the borrowing constraint might bind in period 0 ($\bar{\mu}_{l,0} > 0$). In fact, this is going to be the case in equilibrium.

In equilibrium, tradable consumption must follow its autarky path and so $C_{l,0}^T = C_{l,1}^T = Y_l^T$ and $C_{h,0}^T = C_{h,1}^T = Y_h^T$. Moreover, with zero liquidity current account policies implemented in period 0 cannot alter the allocation in period 1. Hence, $Y_{l,1}^N$ and $Y_{h,1}^N$ are equal to their values under laissez faire. Moreover, it is easy to check that in period 0 all the countries have the same output ($Y_{h,0}^N = Y_{l,0}^N$).

We now solve for the equilibrium interest rate in period 0. Combining the results above with (B.38) and (B.39) gives $\bar{\mu}_{l,0} > 0$. Hence, the equilibrium interest rate solves

$$R_0 = \frac{Y_l^T}{\beta Y_h^T} \frac{\omega + (1-\omega)(1-Y_{h,0}^N)}{\omega + (1-\omega)(1-Y_{l,1}^N)}. \tag{B.40}$$

Using the expressions for equilibrium output, we can simplify the equation above to

$$R_0 = \frac{Y_l^T}{Y_h^T \left(\beta + (1-\omega) Y_1^N (\bar{\pi} - \beta)\right)} \equiv R_0^p. \tag{B.41}$$

Since by assumption 1 $\beta < \bar{\pi}$, then $R_0^p < R_0^{lf}$ and so current account policies depress the interest rate in period 0 compared to laissez faire.

To conclude the proof, we derive the condition under which output in period 0 is below full employment. Combining (B.36) and (B.41) one finds that this is the case if

$$\beta_h > \tilde{\beta}_h \equiv (\bar{\pi}\omega + (1-\omega)\beta)\frac{\bar{\pi}}{\beta}\left(\frac{Y_l^T}{Y_h^T}\right)^2. \tag{B.42}$$

Hence, if the rise in the discount factor in period 1 is sufficiently strong, current account policies will push the world rate low enough to generate a recession in period 0. In this case, the implementation of current account policies depresses period 0 output below its value under laissez faire.

C Microfoundations for the zero lower bound constraint

In this appendix we provide some possible microfoundations for the zero lower bound constraint assumed in the main text. First, let us introduce an asset, called money, that pays a private return equal to zero in nominal terms.[48] Money is issued exclusively by the government, so that the stock

[48] Here we focus on the role of money as a saving vehicle, and abstract from other possible uses. More formally, we place ourselves in the cashless limit, in which the holdings of money for purposes other that saving are infinitesimally small.

of money held by any private agent cannot be negative. Moreover, we assume that the money issued by the domestic government can be held only by domestic agents.

We modify the borrowing limit (3) to

$$B_{i,t+1} + \frac{B^n_{i,t+1}}{P^T_{i,t}} + \frac{M_{i,t+1}}{P^T_{i,t}} \geq -\kappa_{i,t},$$

where $M_{i,t+1}$ is the stock of money held by the representative household in country i at the end of period t. The optimality condition for money holdings can be written as

$$\frac{\omega}{C^T_{i,t}} = \frac{P^T_{i,t}}{P^T_{i,t+1}} \frac{\beta\omega}{C^T_{i,t+1}} + \mu_{i,t} + \mu^M_{i,t},$$

where $\mu^M_{i,t} \geq 0$ is the Lagrange multiplier on the non-negativity constraint for private money holdings, divided by $P^T_{i,t}$. Combining this equation with (5) gives

$$\left(R^n_{i,t} - 1\right) \frac{\beta\omega}{C^T_{i,t+1}} = \mu^M_{i,t} \frac{P^T_{i,t+1}}{P^T_{i,t}}.$$

Since $\mu^M_{i,t} \geq 0$, this expression implies that $R^n_{i,t} \geq 1$. Moreover, if $R^n_{i,t} > 1$, then agents choose to hold no money. If instead $R^n_{i,t} = 1$, agents are indifferent between holding money and bonds. We resolve this indeterminacy by assuming that the aggregate stock of money is infinitesimally small for any country and period.

D Optimal discretionary monetary policy

We derive the constrained efficient allocation by taking the perspective of a benevolent central bank that operates in a generic country i, and solves its maximization problem in period τ. For given initial net foreign assets $B_{i,\tau}$ and paths $\{Y^T_{i,t}, \kappa_{i,t}, R_t\}_{t\geq\tau}$, the central bank maximizes equation (1) subject to equations (4), (6), (11), (13) and[49]

$$C^N_{i,t} = \min\left(\frac{R_t \pi_{i,t+1} C^T_{i,t} C^N_{i,t+1}}{R^n_{i,t} C^T_{i,t+1}}, 1\right) \tag{D.1}$$

$$C^N_{i,t} \leq 1, \pi_{i,t} \geq \gamma \quad \text{with complementary slackness} \tag{D.2}$$

$$R^n_{i,t} \geq 1, \tag{D.3}$$

for any $t \geq \tau$. Start by considering that from equations (4), (6), (11) and (13) it is possible to solve for the paths $\{C^T_{i,t}, B_{i,t+1}\}_{t\geq\tau}$ independently of monetary policy. Hence, monetary policy can affect utility only through its impact on $\{C^N_{i,t}\}_{t\geq\tau}$. Moreover, notice that $B_{i,t+1}$ represents the only endogenous state variable of the economy.

We now restrict attention to a central bank that operates under discretion, that is by taking future policies as given. Since monetary policy cannot affect the state variables of the economy,

[49] Constraint ($D.1$) is obtained by combining (AD) and (12) with the restriction $Y^N_{i,t} \leq 1$. Constraint ($D.2$) is obtained by combining (10) with $L_{i,t} = Y^N_{i,t} = C^N_{i,t}$ and $P^N_{i,t} = W_{i,t}$.

it follows that a central bank operating under discretion cannot influence future variables at all. The problem of the central bank can be thus written as

$$\max_{R_{i,\tau}, C^N_{i,\tau}, \pi_{i,\tau}} \log(C^N_{i,\tau}), \tag{D.4}$$

$$C^N_{i,\tau} = \min\left(\nu_{i,\tau}/R^n_{i,\tau}, 1\right) \tag{D.5}$$

$$C^N_{i,\tau} \leq 1, \pi_{i,\tau} \geq \gamma \quad \text{with complementary slackness} \tag{D.6}$$

$$R^n_{i,\tau} \geq 1, \tag{D.7}$$

where $\nu_{i,\tau} \equiv R_\tau \pi_{i,\tau+1} C^T_{i,\tau} C^N_{i,\tau+1}/C^T_{i,\tau+1}$. The central bank takes $\nu_{i,\tau}$ as given because it is a function of present and future variables that monetary policy cannot affect.

The solution to this problem can be expressed as

$$R^n_{i,\tau} \geq 1, C^N_{i,\tau} \leq 1 \quad \text{with complementary slackness.} \tag{D.8}$$

Intuitively, it is optimal for the central bank to lower the policy rate until the economy reaches full employment or the zero lower bound constraint binds. Moreover, it follows from constraint (D.6) that any $\pi_{i,\tau} \geq \gamma$ is consistent with constrained efficiency. In fact, as long as the central bank faces an infinitesimally small cost from deviating from its inflation target $\bar{\pi}$, then the constrained efficient allocation features $\pi_{i,\tau} = \bar{\pi}$.[50] This is exactly the policy implied by the rule (MP).

E Transitional dynamics in the baseline model

In this appendix we briefly describe the transition toward the stationary equilibrium in our baseline model. Because of the zero liquidity assumption, transitional dynamics are extremely simple and take place in a single period.

Consider a case in which the world starts from an arbitrary bond distribution. At the end of period 0, by the zero liquidity assumption, every country holds zero bonds. It follows that

$$C^T_{i,0} = Y^T_{i,0} + R_{-1} B_{i,0}. \tag{E.1}$$

The period 0 world interest rate is then given by

$$R_0 = \frac{1}{\beta} \max_i \left\{ \frac{Y^T_{i,0} + R_{-1} B_{i,0}}{Y^T_{i,1}} \right\}. \tag{E.2}$$

Moreover, output in a generic country i is given by

$$C^N_{i,0} = \min\left\{1, R_0 \bar{\pi} \frac{Y^T_{i,0} + R_{-1} B_{i,0}}{Y^T_{i,1}} C^N_{i,1}\right\}. \tag{E.3}$$

[50] Recall that we are assuming $\bar{\pi} > \gamma$.

From period 1 on the economy converges to the stationary equilibrium described in the main text.

F The case $R\pi \leq 1$

Throughout the paper we have focused on stationary equilibria in which the condition $R\bar{\pi} > 1$ holds. In this appendix we describe what happens when $R\bar{\pi} \leq 1$, in the context of stationary two-period equilibria satisfying the assumptions stated in Section 2.6.

The key observation here is that in a two-period stationary equilibria the following condition must hold

$$R_h^n R_l^n = (R\bar{\pi})^2. \tag{F.1}$$

This condition, which can be derived using the aggregate demand equation, ensures that agents are indifferent between investing in real and nominal bonds. To see this point, consider that the left-hand side captures the domestic-currency return from holding a domestic nominal bond for two periods. Instead, the right-hand side captures the return, again in domestic currency, from holding for two periods an international bond denominated in terms of the tradable good. In a two-period stationary equilibrium, indeed, on average tradable price inflation must be equal to the inflation target, and so $\pi_h^T \pi_l^T = \bar{\pi}^2$.

Let us consider now the case $R\bar{\pi} < 1$. Since $R_{i,t}^n \geq 1$ the arbitrage condition $(F.1)$ breaks down. Intuitively, households would make pure profits from borrowing in terms of the real international bond and investing in the domestic nominal bond. This investment strategy would not violate the borrowing constraint, since the two bonds enter symmetrically in the borrowing limit. But then, obviously, equilibrium on the credit market could not be reached.

One way to interpret this result is that any inflation target such that $\bar{\pi} < 1/R$ is not sustainable. There is a parallel here with the standard New Keynesian model. In the standard New Keynesian model, in fact, the steady state real interest rate is equal to the inverse of the households' discount factor. This steady state condition, coupled with the zero lower bound on the nominal interest rate, implies that there exists a lower bound on the steady state inflation target that the central bank can implement. Following standard practice in the New Keynesian literature, we then focus on values of the inflation target such that condition $(F.1)$ holds.

We now turn to the case $R\bar{\pi} = 1$. In this case the arbitrage condition $(F.1)$ holds with $R_h^n = R_l^n = 1$. Hence, the economy is stuck in a permanent liquidity trap. But then it is easy to check that equilibrium output is not uniquely pinned down. In fact, there are an infinite number of pairs $Y_l^N < Y_h^N \leq 1$ that satisfy the equilibrium conditions on the non-tradable good market. Intuitively, if monetary policy is permanently constrained by the zero lower bound it cannot pin down equilibrium output, which will then depend on agents' expectations.[51] While this case is interesting in principle, it arises only when the parameters satisfy the knife-edge condition $R\bar{\pi} = 1$. For this reason, we abstracted from this special case throughout the paper.

[51]Notice that this is a different source of indeterminacy compared to the one described in Section 4.4. Here, in fact, output is not determined for a given value of the world interest rate R.

G Planning problem under commitment

Under commitment, the planner chooses a sequence $\{C^T_{i,t}, Y^N_{i,t}, B_{i,t+1}\}_t$ to maximize domestic households' utility

$$\sum_{t=0}^{\infty} \beta^t \left(\omega \log(C^T_{i,t}) + (1-\omega)\log(Y^N_{i,t})\right), \tag{G.1}$$

subject to

$$C^T_{i,t} = Y^T_{i,t} - B_{i,t+1} + RB_{i,t} \tag{G.2}$$

$$B_{i,t+1} \geq -\kappa_{i,t} \tag{G.3}$$

$$Y^N_{i,t} \leq 1 \tag{G.4}$$

$$Y^N_{i,t} \leq C^T_{i,t} R\bar{\pi} \frac{Y^N_{t+1}}{C^T_{t+1}}. \tag{G.5}$$

The resource constraints are captured by $(G.2)$ and $(G.4)$. $(G.3)$ implies that the government is subject to the same borrowing constraint imposed by the markets on individual households.[52] Instead, constraint $(G.5)$, which is obtained by combining the (AD) and (MP) equations, encapsulates the requirement that production of non-tradable goods is constrained by private sector's demand.

Notice that, as in the case of discretion, since each country is infinitesimally small, the domestic planner takes the world interest rate R as given. This feature of the planning problem synthesizes the lack of international coordination in the design of current account policies.

The first order conditions of the planning problem can be written as

$$\bar{\lambda}_{i,t} = \frac{\omega}{C^T_{i,t}} + \bar{\upsilon}_{i,t}\frac{Y^N_{i,t}}{C^T_{i,t}} - \bar{\upsilon}_{i,t-1}\frac{Y^N_{i,t-1}}{\beta C^T_{i,t}} \tag{G.6}$$

$$\frac{1-\omega}{Y^N_{i,t}} + \bar{\upsilon}_{i,t-1}\frac{Y^N_{i,t-1}}{\beta Y^N_{i,t}} = \bar{\nu}_{i,t} + \bar{\upsilon}_{i,t} \tag{G.7}$$

$$\bar{\lambda}_{i,t} = \beta R \bar{\lambda}_{i,t+1} + \bar{\mu}_{i,t} \tag{G.8}$$

$$B_{i,t+1} \geq -\kappa_{i,t} \quad \text{with equality if} \quad \bar{\mu}_{i,t} > 0 \tag{G.9}$$

$$Y^N_{i,t} \leq 1 \quad \text{with equality if} \quad \bar{\nu}_{i,t} > 0 \tag{G.10}$$

$$Y^N_{i,t} \leq C^T_{i,t} R\bar{\pi}\frac{Y^N_{t+1}}{C^T_{t+1}} \quad \text{with equality if} \quad \bar{\upsilon}_{i,t} > 0. \tag{G.11}$$

$\bar{\lambda}_{i,t}, \bar{\mu}_{i,t}, \bar{\nu}_{i,t}, \bar{\upsilon}_{i,t}$ denote respectively the nonnegative Lagrange multipliers on constraints $(G.2)$, $(G.3)$, $(G.4)$ and $(G.5)$.

[52] To write this constraint we have used the equilibrium condition $B^n_{i,t+1} = 0$. It is straightforward to show that allowing the government to set $B^n_{i,t+1}$ optimally would not change any of the results.

It is useful to combine (G.6) and (G.8) to obtain

$$\frac{1}{C_{i,t}^T}\left(\omega + \bar{\upsilon}_{i,t}Y_{i,t}^N - \bar{\upsilon}_{i,t-1}\frac{Y_{i,t-1}^N}{\beta}\right) = \frac{\beta R}{C_{i,t+1}^T}\left(\omega + \bar{\upsilon}_{i,t+1}Y_{i,t+1}^N - \bar{\upsilon}_{i,t}\frac{Y_{i,t}^N}{\beta}\right) + \bar{\mu}_{i,t}. \tag{G.12}$$

We are now ready to define an equilibrium with current account policies under commitment.

Definition 5 ***Equilibrium with current account policies under commitment.*** *An equilibrium with current account policies under commitment is a path of real allocations* $\{C_{i,t}^T, Y_{i,t}^N, B_{i,t+1}, \bar{\mu}_{i,t}, \bar{\nu}_{i,t}, \bar{\upsilon}_{i,t}\}_{i,t}$ *and world interest rate* $\{R_t\}_t$*, satisfying* (14), (20), $(G.7)$, $(G.9)$, $(G.10)$, $(G.11)$ *and* $(G.12)$ *given a path of endowments* $\{Y_{i,t}^T\}_{i,t}$*, a path for the borrowing limits* $\{\kappa_{i,t}\}_{i,t}$*, and initial conditions* $\{R_{-1}B_{i,0}\}_i$ *and* $\bar{\upsilon}_{i,-1}$.

G.1 Stationary equilibrium

Under the simplifying assumptions stated in Section 2.6, it is possible to solve analytically for the equilibrium with current account policies under commitment. The following proposition characterizes the allocation for a small open economy as a function of the world interest rate.

Proposition 7 ***National planner allocation under commitment.*** *Suppose that* $1/\bar{\pi} < R < 1/\beta$*. Define* $\bar{R}^{*c} \equiv ((\omega(1+\beta)-1)/(\bar{\pi}\beta^2))^{1/2}$*. A stationary solution to the national planning problem under commitment satisfies* $B_l = 0$ *and* $B_h = \max\{\mathcal{B}_h^{pc}(R), 0\}$*, where the function* $\mathcal{B}_h^{pc}(R)$ *is defined by*

$$\mathcal{B}_h^{pc}(R) = \begin{cases} \frac{\beta^2}{\omega(1+\beta)-1+\beta^2}\left(Y_h^T - \frac{(\omega(1+\beta)-1)Y_l^T}{\beta^2 R}\right) & \text{if } R < \bar{R}^{*c} \\ \frac{Y_h^T - R\bar{\pi}Y_l^T}{1+R^2\bar{\pi}} & \text{if } \bar{R}^{*c} \le R < R^* \\ \frac{\beta}{1+\beta}\left(Y_h^T - \frac{Y_l^T}{\beta R}\right) & \text{if } R^* \le R. \end{cases} \tag{G.13}$$

Moreover, $\bar{\mu}_h > 0$ *if* $\mathcal{B}_h^{pc}(R) < 0$*, otherwise* $\bar{\mu}_h = 0$*. Finally,* $Y_h^N = 1$ *and* $Y_l^N = \min\{1, R\bar{\pi}(Y_l^T + RB_h)/(Y_h^T - B_h)\}$.

Proof. The proof follows the steps of the proof to Proposition 2.

Using Proposition 7, it is easy to derive results similar to the ones in Corollary 3. That is, holding constant the world interest rate at $R = R^{lf} < R^*$, an economy with current account policies will feature higher B_h, Y_l^N and welfare compared to laissez faire. Indeed, even compared to current account interventions under discretion, a planner endowed with the ability to commit will save more during booms, attain higher output during busts and increase overall welfare. Hence, governments endowed with the ability to commit have an incentive to exploit the forward guidance channel of current account policies.

Let us now trace the general equilibrium impact of current account policies under commitment. For concreteness, we consider a scenario in which $R^{lf} < R^*$, that is in which the laissez-faire equilibrium corresponds to a global liquidity trap. The first consideration is that, just as in the case of discretion, in a zero liquidity economy current account policies cannot alter the equilibrium path of tradable consumption. Moreover, following the steps outlined in the proof to Proposition 3, one can see that the equilibrium interest rate with current account policies satisfies

$$R = R^{pc} \equiv \frac{(\omega(1+\beta)-1)Y_l^T}{\beta^2 Y_h^T} < R^{lf}. \tag{G.14}$$

It is then easy to check that equilibrium output satisfies $Y_l^N = R^{pc}\bar{\pi}Y_l^T/Y_h^T < Y_l^{Nlf}$.[53] Hence, also in the case of commitment current account policies have a negative impact on output and, by extension, welfare.

H Model with capital

In this appendix we sketch a version of the model with investment in physical capital. This extension is interesting because physical capital represents a source of liquidity which responds endogenously to changes in the world interest rate. The key message of this appendix is that, just as in the case in which liquidity is provided by an exogenous supply of bonds from rest-of-the-world agents, current account policies have a negative impact on output and welfare if the elasticity of the global supply of liquidity to the world interest rate is low. The only wrinkle here is that this elasticity is determined by the technological forces shaping the production function.

H.1 Setup and definition of equilibria

We now assume that tradable output can be produced using capital, according to the production function

$$F(K_{i,t}) = Q_{i,t}K_{i,t}^{\alpha}H_i^{1-\alpha},$$

where $0 < \alpha < 1$, $Q_{i,t} \geq 0$ denotes productivity in the tradable sector, and $K_{i,t}$ is the stock of capital installed in country i. H denotes a domestic input in fixed supply, and we assume that each household is endowed with one unit of it (so $H_i = 1$ for all i). It takes one unit of tradable output to produce one unit of capital and, as usual, capital has to be installed one period in advance. Moreover, for simplicity, we assume that capital fully depreciates with use.

Capital is freely traded across countries. No arbitrage between capital and bonds then implies

$$R_t = \alpha Q_{i,t+1}K_{i,t+1}^{\alpha-1}. \tag{H.1}$$

Now denote by $A_{i,t}$ the sum of the bond position and investment in capital owned by the representative household in country i. The budget constraint of the representative household in a generic country i is then

$$P_{i,t}^T C_{i,t}^T + P_{i,t}^N C_{i,t}^N + P_{i,t}^T A_{i,t+1} = W_{i,t}L_{i,t} + P_{i,t}^T(Y_{i,t}^T + (1-\alpha)Q_{i,t}K_{i,t}^{\alpha}) + P_{i,t}^T R_{t-1}A_{i,t}. \tag{H.2}$$

[53] The attentive reader will have noticed that, if $R^{lf} < R^*$, for an equilibrium with current account policies to exist it must be that $\omega(1+\beta) > 1$. Intuitively, if this condition fails to hold planners' desire to save is so strong that international credit markets will fail to clear for any value of the world interest rate. This stark result is due to the fact that our simple model abstracts from many factors, such as disutility from working or uncertainty about the occurrence of future liquidity traps, that affect governments' interventions on the current account.

As in the baseline model, households face a lower bound on their the end-of-period wealth position

$$A_{i,t+1} \geq -\kappa_{i,t}. \tag{H.3}$$

Notice that, under these assumptions, bonds and capital are perfect substitutes in the households' portfolio decision. Hence, the composition of wealth between capital and bonds is indeterminate, and only total wealth $A_{i,t}$ is pinned down in equilibrium.[54] We can then write country i market clearing condition for the tradable good as

$$C_{i,t}^T + A_{i,t+1} = Y_{i,t}^T + (1-\alpha)Q_{i,t}K_{i,t}^{\alpha} + R_{t-1}A_{i,t}. \tag{H.4}$$

Moreover, the world market clearing condition for tradable goods $\int_0^1 C_{i,t}^T = \int_0^1 Y_{i,t}^T + \int_0^1 Q_{i,t}K_{i,t}^{\alpha}di$ implies that

$$\int_0^1 A_{i,t+1}di = \int_0^1 K_{i,t+1}di. \tag{H.5}$$

The rest of the equilibrium conditions are the same as in the baseline model. We are now ready to define a competitive equilibrium.

Definition 6 ***Competitive equilibrium with capital.*** *A competitive equilibrium with capital is a path of real allocations* $\{C_{i,t}^T, C_{i,t}^N, Y_{i,t}^N, A_{i,t+1}, K_{i,t+1}, \mu_{i,t}\}_{i,t}$*, policy rates* $\{R_{i,t}^n\}_{i,t}$ *and world interest rate* $\{R_t\}_t$ *satisfying* $(4), (12), (H.1), (H.3), (H.4), (H.5)$*,* (AD) *and* (MP) *given a path of endowments* $\{Y_{i,t}^T\}_{i,t}$*, a path for the borrowing limits* $\{\kappa_{i,t}\}_{i,t}$*, a path for productivity* $\{Q_{i,t}\}_{i,t}$ *and initial conditions* $\{R_{-1}A_{i,0}, K_{i,0}\}_i$*.*

We now define the equilibrium with current account policies. As in the case of zero liquidity, we consider a stationary equilibrium with constant R. Moreover, again as in the case with zero liquidity, we allow the national planner to control the net foreign asset position of the country (i.e. $A_{i,t+1}$), but not its composition between capital and bonds. Finally, we assume that the planner cannot affect foreigners' holdings of the domestic capital stock. Hence, from period $t = 1$ on, the domestic capital stock is determined by condition $(H.1)$. Let $\tilde{Y}_{i,t}^T \equiv Y_{i,t}^T + (1-\alpha)Q_{i,t}K_{i,t}^{\alpha}$. We can then write the national planning problem as

$$V(A_{i,t}, \tilde{Y}_{i,t}^T) = \max_{C_{i,t}^T, Y_{i,t}^N, A_{i,t+1}} \omega \log C_{i,t}^T + (1-\omega)\log Y_{i,t}^N + \beta V(A_{i,t+1}, \tilde{Y}_{i,t+1}^T) \tag{H.6}$$

subject to

$$C_{i,t}^T = \tilde{Y}_{i,t}^T - A_{i,t+1} + RA_{i,t} \tag{H.7}$$

$$A_{i,t+1} \geq -\kappa_{i,t} \tag{H.8}$$

$$Y_{i,t}^N \leq 1 \tag{H.9}$$

[54] This is true because we abstract from unexpected shocks. In presence of unexpected shocks the portfolio composition would matter, because of valuation effects.

$$Y_{i,t}^N \leq C_{i,t}^T R\bar{\pi} \frac{\mathcal{Y}^N(A_{i,t+1}, \tilde{Y}_{i,t+1}^T)}{\mathcal{C}^T(A_{i,t+1}, \tilde{Y}_{i,t+1}^T)}. \tag{H.10}$$

The first order conditions of the planning problem can be written as

$$\bar{\lambda}_{i,t} = \frac{\omega}{C_{i,t}^T} + \bar{\upsilon}_{i,t} \frac{Y_{i,t}^N}{C_{i,t}^T} \tag{H.11}$$

$$\frac{1-\omega}{Y_{i,t}^N} = \bar{\nu}_{i,t} + \bar{\upsilon}_{i,t} \tag{H.12}$$

$$\bar{\lambda}_{i,t} = \beta R \bar{\lambda}_{i,t+1} + \bar{\mu}_{i,t} + \bar{\upsilon}_{i,t} Y_{i,t}^N \left[\frac{\mathcal{Y}_A^N(A_{i,t+1}, \tilde{Y}_{i,t+1}^T)}{\mathcal{Y}^N(A_{i,t+1}, \tilde{Y}_{i,t+1}^T)} - \frac{\mathcal{C}_A^T(A_{i,t+1}, \tilde{Y}_{i,t+1}^T)}{\mathcal{C}^T(A_{i,t+1}, \tilde{Y}_{i,t+1}^T)} \right] \tag{H.13}$$

$$A_{i,t+1} \geq -\kappa_{i,t} \quad \text{with equality if} \quad \bar{\mu}_{i,t} > 0 \tag{H.14}$$

$$Y_{i,t}^N \leq 1 \quad \text{with equality if} \quad \bar{\nu}_{i,t} > 0 \tag{H.15}$$

$$Y_{i,t}^N \leq C_{i,t}^T R\bar{\pi} \frac{\mathcal{Y}^N(A_{i,t+1}, \tilde{Y}_{i,t+1}^T)}{\mathcal{C}^T(A_{i,t+1}, \tilde{Y}_{i,t+1}^T)} \quad \text{with equality if} \quad \bar{\upsilon}_{i,t} > 0, \tag{H.16}$$

where $\bar{\lambda}_{i,t}, \bar{\mu}_{i,t}, \bar{\nu}_{i,t}, \bar{\upsilon}_{i,t}$ denote respectively the nonnegative Lagrange multipliers on constraints $(H.7)$, $(H.8)$, $(H.9)$ and $(H.10)$, while $\mathcal{Y}_A^N(A_{i,t+1}, \tilde{Y}_{i,t+1}^T)$ and $\mathcal{C}_A^T(A_{i,t+1}, \tilde{Y}_{i,t+1}^T)$ are the partial derivatives respectively of $\mathcal{Y}^N(A_{i,t+1}, \tilde{Y}_{i,t+1}^T)$ and $\mathcal{C}^T(A_{i,t+1}, \tilde{Y}_{i,t+1}^T)$ with respect to $A_{i,t+1}$.

Definition 7 ***Equilibrium with current account policies and capital.*** *An equilibrium with current account policies is a path of real allocations* $\{C_{i,t}^T, Y_{i,t}^N, A_{i,t+1}, K_{i,t+1}\bar{\mu}_{i,t}, \bar{\nu}_{i,t}, \bar{\upsilon}_{i,t}\}_{i,t}$ *and world interest rate* R*, satisfying* $(H.1)$*,* $(H.5)$*,* $(H.11)$*,* $(H.12)$*,* $(H.13)$*,* $(H.14)$*,* $(H.15)$ *and* $(H.16)$ *given a path of endowments* $\{Y_{i,t}^T\}_{i,t}$*, a path for the borrowing limits* $\{\kappa_{i,t}\}_{i,t}$*, a path for productivity* $\{Q_{i,t}\}_{i,t}$ *and initial conditions* $\{R_{-1}A_{i,0}, K_{i,0}\}_i$*. Moreover, the functions* $\mathcal{C}^T(A_{i,t+1}, \tilde{Y}_{i,t+1}^T)$ *and* $\mathcal{Y}^N(A_{i,t+1}, \tilde{Y}_{i,t+1}^T)$ *have to be consistent with the national planners' decision rules.*

H.2 Impact of current account policies on output and welfare

In general, the presence of capital makes it difficult to obtain analytic results. However, it is possible to work out an insightful example analytically. To this end, on top of the assumptions stated in Section 2.6, we assume that the endowment is received only by countries in the high state ($Y_l^T = 0$), and that investment opportunities are available only in high-state countries ($Q_h = 0, Q_l = Q > 0$).[55] These assumptions, while stark, allow us to isolate transparently the role of liquidity supply in shaping the conditions for a paradox of global thrift to occur.

We study stationary equilibria in which liquidity is scarce enough so that agents living in low-state countries end up being borrowing constrained. This is the case if

[55]These assumptions buy tractability because they bring the model close to two-period settings, in which agents receive an endowment during the first period and consume the return to investment in capital during the second period.

$$Y_h^T > \left[Q(\alpha\beta)^\alpha(1+(\beta\alpha)^{1-\alpha})\right]^{\frac{1}{1-\alpha}}.$$

Intuitively, this condition ensures that the endowment received in the high state is sufficiently high compared to capital productivity to make capital a poor asset for consumption smoothing. Under this condition, which we assume to hold from now on, we have

$$C_h^T = Y_h^T - K \tag{H.17}$$

$$C_l^T = QK^\alpha. \tag{H.18}$$

where K denotes the value of the capital stock in a stationary equilibrium. Considering that in equilibrium $R = \alpha QK^{\alpha-1}$, it is easy to see that as the world interest rate falls tradable consumption shifts from the high to the low state. Intuitively, as R falls the capital stock expands, allowing households in high-state countries to increase equilibrium savings.

As in the positive-liquidity model of Section 5.2, the impact of current account policies on output crucially depends on the elasticity of liquidity supply with respect to the world interest rate.

Proposition 8 ***Global equilibrium with current account policies and capital.*** *Suppose that $Y_l^T = 0$, $Q_h = 0$, $Q_l = Q > 0$, $Q\alpha^\alpha\left((\omega+\beta\alpha)/(\beta Y_h^T)\right)^{1-\alpha}\bar{\pi} > 1$ and that under laissez faire the world is stuck in global liquidity trap. Then if $\alpha < \alpha^*$, for every country output and welfare are lower in the equilibrium with current account policies compared to the laissez-faire one. α^* is such that*

$$\frac{\omega+\beta\alpha^*}{1+\beta\alpha^*} = \omega^{\frac{1}{2(1-\alpha^*)}}.$$

Proof. The proof follows the steps of the proof to Proposition 5.[56]

The results provided by Proposition 8 are the natural counterpart of those derived in Proposition 5. In fact, in the model with capital the elasticity of liquidity supply to the world interest rate crucially depends on the parameter α. When α is low capital is subject to sharply decreasing marginal returns. Instead, when α is high the return to capital does not depend much on the capital stock. It follows that, for a given fall in the world interest rate, the capital stock will expand by more the higher α. In other words, the elasticity of liquidity supply with respect to the world interest rate is increasing in α. It then follows, from the logic discussed in Section 5.2, that the lower α the more likely it is that current account policies will have a negative impact on output and welfare.

I Extended model and numerical analysis

In this appendix we report the results of our numerical analysis.

[56]The key step is to note that the results in Proposition 2 apply also to the economy with capital, after replacing $B_{i,t+1}$ with $A_{i,t+1}$ and $Y_{i,t}^T$ with $\tilde{Y}_{i,t}^T$.

I.1 Setup and competitive equilibrium

As in the baseline model, we consider a world composed of a continuum of measure one of small open economies indexed by $i \in [0,1]$. Time is discrete and indexed by $t \in \{0,1,...\}$. There is no uncertainty at the world level, but our small open economies are subject to idiosyncratic risk.

Each country is populated by a continuum of measure one of identical infinitely-lived households. The lifetime utility of the representative household in a generic country i is

$$E_0\left[\sum_{t=0}^{\infty}\beta^t\left(\frac{C_{i,t}^{1-\sigma}-1}{1-\sigma}-\chi\frac{L_{i,t}^{1+\eta}}{1+\eta}\right)\right], \tag{I.1}$$

where $E_t[\cdot]$ is the expectation operator conditional on information available at time t, $0<\beta<1$, $\sigma>0$, $\chi>0$ and $\eta\geq 0$. $L_{i,t}$ denotes labor effort. Consumption $C_{i,t}$ is defined as

$$C_{i,t}=\left(\omega\left(C_{i,t}^T\right)^{1-\frac{1}{\xi}}+(1-\omega)\left(C_{i,t}^N\right)^{1-\frac{1}{\xi}}\right)^{\frac{\xi}{\xi-1}}, \tag{I.2}$$

where $0<\omega<1$ and $\xi>0$. $C_{i,t}^T$ and $C_{i,t}^N$ denote consumption of respectively a tradable and a non-tradable good.

Households. Households can trade in one-period real and nominal bonds. Real bonds are denominated in units of the tradable consumption good and pay the gross interest rate R_t. The interest rate on real bonds is common across countries, and R_t can be interpreted as the *world interest rate*. Nominal bonds are denominated in units of the domestic currency and pay the gross nominal interest rate $R_{i,t}^n$. To simplify the analysis, we assume that households cannot purchase foreign currency denominated bonds.[57]

The household budget constraint in terms of the domestic currency is

$$P_{i,t}^TC_{i,t}^T+P_{i,t}^NC_{i,t}^N+P_{i,t}^TB_{i,t+1}+B_{i,t+1}^n=W_{i,t}L_{i,t}+P_{i,t}^TY_{i,t}^T+P_{i,t}^TR_{t-1}B_{i,t}+R_{i,t-1}^nB_{i,t}^n. \tag{I.3}$$

The left-hand side of this expression represents the household's expenditure. $P_{i,t}^T$ and $P_{i,t}^N$ denote respectively the price of a unit of tradable and non-tradable good in terms of country i currency. Hence, $P_{i,t}^TC_{i,t}^T+P_{i,t}^NC_{i,t}^N$ is the total nominal expenditure in consumption. $B_{i,t+1}$ and $B_{i,t+1}^n$ denote respectively the purchase of real and nominal bonds made by the household at time t. If $B_{i,t+1}<0$ or $B_{i,t+1}^n<0$ the household is holding a debt.

The right-hand side captures the household's income. $W_{i,t}$ denotes the nominal wage, and hence $W_{i,t}L_{i,t}$ is the household's labor income. Labor is immobile across countries and so wages are country-specific. $Y_{i,t}^T$ is an endowment of tradable goods received by the household. Changes in $Y_{i,t}^T$ can be interpreted as movements in the quantity of tradable goods available in the economy, or as shocks to the country's terms of trade. $P_{i,t}^TR_{t-1}B_{i,t}$ and $R_{i,t-1}^nB_{i,t}^n$ represent the gross returns on investment in bonds made at time $t-1$.

[57] Due to the presence of uncertainty, here the assumption that households cannot trade foreign nominal bonds is no longer innocuous. In fact, if they were allowed to, households would diversify their portfolio of bonds to insure against the shocks hitting their country. The resulting model, however, would be extremely complicated to solve. For this reason we have chosen to prevent households from holding foreign-currency denominated bonds.

We model idiosyncratic fluctuations in the tradable good endowment by assuming that $Y_{i,t}^T$ follows the log-normal AR(1) process

$$\log\left(Y_{i,t}^T\right) = \rho \log\left(Y_{i,t-1}^T\right) + \epsilon_{i,t},$$

where $\epsilon_{i,t}$ is normally distributed with zero mean and standard deviation σ_ϵ. The shock $\epsilon_{i,t}$ is uncorrelated across countries, and hence the world endowment of tradable goods is constant over time.

There is a limit to the amount of debt that a household can take. In particular, the end-of-period bond position has to satisfy

$$B_{i,t+1} + \frac{B_{i,t+1}^n}{P_{i,t}^T} \geq -\kappa_{i,t} + \theta\left(R_{t-1}B_{i,t} + R_{i,t-1}^n \frac{B_{i,t}^n}{P_{i,t}^T}\right), \tag{I.4}$$

where $\kappa_{i,t} \geq 0$ and $\theta \geq 0$. In our numerical simulations we will consider the case $\kappa_{i,t} > 0$, so that countries will be able to accumulate positive amounts of debt. We will also, following Justiniano et al. (2015) and Guerrieri and Iacoviello (2017), introduce inertia in the borrowing limit by setting $\theta > 0$. One reason to consider an inertial adjustment of the borrowing limit is the fact that the model features only debt contracts that last one period, which in our numerical simulations corresponds to one year. In reality, however, debt typically takes longer maturities. This formalization of the borrowing constraint captures in a tractable way the fact that long-term debt allows agents to adjust gradually to episodes of tight access to credit.

Countries are subject to financial shocks, modeled as idiosyncratic fluctuations in the borrowing limit $\kappa_{i,t}$. Our aim is to capture economies that alternate between tranquil times and financial crises. The simplest way to formalize this notion is to assume that $\kappa_{i,t}$ transitions between two values, κ_h and κ_l with $\kappa_h > \kappa_l$, according to a first-order Markov process. As we will see periods of tight access to credit, i.e. periods in which $\kappa_{i,t} = \kappa_l$, will trigger dynamics similar to a financial crisis event in countries featuring a significant stock of external debt.

Each household chooses its desired amount of hours worked, denoted by $L_{i,t}^s$. However, due to the presence of nominal wage rigidities to be described below, the household might end up working less than its desired amount of hours, i.e.

$$L_{i,t} \leq L_{i,t}^s, \tag{I.5}$$

where $L_{i,t}$ is taken as given by the household.

The household's optimization problem consists in choosing a sequence $\{C_{i,t}^T, C_{i,t}^N, B_{i,t+1}, B_{i,t+1}^n, L_{i,t}^s\}_t$ to maximize lifetime utility $(I.1)$, subject to the budget constraint $(I.3)$, the borrowing limit $(I.4)$ and the constraint on hours worked $(I.5)$, taking initial wealth $P_0^T R_{-1} B_{i,0} + R_{i,-1}^n B_{i,0}^n$, a sequence for income $\{W_{i,t}L_{i,t} + P_{i,t}^T Y_{i,t}^T\}_t$, and prices $\{R_t, R_{i,t}^n, P_{i,t}^T, P_{i,t}^N\}_t$ as given. The household's first-order conditions can be written as

$$\frac{\omega C_{i,t}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t}^T\right)^{\frac{1}{\xi}}} = \beta R_t E_t\left[\frac{\omega C_{i,t+1}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t+1}^T\right)^{\frac{1}{\xi}}} - \theta\mu_{i,t+1}\right] + \mu_{i,t} \tag{I.6}$$

$$\frac{\omega C_{i,t}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t}^{T}\right)^{\frac{1}{\xi}}} = \beta R_{i,t}^{n} E_t \left[\frac{P_{i,t}^{T}}{P_{i,t+1}^{T}} \left(\frac{\omega C_{i,t+1}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t+1}^{T}\right)^{\frac{1}{\xi}}} - \theta \mu_{i,t+1} \right) \right] + \mu_{i,t} \tag{I.7}$$

$$B_{i,t+1} + \frac{B_{i,t+1}^{n}}{P_{i,t}^{T}} \geq -\kappa_{i,t} + \theta \left(R_{t-1} B_{i,t} + R_{i,t-1}^{n} \frac{B_{i,t}^{n}}{P_{i,t}^{T}} \right) \quad \text{with equality if} \quad \mu_{i,t} > 0 \tag{I.8}$$

$$C_{i,t}^{N} = \left(\frac{1-\omega}{\omega} \frac{P_{i,t}^{T}}{P_{i,t}^{N}} \right)^{\xi} C_{i,t}^{T}, \tag{I.9}$$

$$L_{i,t}^{s} = \left(\frac{1-\omega}{\chi} \frac{W_{i,t}}{P_{i,t}^{N}} \frac{C_{i,t}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t}^{N}\right)^{\frac{1}{\xi}}} \right)^{\frac{1}{\eta}}, \tag{I.10}$$

where $\mu_{i,t}$ is the nonnegative Lagrange multiplier associated with the borrowing constraint. Equations $(I.6)$ and $(I.7)$ are the Euler equations for, respectively, real and nominal bonds. Equation $(I.8)$ is the complementary slackness condition associated with the borrowing constraint. Equation $(I.9)$ determines the optimal allocation of consumption expenditure between tradable and non-tradable goods. Equation $(I.10)$ gives the household's labor supply.

It is useful to combine $(I.6)$ and $(I.7)$ to obtain a no arbitrage condition between real and nominal bonds

$$R_{i,t}^{n} = R_t \frac{E_t \left[\frac{\omega C_{i,t+1}^{\frac{1}{\xi}-\sigma}}{(C_{i,t+1}^{T})^{\frac{1}{\xi}}} - \theta \mu_{i,t+1} \right]}{E_t \left[\frac{P_{i,t}^{T}}{P_{i,t+1}^{T}} \left(\frac{\omega C_{i,t+1}^{\frac{1}{\xi}-\sigma}}{(C_{i,t+1}^{T})^{\frac{1}{\xi}}} - \theta \mu_{i,t+1} \right) \right]}. \tag{I.11}$$

We can then use $(I.9)$ and $(I.11)$ to get the analogue of the baseline model's AD equation

$$C_{i,t}^{N} = C_{i,t}^{T} \left(\frac{R_t}{R_{i,t}^{n}} \frac{E_t \left[\frac{\omega C_{i,t+1}^{\frac{1}{\xi}-\sigma}}{(C_{i,t+1}^{T})^{\frac{1}{\xi}}} - \theta \mu_{i,t+1} \right]}{E_t \left[\pi_{i,t+1} \left(\frac{C_{i,t+1}^{T}}{C_{i,t+1}^{N}} \right)^{\frac{1}{\xi}} \left(\frac{\omega C_{i,t+1}^{\frac{1}{\xi}-\sigma}}{(C_{i,t+1}^{T})^{\frac{1}{\xi}}} - \theta \mu_{i,t+1} \right) \right]} \right)^{\xi}. \tag{I.12}$$

where $\pi_{i,t} \equiv P_{i,t}^{N} / P_{i,t-1}^{N}$.

Firms and nominal rigidities. Non-traded output $Y_{i,t}^{N}$ is produced by a large number of competitive firms. Labor is the only factor of production, and the production function is

$$Y_{i,t}^{N} = L_{i,t}. \tag{I.13}$$

Profits are given by $P_{i,t}^{N} Y_{i,t}^{N} - W_{i,t} L_{i,t}$, and the zero profit condition implies that in equilibrium $P_{i,t}^{N} = W_{i,t}$. Using this condition we can simplify the labor supply equation $(I.10)$ to

$$L_{i,t}^{s} = \left(\frac{1-\omega}{\chi} \frac{C_{i,t}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t}^{N}\right)^{\frac{1}{\xi}}} \right)^{\frac{1}{\eta}}. \tag{I.14}$$

Nominal wages are subject to the downward rigidity constraint

$$W_{i,t} \geq \gamma W_{i,t-1},$$

where $\gamma > 0$. Equilibrium on the labor market is captured by the condition

$$L_{i,t} \leq L^s_{i,t}, \quad W_{i,t} \geq \gamma W_{i,t-1} \quad \text{with complementary slackness.} \tag{I.15}$$

This condition implies that unemployment, defined as a downward deviation of hours worked from the household's desired amount, arises only if the constraint on wage adjustment binds.

Monetary policy and inflation. The objective of the central bank is to set $\pi_{i,t} = \bar{\pi}$. As in the baseline model, we focus on the case $\bar{\pi} > \gamma$, so that $\pi_{i,t} = \bar{\pi} \rightarrow L_{i,t} = L^s_{i,t}$. The central bank runs monetary policy by setting the nominal interest rate $R^n_{i,t}$, subject to the zero lower bound constraint $R^n_{i,t} \geq 1$. We also, as in the baseline model, restrict attention to the constant-inflation limit $\bar{\pi} \rightarrow \gamma$. Hence monetary policy can be described by the rule

$$R^n_{i,t} = \begin{cases} \geq 1 & \text{if } Y^N_{i,t} = L^s_{i,t} \\ = 1 & \text{if } Y^N_{i,t} < L^s_{i,t}, \end{cases} \tag{I.16}$$

where we have used (10) and the equilibrium relationships $W_{i,t} = P^N_{i,t}$ and $L_{i,t} = Y^N_{i,t}$.

Market clearing and definition of competitive equilibrium Since households inside a country are identical, we can interpret equilibrium quantities as either household or country specific. For instance, the end-of-period net foreign asset position of country i is equal to the end-of-period holdings of bonds of the representative household, $NFA_{i,t} = B_{i,t+1} + B^n_{i,t+1}/P^T_{i,t}$. Throughout, we focus on equilibria in which nominal bonds are in zero net supply, so that

$$B^n_{i,t} = 0, \tag{I.17}$$

for all i and t. This implies that the net foreign asset position of a country is exactly equal to its investment in real bonds, i.e. $NFA_{i,t} = B_{i,t+1}$.

Market clearing for the non-tradable consumption good requires that in every country consumption is equal to production

$$C^N_{i,t} = Y^N_{i,t}. \tag{I.18}$$

Instead, market clearing for the tradable consumption good requires

$$C^T_{i,t} = Y^T_{i,t} + R_{t-1}B_{i,t} - B_{i,t+1}. \tag{I.19}$$

Finally, we generalize slightly, compared to the baseline economy, the world bond market clearing condition. In fact, we allow our model economy to run imbalances with respect to the rest of the world. More specifically, the bond market clearing condition is now

$$\int_0^1 B_{i,t+1}\, \mathrm{d}i = B^{rw}, \tag{I.20}$$

where B^{rw} is a constant, corresponding to bond supply by the rest of the world. This formulation allows us to capture, in our numerical simulations, the negative net foreign asset position toward the rest of the world characterizing our sample of advanced economy.

We are now ready to define a competitive equilibrium.

Definition 8 ***Competitive equilibrium.*** *A competitive equilibrium is a path of real allocations* $\{C_{i,t}, L_{i,t}, L^s_{i,t}, C^T_{i,t}, C^N_{i,t}, Y^N_{i,t}, B_{i,t+1}, B^n_{i,t+1}, \mu_{i,t}\}_{i,t}$*, policy rates* $\{R^n_{i,t}\}_{i,t}$ *and world interest rate* $\{R_t\}_t$*, satisfying* $(I.2)$*,* $(I.6)$*,* $(I.8)$*,* $(I.12)$*,* $(I.13)$*,* $(I.14)$*,* $(I.16)$*,* $(I.17)$*,* $(I.18)$*,* $(I.19)$ *and* $(I.20)$ *given a path of endowments* $\{Y^T_{i,t}\}_{i,t}$*, a path for the borrowing limits* $\{\kappa_{i,t}\}_{i,t}$*, and initial conditions* $\{B_{i,0}\}_i$*.*

I.2 National planning problem and equilibrium with current account policies

To streamline the exposition of the planning problem, we impose, as in the numerical analysis, the parametric restriction $\sigma = 1/\xi$. This assumption simplifies the derivation of the planning problem. In particular, it implies that the labor supply equation $(I.10)$ reduces to

$$L^s_{i,t} = \left(\frac{1-\omega}{\chi}\right)^{\frac{1}{\eta+\frac{1}{\xi}}} \equiv L^s, \tag{I.21}$$

where we have also used the fact that, when households work their desired amount of hours, $L^s_{i,t} = C^N_{i,t}$.

Define $z_{i,t} \equiv \{Y^T_{i,t}, \kappa_{i,t}\}$. The problem of the national planner in a generic country i can be represented as

$$V(B_{i,t}, z_{i,t}) = \max_{C^T_{i,t}, Y^N_{i,t}, B_{i,t+1}} \frac{\omega (C^T_{i,t})^{1-\frac{1}{\xi}} + (1-\omega)(Y^N_{i,t})^{1-\frac{1}{\xi}} - 1}{1-\frac{1}{\xi}} - \frac{\chi (Y^N_{i,t})^{1+\eta}}{1+\eta} + \beta E_t \left[V(B_{i,t+1}, z_{i,t+1})\right] \tag{I.22}$$

subject to

$$C^T_{i,t} = Y^T_{i,t} - B_{i,t+1} + R_{t-1} B_{i,t} \tag{I.23}$$

$$B_{i,t+1} \geq -\kappa_{i,t} + \theta R_{t-1} B_{i,t} \tag{I.24}$$

$$Y^N_{i,t} \leq L^s \tag{I.25}$$

$$Y^N_{i,t} \leq C^T_{i,t} \left(\frac{R_t}{\bar{\pi}}\right)^{\xi} \Psi(B_{i,t+1}, z_{i,t+1}). \tag{I.26}$$

The resource constraints are captured by (20) and (22). (21) implies that the government is subject to the same borrowing constraint imposed by the markets on individual households.[58] Instead, constraint (23), which is obtained by combining the (I.12) and (I.16) equations, encapsulates the requirement that production of non-tradable goods is constrained by private sector's demand. The function $\Psi(B_{i,t+1}, z_{i,t+1})$ captures how the future planners' decisions affect constraint (23) in the

[58] To write this constraint we have used the equilibrium condition $B^n_{i,t+1} = 0$.

present.[59] Since the current planner cannot make credible commitments about its future actions, these variables are not into its direct control. However, the current planner can still influence these quantities through its choice of net foreign assets. In what follows, we focus on equilibria in which $\Psi(B_{i,t}, z_{i,t})$ is differentiable. This is the case in the numerical simulations considered in the paper.

To solve this problem, we start by guessing that constraint $(I.25)$ does not bind. The planner's first order conditions can then be written as

$$\bar{\lambda}_{i,t} = \frac{\omega}{(C_{i,t}^T)^{-\frac{1}{\xi}}} + \bar{v}_{i,t} \frac{Y_{i,t}^N}{C_{i,t}^T} \tag{I.27}$$

$$\bar{v}_{i,t} = \frac{1-\omega}{(Y_{i,t}^N)^{\frac{1}{\xi}}} - \chi (Y_{i,t}^N)^{\eta} \tag{I.28}$$

$$\bar{\lambda}_{i,t} = \beta R_t E_t \left[\bar{\lambda}_{i,t+1} - \theta \bar{\mu}_{i,t+1} \right] + \bar{\mu}_{i,t} + \bar{v}_{i,t} Y_{i,t}^N \frac{\Psi_B(B_{i,t+1}, z_{i,t+1})}{\Psi(B_{i,t+1}, z_{i,t+1})} \tag{I.29}$$

$$B_{i,t+1} \geq -\kappa_{i,t} + \theta R_{t-1} B_{i,t} \quad \text{with equality if} \quad \bar{\mu}_{i,t} > 0 \tag{I.30}$$

$$Y_{i,t}^N \leq C_{i,t}^T \left(\frac{R_t}{\bar{\pi}} \right)^{\xi} \Psi(B_{i,t+1}, z_{i,t+1}) \quad \text{with equality if} \quad \bar{v}_{i,t} > 0, \tag{I.31}$$

where $\bar{\lambda}_{i,t}, \bar{\mu}_{i,t}, \bar{v}_{i,t}$ denote respectively the nonnegative Lagrange multipliers on constraints $(I.23)$, $(I.24)$ and $(I.26)$, while $\Psi_B(B_{i,t+1}, z_{i,t+1})$ is the partial derivative of $\Psi(B_{i,t+1}, z_{i,t+1})$ with respect to $B_{i,t+1}$.

Note that equation $(I.28)$ implies that, as we guessed, constraint $(I.25)$ does not bind. Intuitively, the labor supply decision of the planner coincides with the households' one.

It is useful to combine $(I.27)$ and $(I.29)$ to obtain

$$\begin{aligned} \frac{\omega}{(C_{i,t}^T)^{-\frac{1}{\xi}}} + \bar{v}_{i,t} \frac{Y_{i,t}^N}{C_{i,t}^T} = \beta R_t E_t & \left[\frac{\omega}{(C_{i,t+1}^T)^{-\frac{1}{\xi}}} + \bar{v}_{i,t+1} \frac{Y_{i,t+1}^N}{C_{i,t+1}^T} - \theta \bar{\mu}_{i,t+1} \right] \\ & + \bar{\mu}_{i,t} + \bar{v}_{i,t} Y_{i,t}^N \frac{\Psi_B(B_{i,t+1}, z_{i,t+1})}{\Psi(B_{i,t+1}, z_{i,t+1})} \end{aligned} \tag{I.32}$$

This is the planner's Euler equation. We are now ready to define an equilibrium with current account policy.

[59] Formally, the function $\Psi(B_{i,t+1}.z_{i,t+1})$ is defined as

$$\Psi(B_{i,t+1}, z_{i,t+1}) \equiv \left(\frac{E_t \left[\frac{\omega}{\mathcal{C}^T(B_{i,t+1}, z_{i,t+1})^{\frac{1}{\xi}}} - \theta \mu(B_{i,t+1}, z_{i,t+1}) \right]}{E_t \left[\left(\frac{\mathcal{C}^T(B_{i,t+1}, z_{i,t+1})}{\mathcal{Y}^N(B_{i,t+1}, z_{i,t+1})} \right)^{\frac{1}{\xi}} \left(\frac{\omega}{\mathcal{C}^T(B_{i,t+1}, z_{i,t})^{\frac{1}{\xi}}} - \theta \mu(B_{i,t+1}, z_{i,t+1}) \right) \right]} \right)^{\xi},$$

where $\mathcal{C}^T(B_{i,t+1}, Y_{i,t+1}^T)$ and $\mathcal{Y}^N(B_{i,t+1}, Y_{i,t+1}^T)$ determine respectively consumption of tradable goods and production of non-tradable goods in period $t+1$ as a function of the state variables at the beginning of next period. In turn, $\mu(B_{i,t+1}, z_{i,t+1})$, households' Lagrange multiplier on the borrowing constraint, is defined as

$$\mu(B_{i,t+1}, z_{i,t+1}) = \frac{\omega}{\mathcal{C}^T(B_{i,t+1}, z_{i,t+1})^{\frac{1}{\xi}}} - \beta R_{t+1} E_t \left[\frac{\omega}{\mathcal{C}^T(B_{i,t+2}, z_{i,t+2})^{\frac{1}{\xi}}} - \theta \mu(B_{i,t+2}, z_{i,t+2}) \right].$$

Definition 9 ***Equilibrium with current account policy.*** *An equilibrium with current account policy is a path of real allocations* $\{C^T_{i,t}, Y^N_{i,t}, B_{i,t+1}, \bar{\mu}_{i,t}, \bar{\upsilon}_{i,t}\}_{i,t}$ *and world interest rate* $\{R_t\}_t$*, satisfying* $(I.20)$*,* $(I.23)$*,* $(I.28)$*,* $(I.30)$*,* $(I.31)$ *and* $(I.32)$ *given a path of endowments* $\{Y^T_{i,t}\}_{i,t}$*, a path for the borrowing limits* $\{\kappa_{i,t}\}_{i,t}$*, and initial conditions* $\{B_{i,0}\}_i$*. Moreover, the function* $\Psi(B_{i,t+1}, Y^T_{i,t+1})$ *has to be consistent with the national planners' decision rules.*

I.3 Parameters

The extended model cannot be solved analytically, and we study its properties using numerical simulations. We employ a global solution method, described in Appendix I.7, in order to deal with the nonlinearities involved by the occasionally binding borrowing and zero lower bound constraints.

One period corresponds to one year. We set the coefficient of relative risk aversion to $\sigma = 2$, the elasticity of substitution between tradable and non-tradable goods to $\xi = 0.5$, and the share of tradable goods in consumption expenditure to $\omega = 0.25$, in line with the international macroeconomics literature. The inverse of the Frisch elasticity of labor supply η is set equal to 2.2, as in Galí and Monacelli (2016). We normalize $\chi = 1 - \omega$, which implies that equilibrium labor at full employment is equal to 1.[60]

The next set of parameters is selected to match some salient features characterizing advanced economies in the aftermath of the 2008 global financial crisis.[61] We set the discount factor to $\beta = 0.988$, so that under laissez faire the steady-state world interest rate R^{lf} is equal to 1.007. This target captures the low interest rate environment that has characterized advanced economies in the post-crisis years. In fact, 0.7% corresponds to the average real world interest rate over the period 2009-2015, estimated as in King and Low (2014). We calibrate B^{rw} and $\bar{\pi}$ using data from a sample of advanced economies.[62] We set B^{rw}, the bond supply from the rest of the world, to reproduce the fact that advanced economies have been in the recent past net debtors toward the rest of the world.[63] In particular, we set B^{rw} so that under laissez-faire the net debt position of our model economies is equal to 9.4% of their aggregate GDP. This corresponds to the aggregate net debt-to-GDP ratio of our sample countries, averaged over the period 2009-2015. $\bar{\pi}$ is chosen to match the average core inflation rate experienced by our sample countries between 2009 and 2015. This target implies $\bar{\pi} = 1.0125$.

We calibrate the tradable endowment process based on data on the cyclical component of tradable output in our sample countries. We identify tradable output in the data as per capita

[60] As shown in Appendix I.1, in absence of nominal wage rigidities equilibrium labor in the extended model would be constant. This property arises due the fact that production takes place only in the non-tradable sector and the parametric assumption $\sigma = 1/\xi$, which implies that utility is separable in consumption of tradable and non-tradable goods.

[61] Appendix K provides a detailed description of the data sources and the procedures we employed to calibrate the model.

[62] Our sample of advanced economies is composed of Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States.

[63] Indeed, in recent years advanced economies have been net recipients of capital inflows from emerging countries. As is well known, see for instance Bernanke (2005), a large driver of these capital flows has been the accumulation of reserves by central banks in emerging markets. It is not clear how to model the reaction of these flows to changes in the world interest rate. For this reason, in our baseline model we have opted for the simplest assumption of an inelastic supply of funds from the rest of the world. In Appendix I.8, however, we examine the robustness of our results to the presence of an elastic supply of funds from rest-of-the-world countries.

GDP in agriculture, forestry, fishing, mining, and manufacturing at constant prices. The sample period goes from 1970 to 2015. Since our model abstracts from aggregate shocks, we control for global movements in tradable output by subtracting, for each year, aggregate per-capita tradable output from the country-level series. We then extract the cyclical component from the resulting series by subtracting a country-specific log-linear trend. The first order autocorrelation ρ and the standard deviation σ_{YT} of the tradable endowment process are set respectively to 0.87 and 0.056, to match their empirical counterparts. In the computations, we approximate the tradable endowment process with the quadrature procedure of Tauchen and Hussey (1991) using 7 nodes.

We are left to calibrate the parameters governing the borrowing limit and the financial shocks. We are interested in capturing economies that alternate between tranquil times, characterized by abundant access to credit, and financial crisis episodes triggered by sudden stops in capital inflows. We start by setting κ_h to a value high enough so that the borrowing constraint never binds when $\kappa_{i,t} = \kappa_h$. The parameters κ_l and θ, joint with the transition probabilities $p(\kappa_l|\kappa_h)$ and $p(\kappa_l|\kappa_l)$, thus determine how often the borrowing constraint binds, as well as agents' ability to smooth consumption in response to endowment shocks.

We set the probability of an adverse financial shock $p(\kappa_l|\kappa_h)$ and its persistence $p(\kappa_l|\kappa_l)$ to target the frequency and duration of financial crises in our sample countries. We follow Bianchi and Mendoza (2018) and define a financial crisis as a sharp improvement in the trade balance, capturing unusually large drops in foreign financing. Different from Bianchi and Mendoza (2018), since our model abstract from global financial shocks, to identify financial crisis episodes in the data we control for time fixed effects.[64] The resulting annual frequency of financial crises is 1% and their average duration is 5 years. We match these statistics by setting $p(\kappa_l|\kappa_h) = 0.125$ and $p(\kappa_l|\kappa_l) = 0.2$.

To choose values for θ and κ_l we employ the following strategy. To set θ we exploit the fact that this parameter corresponds to the fraction of debt that can be rolled over every period, irrespective of whether the borrowing constraint binds or not. Hence, drawing a parallel with long-term debt, $1-\theta$ can be interpreted as the fraction of debt maturing in a given period. Following this logic we set $\theta = 0.9$ to mimic an average debt maturity of 10 years, close to the average US households' debt maturity reported by Jones et al. (2017).[65] To set κ_l we target the negative correlation between current account and GDP characterizing our sample countries. In fact, in absence of financial frictions our model would generate a counterfactual positive correlation between these two variables, since agents would smooth consumption by saving in good times and borrowing during downturns. As financial shocks become more severe, i.e. as κ_l falls, the correlation between current account and GDP implied by the model falls, until it eventually turns negative. Given $\theta = 0.9$, setting $\kappa_l = 0$ generates a correlation between the current account-to-GDP ratio and GDP of -0.21, equal to its empirical counterpart.

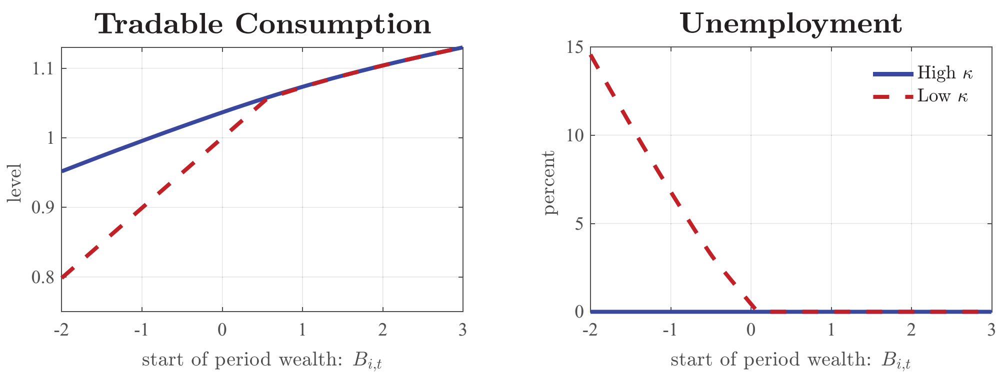
[64] See Appendix K for a detailed description of the procedure that we use to identify financial crisis events in the data.

[65] Following Jones et al. (2017) and interpreting θ as the fraction of debt that matures every period, average debt maturity D can be written as $D = R/(\theta + R - 1)$.

Table 1: Parameters

	Value	Source/Target
Risk aversion	$\sigma = 2$	Standard value
Elasticity consumption aggr.	$\xi = 0.5$	Standard value
Tradable share in expenditure	$\omega = 0.25$	Standard value
Frisch elasticity of labor supply	$1/\eta = 1/2.2$	Galí and Monacelli (2016)
Labor disutility coefficient	$\chi = 1 - \omega$	Normalization
Discount factor	$\beta = 0.988$	$R^{lf} = 0.7\%$
Bond supply r.o.w.	$B^{rw} = -0.376$	$B^{rw} / \int_0^1 GDP_{i,t} di = -9.4\%$
Inflation target	$\bar{\pi} = 1.0125$	Average core inflation
Tradable endowment process	$\rho = 0.87$, $\sigma_{Y^T} = 0.056$	Estimate for advanced economies
Prob. negative financial shock	$p(\kappa_l \vert \kappa_h) = 0.125$	1% prob. financial crisis
Persistence negative financial shock	$p(\kappa_l \vert \kappa_l) = 0.2$	5 years crisis duration
Tight credit regime	$\kappa_l = 0$	$Corr(CA/GDP, GDP) = -0.21$
	$\theta = 0.9$	mimics 10y debt maturity

Figure 7: Policy functions in the laissez-faire steady state.



I.4 Debt and liquidity traps under laissez faire

Before discussing the impact of current account policies, in this section we briefly describe the steady-state equilibrium under laissez faire. We will show that a country that has accumulated a high stock of debt is at risk of experiencing liquidity traps characterized by severe rises in unemployment.

Figure 7 displays the optimal choices for tradable consumption and unemployment as a function of $B_{i,t}$, i.e. the country's stock of wealth at the start of the period. The solid lines refer to countries with abundant access to credit ($\kappa_{i,t} = \kappa_h$), while the dashed lines correspond to countries hit by negative financial shocks ($\kappa_{i,t} = \kappa_l$).[66] The left panel of Figure 7 shows that, as it is natural, tradable consumption is increasing in wealth. Moreover, the figure shows that high-debt countries hit by negative financial shocks experience sharp falls in tradable consumption, triggered by the binding borrowing constraint. Taking stock, tradable consumption is low in high-debt countries, especially when these are hit by negative financial shocks.

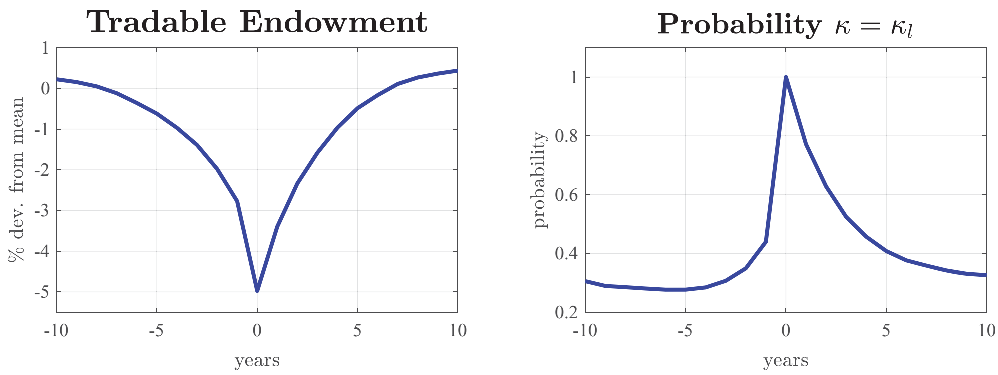
The right panel of Figure 7 shows that high-debt countries with tight access to credit are exactly the ones experiencing high unemployment. To understand this result consider that, just as in the

[66] Both policy functions are conditional on $Y^T_{i,t}$ being equal to its mean value.

with abundant access to credit ($\kappa_{i,t} = \kappa_h$), while the dashed lines correspond to countries hit by negative financial shocks ($\kappa_{i,t} = \kappa_l$).[66] The left panel of Figure 7 shows that, as it is natural, tradable consumption is increasing in wealth. Moreover, the figure shows that high-debt countries hit by negative financial shocks experience sharp falls in tradable consumption, triggered by the binding borrowing constraint. Taking stock, tradable consumption is low in high-debt countries, especially when these are hit by negative financial shocks.

The right panel of Figure 7 shows that high-debt countries with tight access to credit are exactly the ones experiencing high unemployment. To understand this result consider that, just as in the baseline model, demand for non-tradable consumption is increasing in consumption of tradable goods. Hence, the combination of high debt and tight access to credit depresses both consumption

Figure 8: Liquidity trap events: tradable endowment and financial shocks.



of tradable goods and demand for non-tradables. Low demand for non-tradables, in turn, pushes the policy rate against the zero lower bound and the economy into a recessionary liquidity trap. This explains why high-debt countries are exposed to the risk of sharp rises in unemployment in the event of a negative financial shock.

Figures 8 and 9 provide a snapshot of the liquidity trap events generated by the model. To construct these figures, we simulated the behavior of a country under laissez faire for a large number of periods and collected all the liquidity trap events. We then took averages of several macroeconomic indicators across all these events, centering each episode around the period associated with the peak in unemployment.[67] Figure 8 displays the average path of the tradable endowment and financial shocks, while the solid lines in Figure 9 illustrate the dynamics of GDP, tradable consumption, current account and unemployment.

Large rises in unemployment are preceded by low realizations of the tradable endowment shock, to which households respond by accumulating debt in order to sustain tradable consumption. This explains the current account deficits characterizing the run up to the unemployment crisis. Debt accumulation, however, puts the economy at risk of a large drop in tradable consumption in the event of a tightening in the borrowing limit. This is exactly what happens in period 0, when a

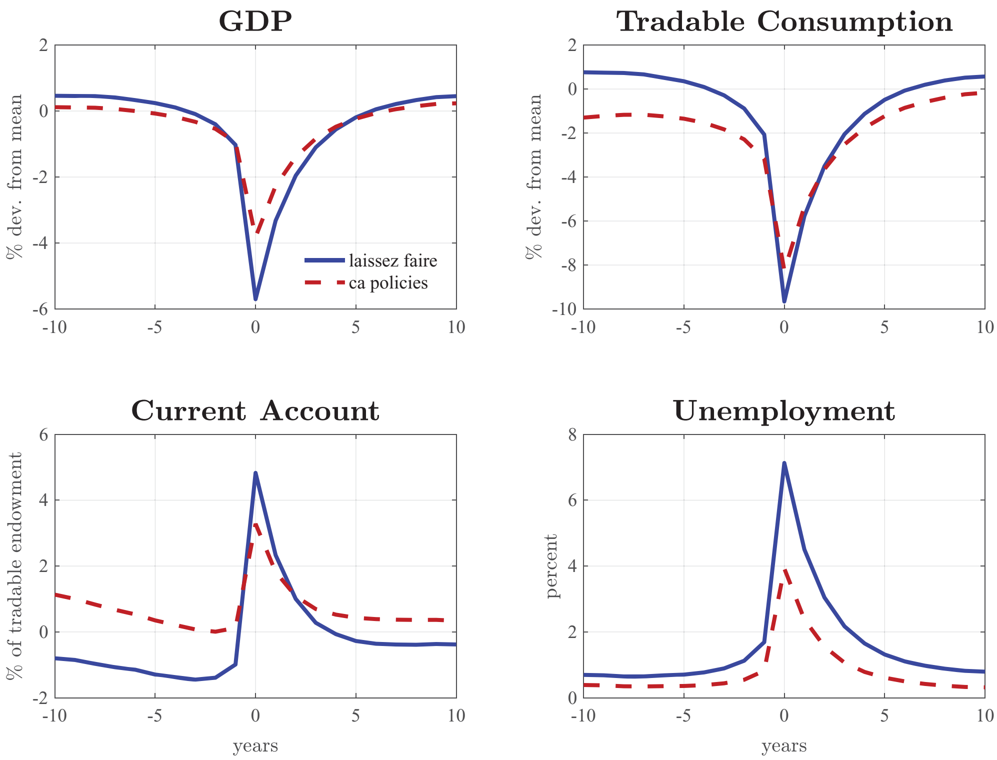
[67] More precisely, we say that a country is in a liquidity trap in a given period t if $L_{i,t} < 1$, that is if unemployment is positive. We then define the unemployment peak during a liquidity trap as the period in which unemployment is at its highest value compared to the 10 periods before and after. The period associated with the unemployment peak corresponds to period 0 in Figures 8 and 9.

negative financial shock generates a current account reversal and a large drop in consumption of tradable goods. As tradable consumption falls also aggregate demand for non-tradables drops. Constrained by the zero lower bound, the central bank is unable to react to the decline in domestic demand. The result is a sharp recession lasting several years.[68]

Though negative financial shocks in our model are rare events, the fact that they trigger severe and persistent recessions imply that their impact on unemployment and output is significant. Indeed, in the laissez-faire equilibrium average unemployment is 1.26%.[69] Thus, the combination of financial frictions and of the zero lower bound constraint on monetary policy implies that under laissez faire the world economy operates substantially below potential.

Summing up, the model is able to generate liquidity trap events characterized by severe and persistent rises in unemployment. Crucially, large recessions are triggered by negative financial shocks, and they are more likely to happen in high-debt countries. It is this feature of the model, as we will see in the next section, that creates space for current account policies.

Figure 9: Liquidity trap events: macroeconomic indicators. Solid (dashed) lines refer to economies under laissez faire (current account policies). GDP is defined as $GDP_{i,t} = Y^T_{i,t} + p^N Y^N_{i,t}$, where p^N denotes the unconditional mean of $P^N_{i,t}/P^T_{i,t}$ in the laissez-faire steady state.



I.5 Current account policies: a small open economy perspective

We now turn to government interventions on the international credit markets. As an intermediate step, it is useful to start by taking a partial equilibrium perspective, i.e. by abstracting from the

[68]Interestingly, the 6% peak drop in GDP during our typical crisis event is quantitatively in line with the Romer and Romer (2017) empirical estimates of the output response to financial crises in advanced economies.

[69]Since we are focusing on a stationary equilibrium, here average unemployment refers both to the cross-sectional average, that is $1 - \int_0^1 L_{i,t} di$, as well as to the unconditional expected value for a given country.

impact of current account policies on the world interest rate. Hence, in this section we consider a single small open economy that implements the optimal current account policy, while the rest of the world sticks to laissez faire.

The dashed lines in Figure 9 show how public interventions on the current account affect the behavior of a country during the liquidity trap events described in the previous section.[70] The key result is that the government intervenes in the run up to the crisis by reducing households' debt accumulation and improving the country's current account. Limiting debt accumulation, the reason is, reduces the exposure of the economy to negative financial shocks. As a result, both the current account reversal and the rise in unemployment occurring in period 0, when access to credit gets tight, are substantially milder under the optimal current account policy compared to laissez faire.

As in the baseline model, the government intervenes on the current account due to the presence of aggregate demand externalities. Private agents, in fact, do not internalize the impact of their borrowing decisions on aggregate demand and employment. It is then natural to think that a government will intervene more aggressively to improve the current account, when conditions are such that a negative financial shock will trigger a sharp rise in unemployment. This is precisely the result illustrated by Figure 10, which shows that the "forced savings" induced by current account interventions are larger in high-debt countries experiencing lax access to credit.[71]

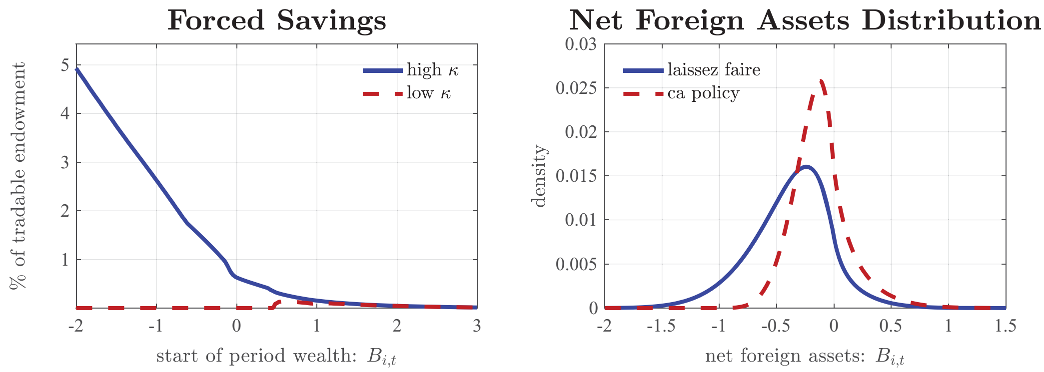
Quantitatively, public interventions on the current account have a sizable impact on average savings. To illustrate this point, the right panel of Figure 10 compares the stationary net foreign asset distribution of a small open economy operating under laissez faire (solid line), against the one of a country with current account policies (dashed line). The implementation of current account policies induces a rightward shift of the net foreign asset distribution, corresponding to an increase in average savings. The counterpart of this rise in savings is a reduction in unemployment. In fact, the implementation of current account policies by a single country would reduce its average unemployment to 0.5%, down from the 1.26% average unemployment characterizing laissez-faire economies.

Of course, in our model it is perfectly possible for a single country to reduce its average unemployment by means of current account policies. In fact, since we are focusing on small open economies, a change in saving behavior by a single country will not affect the world interest rate. As we show next, matters are completely different when current account policies are adopted on a global scale.

[70]To construct this figure, for each liquidity trap event identified under laissez faire we collected the value of net foreign assets in period $t-10$, where period t corresponds to the unemployment peak during the event, as well as the path for the shocks in periods $t-10$ to $t+10$. We then, for each event, fed the corresponding sequence of shocks and initial value for the net foreign assets to the decision rules derived under current account policy. Finally, we took averages of our variables of interest across all the events.

[71]Formally, forced savings are defined as $C_{i,t}^T - \tilde{C}_{i,t}^T$, where $\tilde{C}_{i,t}^T$ is the notional consumption that would be chosen by households absent government intervention. In the figure, $Y_{i,t}^T$ is kept equal to its mean value.

Figure 10: Forced savings and stationary net foreign asset distribution in a small open economy. Right panel: solid (dashed) lines refer to economies under laissez faire (current account policies).



I.6 Revisiting the paradox of global thrift

We have seen that, as in the baseline model, governments have a strong incentive to manipulate their country's current account when the zero lower bound is expected to bind in the future. It is then interesting to consider what happens when current account policies are implemented on a global scale. It turns out that, under our benchmark parametrization, the outcome is a large drop in the world interest rate, which ends up exacerbating the output and welfare losses due to the zero lower bound. This result shows that the logic of the paradox of global thrift goes beyond the simple baseline model presented in Section 2.

Throughout this section we run the following experiment. Imagine that the world starts from the laissez-faire steady state. In period 0 all the countries in the world experience a previously unexpected change in the policy regime, so that governments start implementing the self-oriented optimal current account policy. We are interested in tracing the impact of this policy change on output and welfare.

Before moving on, a few words on multiplicity of equilibria under current account policies are in order. The logic of Proposition 4 applies also to the extended model, and thus the possibility that under some parametrizations multiple equilibria under current account policies exist cannot be discarded. That said, in all the numerical simulations that follow we could not find evidence of multiple equilibria. We thus leave an analysis of equilibrium multiplicity in the extended model for future research.

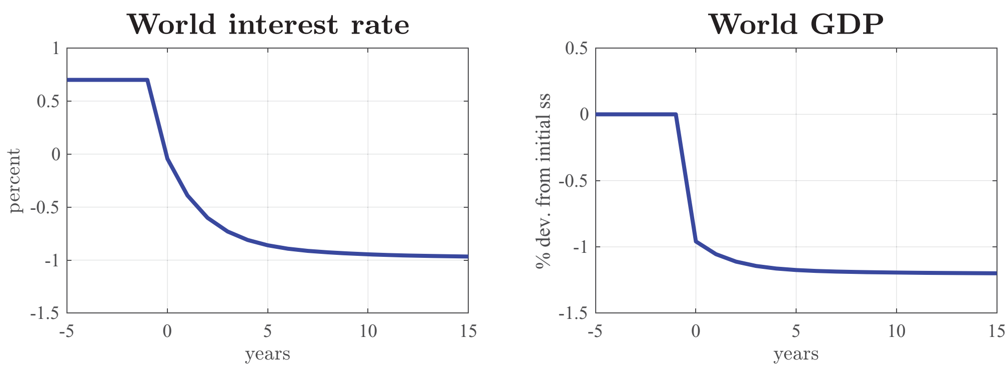
I.6.1 Output response to current account policies

Figure 11 plots the path of the world interest rate and world GDP during the transition toward the steady state with current account policies. The change in policy regime induces a gradual drop in the world interest rate. Intuitively, public interventions on the current account increase the aggregate demand for bonds by our model economies. Given the fixed bond supply from the rest of the world the result is a large drop in the world rate, which falls by 170 basis points compared to its value under laissez-faire. The drop in the world interest rate, in turn, exacerbates the zero lower bound constraint on monetary policy and leads to a fall in world output. Indeed, world

GDP in the steady state with public interventions on the current account is 1.2% lower than in the laissez-faire equilibrium.[72]

The first row of Table 2 shows the drop in the present value of expected output caused by the global implementation of current account policies, as a percent of expected output in the laissez-faire steady state.[73] On average, the cumulative output loss caused by current account interventions is equal to 1.22% of output in the laissez faire steady state. Moreover, the expected

Figure 11: Transition toward steady state with current account policies. World GDP is defined as $\int_0^1 GDP_{i,t}di = \int_0^1 Y_{i,t}^T + p^N Y_{i,t}^N di$, where p^N denotes the unconditional mean of $P_{i,t}^N/P_{i,t}^T$ in the laissez-faire steady state.



output losses are higher in countries starting the transition with a high stock of debt and tight access to credit. As it is intuitive, the countries that suffer the largest drops in expected output upon implementation of current account policies are those that start the transition inside a liquidity trap.

I.6.2 Welfare response to current account policies

We now turn to the impact that current account policies, and the associated drop in the world interest rate, have on welfare. As we discussed in the context of our baseline model, a lower world rate exacerbates the inefficiencies due to the zero lower bound and lead to an inefficiently low production of non-tradable goods. This effect is at the heart of the paradox of global thrift. In the extended model, however, there are two additional effects to consider. First, given that we have moved away from the zero liquidity limit, in the extended model a drop in the world rate redistributes wealth from creditor to debtor countries. Second, since the countries that form our economy are net debtors with respect to the rest of the world, a lower world interest rate redis-

[72]The differences in terms of unemployment are even larger. In fact, steady state aggregate unemployment when governments' intervene on the current account is 2.9%, compared to the 1.3% aggregate unemployment in the laissez-faire steady state.

[73]Formally, for any country i we computed the expected cumulative output loss τ_i^y caused by current account policies as

$$E_0\left[\beta^t \sum_{t=0}^{\infty} (1-\tau_i^y)\, GDP_{i,t}^{lf}\right] = E_0\left[\sum_{t=0}^{\infty} \beta^t GDP_{i,t}^{tr}\right],$$

where $GDP_{i,t}^{lf}$ denotes GDP in the laissez-faire steady state, while $GDP_{i,t}^{tr}$ refers to the path of GDP during the transition toward the steady state with current account policies. GDP is defined as $GDP_{i,t} = Y_{i,t}^T + p^N Y_{i,t}^N$, where p^N denotes the unconditional mean of $P_{i,t}^N/P_{i,t}^T$ in the laissez-faire steady state.

tributes wealth from rest-of-the-world countries toward our model economies.[74] In what follows, we start by discussing how current account policies affect total welfare. We then isolate the channel that is directly connected with the paradox of global thrift by focusing on the non-tradable sector.

The second row of Table 2 illustrates the impact of current account policies on total welfare, by reporting the proportional increase in consumption for all possible future histories that agents living in the laissez-faire equilibrium must receive, in order to be indifferent between the status quo

Table 2. Impact of current account policies.

	Average	Net foreign assets ($B_{i,0}$, perc.)				Financial shock ($\kappa_{i,0}$)	
		5th	25th	50th	75th	κ_l	κ_h
Output losses	1.22	1.32	1.24	1.20	1.19	1.24	1.21
Welfare losses	0.087	0.083	0.082	0.085	0.090	0.101	0.078
Welfare losses (NT)	0.308	0.357	0.319	0.301	0.293	0.315	0.304

Notes: All numbers are in percent.

or switching to the equilibrium with current account interventions.[75] These calculations explicitly consider the welfare effect of the whole transitional dynamics toward the steady state with current account policies. The table reports the results in terms of welfare losses, so a positive entry means that the implementation of current account policies lowers welfare compared to the laissez-faire equilibrium.

On average households experience a drop in welfare from governments' interventions on the current account. In fact, on average households are willing to give up permanently 0.087% of their consumption in the laissez-faire equilibrium to prevent the government from implementing the current account policies.[76] While this is not a particularly large number, recall that we are evaluating the welfare impact of programs that governments implement in order to increase citizens' welfare. It is thus striking that these policies end up *lowering* welfare instead.

Interestingly, the welfare losses are evenly spread across debtor and creditor countries. This is the result of two opposing effects. On the one hand, high-debt countries experience larger output losses upon the implementation of current account policies. This effect points toward higher welfare losses in high debt countries. However, high-debt countries also experience a reduction in the cost of servicing their debt following the drop in the world rate. This effect points toward lower welfare

[74] As we explain in Section 5.2, rest-of-the-world agents are akin to noise traders. Hence, one must be careful when considering the welfare impact of a wealth redistribution between our model economies and the agents from the rest of the world.

[75] More formally, for any country i we computed the welfare loss τ_i^w as

$$E_0\left[\sum_{t=0}^{\infty}\beta^t U\left((1-\tau_i^w)C_{i,t}^{lf}, L_{i,t}^{lf}\right)\right] = E_0\left[\sum_{t=0}^{\infty}\beta^t U\left(C_{i,t}^{tr}, L_{i,t}^{tr}\right)\right],$$

where superscripts lf denote the value of the corresponding variable in the laissez faire steady state, while tr refers to the transition toward the steady state with current account interventions.

[76] As we discuss in Appendix I.8, our model is likely to underestimate the welfare losses due to unemployment because it assumes that voluntary and involuntary leisure are perfect substitutes. There we show that reducing the Frisch elasticity of labor supply, which corresponds to an increase in the disutility from involuntary unemployment, from our benchmark value of 0.45 to 0.35 increases the welfare losses associated with current account policies by one order of magnitude.

losses in high-debt countries. The fact that the welfare losses are evenly distributed across the initial net foreign asset distribution means that these two effects essentially cancel out. Turning to the financial shock, the welfare losses tend to be higher in countries starting the transition during a period of tight access to credit. This is unsurprising, because these are the countries in which the output losses caused by the drop in the world rate are larger.

The third row of Table 2 illustrates the contribution of the non-tradable sector to the welfare losses. To this end, we computed a measure of welfare losses that takes into account only changes in non-tradable consumption and labor effort, thus neglecting the impact of changes in tradable consumption on welfare.[77] This statistic isolates the welfare costs directly linked to the paradox of global thrift, i.e. to the fact that the global implementation of current account policies exacerbates the inefficiencies due to the zero lower bound. In particular, this measure abstracts from the welfare gains driven by the transfer of wealth from the rest of the world to our model economies caused by the drop in the world interest rate.

The table shows that current account interventions substantially exacerbate the inefficiencies due to the zero lower bound. In fact, once we abstract from the wealth effect originating from changes in the world interest rate, on average households are willing to give up permanently 0.308% of their non-tradable consumption in the laissez-faire equilibrium to prevent the government from implementing the current account policies. Moreover, this welfare measure shows that high-debt countries are the ones who suffer the most from the inefficient drop in production caused by the global implementation of current account policies. Indeed, these are the countries in which monetary policy is most constrained by the zero lower bound.

Summing up, the results from the extended model largely confirm the analytic results that we derived using the simplified framework of Section 2. Current account policies generate a large increase in global savings, giving rise to a sharp drop in the world interest rate. In turn, the lower world rate exacerbates the distortions due to the zero lower bound and leads to a drop in world output. The output drop is larger in countries with a high stock of debt and tight access to credit. Moreover, though governments design current account policies to increase their citizens' welfare, once implemented on a global scale these policy interventions can be welfare-reducing. Because our model is highly stylized, we interpret the quantitative results as being only suggestive. Still,

[77] Here we exploit the fact that under our parametrization the value function is separable in the consumption of tradable and non-tradable goods. To see this point, consider that throughout our numerical simulations we assumed $\sigma = 1/\xi$. Under this assumption it is easy to see that

$$U\left(C_{i,t}, L_{i,t}\right) = \frac{\left(\omega C_{i,t}^T\right)^{1-\sigma} - 1}{1-\sigma} + \frac{\left((1-\omega) C_{i,t}^N\right)^{1-\sigma} - 1}{1-\sigma} - \chi \frac{L_{i,t}^{1+\eta}}{1+\eta}.$$

Now define

$$U^N\left(C_{i,t}^N, L_{i,t}\right) \equiv \frac{\left((1-\omega) C_{i,t}^N\right)^{1-\sigma} - 1}{1-\sigma} - \chi \frac{L_{i,t}^{1+\eta}}{1+\eta}.$$

We computed the welfare losses pertaining to the non-tradable sector τ_i^{wN} as

$$E_0\left[\sum_{t=0}^{\infty} \beta^t U^N\left((1-\tau_i^{wN}) C_{i,t}^{Nlf}, L_{i,t}^{lf}\right)\right] = E_0\left[\sum_{t=0}^{\infty} \beta^t U^N\left(C_{i,t}^{Ntr}, L_{i,t}^{tr}\right)\right],$$

where superscripts lf denote the value of the corresponding variable in the laissez faire steady state, while tr refers to the transition toward the steady state with current account interventions.

the model points toward the possibility of significant output and welfare losses associated with the paradox of global thrift.[78]

I.7 Numerical solution method

To solve the model numerically we follow the method proposed by Guerrieri and Lorenzoni (2017).

We start by discussing the computations needed to solve for the steady state. Computing the steady state of the model involves finding the interest rate that clears the bond market at the world level. The first step consists in deriving the optimal policy functions $C^T(B,z)$ and $C^N(B,z)$, where $z = \{Y^T, \kappa\}$ for a given interest rate R. To compute the optimal policy functions we discretize the endogenous state variable B using a grid with 500 points, and then iterate on the Euler equation and on the intratemporal optimality conditions using the endogenous gridpoints method of Carroll (2006). The decision rule $C^T(B,z)$, coupled with the country-level market clearing condition for tradable goods, fully determines the transition for the country's bond holdings. Using the optimal policies, it is then possible to derive the inverse of the bond accumulation policy $g(B,z)$. This is used to update the conditional bond distribution $M(B,z)$ according to the formula $M_\tau(B,z) = \sum_z M_{\tau-1}(g(B,\tilde{z}),\tilde{z}) P(z|\tilde{z})$, where τ is the τ-th iteration and $P(z|\tilde{z})$ is the probability that $z_{t+1} = z$ if $z_t = \tilde{z}$. Once the bond distribution has converged to the stationary distribution, we check whether the market for bonds clears. If not, we update the guess for the interest rate.

To compute the transitional dynamics, we first derive the initial and final steady states. We then choose a T large enough so that the economy has approximately converged to the final steady state at $t = T$ (we use $T = 100$, increasing T does not affect the results reported). The next step consists in guessing a path for the interest rate. We then set the policy functions for consumption in period T equal to the ones in the final steady state and iterate backward on the Euler equation and on the intratemporal optimality conditions to find the sequence of optimal policies $\{C_t^T(B,z), C_t^N(B,z)\}$. Next, we use the optimal policies to compute the sequence of bond distributions $M_t(B,z)$ going forward from $t = 0$ to $t = T$, starting with the distribution in the initial steady state. Finally, we compute the world demand for bonds in every period and update the path for the interest rate until the market clears in every period.

I.8 Sensitivity analysis

In this appendix we discuss how the results are affected by changes in some key model parameters.

We start by considering changes in the Frisch elasticity of labor supply $1/\eta$. This is an important parameter, because it determines the impact on welfare of deviations of employment from its natural value. More precisely, the lower the Frisch elasticity the higher the welfare losses associated with involuntary unemployment. In our benchmark parametrization we considered a Frisch elasticity of 0.45, in line with the value used by the New Keynesian literature. However, in our setting this assumption is likely to underestimate the welfare costs of unemployment. This is due to the

[78] In Appendix I.8 we provide a sensitivity analysis and show how our quantitative results are affected by changes in some key model parameters. In particular, we consider changes in the disutility from involuntary unemployment and in inflation expectations. We also consider a version of the model in which the supply of bonds from the rest of the world responds to variations in the world interest rate.

fact that in the benchmark New Keynesian model there is no involuntary unemployment. Instead, in our world characterized by wage rigidities all the fluctuation in employment are involuntary. It is then interesting to see how the results change when the welfare costs associated with fluctuations in unemployment increase.

The second row of Table 3 shows that lowering the Frisch elasticity to 0.35 substantially increases both the output and welfare losses caused by current account policies. This result is due to the fact that higher welfare costs from unemployment induce governments to intervene more aggressively on the current account. Hence, the implementation of current account policies leads to a larger drop in the world interest rate, which exacerbates the inefficiencies due to the zero lower bound compared to our benchmark parametrization. As a result, lowering the Frisch elasticity to 0.35 more than doubles the welfare losses triggered by current account policies with respect to the benchmark parametrization. The third row of table 3 shows that, as it is natural, the opposite occurs for a higher value of the Frisch elasticity equal to 0.55.

In our second experiment we consider changes in inflation $\bar{\pi}$. As it is well known higher inflation expectations, in our model captured by a higher $\bar{\pi}$, reduce the constraint on monetary policy imposed by the zero lower bound on the policy rate. In our benchmark parametrization we have set $\bar{\pi} = 1.0125$. This is lower that the 2% inflation target characterizing countries such as the US or Euro area, but higher than the average inflation experienced by countries undergoing long-lasting liquidity traps such as Japan.

It turns out that in our model even relatively small variations in inflation expectations can have a substantial impact on the output and welfare losses triggered by current account interventions. For instance, lowering $\bar{\pi}$ to 1 roughly doubles the output and welfare losses associated with current account policies. Instead, increasing $\bar{\pi}$ to 1.015 substantially mitigates the drop in global output triggered by the implementation of current account policies. Moreover, in this case the average impact on welfare of current account policies is slightly positive. However, current account interventions still exacerbate the inefficiencies due to the zero lower bound. In fact, once the focus is restricted to the non-tradable sector, current account policies have a negative impact on welfare is negative. These results suggests that inflation expectations play a key role in shaping the impact of current account policies on the global economy.

To conclude, we relax the assumption of an inelastic bond supply from the rest of the world. In particular, we assume that the supply of bonds from the rest of the world is given by

$$B_t^{rw} = B^{rw} \left(\frac{R_t}{R^{lf}} \right)^{\zeta},$$

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Table 3. Sensitivity analysis

	Output losses	Welfare losses	Welfare losses (NT)
Benchmark	1.22	0.09	0.30
Lower Frisch elasticity ($1/\eta = 0.35$)	1.76	0.23	0.52
Higher Frisch elasticity ($1/\eta = 0.55$)	0.54	-0.02	0.09
Lower inflation ($\bar{\pi} = 1.000$)	2.01	0.25	0.52
Higher inflation ($\bar{\pi} = 1.015$)	0.40	-0.03	0.06
Elastic B^{rw} (low, $\zeta = 1$)	0.74	0.00	0.16
Elastic B^{rw} (high, $\zeta = 10$)	0.25	-0.05	0.02

Notes: All the numbers are in percent. For each variable the table shows its average cross-sectional value.

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$$B_t^{rw} = B^{rw} \left(\frac{R_t}{R^{lf}} \right)^{\zeta},$$

so that the supply of bonds by the rest of the world is increasing in the world interest rate. Notice that this specification implies that in the laissez-faire steady state the bond supply from rest-of-the-world countries takes the same value as in our benchmark calibration. The parameter ζ captures the elasticity of B_t^{rw} with respect to R_t, and hence by how much the world interest rate falls as a consequence of the adoption of current account policies. Unfortunately, we could find reliable estimates for this elasticity.[79] Hence, we report the results for two benchmark value, $\zeta = 1$ (low elasticity) and $\zeta = 10$ (high elasticity).

The key difference with respect to the benchmark economy with inelastic B^{rw}, is that now the parameter ζ is a key determinant of the response of R to the implementation of current account policies. More precisely, the higher ζ the less R will drop after an increase in the supply of savings

[79] As we alluded to in the main text, the key challenge is that a significant fraction of lending from emerging to advanced countries is in the form of reserve accumulation by emerging countries' governments. These flows might be driven by different considerations than the standard trade-off between risk and return. Because of this, it is hard to pin down quantitatively how these flows react to changes in the world rate.

by our model economies. It is then natural to think that the negative impact that current account policies will have on world output will be milder the higher ζ. This is precisely the result shown by the two last rows of Table 3. However, current account policy produce a substantial drop in world output even when ζ takes the relatively high value of 10. A similar result applies to the welfare losses driven by the fact that current account policies exacerbate the inefficiencies due to the zero lower bound constraint. In fact, once the focus is restricted to the non-tradable sector, current account policies have a negative impact on welfare even for $\zeta = 10$. Summing up, while assuming an elastic supply of bonds from the rest of the world changes the quantitative predictions of the model, the results that current account policies depress global output and exacerbate the inefficiencies due to the zero lower bound hold for relatively high elasticities.

J International spillovers with symmetric countries

In this appendix we provide more details on the two examples informally described in Section 5.5. The key difference between these examples and the baseline model is that here we abstract from heterogeneity across countries, and introduce heterogeneity within countries. To this end, we consider countries inhabited by two groups of households: savers and borrowers. We start by deriving some preliminary results that apply to these two-agents economies, and then move to the specific examples mentioned in the main text.

J.1 Some preliminary results

In both examples, we consider a world composed of a measure one of small open economies. In each country, a fraction θ of the population is composed of borrowing-constrained agents (i.e. the borrowers), while the complement fraction is composed of agents on their Euler equation (i.e. the savers). Borrowers and savers are identical within their groups.

Aggregate demand equation. Market clearing for non-tradables goods in a generic country i implies

$$Y_{i,t}^N = (1-\theta)C_{s,i,t}^N + \theta C_{b,i,t}^N, \tag{J.1}$$

where $C_{s,i,t}^N$ and $C_{b,i,t}^N$ denote demand for non-tradables by respectively savers and borrowers. Moreover, we have that

$$C_{j,i,t}^N = \frac{1-\omega}{\omega}\frac{P_{i,t}^T}{P_{i,t}^N}C_{j,i,t}^T, \tag{J.2}$$

for $j = s, b$. Following the same steps used for the baseline model we can then write

$$Y_{i,t}^N = \frac{R_t\bar{\pi}}{R_{i,t}^n}\frac{(1-\theta)C_{s,i,t}^T + \theta C_{b,i,t}^T}{(1-\theta)C_{s,i,t+1}^T + \theta C_{b,i,t+1}^T}Y_{i,t+1}^N. \tag{J.3}$$

This equation describes the aggregate demand for non-tradable goods in this two-agents model. In the examples that follow, we will consider economies that are at full employment from period 2 on, and experience unemployment in period 1. That is, we will focus on the case

$$Y_{i,1}^{N} = R_1 \bar{\pi} \frac{(1-\theta) C_{s,i,1}^{T} + \theta C_{b,i,1}^{T}}{(1-\theta) C_{s,i,2}^{T} + \theta C_{b,i,2}^{T}} < 1. \tag{J.4}$$

Tradable consumption. The budget constraint of a generic household j is

$$C_{j,i,t}^{T} + \frac{P_{i,t}^{T}}{P_{i,t}^{N}} C_{j,i,t}^{N} = Y_{j,i,t}^{T} + \frac{P_{i,t}^{T}}{P_{i,t}^{N}} Y_{i,t}^{N} + R_{t-1} B_{j,i,t} - B_{j,i,t+1}, \tag{J.5}$$

where we have assumed that labor income is split evenly across all households ($W_{i,t} L_{j,i,t} = P_{i,t}^{N} Y_{i,t}^{N}$), and normalized the holdings of nominal bonds by every household to zero. Using (J.2) we can rewrite this expression as

$$C_{j,i,t}^{T} = \omega \left(Y_{j,i,t}^{T} + R_{t-1} B_{j,i,t} - B_{j,i,t+1} \right) + (1-\omega) C_{i,t}^{T}, \tag{J.6}$$

where $C_{i,t}^{T} = (1-\theta) C_{s,i,t}^{T} + \theta C_{b,i,t}^{T}$. To understand why aggregate tradable consumption enters this expression, consider that a rise in $C_{i,t}^{T}$ is associated with higher aggregate demand for non-tradable goods. In turn, higher demand for non-tradables leads to an increase in wages or hours worked, and thus in every households' income.[80]

We now trace the impact of a change in initial wealth on the path of tradable consumption in periods 1 and 2, holding the world interest rate constant. Using (J.6) and the fact that $C_{s,i,t+1}^{T} = \beta R_t C_{s,i,t}^{T}$ we obtain

$$C_{s,i,2}^{T} = \beta R_1 C_{s,i,1}^{T} \tag{J.7}$$

$$C_{s,i,1}^{T} = (1-\beta) R_0 \left(\bar{Y}_{s,i,1} + (\omega + (1-\omega)(1-\theta)) B_{s,i,1} + (1-\omega)\theta B_{b,i,1} \right), \tag{J.8}$$

where

$$\bar{Y}_{s,i,1} = \sum_{t=1}^{\infty} \frac{(\omega + (1-\omega)(1-\theta)) Y_{s,i,t}^{T} + (1-\omega)\theta Y_{b,i,t}^{T}}{\Pi_{m=0}^{t-1} R_m}. \tag{J.9}$$

Equation (J.8) is the usual consumption function characterizing unconstrained agents with log-utility. To see this point, consider that if agents derived utility from tradable goods only ($\omega = 1$), this expression would imply that savers would spend a fraction $1-\beta$ of an increase in their wealth on consumption. Compared to the usual benchmark, however, here there are two twists. First, holding constant labor income, only a fraction ω of the increase in expenditure goes to the consumption of tradable goods. Second, a rise in savers' initial wealth increases aggregate tradable consumption. As a consequence savers' labor income rises, further stimulating tradable consumption. This is captured by the term $(1-\beta)(1-\omega)(1-\theta) R_0 B_{s,i,1}$. A similar effect explains the term $(1-\beta)(1-\omega)\theta R_0 B_{b,i,1}$, which captures the impact on savers' tradable consumption of a change in borrowers' initial wealth.

Turning to borrowers, we can use the fact that they are borrowing constrained in period 1 to write

[80] In the case of a representative household this equation further simplifies to

$$C_{j,i,t}^{T} = Y_{j,i,t}^{T} + R_{t-1} B_{j,i,t} - B_{j,i,t+1},$$

because in this case in equilibrium every household spends on non-tradable goods an amount exactly equal to its labor income.

$$C^T_{b,i,1} = \frac{1}{1-(1-\omega)\theta}\left(\omega(Y^T_{b,i,1} + R_0 B_{b,i,1}) + (1-\omega)(1-\theta)C^T_{s,i,1}\right). \tag{J.10}$$

The key aspect here is that borrowers' propensity to consume out of their wealth is equal to 1. Of this, a fraction ω is devoted to tradable consumption. Moreover, as borrowers increase their consumption of tradable goods their labor income rises, generating a multiplier effect captured by the term $(1-(1-\omega)\theta)^{-1}$. For the same reason, borrowers' tradable consumption reacts to changes in savers' consumption, as captured by the last term on the right hand side of the expression. Moreover, in the examples that follow borrowers will hold zero assets from period 2 on. It follows that

$$C^T_{b,i,2} = \frac{1}{1-(1-\omega)\theta}\left(\omega Y^T_{b,i,2} + (1-\omega)(1-\theta)C^T_{s,i,2}\right). \tag{J.11}$$

Wealth and output in a small open economy. We now seek to understand how changes in $B_{s,i,1}$ and $B_{b,i,1}$ affect national output in period 1. We assume the perspective of the government of a single small open economy, which takes the rest of the world as given. Hence, we will keep holding constant the world interest rate.

Using the consumption functions derived above, we can now differentiate equation $(J.4)$ to obtain

$$\frac{\partial Y^N_{i,1}}{\partial B_{b,i,1}} = \frac{Y^N_{i,1}}{C^T_{i,1}}\theta\left(\frac{\omega}{1-(1-\omega)\theta} + (1-\beta)\frac{(1-\theta)(1-\omega)}{1-(1-\omega)\theta}\left(1-\frac{\beta R_1 C^T_{i,1}}{C^T_{i,2}}\right)\right) > 0 \tag{J.12}$$

$$\frac{\partial Y^N_{i,1}}{\partial B_{s,i,1}} = \frac{Y^N_{i,1}}{C^T_{i,1}}(1-\theta)(1-\beta)\left(1-\beta R_1\frac{C^T_{i,1}}{C^T_{i,2}}\right) > 0. \tag{J.13}$$

These two expressions characterize the impact on output of a marginal change in wealth, as perceived by domestic governments taking the rest of the world as given. The important observation is that, from the point of view of a domestic government, a rise in national wealth leads to an increase in demand for non-tradable goods and output during a liquidity trap. This happens because both savers and borrowers react to a rise in wealth by increasing their spending on consumption. Hence, just as in the baseline model, governments perceive that increasing national savings before a liquidity trap leads to higher output during the liquidity trap.

Having established these preliminary results, we now turn to our illustrative examples.

J.2 Example 1: contractionary international spillovers

Setup. Imagine that all countries are symmetric. Since countries are identical, in what follows we will streamline notation by suppressing the country subscripts. At the end of period 0, all households are also identical, and they all enter period 1 with assets B_1. This initial endowment of wealth should be thought as the return to past investment in outside liquidity, such as bonds provided by rest-of-the-world agents, as in Section 5.2, or investment in physical capital, as in Appendix H. Just to streamline the exposition, we assume that this source of liquidity disappears from period 1 on, and that no borrowing is allowed.

In period 1, households receive an idiosyncratic tradable endowment shock.[81] In particular, in each country one half of the population receives endowment Y_h^T, while the other half receives $Y_l^T < Y_h^T$. From period 1 on all the households receive the same endowment Y_h^T. As we will see, this path of endowment might generate a world-wide liquidity trap in period 0.

Solving for the equilibrium. From period 2 on the economy enters a steady state in which every household holds zero assets and consumes $C^T = Y_h^T$ and $C^N = Y^N$, where the absence of a time subscript denotes the steady state value of a variable. Moreover, the world interest rate is constant and equal to $R = 1/\beta$. It is then easy to check that if $\pi/\beta > 1$, which we assume to hold from now on, in steady state the zero lower bound does not bind and every country operates at full employment ($Y^N = 1$).

Let us now solve for the equilibrium in period 1. Naturally, agents receiving the high endowment Y_h^T would like to save. We will therefore denote them with the subscript s (savers). Instead, agents receiving Y_l^T will want to borrow, and we henceforth denote them with the subscript b (borrowers). Since borrowing is not allowed and no outside liquidity is available, however, every agent holds zero assets at the end of the period. Using equation (J.6) we can then write

$$C_{s,1}^T = \frac{1+\omega}{2} Y_h^T + \frac{1-\omega}{2} Y_l^T + R_0 B_1 \tag{J.14}$$

$$C_{b,1}^T = \frac{1+\omega}{2} Y_l^T + \frac{1-\omega}{2} Y_h^T + R_0 B_1. \tag{J.15}$$

To clear the global asset market, the world interest rate needs to adjust until desired savings by high-endowment agents are equal to zero. This is the case if

$$R_1 = \frac{2Y_h^T}{\beta\left((1+\omega)Y_h^T + (1-\omega)Y_l^T + 2R_0 B_1\right)}. \tag{J.16}$$

Notice that the presence of initial wealth ($B_1 > 0$) puts downward pressure on the world interest rate. Intuitively, the fact that savers need to decumulate assets depresses global rates. In this respect, this example shares some similarities with Rognlie et al. (2018), who consider a scenario in which interest rates are depressed during an episode of decumulation of housing capital.

What about output? Using expression (J.4), it is easy to check that a global liquidity trap occurs in period 1 if Y_l^T is sufficiently low.[82] In this case, every country operates below capacity and non-tradable output is equal to

$$Y_1^N = \frac{\bar{\pi}}{\beta} \frac{Y_h^T + Y_l^T + 2R_0 B_1}{(1+\omega)Y_h^T + (1-\omega)Y_l^T + 2R_0 B_1} < 1. \tag{J.17}$$

[81] One could see this as an inequality shock, perhaps originating from a negative shock affecting asymmetrically workers operating in different sectors of the economy. Alternatively, this could be the outcome of heterogeneous wealth shocks, perhaps due to asymmetric changes in house prices around the country.

[82] Precisely, a liquidity trap occurs if

$$Y_l^T\left(\frac{\bar{\pi}}{\beta} - (1-\omega)\right) < Y_h^T\left(1+\omega - \frac{\bar{\pi}}{\beta}\right) + 2R_0 B_1\left(1 - \frac{\bar{\pi}}{\beta}\right).$$

Since borrowing is not allowed, the negative endowment shock forces unlucky households to cut their expenditure on consumption. If the shock is sufficiently large, therefore, monetary policy ends up being constrained by the zero lower bound and a global recession occurs. This is the case that we will consider in the analysis that follows.

Output response to a change in wealth by a single small open economy. Following the logic of Section $J.1$, one can see that in this setting governments perceive that a rise in period 0 savings, and thus in B_1, will lead to higher output in period 1. More precisely, using expressions ($J.12$) and ($J.13$) one finds that an individual government perceives that a change in B_1 affects its country's output in period 1 according to

$$\frac{\partial Y_1^N}{\partial B_1} = \frac{Y_1^N}{C_1^T}\frac{1}{1+\omega}\left(\omega + (1-\beta)\left(1 - \beta R_1 \frac{C_1^T}{C_2^T}\right)\right) > 0. \tag{J.18}$$

Hence, in this example governments have an incentive to increase savings in period 0, and so B_1, to boost aggregate demand and output during the liquidity trap occurring in period 1.

International spillovers. As in the baseline model, here international spillovers arise because each country's output depends on the world interest rate. In turn, the world interest rate is determined by each country's saving and borrowing decisions. To understand the direction of the international spillovers, we thus need to trace the impact of a rise in B_1 on the world interest rate R_1.[83]

Differentiating equation ($J.16$) gives

$$\frac{\partial R_1}{\partial B_1} = -2R_0 \frac{R_1}{C_{s,1}^T} < 0. \tag{J.19}$$

According to this expression, the increase in B_1 leads to a drop in R_1. Intuitively, since savers enter period 1 with higher wealth their supply of savings increases. At the global level, the increase in saving supply leads to a fall in the world interest rate during the liquidity trap in period 1. In turn, the drop in the world interest rate lowers global aggregate demand and output (see equation ($J.4$)). Hence, this general equilibrium effect counteracts, at least partly, the positive direct impact of the increase in wealth on output. This effect is ignored by national governments and represents a negative aggregate demand spillover.[84] In this example, therefore, the international spillovers from prudential policies aiming at increasing savings before a liquidity trap are contractionary.

[83] For completeness, a second source of spillovers is present, since saving decisions in period 0 have an impact on R_0. As showed in Section 5.4, this effect could produce a recession in period 0. We ignore this possibility in this example.

[84] It turns out that in this particular example the total impact of an increase in national assets on output is positive. However, it is not hard to construct examples in which prudential policies aiming at increasing B_1 completely backfire and lead to a drop in output during the liquidity trap. For instance, this would be the case if in period 1 agents were hit by an idiosyncratic shock to the return on their assets. In particular, imagine that $C_{s,1}^T = Y^T + R_0 B_1(\omega + (1-\omega)(1+\iota)/2)$ and $C_{b,1}^T = Y^T + R_0 B_1(\iota\omega + (1-\omega)(1+\iota)/2)$, where $\iota < 1$ captures the difference in asset returns between lucky and unlucky agents. Following the steps outlined in this section, one can show that in this case a rise in B_1 will produce, due to its negative general equilibrium impact on the world interest rate, a drop in period 1 output.

J.3 Example 2: expansionary international spillovers

We now provide an example in which the international spillovers are expansionary. This example is inspired by the deleveraging scenarios studied by Farhi and Werning (2016) and Korinek and Simsek (2016).

Setup. Imagine that all countries are symmetric. Since countries are identical, in what follows we will streamline notation by suppressing the country subscripts. Every household receives each period an endowment of tradable goods equal to Y^T. One half of the population enters period 1 with some pre-existing debt ($B_{b,1} = -D_1 < 0$). These debts are fully owed to the other half of the population, which enters period 1 with assets $B_{s,1} = D_1$. As in Eggertsson and Krugman (2012), in period 1 a tightening of the borrowing limit forces borrowers to reduce their debts. This deleveraging shock generates a liquidity trap in period 1. For simplicity, we assume that the tightening of the borrowing limit forces borrowers to reduce their debts all the way to zero. We also assume that there is no outside liquidity.

Solving for the equilibrium. From period 2 on the economy enters a steady state in which every household holds zero assets and consumes $C^T = Y^T$ and $C^N = Y^N$, where the absence of a time subscript denotes the steady state value of a variable. Moreover, the world interest rate is constant and equal to $R = 1/\beta$. It is then easy to check that if $\pi/\beta > 1$, which we assume to hold from now on, in steady state the zero lower bound does not bind and every country operates at full employment ($Y^N = 1$).

Let us now solve for the equilibrium in period 1. Naturally, agents starting the period with positive assets would like to save. We will therefore denote them with the subscript s (savers). Instead, agents starting the period with a pre-existing debt will want to borrow, and we henceforth denote them with the subscript b (borrowers). Since from period 1 on borrowing is not allowed and no outside liquidity is available, however, every agent holds zero assets at the end of the period. Using equation (J.6) we can then write

$$C^T_{s,1} = Y^T + \omega R_0 D_1 \tag{J.20}$$

$$C^T_{b,1} = Y^T - \omega R_0 D_1. \tag{J.21}$$

To clear the global asset market, the world interest rate needs to adjust until desired savings by savers are equal to zero. This is the case if

$$R_1 = \frac{Y^T}{\beta \left(Y^T + \omega R_0 D_1\right)}. \tag{J.22}$$

Notice that the world interest rate is decreasing in borrowers' start-of-period debt D_1. This happens because the deleveraging shock forces borrowers to cut their consumption of tradable goods by an amount equal to $\omega R_0 D_1$. The world interest rate needs to fall so that savers are induced to increase tradable consumption by the same amount.

Let us now turn to output. Using expression ($J.4$), it is easy to check that a global liquidity trap occurs in period 1 if D_1 is sufficiently high.[85] In this case, every country operates below capacity and non-tradable output is equal to

$$Y_1^N = \frac{\bar{\pi} Y^T}{\beta \left(Y^T + \omega R_0 D_1\right)} < 1. \tag{J.23}$$

Intuitively, the deleveraging shock pushes debtors against their borrowing limit. This forces them to cut on spending. If the shock is sufficiently large, i.e. if initial debt is sufficiently big, the associated fall in aggregate demand pushes the world in a liquidity trap.

Output response to a change in borrowers' debt by a single small open economy. As in Farhi and Werning (2016) and Korinek and Simsek (2016), we now trace the impact on output of policies that reduce borrowers' debt ex-ante. Let us start by taking the perspective of a single small open economy. Following the logic of Section $J.1$, one can see that a government ruling a small open economy perceives that reducing borrowers' debt ex-ante will lead to higher domestic aggregate demand and output during the liquidity trap. More precisely, using ($J.12$) one finds that an individual government perceives that a change in D_1 affects its country's output in period 1 according to[86]

$$\frac{\partial Y_1^N}{\partial D_1} = -\frac{Y_1^N}{C_1^T}\frac{1}{1+\omega}\left(\omega + (1-\beta)\frac{1-\omega}{2}\left(1 - \frac{\beta R_1 C_1^T}{C_2^T}\right)\right) < 0. \tag{J.24}$$

Hence, in this example governments have an incentive to reduce the debt held by domestic borrowers in period 0, and so D_1, to boost output during the liquidity trap occurring in period 1.[87]

International spillovers. In this example, there are two sources of international spillovers. Both spillovers arise from the fact that in general equilibrium a drop in borrowers' debt has to be matched by an equivalent fall in the assets held by savers. Individual governments, however, take the global demand for borrowing as given. Thus they do not internalize the impact of their policy decisions on global demand for borrowing and, consequently, on the assets held by domestic savers.

The first source of spillover is contractionary. As highlighted by equation ($J.13$), a fall in the assets held by domestic savers at the start of the liquidity trap induces a drop in domestic aggregate demand and output. Therefore, policy interventions that reduce borrowers' debt in period 0 negatively affect aggregate demand in the rest of the world, because they reduce the assets held by savers at the start of the liquidity trap. In fact, governments' interventions aiming at increasing tradable consumption during the liquidity trap by reducing D_1 completely backfire.

[85] Precisely, a liquidity trap occurs if

$$\omega R_0 D_1 > \left(\frac{\bar{\pi}}{\beta} - 1\right) Y^T.$$

[86] To derive this expression, consider that we are taking the perspective of a single government that engineers a reduction in domestic borrowers' debts, without affecting the assets held by domestic savers.

[87] Contrary to the closed-economy models studied by Farhi and Werning (2016) and Korinek and Simsek (2016), in this example governments would also have an incentive to increase the stock of assets held by domestic savers at the end of period 0. In fact, individual governments perceive that higher national wealth increases domestic output during the liquidity trap. The difference with respect to Farhi and Werning (2016) and Korinek and Simsek (2016) arises because, in our world characterized by international financial integration, governments do not internalize the fact that in general equilibrium a fall in the debt held by borrowers has to be matched by a fall in the assets held by savers.

Indeed, if all the countries in the world engineer a reduction in D_1 the associated drop in the assets held by savers neutralize the impact of the policy on tradable consumption in period 1.

There is also, however, an expansionary spillover passing through the world interest rate. Differentiating equation (J.22), in fact, gives

$$\frac{\partial R_1}{\partial D_{s,1}} = -\omega R_0 \frac{R_1}{C^T_{s,1}} < 0. \tag{J.25}$$

This term is negative. The intuition goes along these lines. If all the borrowers in the world reduce their debts in period 0, savers enter period 1 with a smaller stock of assets. As savers enter period 1 with a smaller stock of wealth, they contract the global saving supply. This leads to a higher world interest rate during the liquidity trap. In turn, the rise in the world interest rate increases global aggregate demand and output (see equation (J.4)). This effect is ignored by national governments and represents a positive aggregate demand spillover.

It tuns out that in equilibrium the expansionary spillover dominates the contractionary one. In fact, it is easy to see from equation (J.23) that if all the countries in the world reduce D_1 the result is an increase in world output during the liquidity trap in period 1. In this example, therefore, the international spillovers from prudential policies aiming at reducing national debt before a liquidity trap are overall expansionary.

K Data appendix

This appendix provides details on the construction of the series used in the calibration and to construct Figure 1.

K.1 Data used in the calibration

The countries in the sample are Australia, Austria, Canada, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States.

1. *World interest rate.* The series for the world interest rate is constructed by Rachel and Smith (2015) following the methodology proposed by King and Low (2014).[88]

2. *Net foreign assets.* The data for the net foreign asset position and GDP come from External Wealth of Nations' dataset by Lane and Milesi-Ferretti (2007).

3. *Core inflation rate.* Core inflation is computed as the percentage change with respect to the previous year of the CPI for all items excluding food and energy. The series are yearly and provided by the OECD.

4. *Tradable endowment process.* Tradable output is defined as the aggregate of value added in agriculture, hunting, forestry, fishing, mining, manufacturing and utilities. To extract

[88] We thank Lukasz Rachel for providing us with the data.

the cyclical component from the actual series we used the following procedure. For each country we divided tradable output by total population and took logs. Since our model abstracts from aggregate shocks, for every year we subtracted from the country-level series the logarithm of the average cross-sectional tradable output per capita. For every country we then obtained the cyclical component of the resulting series by removing a country-specific log-linear trend. The first order autocorrelation and the standard deviation of the final series are respectively 0.87 and 0.056. We use yearly data for the period 1970-2015, coming from the United Nations' National account main aggregate database.

5. *Identifying financial crises.* We identify a financial crisis in the data as an episode in which the cyclical component of the trade balance is one standard deviation above its average and the cyclical component of tradable output, as defined above, is one standard deviation below its average. We define the start of a financial crisis as the first year in which the cyclical component of the trade balance is half standard deviation above its mean, while a financial crisis ends when the cyclical component of the trade balance falls below one standard deviation above its mean.
   To compute the cyclical component of the trade balance we used the following procedure. We collected yearly series for the trade balance for the period 1970-2015 from the OECD. The data are in 2010 constant US dollars. For each country, we then divided by total population. Since our model abstracts from aggregate shocks, for every year we subtracted the cross-sectional average from the series. Finally, we obtained the cyclical component from the resulting series by subtracting a country-specific linear trend.

K.2 Data used to construct Figure 1

1. *Policy rates.* Monthly series. US: Effective Federal Funds Rate from the Fed Board of Governors of the Federal Reserve System. Euro area and Japan: Central bank discount rate from the IMF International Financial Statistics database. UK: Bank of England policy rate.

2. *GDP per capita.* Constant prices, series from the World Bank.

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