An Equilibrium Model of "Global Imbalances" and Low Interest Rates

Ricardo J. Caballero Emmanuel Farhi Pierre-Olivier Gourinchas*

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Abstract

Three of the most important recent facts in global macroeconomics — the sustained rise in the US current account deficit, the stubborn decline in long run real rates, and the rise in the share of US assets in global portfolios — appear as anomalies from the perspective of conventional wisdom and models. Instead, in this paper we provide a model that rationalizes these facts as an equilibrium outcome stemming from the heterogenity in different regions of the world in their capacity to generate financial assets from real investments. In extensions of the basic model, we also generate exchange rate and FDI excess returns which are broadly consistent with the recent trends in these variables. Beyond the specific sequence of events that motivate our analysis, the framework is flexible enough to shed light on a range of scenarios in a global equilibrium environment.

JEL Codes: E0, F3, F4, G1

Keywords: Current account deficits, capital flows, interest rates, global portfolios and equilibrium, growth and financial development asymmetries, exchange rates, FDI, intermediation rents.

*Respectively: MIT and NBER; Harvard; Berkeley and NBER. E-mails: caball@mit.edu, efarhi@harvard.edu, pog@berkeley.edu. We thank Daron Acemoglu, Philippe Bachetta, Olivier Blanchard, VV Chari, Mike Dooley, Jeff Frankel, Francesco Giavazzi, Gita Gopinath, Gian Maria Milessi Ferreti, Enrique Mendoza, Michael Mussa, Maury Obstfeld, Fabrizio Perri, Paolo Pesenti, Richard Portes, Helene Rey,Andrei Shleifer, Lars Svensson, Jaume Ventura, Joachim Voth, Ivan Werning, and seminar participants at AEA meetings, Berkeley, Brown, BIS' conference on financial globalization, CEPR's first annual workshop on Global Interdependence, CREI-Ramon Arces conference, ESSIM in Tarragona, Harvard, IMF, MIT, MIT-Central Banks Network, NBER-EFG, NBER-IFM, Princeton, SCCIE, SED in Vancouver, Stanford, University of Houston and Yale for their comments. Caballero and Gourinchas thank the NSF for financial support. First draft: September 2005.

1 Introduction

Three facts have dominated the discussion in global macroeconomics in recent times:

Fact 1: The US has run a persistent current account deficit since the early 1990s, which has accelerated dramatically since the late 1990s. By 2004, it exceeded US$600 billions a year. The solid dark line in Figure 1(a) illustrates this path, as a ratio of World's GDP (this line also includes the deficits of the U.K. and Australia, for reasons that will be apparent below, but it is overwhelmingly dominated by the U.S. pattern). The counterpart of these deficits has been driven by the surpluses in Japan and Continental Europe throughout the period and, starting at the end of the 1990s, by the large surpluses in Asia ex-Japan, commodity producers, and the turnaround of the current account deficits in most non-European emerging market economies.

Fact 2: The long run real interest rate has been steadily declining over the last decade, despite recent efforts from central banks to raise interest rates – the "Greenspan's Conundrum". See Figure 1(b).

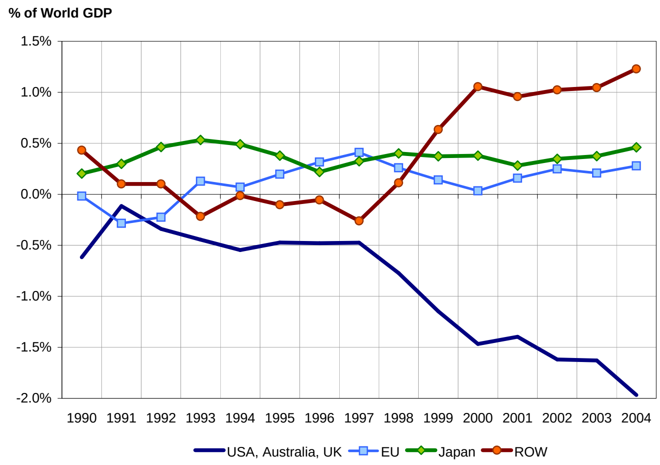
Fact 3: The importance of US assets in global portfolios has increased throughout the period and by 2004 it amounted to over 17 percent of the rest of the world's financial wealth, which is equivalent to 43 percent of their annual output. See Figure 1(c).

Despite extensive debates on the factors behind and the sustainability of this environment, there are very few formal structures to analyze these joint phenomena. The conventional view and its recent formalizations, attempt mostly to explain (the first half of) fact 1, largely ignore fact 2, and take 3 as an exogenous anomaly. The analysis about the future then consists of telling the story that follows once this "anomaly" goes away. However, capital flows are primarily an asset market phenomenon and hence the paths of interest rates and portfolios must be made an integral part of the analysis if we are to conjecture on what got the world into the current situation and how it is likely to get out of it.[1]

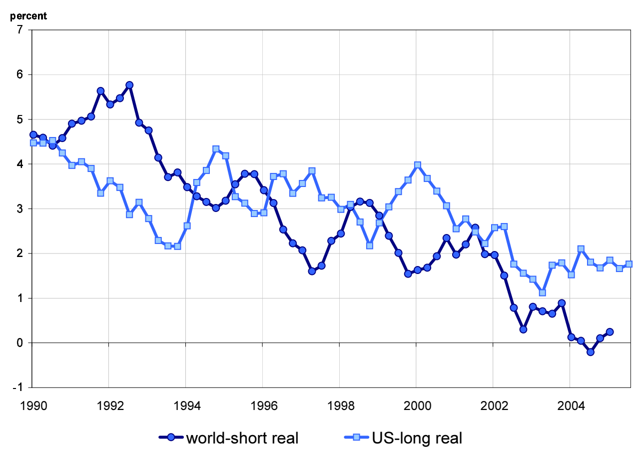
The main purpose of this paper is to provide a framework to analyze global equilibrium, and its response to a variety of relevant shocks and structural changes. As an important side product, the framework also sheds light on the above facts. The model is designed to highlight the role of global asset-markets and, in particular, of asset-supply in shaping global capital flows, interest rates and portfolios. We use this model to show that the dominant features in Figure 1, together with observed exchange rates and gross flows patterns, can arise naturally from observed financial market shocks and structural factors which interact with heterogeneous degrees of financial market development in different regions of the world.

In Figure 1(a), we divide the world into four groups: The US (and "similar" economies such as Australia and the U.K.) (U); the EuroZone (E); Japan (J); and the rest (R). The latter include emerging markets, oil producing countries, and high saving newly industrialized economies, such as Hong-Kong, Singapore and Korea. While most of the academic literature has focused on the interaction between U and E, it is apparent

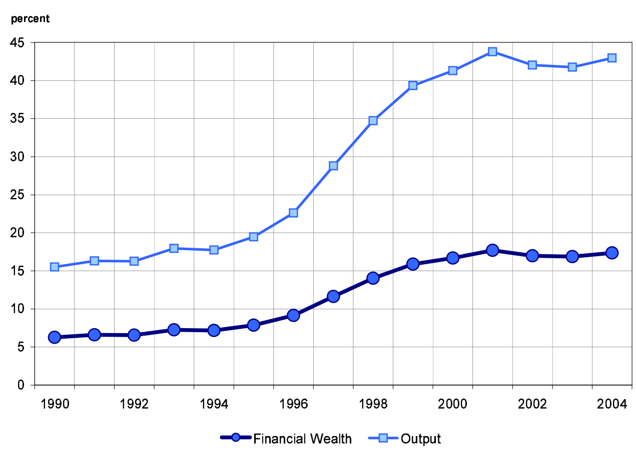
[1] Recently, some of the debate in policy circles also has began to highlight the role of equilibrium in global capital markets for US current account deficits. See especially Bernanke (2005) and IMF (2005). We will revisit the "saving glut" view after we have developed our framework.



(a) Current Account by Region (percent of world output)



(b) World and US Real Interest Rates



(c) Share of US Assets in Rest of the World's Output and Financial Wealth

Figure 1: Three Stylized Facts. Sources: (a) WDI and Deutsche Bank. (b) International Financial Statistics and Survey of Professional Forecasters. (c) World Development Indicators, Bureau of Economic Analysis, European Central Bank, Bank of Japan and Authors' calculations (see appendix)

from the figure that the most important interaction is that between U and R. Thus, our analysis is about global equilibrium in a $U-R$ world.[2] The key feature of the model is that it focuses on the regions' ability to *supply* financial assets to savers. On net, region U supplies assets; region R demands financial assets. Thus, fast growth in R coupled with their inability to generate sufficient local store of value instruments increases their demand for saving instruments from U.

In this world, we investigate the implications of a collapse in asset markets in R, such as that experienced by emerging markets in the late 1990s, as well as of the gradual integration and emergence of fast growing R economies, such as China.[3] We show that both phenomena point in the same direction, in terms of generating a rise in capital flows toward U, a decline in real interest rates, and an increase in the importance of U's assets in global portfolios. Moreover, while there are natural forces that undo some of the initial trade deficits in U, these are tenuous, as U's current account never needs to turn into surplus and capital flows "indefinitely" toward U.

Although not as important as the recent patterns in R, much of the analysis we conduct also applies to the high saving rate (and hence high asset demand) of Japan and the aftermath of the collapse in the Japanese bubble in the early 1990s. Thus we also discuss these features in our analysis, as they help to explain the milder imbalances observed in the first half of the 1990s.

In the basic model, there is a single good and productive assets are fixed and (implicitly) run by local agents. We relax these assumptions in extensions. In the first one we allow for an investment margin and a reason for foreign direct investment (FDI). These additions enrich the framework along two important dimensions in matching the facts: First, the collapse in asset markets in R can lead to an investment slump in R – as opposed to just an increase in saving rates – which exacerbates the results from the basic model. Second, the intermediation rents from FDI, whose main reason is to transfer "corporate governance" from one country to another, reduce the trade surpluses that U needs to generate to repay for its persistent early deficits. In some instances, these rents allow U to finance permanent trade deficits.

In the second extension we allow for heterogeneous goods and discuss real exchange rate determination. The exchange rate patterns generated by the expanded model in response to the shocks highlighted above are broadly consistent with those observed in the data. In particular, U's exchange rate appreciates in the short run, and then (very) gradually depreciates in the absence of further shocks.

As we mentioned above, much of the academic literature has focused on the $U-E$ and (less frequently) the $U-J$ dimensions. For instance, Blanchard, Giavazzi and Sa (2005) analyze US external imbalances

[2]For completeness, in an earlier version of this paper we accounted for the $U-E$ pattern in terms of the growth differential between U and E. This differential not only explains the flows from E to U but also why a disproportionate share of the flows from R go to U rather than to E. See Caballero, Farhi and Gourinchas (2006b).

[3]See Caballero and Krishnamurthy (2006) for a model of bubbles in emerging markets as a result of their inability to generate reliable financial assets. When local bubbles crash, countries need to seek stores of value abroad. This pattern could also arise from a fundamental shock due to a change in public perception of the soundness of the financial system and local conglomerates, degree of "cronysm," and so on.

from the point of view of portfolio balance theory à la Kouri (1982). Their approach takes world interest rates as given and focuses on the dual role of the exchange rate in allocating portfolios between imperfectly substitutable domestic and foreign assets and relative demand through the terms of trade. In their model, the large recent US current account imbalances result from exogenous increases in U.S. demand for foreign goods and in foreign demand for U.S. assets. Their model predicts a substantial future depreciation of the US dollar since the exchange rate is the only equilibrating variable and current account deficits must be reversed. Obstfeld and Rogoff (2004) and (2005) consider an adjustment process through the global reallocation of demand for traded versus non traded and domestic versus foreign goods. Their analysis takes as given that a current account reversal needs to occur in the US, as well as the levels of relative supply of traded and non-traded goods in each country. Because the current account deficits represents a large share of traded output, they too, predict a large real depreciation of the dollar. These papers differ from ours in terms of the shocks leading to the current "imbalances", our emphasis on equilibrium in global financial markets and, most importantly, on the connection between this equilibrium and the countries' ability to produce sound financial assets.

Among the papers focusing on developed economies flows, the closest paper to ours in terms of themes and some of the implications is Caballero, Farhi and Hammour (2006a), who present several models of speculative investments booms in U and low global interest rates. One of the mechanisms they discuss is triggered by a slowdown in investment opportunities in the rest of the world. However the emphasis in that paper is on the investment side of the problem and ignores the role of R and asset supply, which are central to our analysis in this paper. Kraay and Ventura (forthcoming 2007) analyze an environment similar to that in Caballero et al.. Their emphasis is on the allocation of excess global savings to a US bubble but it does not connect capital flows to growth and domestic financial markets fundamentals as we do here. Finally, Cooper (2005) presents a view about the $U-J$ region similar to ours in terms of substantive conclusions.

For the $U-R$ part, Dooley, Folkerts-Landau and Garber (2003) and Dooley and Garber (forthcoming 2007) have argued that the current pattern of US external imbalances does not represent a threat to the global macroeconomic environment. Their "Bretton Woods II" analysis states that the structure of capital flows is optimal from the point of view of developing countries trying to maintain a competitive exchange rate, to develop a productive traded good sector, or to absorb large amounts of rural workers in the industrial sector. Unlike theirs, our analysis emphasizes the role of private sector capital flows and argues that the exchange rate is mostly a sideshow.[4]

[4]We do not deny the existence of large reserves accumulation by China and others. Nonetheless, we make three observations. First, most of these reserves are indirectly held by their local private sectors through (quasi-collateralized) low-return sterilization bonds in a context with only limited capital account openness. Second, US gross flows are an order of magnitude larger than official flows – rather than imputing Chinese reserves accumulation to financing the US current account deficit, one could equally well (or poorly) argue that they are financing FDI flows to emerging markets, including China. Third, the role of official interventions was most important at a time when the US was experiencing a temporary slowdown, while our analysis refers to more persistent trends.

Section 2 is the core of the paper and presents the main model and mechanisms. Section 3 supports the main quantitative claims. Section 4 introduces an investment margin and a reason for FDI, while Section 5 analyzes exchange rate determination. Section 6 concludes and is followed by several appendices.

2 A Model with Explicit Asset Supply Constraints

In this section we develop a stylized model that rationalizes the broad patterns of capital flows, interest rates and global portfolios shown in Figure 1. The model highlights equilibrium in capital markets and, in particular, the supply side of the market for global saving instruments. It is apparent from figure 1(a) that the dominant part of the story is the interaction between U and R.[5]

This interaction is the focus of this paper, which we explain in terms of the depressed financial markets conditions in R. Moreover, an important component of the surpluses generated by the J region is due to the collapse in the Japanese asset bubble in the early 1990s. In this sense the mechanism is similar to the one we highlight in the $U-R$ interaction, and we explore it in more details in section 3. Finally, we also show that the exceptional growth conditions in R exacerbate rather than offset the pattern of capital flows.

2.1 The Basic Structure

2.1.1 A closed economy

Time evolves continuously. Infinitesimal agents (traders) are born at a rate θ per unit time and die at the same rate; population mass is constant and equal to one. At birth, agents receive a perishable endowment of $(1-\delta)X_t$ which they save in its entirety until they die (exit). Agents consume all their accumulated resources at the time of death. The term $(1-\delta)X_t$ should be interpreted as the share of national output that is not capitalizable (more on this later on).

The only saving vehicles are identical "trees" producing an aggregate dividend of δX_t per unit time. Agents can save only in these trees, whose value at time is V_t. The return on the tree equals the dividend price ratio $\delta X_t/V_t$ plus the capital gain $\dot{V}_t/V_t$. This return is equal to the interest rate in the economy, r_t, so that:

$$r_t V_t = \delta X_t + \dot{V}_t. \tag{1}$$

[5] In Caballero et al. (2006b), we also considered an E-region, composed of countries with deep financial markets but bad growth conditions, such as continental Europe. The $U-E$ model has essentially similar implications as the textbook two-country model: as a result of a growth slowdown in E, the interest rate drops almost indefinitely and capital flows from E to U, resulting in a current account deficit in U. While both the depressed growth conditions in E and the depressed financial markets in R compound to generate large and persistent capital flows to U, our results indicated that the $U-R$ interaction played a more important role. See also Engel and Rogers (2006) for the conclusion that the $U-E$ growth differentials is not large enough to account for the US current account deficit. However, an important caveat highlighted in the previous version of our paper is that the growth differential between U and E also affects the allocation of funds from R, in favor of U.

Let W_t denote the savings accumulated by agents up to date t. Savings decrease with withdrawals (deaths), and increase with the endowment allocated to new generations and the return on accumulated savings:

$$\dot{W}_t = -\theta W_t + (1-\delta)X_t + r_t W_t. \tag{2}$$

In equilibrium, savings must be equal to the value of the trees:

$$W_t = V_t. \tag{3}$$

Replacing (3) into (1), and the result into (2), yields a relation between savings and output:[6]

$$W_t = \frac{X_t}{\theta}, \tag{4}$$

which together with (1) and (3) yields the equilibrium interest rate:

$$r_t = \frac{\dot{X}_t}{X_t} + \delta\theta. \tag{5}$$

This interest rate is the only price in the economy for now. Conditional on exogenous output X_t, the interest rate rises with growth because the latter lifts the rate of growth of financial wealth demand (W), and hence the expected capital gains from holding a tree; it rises with δ because this increases the share of income that is capitalizable and hence the supply of assets; and it rises with θ because this lowers financial wealth demand and hence asset prices.

We assume that the total endowment in the economy, X_t, grows at rate g. Hence r_t is given by r_{aut} where

$$r_{aut} = g + \delta\theta.$$

2.1.2 Discussion of our setup

This minimalist model has two ingredients that need further discussion: The parameter δ and the consumption function corresponding to our particular specification of preferences and demographics.

Let us start with the former. Denote by PV_t the present value of the economy's future output:

$$PV_t = \int_t^\infty X_s e^{-\int_t^s r_\tau d\tau} ds.$$

The parameter δ represents the share of PV_t that can be capitalized today and transformed into a tradable asset:

$$V_t = \delta PV_t.$$

The asset belongs to the agents currently alive, and represents their aggregate savings.

In practice, δ captures many factors behind pledgeability of future revenues. At the most basic level, one can think of δ as the share of capital in production. But in reality only a fraction of this share can be

[6] By Walras' Law, noticing that θW_t corresponds to consumption, we can re-write this relation as a goods-market equilibrium condition: $\theta W_t = X_t$.

committed to asset holders, as the government, managers, and other insiders can dilute and divert much of profits. It is for this reason that we refer to δ as an index of financial development, by which we mean an index of the extent to which property rights over earning are well defined and tradable in financial markets.

For given output and interest rate paths, as δ rises the share of tradeable PV_t rises and that of its complement, N_t:

$$N_t = (1 - \delta)PV_t$$

falls one for one.[7]

This takes us to the second key ingredient, our specification of preferences and demographics. For a change in δ to have any effect, it must have an impact on prices in the closed endowment economy. In the open economy environment we consider later on, these price effects impact allocations across regions in the world as well. In particular, δ must affect the total resources perceived by consumers (and hence by savers). If not, the economy is characterized by a situation akin to Ricardian equivalence: A rise in δ increases the supply of assets but it also raises the demand for assets one for one since non-capitalizable future income N_t falls by the same amount as V_t rises; as a result interest rates are left unchanged.

Thus, our choices are designed to provide the simplest model with non-Ricardian features. This is all that matters. Of course there is a large number of alternatives to achieve the same goal, at the cost of additional complexity. For example, we could assume a perpetual youth model à la Blanchard (1985) with log preferences throughout. In fact, such a model converges to ours if instead of giving agents a flow of labor income though life, we give them a lump sum at birth (see Appendix B). Moreover, our assumption of consumption in the last day of life does the same for the aggregate as Blanchard's annuity market, in that the agent does not need to worry about longevity risk. Similarly, Weil (1987)'s model of population growth with infinitely lived agents converges to ours if newly born agents receive the present value of their wages at birth. In both of these models, and their extensions to include ours, the consumption function of current agents takes the form (see Appendix B):

$$C_t = \theta(W_t + \beta_t N_t); \qquad \beta_t < 1.$$

The key point in these model as in ours is that current consumers do not have full rights over N_t while they do over V_t (and hence W_t).[8]

Finally, note that there is no need for an overlapping generations structure to have a role for asset supply. What is needed is some demand for liquidity and that changing the supply of assets has aggregate allocational consequence. For example, Woodford (1990)'s model of infinitely lived agents with alternating

[7] Of course, in reality limited financial development affects not only the distribution of revenues but also output and growth. Adding this dimension would exacerbate our results but make them less transparent.

[8] In Blanchard's model, the consumption function is $C_t = (p + \tilde{\theta})(W_t + H_t)$ where p is the probability of death and $\tilde{\theta}$ is the discount factor. H_t represents the aggregate value of non-tradable wealth and is strictly smaller than N_t as long as $p > 0$.

In Weil's model, and with the same notation, the consumption function is $C_t = \tilde{\theta}(W_t + H_t)$ and $H_t < N_t$ as long as the growth rate of population $n > 0$.

liquidity demand also creates an environment where a change in the availability of financial assets affects allocations and interest rates.

2.1.3 A Small Open Economy

Let us now open the economy, which faces a given world interest rate, r, such that:

Assumption 1 $g < r < g + \theta$

Definition 1 *(Trade Balance and Current Account): Let us denote the trade balance and current account at time t as TB_t and CA_t, respectively, with:*

$$\begin{aligned} TB_t &\equiv X_t - \theta W_t \\ CA_t &\equiv \dot{W}_t - \dot{V}_t \end{aligned}$$

The definition of the trade balance is standard. The current account is also standard; it is the dual of the financial account and is defined as the increase in the economy's net asset demand.[9]

To find the steady state of this economy, we integrate (1) forward and (2) backward:

$$\begin{aligned} V_t &= \int_t^\infty \delta X_s e^{-r(s-t)} ds \\ W_t &= W_0 e^{(r-\theta)t} + \int_0^t (1-\delta) X_s e^{(r-\theta)(t-s)} \end{aligned}$$

Assumption 1 implies that, asymptotically,

$$\frac{V_t}{X_t} \underset{t\to\infty}{\rightarrow} \frac{\delta}{r-g} \tag{6}$$

$$\frac{W_t}{X_t} \underset{t\to\infty}{\rightarrow} \frac{1-\delta}{g+\theta-r} \tag{7}$$

Equation (6) is just Gordon's formula. It shows that the asymptotic supply of assets, normalized by the size of the economy, is a decreasing function of r.[10] Equation (7) describes the asymptotic demand for assets which, normalized by the size of the economy, is an increasing function of r. Figure 2 represents the equilibrium in a supply and demand diagram, a variation on the Metzler diagram. The supply curve and demand curve cross at $r = r_{aut}$.

If $r < r_{aut}$

$$\frac{\delta}{r-g} > \frac{1-\delta}{g+\theta-r}$$

[9] At times it may be useful to think of the current account in terms of the trade balance and gross portfolio holdings:

$$\begin{aligned} CA_t^i &= X_t^i - \theta W_t^i + r_t(\alpha_t^{i,j} V_t^j - \alpha_t^{j,i} V_t^i) \\ &= TB_t^i + r_t(\alpha_t^{i,j} V_t^j - \alpha_t^{j,i} V_t^i) \end{aligned}$$

where $i \neq j$, $\alpha_t^{i,j}$ is the share of region j's trees held by agents in region i, $\alpha_t^{j,i}$ is the share of region i's trees held by agents in region j. In the particular case of our open economy, i corresponds to the country and j to the rest of the world.

[10] Note that with a constant interest rate, this expression holds not only asymptotically but at all points in time.

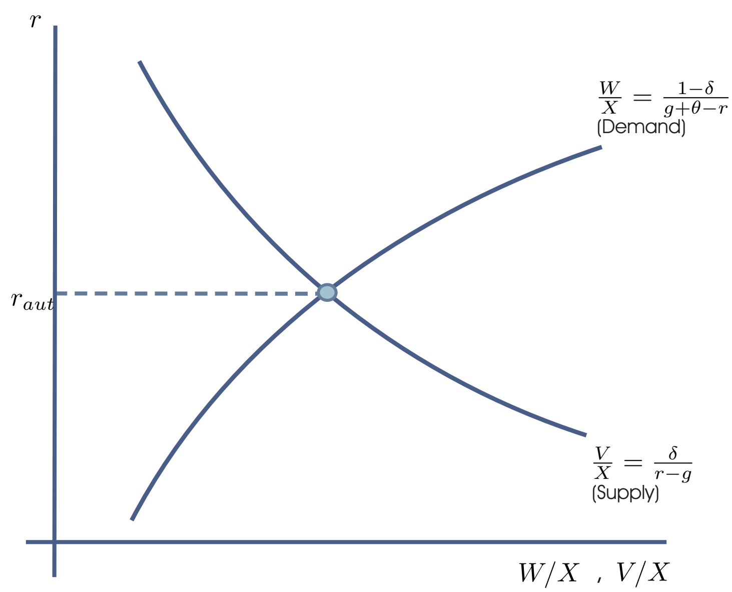


Figure 2: The Metzler diagram.

and domestic asset supply exceeds demand. Since along the balanced growth path $\dot{W}_t = gW_t$ and $\dot{V}_t = gV_t$, the above inequality implies that the economy runs an asymptotic current account deficit (financed by an asymptotic capital account surplus):

$$\frac{CA_t}{X_t} \underset{t\to\infty}{\to} g\left(\frac{1-\delta}{g+\theta-r} - \frac{\delta}{r-g}\right) = -g\frac{(r_{aut}-r)}{(g+\theta-r)(r-g)}. \tag{8}$$

Note also that, asymptotically, the trade balance is in surplus. The lower rate of return on savings depresses wealth accumulation and, eventually, consumption

$$\frac{TB_t}{X_t} \underset{t\to\infty}{\to} \frac{r_{aut}-r}{g+\theta-r}. \tag{9}$$

Importantly, however, this asymptotic trade surplus is *not* enough to service the accumulated net external liabilities of the country, which is why the current account remains in deficit forever.

Conversely, note that when $r > r_{aut}$, (8) and (9) still hold, but now the economy runs an asymptotic current account surplus.

We can prove a stronger result that will be useful later on.

Lemma 1 *Consider a path for the interest rate $\{r_t\}_{t\geq 0}$ such that $\lim_{t\to\infty} r_t = r$ with $g < r < g+\theta$. Then*

$$\frac{V_t}{X_t} \underset{t\to\infty}{\to} \frac{\delta}{r-g}, \qquad \frac{W_t}{X_t} \underset{t\to\infty}{\to} \frac{1-\delta}{g+\theta-r}$$
$$\frac{CA_t}{X_t} \underset{t\to\infty}{\to} -g\frac{(r_{aut}-r)}{(g+\theta-r)(r-g)}, \qquad \frac{TB_t}{X_t} \underset{t\to\infty}{\to} \frac{r_{aut}-r}{g+\theta-r}$$

Proof. See the appendix. ■

2.2 The World Economy: Shocks

Let us now study global equilibrium with two large regions, $i = \{U, R\}$. Each of them is described by the same setup as in the closed economy, with an instantaneous return from hoarding a unit of either tree, r_t, which is common across both regions and satisfies:

$$r_t V_t^i = \delta^i X_t^i + \dot{V}_t^i \tag{10}$$

where V_t^i is the value of country i's tree at time t.

We will assume throughout this section that both regions have common parameters g and θ. Let W_t^i denote the savings accumulated by active agents in country i at date t:

$$\dot{W}_t^i = -\theta W_t^i + (1-\delta^i) X_t^i + r_t W_t^i. \tag{11}$$

Adding (10) and (11) across both regions, yields:

$$r_t V_t = \left(\delta^U - x^R(\delta^U - \delta^R)\right) X_t + \dot{V}_t \tag{12}$$

$$\dot{W}_t = -\theta W_t + (1 - \delta^U + x^R(\delta^U - \delta^R)) X_t + r_t W_t \tag{13}$$

with

$$W_t = W_t^U + W_t^R, \qquad V_t = V_t^U + V_t^R, \qquad X_t = X_t^U + X_t^R, \qquad x^R \equiv \frac{X_t^R}{X_t}.$$

From now on, the solution for global equilibrium proceeds exactly as in the closed economy above, with

$$\theta W_t = X_t. \tag{14}$$

and

$$r_t = g + \left(\delta^U - x^R(\delta^U - \delta^R)\right)\theta. \tag{15}$$

Let us now specify the initial conditions and the shock.

Assumption 2 *(Initial Conditions): The world is initially symmetric, with $\delta^U = \delta^R = \delta$. There are no (net) capital flows across the economies and $W_t^U/x^U = V_t^U/x^U = V_t^R/x^R = W_t^R/x^R$.*

Suppose now that, unexpectedly, at $t = 0$, δ^R drops permanently to

$$\delta^R < \delta^U.$$

How should we interpret a drop in δ^R? In general, as the realization that local financial instruments are less sound than they were once perceived to be. This could result from, *inter alia*, a crash in a bubble; the realization that corporate governance is less benign than once thought; a significant loss of informed and intermediation capital; the sudden perception —justified or not— of "crony capitalism"; a sharp decline in property rights protection, and so on. All of these factors -and more- were mentioned in the events surrounding the Asian/Russian crises (e.g. Fischer (1998)), and a subset of them (the “bubble” crash in particular) have been used to describe the crash in Japan in the early 1990s.[11]

Lemma 2 *(Continuity): At impact, r drops while V and W remain unchanged.*

Proof. At any point in time, it must be true that

$$W_t = \frac{X_t}{\theta}$$

It follows that W_t does not jump at $t = 0 : W_{0-} = W_{0+} = X_0/\theta$. Since $W_t = V_t$ must hold at all times, we conclude that V_t does not jump either: $V_{0-} = V_{0+} = X_0/\theta$. But for this absence of a decline in V at impact to be consistent with the asset pricing equation, the decline in the global supply of assets due to a decline in δ^R must be offset by a drop in r:

$$r_{0+} = g + \left(\delta^U - x^R(\delta^U - \delta^R)\right)\theta < r_{0-} = g + \delta^U\theta.$$

■

While global wealth and capitalization values do not change at impact, the allocation of these across economies does. On one hand, it stands to reason that the lower δ^R implies that V_0^U/V_0^R must rise since both dividend streams are discounted at the common global interest rate. On the other, whether W_0^U/W_0^R rises or not depends on the agents' initial portfolio allocations. However, as long as there is some home bias in these portfolios, W_0^U/W_0^R rises as well. Because the conventional view has taken the well established fact of home bias as a key force bringing about rebalancing of portfolios, we shall assume it as well, as this isolates the contribution of our mechanisms more starkly. Moreover, for clarity, in the main propositions we assume an extreme form of home bias, but then extend the simulations and figures to more realistic scenarios.

Assumption 3 *(Home Bias). Agents first satisfy their saving needs with local assets and only hold foreign assets once they run out of local assets.*

This assumption implies that, at impact, local wealths' changes match the changes in the value of local trees one-for-one:

$$\begin{aligned} W_{0+}^R &= V_{0+}^R \\ W_{0+}^U &= V_{0+}^U \end{aligned}$$

These changes in wealth have a direct impact on consumption, which are reflected immediately in the trade balance and current account.

Note that our current account definition excludes, as does the one of national accounts, unexpected valuation effects – unexpected capital gains and losses from international positions. This is not a relevant

[11]We assume this shock is unanticipated, but this is not crucial to our analysis: Our long-run results would remain if we relaxed this assumption, and the short-run results we derive below would hold if there was some degree of market incompleteness, preventing agents from completely hedging away those shocks.

issue for now since the only surprise takes place at date 0, when agents are not holding international assets. We shall return to this issue when below.

Also note that since $CA_t^R + CA_t^U = 0$, we only need to describe one of the current accounts to characterize both. Henceforth, we shall describe the behavior of CA_t^U, with the understanding that this concept describes features of the global equilibrium rather than U-specific features.

Proposition 1 *(Crash in R's Financial Markets): Under Assumption 3, if δ drops in R to $\delta^R < \delta^U$, then the current account of U turns into a deficit at impact and remains in deficit thereafter, with CA_t^U/X_t^U converging to a strictly negative limit. The interest rate falls permanently below r_{aut}^U.*

Proof. Note first that since both regions are growing at the same rate, the interest rate remains constant after dropping at date 0 (since x^R is constant):

$$r_t = r^+ = r_{aut}^U - x^R(\delta^U - \delta^R)\theta < r_{aut}^U. \tag{16}$$

Next, because the interest rate is constant, the values of the trees change immediately to their new balanced growth path:

$$V_t^R = \frac{\delta^R X_t^R}{r^+ - g}, \qquad V_t^U = \frac{\delta^U X_t^U}{r^+ - g}.$$

Let us now describe the balanced growth path and then return to describe transitory dynamics. In the balanced growth path, we know from Lemma 1 that

$$W_t^R = \frac{(1-\delta^R)X_t^R}{\theta + g - r^+} \qquad W_t^U = \frac{(1-\delta)X_t^U}{\theta + g - r^+}$$

and

$$\frac{CA_t^U}{X_t^U} = -g\frac{r_{aut}^U - r^+}{(g+\theta-r^+)(r^+ - g)} < 0.$$

For transitory dynamics, define $w_t^R = W_t^R/X_t^R$ so that

$$\dot{w}_t^R = (r^+ - g - \theta)w_t^R + (1-\delta^R).$$

with a balanced growth equilibrium value of $(1-\delta^R)/\left(\theta + g - r^+\right)$.

From Assumption 3 we have that

$$w_{0+}^R = \frac{V_{0+}^R}{X_0^R} < \frac{1-\delta^R}{\theta + g - r^+}$$

since $r^+ > r_{aut}^R$. That is, w_t^R is below its balanced growth path at $t = 0^+$.

Since $r^+ < r_{aut}^U < g + \theta$, we must have $\dot{w}_t^R > 0$ when w_t^R is below its steady state, or equivalently:

$$\dot{W}_t^R > gW_t^R$$

Thus we also have that U's current account $CA_t^U = \dot{V}_t^R - \dot{W}_t^R$ is in deficit – in fact, a larger deficit– before converging to its new balanced growth path. ∎

That is, U runs a permanent current account deficit. The latter is the counterpart of the increasing flow of resources from R-savers, who have few reliable local assets to store value and hence must resort to U-assets. In balanced growth, R-savings grow at the rate of growth of income g. If R-savings are below output-detrended steady state, then the rate of accumulation exceeds the rate of growth of the economy and capital flows toward U grow at a fast rate – faster than g.

The collapse in δ^R decreases the global supply of assets by reducing the share of R's income that can be capitalized. The shock is entirely absorbed via a decline in world interest rates, reflecting a decline in the global dividend rate from δ^U to $\delta^U - x^R(\delta^U - \delta^R)$. While global wealth and capitalization do not change at impact, the allocation of wealth and assets across countries does. The collapse in δ^R implies that V_0^U/V_0^R must rise as an unchanged stream of U's dividends is now discounted at a lower interest rate. Correspondingly, under our home bias assumption, the ratio W_0^U/W_0^R must also rise.[12]

We can resort to the analysis of a small open economy in Section 2.1, and its Figure 2, to understand the asymptotic result. For this, note that the equilibrium interest rate r^+ falls to a level in between the two ex-post Autarky rates r_{aut}^R and r_{aut}^U:

$$r_{aut}^U = g + \delta^U\theta > r^+ = g + \delta^U\theta - x^R(\delta^U - \delta^R)\theta > g + \delta^R\theta = r_{aut}^R$$

Thus the gap between W_t^U/X_t^U and V_t^U/X_t^U is negative and *non*-vanishing (see Lemma 1). Or, from the other region's perspective, the gap between W_t^R/X_t^R and V_t^R/X_t^R is positive and non-vanishing. Figure 3 presents the asymptotic result. Starting from a symmetric equilibrium at A and A^* with a world interest rate r_{aut}^U, the decline in δ^R shifts the V^R/X^R curve to the left – decline in asset supply – and the W^R/X^R curve to the right – increase in asset demand. The world interest rate declines just enough so that the net foreign assets in U ($NA^U \equiv W^U - V^U < 0$) and the net foreign assets in R ($NA^R \equiv W^R - V^R > 0$) sum to zero. Note that the asymptotic result remain unchanged irrespective of the degree of home bias that we assume. Our home bias assumption only has bite in the short run.

Figure 4 characterizes the entire path following a collapse of δ^R calibrated so that R's asset prices drop by 25% on impact, which is roughly the extent of the shock during the Asian/Russian crisis (see the next section for calibration details). Panel A shows that U's current account exhibits a large initial deficit of 10 percent. This sharp and concentrated initial drop is due to the absence of realistic smoothing mechanisms in the model. Still, note that even in this fast environment current account deficits are persistent. The current account remains negative along the path and asymptotes at -1.4 percent of output. The large initial current account deficits worsen the net foreign asset position from -3 percent at impact to -48 percent (panel B). The real interest rate drops by slightly more than 25 basis points and remains permanently lower. Finally, U's share in R's portfolio increases gradually from 7 percent (immediately after the shock) to 31 percent.[13]

[12]It is easy to show that if δ^R crashes to zero, then a bubble must arise in U-trees. While that drop in δ^R is extreme, it captures the flavor of the behavior of U's asset markets in recent years. In the less extreme version we have highlighted, we still capture this flavor through the rise in the value of U's fundamentals following the decline in equilibrium interest rates.

[13]The initial jump from 5 to 7 percent reflects the drop in R's wealth and jump in V^U at $t = 0^+$.

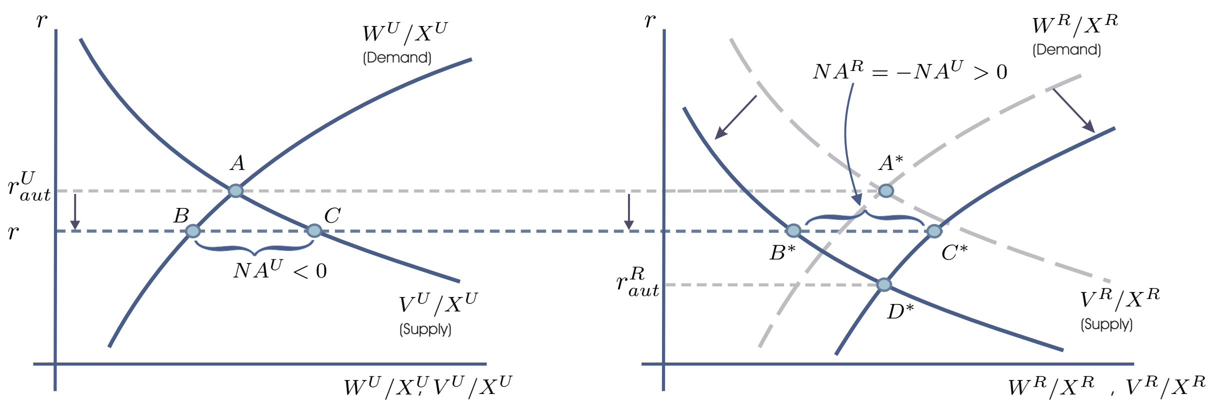


Figure 3: The Metzler diagram for a permanent drop in δ^R.

In summary, the model is able to generate, simultaneously, large and long lasting current account deficits in U (Fact 1); a decline in real interest rates (Fact 2) and an increase in the share of U's assets in global portfolios (Fact 3).

Importantly, CA_t^U/X_t^U does not vanish asymptotically as it converges to:

$$\frac{CA_t^U}{X_t^U} = -g\frac{(\delta^U - \delta^R)x^R\theta}{(\theta + g - r^+)(r^+ - g)} < 0.$$

The reason for this asymptotic deficit is that excess savings needs in R grow with R's output.

Note also that the size of the permanent current account deficit in U (relative to output) is increasing in the relative size of R (equal to x^R). This observation hints at an important additional source of large and persistent deficits in U. In practice, the rate of growth of significant parts of the R region exceeds that of U, and hence the relative importance of this source of funding of U-deficits rises over time — both, because of differential growth and because many R countries are gradually globalizing. We turn to these secular mechanisms next.

2.3 The World Economy: Trends

Aside from shocks, there are important trends that interact with the mechanisms we have discussed. For example, many of the low-δ regions are among the fastest growing regions in the world. Similarly, many of these regions are also high saving (low-θ) regions. In this section we focus on these medium and low frequency interactions.

2.3.1 Fast growth and integration of low-δ regions

Standard models imply that capital flows from low to high growth economies. We argue here that this conclusion can be overturned when the fast growth region is one with limited ability to generate assets for

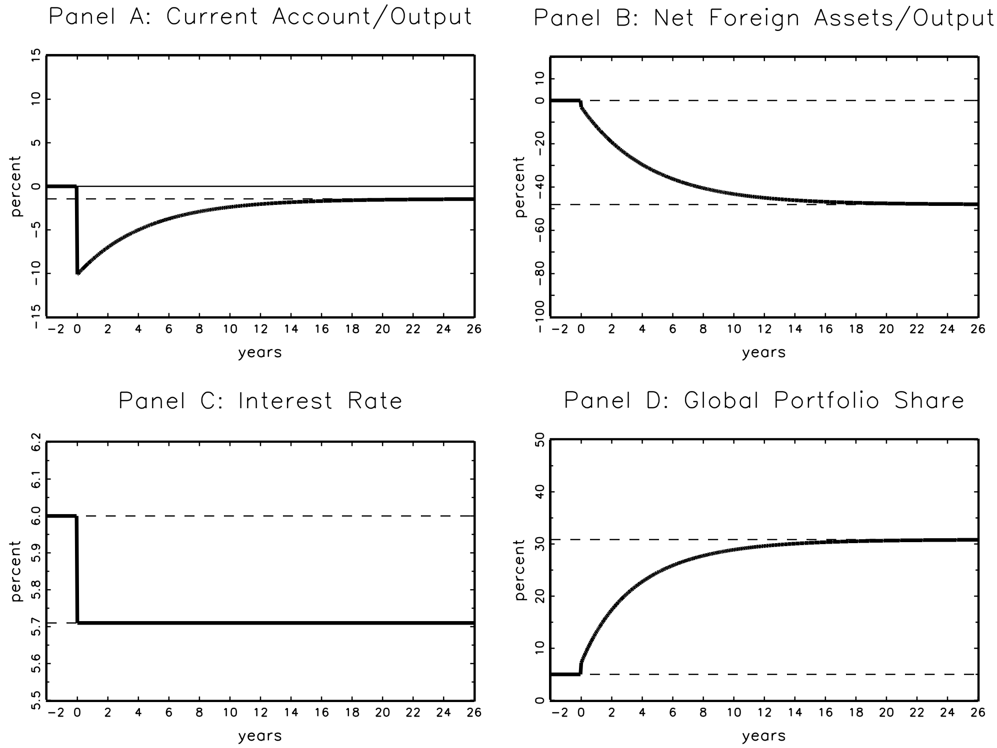


Figure 4: A Permanent Collapse in δ^R

savers (low δ). In particular, faster growth in low δ regions may imply lower long run interest rates and larger current account deficits for the low growth / high δ economy.[14]

Let us maintain the assumption that $\delta^U - \delta^R > 0$, but replace the symmetric growth assumption by:

$$g^R > g^U.$$

The interest rate in this case is:

$$r_t = (1 - x_t^R)\left(g^U + \delta^U\theta\right) + x_t^R(g^R + \delta^R\theta). \tag{17}$$

Let us assume that the additional growth in R is not enough to offset the effect of a lower δ^R on interest rates. In particular:

Assumption 4 *(Lower autarky rate in R)* $\quad r^R_{aut} = g^R + \delta^R\theta < r^U_{aut} - x^R_0(\delta^U - \delta^R)\theta < r^U_{aut} = g^U + \delta^U\theta.$

Proposition 2 *(High growth in low δ region) Suppose that Assumptions 3 and 4 hold, and that $g^R > g^U$. If at date 0 the two regions integrate (or δ^R drops in a previously integrated world), then:*

$$r^U_{aut} > r_{0^+} > r_\infty = r^R_{aut}$$

[14] In the working paper version of this paper (Caballero et al. (2006b)), we show that the standard view applies for flows from Europe to the US. Lower growth in the former leads to capital outflows toward the latter. The preceding results indicate that the conventional view of looking at the growth rate of the trading partners to determine the pattern of net capital flows is incorrect. It matters a great deal who is growing faster and who is growing slower than the US. If those that compete with the US in asset production (such as Europe) grow slower and those that demand assets (such as emerging Asia and oil producing economies) grow faster, then both factors play in the direction of generating capital flows toward the US.

and the asymptotic current account deficit in U relative to its output is larger when $g^R > g^U$ than when $g^R = g^U$:

$$\lim_{\substack{t\to\infty \\ g^R>g^U}} \frac{CA_t^U}{X_t^U} < \lim_{\substack{t\to\infty \\ g^R=g^U}} \frac{CA_t^U}{X_t^U} < 0.$$

Proof. See the appendix. ■

The result in this proposition is intuitive given the previous proposition: As R's growth rises, so does its demand for financial assets. Since this rise is not matched by an increase in R's ability to generate financial assets, these must be found in U and interest rates drop as the price of U-assets rise. The corresponding increase in capital flows finances the larger current account deficit in U. Long run interest rates are lower than short term interest rates because the relative importance of the country with excess demand for assets, R, rises over time.

As before, let us now describe the asymptotic result in terms of Figure 2, from Section 2.1. First, since in the long run R dominates the global economy when $g^R > g^U$, the equilibrium interest rate converges to the Autarky interest rate for R:

$$r_\infty = r_{aut}^R = g^R + \delta^R\theta.$$

Thus, relative to X_t^R, the gap between W_t^R and V_t^R is vanishing, and so is that between W_t^U and V_t^U.

However, note that this limit interest rate is below the Autarky rate in U:

$$r_\infty = g^R + \delta^R\theta < g^U + \delta^U\theta = r_{aut}^U.$$

The inequality implies that, relative to X_t^U, the gap between W_t^U and V_t^U is negative and *not* vanishing. Moreover, since

$$r_\infty < r^+ < r_{aut}^U,$$

that gap is larger when $g^R > g^U$ than when $g^R = g^U$.

2.3.2 Fast growth and integration of low-θ regions

From the interest rate expression ($r = g + \delta\theta$), it is apparent that there is a certain symmetry between the impact of a decline in δ^R and of a drop in θ^R (a formalization of the "saving-glut" hypothesis). However, while both have similar implications for capital flows and interest rates, only the δ story is consistent with the observed *decline* in asset prices in the R region at the time of the inflection point in capital flows during the late 1990s (see Figure 1).

We view the low θ^R story as an appealing lower frequency mechanism, which is playing an increasingly important role. As low θ economies such as China integrate to the global economy and grow in their relative contribution to global output, their high net demand for assets leads to lower interest rates and larger capital flows toward U.[15]

[15]The recent paper by Mendoza, Quadrini and Rios-Rull (2007) can be seen as a nice elaboration on this story. In their case the reason for $\theta^R < \theta^U$ is the higher development of risk sharing markets (and hence lesser need for precautionary savings) in

The analysis is analogous to that for a low δ^R scenario. Moreover, in practice these factors compound as many of the low δ economies are also low θ economies (e.g., China). However, for analytical clarity, let us set $\delta^U = \delta^R = \delta$ for now and instead assume that

$$\theta^U - \theta^R > 0$$

and

$$g^R > g^U.$$

The interest rate in this case is (see the appendix for a detailed derivation):

$$r_t = \sum_i x_t^i r_{aut}^i + \sum_i x_t^i \theta^i \left(\theta^i W_t^i / X_t^i - 1\right) \tag{18}$$

The first term of this expression is the output-weighted average of the autarky interest rates $r_{aut}^i = g^i + \delta\theta^i$. The second term represents a demand effect. A reallocation of wealth towards countries with high propensity to consume – high θ – decreases the demand for assets. For a given level of output, this demand term puts upward pressure on world interest rates.

As in the previous section, we assume that the additional growth in R is not enough to offset the effect of a lower θ^R on interest rates:

Assumption 5 *(Lower autarky rate in R)* $\quad r_{aut}^R = g^R + \delta\theta^R < r_{aut}^U = g^U + \delta\theta^U$

Then:

Proposition 3 *(High growth in low θ region) Suppose that Assumptions 3 and 5 hold, and that $g^R > g^U$. If at date 0 the two regions integrate, then:*

$$r_\infty = r_{aut}^R$$

and the asymptotic current account deficit in U relative to its output is larger when $g^R > g^U$ than when $g^R = g^U$:

$$\lim_{\substack{t\to\infty \\ g^R > g^U}} \frac{CA_t^U}{X_t^U} < \lim_{\substack{t\to\infty \\ g^R = g^U}} \frac{CA_t^U}{X_t^U} < 0$$

We omit the proof of this proposition since it follows the same lines as the proof of Proposition 2. The result is intuitive: As R's growth rises, so does its demand for financial assets. Since this rise is not matched by an increase in R's ability to generate financial assets, these must be found in U and interest rates drop as the price of U-assets rise. The corresponding increase in capital flows finances the larger current account deficit in U. Long run interest rates with $g^R > g^U$ are lower because the relative importance of the country with excess demand for assets, R, rises over time.

U than in R. In addition to its substantive point, this observation allows us to illustrate the flexibility of the framework we propose to address a wide variety of issues at once, which can then be individually studied with more detailed models.

3 Quantitative Relevance

In this section we provide support for and deepen the quantitative aspects of the analysis presented in the previous sections. Note, however, that the strength of the framework we have developed is its simplicity and versatility. It is not designed to match high frequency dynamics or to make very precise quantitative statements. Our goal here is simply to show that the mechanisms we have described up to now are of the right order of magnitude.

3.1 'Calibration'

Table 1 summarizes the parameter assumptions. The calibration of the model requires parameter values for δ, θ, g, which we assign based on US aggregate data.

Parameter	θ	g	δ	x_0^R	μ_{0-}^{RU}	NA_{0-}^U	δ^R
Value	0.25	3%	0.12	0.3	0.05	0	0.08

Table 1: Main Parameters

Equation (4) shows that θ is the output to wealth ratio, X/W. We estimate W as the net worth of the household sector, which according to the U.S. Flow of Funds is \$48.16 trillion in 2004.[16] With a U.S. GDP of \$11.72 trillion in 2004, this implies a value of $\theta = 11.72/48.16 \simeq 0.24$. In the simulations, we round this parameter to 0.25. Average real output growth in the U.S. between 1950 and 2004 equals 3.33%. We round this number and set g to 3 percent. Finally, since we cannot measure the share of capitalizable income directly, we calibrate the value of δ indirectly. To do so, we assume a value of r_{aut} of 6%. This implies a value of δ of $(r_{aut} - g)/\theta = 0.12$, which corresponds to about a third of the share of capital in national accounts.

We now explore a number of relevant scenarios.

3.2 Section 2.2 scenario: A Permanent Asset Supply Shock

We start with the analysis of a permanent collapse in δ^R in a $U - R$ world, as discussed in section 2.2. To do so, we need to construct initial output shares x_0^i, initial cross border portfolio holdings $\mu_0^{ij} = \alpha_0^{ij} V_0^j / W_0^i$ and the drop in δ^R. We define U as the U.S., the U.K. and Australia. These countries are good asset suppliers, and experienced robust growth in the past decade.[17] We identify R with developing and oil producing countries with a good income growth potential, but limited asset production capacity.[18]

[16] See the Balance Sheet Table B100, line 41 of the December 2005 release.

[17] UK and Australia's annual real GDP growth rate averaged 2.49% and 3.32% respectively between 1980 and 2004.

[18] In our sample, R includes the following countries: Argentina, Brazil, Chile, China, Colombia, Costa Rica, Ecuador, Egypt, Hong-Kong, India, Indonesia, Korea, Mexico, Malaysia, Nigeria, Panama, Peru, Philippines, Poland, Russia, Singapore, Thailand and Venezuela. Output data for Poland and Russia starts in 1990.

We measure the initial output share as the average output share between 1980 and 1990, using GDP data in current dollars from the World Development Indicators. We find $x_0^R = X_0^R / \left(X_0^R + X_0^U\right) \approx 0.30$.

We estimate the initial holdings of U assets by the rest of the world as the ratio of U.S. gross external liabilities to the financial wealth of the rest of the world. According to the Bureau of Economic Analysis International Investment Position, U.S. gross external liabilities reached \$2.5 trillion in 1990.[19] To estimate the financial wealth of the rest of the world, we calculate the ratio of financial wealth to output for the U.S., the E.U. and Japan between 1982 and 2004.[20] We find a GDP weighted average of 2.48. We apply this ratio to the GDP of the rest of the world and estimate, for 1990, a rest-of-the-world financial wealth of \$39.3 trillion. This yields a portfolio share equal to $2.5/39.3 = 0.06$. We round this number to $\mu_{0-}^{R,U} = 5\%$. We also assume that the world starts in a symmetric steady state with zero initial net foreign asset position.[21]

Finally, we calibrate the decline in δ^R so as to match the average decline in stock market values around the time of the Asian crisis. From Section 2.2, R's assets price drops from $V_{0-}^R = X_0^R/\theta$ before the shock to $V_{0+}^R = \delta^R/\theta\bar{\delta}X_0^R$ where $\bar{\delta} = x_0^U\delta + x_0^R\delta^R$ is the world capitalization index. Hence the drop in asset values at $t = 0$ is $V_{0+}^R/V_{0-}^R = \delta^R/\bar{\delta} < 1$. Solving this expression for δ^R, we obtain

$$\delta^R = \delta \frac{x_0^U V_{0+}^R}{V_{0-}^R - x_0^R V_{0+}^R}$$

Since our model does not have short-run liquidity and fire-sale mechanisms, we chose to calibrate the decline in prices not at impact but over a couple of years (between July 1997 and June 1999). At this frequency, the decline in dollar asset values was 16 percent in Hong-Kong, 5 percent in Korea and 62 percent in Indonesia.[22] Figure (4) was generated with a 25 percent decline in δ^R: $V_{0+}^R = 0.75V_{0-}^R$, which is within the range observed in the data and implies $\delta^R = 0.08$.

3.3 The World Economy: Asian Shocks.

We now turn to a set of more complex and realistic scenarios. We consider first a three-region world, $U - J - R$, where J stands for Japan and R stands -as before- for emerging and oil producing countries. We start this economy in steady state in 1990 with initial output shares $x_0^J = 0.22$ and $x_0^R = 0.23$. The initial portfolio shares are calibrated such that there are no initial external imbalances and $\mu_0^{JU} = \mu_0^{RU} = 0.05$. In this initial steady state, we assume that $\delta^J > \delta$. This captures the effect of the Japanese financial bubble of

[19] Source: BEA, NIIP Table 2, line 25, July 2006 release.

[20] Sources: U.S.: Flow of Funds, Table B100 line 8, household financial assets; E.U.: Table 3.1 of the ECB Bulletin, financial and capital account of the non financial sector; Japan: Flow of Funds, households total financial assets, available at http://www.boj.or.jp/en/stat/stat_f.htm.

[21] According to the Bureau of Economic Analysis, the US had a balanced net foreign asset position in 1988. This implies $\alpha_0^{RU} = \mu_{0-}^{RU}\frac{x_0^R}{1-x_0^R} = 0.02$ and $\alpha_0^{UR} = \alpha^{RU}V^U/V^R = \alpha^{RU}\left(1 - x^R\right)/x^R = 0.05$.

[22] We calculate the decline of the Hang Sen Composite Index (Hong Kong), the KOSPI (Korea) and the Jakarta Stock Index (Indonesia). All price indices were converted into dollars using daily exchange rates. The larger declines observed over shorter horizons can be attributed to the stock market and exchange rate overshooting.

the 1980's. To preserve the symmetry of the problem, we also impose $r^J_{aut} = r^U_{aut}$ by setting $\theta^J = \delta\theta/\delta^J < \theta$. The lower θ^J is consistent with the higher Japanese national saving rate.

This world economy experiences two consecutive shocks. First, in 1990, we interpret the collapse of the Japanese bubble as a permanent collapse in δ^J, back to δ. We calibrate the initial δ^J so as to to match the 30% decline in the Nikkei stock index between December 1989 and December 1991, and find $\delta^J = 0.19$. Second, we interpret the 1997-1999 Asian and Russian crisis as a collapse in δ^R calibrated to a 25% decline in stock market values in R. We consider two scenarios. In the first and main scenario, the collapse is permanent. This yields $\delta^R = 0.08$. In the second scenario, the collapse is temporary, and we impose - somewhat arbitrarily- that δ^R reverts to δ after 35 years, which yields $\delta^R = 0.05$.[23] The purpose of the second scenario is simply to show that nothing important is being driven by the behavior of the model at infinity when the shock is permanent.

Table 2 reports average values for the current account-output ratio, the net foreign asset position, the equilibrium interest rate,and the share of U in global portfolios (defined as $\mu^{\cdot U} = \left(\alpha^{RU} + \alpha^{JU}\right) V^U / \left(W^R + W^J\right)$).

	Model										Data	
Interval (years):	$1990-1997$		$1997-2006$		$2006-2020$		$2020-2050$		∞		$90-97$	$97-06$
Shock:	P	T	P	T	P	T	P	T	P	T		
CA^U/X^U	-6.2	-6.2	-7.0	-6.6	-3.3	-2.1	-2.9	-1.3	-2.9	-1.8	-1.1	-4.3
NFA^U/X^U	-22.3	-22.3	-73.4	-72.5	-93.7	-83.9	-96.2	-64.5	-96.3	-59.1	-3.9	-17.7
$r - r_{aut}$	0.10	0.10	-0.48	-0.64	-0.52	-0.67	-0.53	-0.47	-0.53	-0.34	-0.78	-1.63
$\mu^{\cdot U}$	9.7	9.7	20.0	19.7	23.3	21.2	23.7	17.4	23.7	16.4	7.3	16.0

Table 2: Calibrated Exercise 1: Asian Shocks. All variables in percent. Columns labelled "P" ("T") for permanent (transitory) shocks

Starting from an initial interest rate of 6 percent, the collapse in δ^J lowers asset values in J and reallocates demand from low θ countries (J) to high θ ones (U and R). The resulting increase in demand on the goods market pushes up world interest rates by 10 basis points, to 6.10 percent on average for the first 7 years. The current account in U worsens significantly, to -6.2 percent of output and $U's$ net foreign asset position falls to -22 percent of output. In 1997, the unexpected decline in δ^R reduces world interest rates by 58 basis points, and increases global imbalances. The current account deficit surges to -7 percent and net foreign debt increases to 73 percent of output while the share of foreign assets in foreign portfolios increases from 10 percent to 20 percent.

After 2006, these imbalances are gradually reduced. In the case where the δ^R shock is permanent (columns labelled "P"), the U.S. net foreign debt position stabilizes at 96 percent of output, with a long run current

[23] The required collapse in δ^R is more severe in the latter case, since for a given δ^R, V^R does not collapse as much when shocks are transitory.

account deficit of 2.9 percent of output, and world interest rates permanently depressed by 53 basis points. When the δ^R shock is expected to be temporary (columns labelled "T"), the dynamics are broadly similar, but the rebalancing is more significant, with a long run net debt position of 59 percent of output and a current account deficit of 1.8 percent of output.

Comparing the first two periods (1990-1997 and 1997-2006) to the data in the last two column of the table, we observe that the model predicts a smaller decline in world interest rates (47 basis points versus 150 in the data), and a larger build-up in imbalances (7.0 percent deficit of the current account, versus 4.3 in the data). The model also overpredicts the impact of the Japanese crash on imbalances. These departures are largely due to the assumption of perfect capital markets integration and the lack of additional frictions to adjustment. However, as we mentioned earlier, our purpose here is only to show that the mechanism yields numbers of the right order of magnitude, which it does.

3.4 The World Economy: Emerging Trends

The next scenario considers a three region world $U - U^c - M$. U and U^c are identical and initially in steady state (U^c represents J and R economies different from M). M represents a subset of emerging markets accounting initially for half of the non-U part of the world economy (i.e. $x_0^M = x_0^{U^c} = 0.25$). We assume that this region has initially a poor capacity to produce financial assets (we set $\delta^M = 0.05$, similar to the post Asian crisis value for δ^R in our previous scenario), a high propensity to save (we set $\theta^M = 0.2$) and a faster growth rate $g^M = 4.5\%$. Hence the autarky interest rate in M is low relative to $r_{aut}^U \left(r_{aut}^M = g^M + \delta^M\theta^M = 5.5\%\right)$. In 1990, we assume that M perfectly integrates into the world economy. Again, we consider two possible cases. In the first case, δ^M and g^M are permanently different. In the second case, they converge to their values in U after 60 years.

	Model										data	
Interval (years):	$1990-1997$		$1997-2006$		$2006-2020$		$2020-2050$		∞		$90-97$	$97-06$
Shock:	P	T	P	T	P	T	P	T	P	T		
CA^U/X^U	-4.2	-4.1	-2.1	-2.1	-1.6	-1.6	-1.7	-1.7	-2.7	-1.5	-1.1	-4.3
NFA^U/X^U	-15.5	-15.3	-32.1	-31.7	-39.5	-38.9	-47.2	-45.9	-88.9	-51.3	-3.9	-17.7
$r - r_{aut}$	-0.01	-0.01	-0.13	-0.13	-0.18	-0.18	-0.23	-0.23	-0.50	-0.31	-0.78	-1.63
$\mu^{\cdot U}$	5.9	5.9	8.9	8.8	9.3	9.2	8.6	8.4	0.0	7.8	7.3	16.0

Table 3: Calibrated Exercise 2: Emerging Trends. All variables in percent."P" ("T") for permanent (transitory) shocks.

Table 3 presents the results. The integration of M into the world economy lowers world equilibrium interest rate. This effect is initially muted since the reallocation of consumption from low θ (M) to high θ (U and U^c) countries reduces current asset demand and because M is initially small. Nevertheless, external imbalances build-up immediately with a U current account deficit averaging -4.2 percent and net foreign assets of -15 percent of output. Over time, as M grows, the world equilibrium interest rate converges slowly toward r_{aut}^{M}. The resulting imbalances in U increase and stabilize at -89 percent of output (NFA) and -2.7 percent (CA). This process is very gradual, essentially controlled by the growth differential between the two regions. Again, the dynamics are similar when the shock is expected to reverse after 60 years.

We conclude that this secular mechanism also can account for a significant share of the global facts described in Figure 1.

4 Investment Slumps and Foreign Direct Investment

Let us now add an investment margin to our model and a reason for foreign direct investment (FDI). We capture the former with the emergence of options to plant new trees over time, and the latter with U's ability to convert new R trees into δ^U (rather than δ^R) trees. These additions enrich the framework along two important dimensions in matching the facts: First, the collapse in δ^R can lead to an investment slump in R which exacerbates our results in the previous section. Second, the intermediation rents from FDI reduce the trade surpluses that U needs to generate to repay for its persistent early deficits.[24]

4.1 An Investment Margin and Slump

Let us split aggregate output in each region into the number of trees, N, and the output per tree, Z:

$$X_t^i = N_t^i Z_t^i$$

At each point in time, $g^n N_t^i$ options to plant new trees arise. These options are distributed to newborns at birth. At the same time, the output of each planted tree grows at the rate g^z. Planting the $g^n N_t^i$ new trees consumes resources I_t^i:

$$I_t^i = \kappa X_t^i.$$

[24]The argument in this section is related to that in Despres, Kindleberger and Salant (1966) and Kindleberger (1965), who during the Bretton Woods era argued that the US had a unique role as a provider of international currency liquidity. More recently, Gourinchas and Rey (forthcoming 2007) have documented that the total return on US gross assets (mostly equity and FDI) consistently exceeded the total return on gross liabilities (mostly safe instruments) by an average of 3.32 percent per year since 1973. Of course part of this excess return is due to the risk-premium differential associated to the leveraged nature of US investments. Our analysis omits this risk dimension and focuses on the "intermediation" rent obtained by the US.

Everything suggests that this "intermediation" role of the US has only grown in importance as total gross capital flows to/from the US have risen from $222 billion in 1990 to $2.3 trillion in 2004 (see BEA, US International Transactions Accounts, Table 1). See also Lane and Milesi-Ferretti (forthcoming 2007) for a systematic analysis of cross border flows and positions for a large sample of countries.

Let us assume first that κ is low enough so that all investment options are exercised (see below), and hence aggregate output grows at rate g, with (equal for both regions):

$$g = g^n + g^z.$$

Suppose for now that δ^i is specific to the region where the tree is planted, not to who planted it. Then

$$r_t V_t^i = \delta^i X_t^i + \dot{V}_t^i - g^n V_t^i \tag{19}$$

where V_t^i represents the value of all (new and old) trees planted at time t in region i, and $\dot{V}_t^i - g^n V_t^i$ represents the expected capital gains from those trees.

The options to invest are allocated to all those alive at time t within each region, who immediately exercise them by investing I_t^i.[25] Thus,

$$\dot{W}_t^i = (r_t - \theta) W_t^i + (1 - \delta^i) X_t^i + g^n V_t^i - I_t^i.$$

As usual, aggregating across both regions to find the equilibrium interest rate, yields:

$$r_t V_t = \delta^U X_t - (\delta^U - \delta^R) X_t^R + \dot{V}_t - g^n V_t \tag{20}$$

$$\dot{W}_t = (r_t - \theta) W_t + (1 - \delta^U) X_t + (\delta^U - \delta^R) X_t^R + g^n V_t - I_t \tag{21}$$

so that:

$$W_t = V_t = (1 - \kappa) \frac{X_t}{\theta}.$$

and

$$r = g^z + \frac{\theta}{1-\kappa} (\delta^U - x^R (\delta^U - \delta^R)) < r^U_{aut} = g^z + \frac{\theta \delta^U}{1 - \kappa}, \tag{22}$$

which amounts to the same model as in the previous section, with the exceptions that only the rate of growth of output per-tree enters, and that the investment cost reduces wealth accumulation and hence raises the interest rate (since it lowers the price of trees).

Let us now assume that the drop in δ^R is large enough that investment is not privately profitable in R (κ is large relative to $g^n V_t^R / X_t^R$). This immediately delivers an (extreme) investment slump in R.[26] Moreover, the equations for R change to:

$$g^R = g^z < g.$$

[25] Note that the share of options that are allocated to existing owners of trees are subsumed within the Z component. In fact, we can reinterpret the model in Section 2 as an investment model where all the options are allocated to the owners of existing trees. The only reason we modified the allocation of options in this section is to spread the excess returns from FDI over time in a more realistic manner (otherwise the entire capitalized excess returns accrues to the first generation in U).

[26] See Caballero and Krishnamurthy (2006) for a more detailed emerging markets model where the collapse in the "bubble" component of (something like) δ^R leads to an investment slowdown in R.

$$r_t V_t^R = \delta^R X_t^R + \dot{V}_t^R \tag{23}$$

$$\dot{W}_t^R = (r_t - \theta) W_t^R + (1 - \delta^R) X_t^R. \tag{24}$$

Solving for global equilibrium, yields:

$$V_t = W_t = (1 - \kappa x_t^U) \frac{X_t}{\theta}.$$

Note that now at the time of the crash in δ^R there is an *increase* in the value of global assets equal to:

$$\Delta V_0 = \kappa \frac{X_t^R}{\theta} > 0.$$

The mechanism behind this increase in asset value —made of a milder decline in asset values in R and a sharper appreciation in U— is a further drop in interest rates at impact following the investment collapse in R.[27] Moreover, the latter exacerbates the initial current and trade deficit in U.

The following proposition summarizes these results more precisely and is proved in the appendix. It compares two situations when $g^n V_t^R / X_t^R < \kappa$. In situation 1, R agents make the optimal decision not to invest. In situation 2, which is intended only to serve as a benchmark, R agents are forced to exercise their investment options.

Proposition 4 *(Investment slump) At impact, the drop in interest rate is larger under situation* 1 *than under situation* 2. *Also, the initial current account and trade balance deficits in U are larger in situation* 1 *than in situation* 2.

4.2 An Intermediation Margin: Foreign Direct Investment

Let us now assume that R residents can sell the options to the new trees to U residents at price, P:

$$P_t = \kappa_P X_t^{Rn}.$$

where X_t^{Rn} denotes the output from the trees sold to U. We think of this price as the result of some bargaining process but its particular value is not central for our substantive message as long as it leaves some surplus to U.

There are gains from trade: If U residents plant the new R trees, the share of output from the new trees that can be capitalized rises from δ^R to δ^U. Suppose that P_t is such that all new R trees are planted by U residents. In fact, the following assumption ensures that U investors and R sellers gain from foreign direct investment along the entire path.

[27] Note that in the long run the interest rate converges to r_{aut} since now U is growing faster than R. However this long run rise is not enough to offset the sharp decline in interest rates in the short (and medium) run.

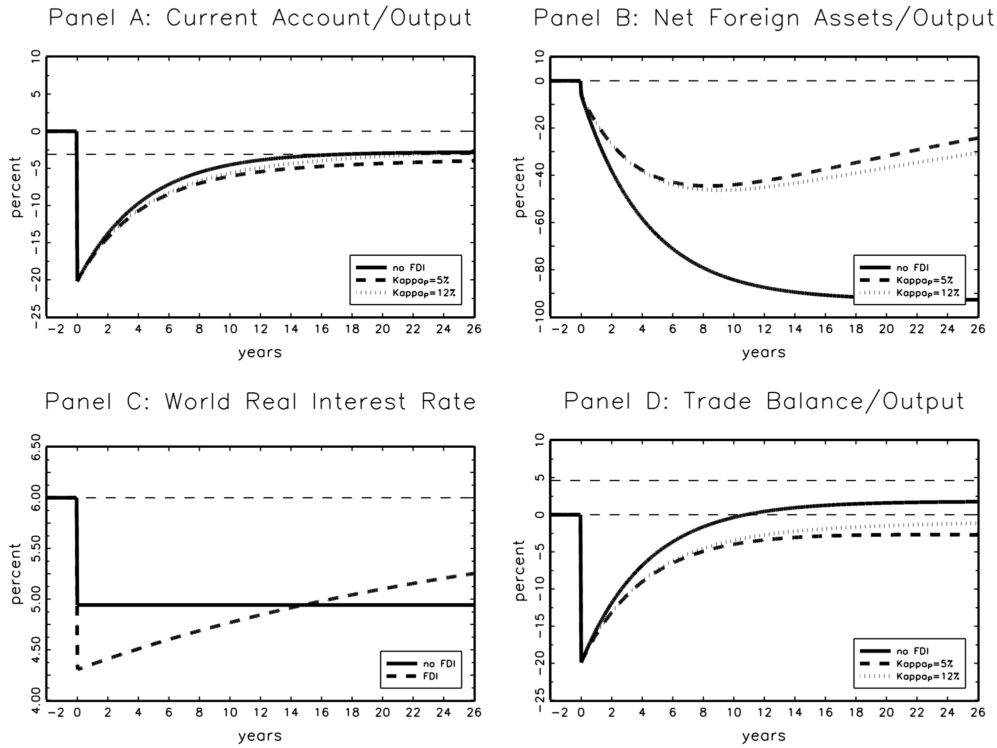


Figure 5: A Collapse in δ^R with and without FDI

Assumption 6 (Asymptotic Bilateral Private Gains from FDI) *Let κ_P and $(\delta^U - \delta^R)$ be such that:*

$$g^n \frac{\delta^U}{r^U_{aut} - g^z} > \kappa + \kappa_P > g^n \frac{\delta^R}{r^U_{aut} - g^z}$$

Proposition 5 *If Assumption 6 holds, then U runs an asymptotic trade deficit financed by its intermediation rents.*

Proof. See the appendix. ■

Does this mean that the intertemporal approach of the current account has been violated? Certainly not. It simply means that the intermediation rents rather than future trade surpluses pay for the initial (and now permanent) trade deficits. Alternatively, one could account for these intermediation services as "non-traditional" net exports and imports for U and R, respectively. In which case, we have:

$$\widehat{TB}^U_t = TB^U_t + g^n V^R_t - (\kappa + \kappa_P) X^R_t$$

and, assuming $r_{aut} > g$ so the integral converges, it follows that:

$$W^U_t - V^U_t = -\int_t^{+\infty} \widehat{TB}^U_s e^{-\int_t^s r_u du} ds$$

Figure 5 reports the path of U's trade balance following a collapse in δ^R.[28] We consider three cases: first, when κ_P is sufficiently high that no FDI takes place. Second, when all the rents asymptotically go

[28]We calibrate the decline in δ^R as before, to a drop in V^R of 50%. See the appendix for details of the simulation.

to R (i.e. when the second inequality of Assumption 6 holds exactly) and lastly when all the rents from FDI asymptotically go to U (i.e. when the first inequality of Assumption 6 holds exactly).[29] We assume parameters such that in all cases the investment options are exercised. The model without FDI is very similar to the model of section 2.2: following a collapse in δ^R, the interest rate falls permanently from r^U_{aut} to $\bar{r} = g^z + \bar{\delta}\theta/(1-\kappa)$ where $\bar{\delta}$ is the fraction of world income that can be capitalized. By now, the consequences are well known: the wealth transfer to U generates a trade deficit, an accumulation of foreign debt, eventually followed by trade surpluses (panel D).

In the presence of FDI, the results are starkly different. Let's start with the long run. The asymptotic effect of FDI is to increase the supply of U-like assets sufficiently to offset the initial shock. This has a strong implication for the path of net foreign assets (panel B): since r_t converges to r^U_{aut} as long as FDI takes place (Panel C), the Metzler diagram tells us that long run external imbalances disappear asymptotically. This is independent of the cost of ownership of the R trees (κ_P) as long as Assumption 6 is satisfied. The reason is that κ_P controls the distribution of wealth between U and R, leaving total wealth unchanged.

Consider the short run now. The interest rate satisfies (see the appendix for a derivation):

$$r_t = g^z + \frac{\theta}{1-\kappa}\left[\delta\left(x^U_t + x^{Rn}_t\right) + \delta^R x^{Ro}_t\right] - \frac{\theta}{1-\kappa} g^n \frac{N^R_0 v^{Ro}_t}{X_t}\left[\frac{\delta}{\delta^R} - 1\right] \tag{25}$$

where x^{Rn}_t (resp. x^{Ro}_t) denote the new (resp. old) R's trees share of world output and v^{Rn}_t (resp. v^{Ro}_t) represent the value of one new (resp. old) R tree. The last term of this equation makes clear that initially $r_t < \bar{r}$ since $v^{Ro}_0 > 0$ and $\delta > \delta^R$. The reason for this last term is the initial increase in asset demand arising from the total flow of financial savings generated by FDI.[30]

In the short run, FDI increases asset demand -which lowers further interest rates; in the long run, it increases asset supply, which brings interest rates back to r_{aut}. From (19) and (25) we note also that the dynamics of interest rates and asset values are independent of κ_P, as long as FDI takes place. Hence, the initial increase in U's wealth is also independent of the cost of FDI. It follows that U's initial trade imbalance $X^U_0 - \theta W^U_0 - I^U_0$ is also independent of κ_P. Indeed, we observe on Panels A and D that U's initial current accounts and trade deficits are the same for different realizations of κ_P.

A lower value of κ_P – and correspondingly higher rents for U – implies a permanently larger trade deficit in U, ranging from 0 to 4% of output (Panel D).

To understand why U runs asymptotic trade deficits as soon as it has strictly positive asymptotic surpluses, consider first the case where U has no FDI rents asymptotically. In that case, U has no asymptotic trade deficit either. Yet, Panel D indicates that U never runs a trade surplus. The reason is that U earns

[29] For this simulation, we assume $\kappa = 0$, $g^n = g = 0.03$, $g^z = 0$ and we vary κ_P between 5% and 12%. For comparability, we also choose δ^U so that $r^U_{aut} = 6\%$. We obtain $\delta = 0.24$.

[30] In other words, when there is FDI, savings decline less in U and increase more in R. The precise allocation depends upon the value of κ_P. The reason for the additional savings is the future rise in interest rates which depresses current asset values (and hence short run rates have to fall more to restore equilibrium).

rents on its FDI investment along the path, which allow it to run trade deficits in every period. In fact, we can define these rents (over total wealth W^U) as:

$$\chi_t = \frac{g^n N_t^R v_t^{Rn} - (\kappa_p + \kappa) X_t^{Rn} - \kappa X_t^{Ro}}{W_t^U}$$

Asymptotically, these rents converge (from above) to

$$\chi_\infty = \left[g^n \frac{\delta^U}{r_\infty - g^z} - (\kappa_p + \kappa) \right] \frac{X_t^R}{W_t^U} \tag{26}$$

which is equal to zero when the first inequality of Assumption 6 holds exactly.

We can now understand why U can run permanent trade deficits: When Assumption 6 holds strictly, intermediation rents remain positive and provide the resources to finance permanent trade deficits.

5 Multiple Goods and Exchange Rates

Up to now, our conclusions have abstracted from (real) exchange rate considerations. The main point of this section is to show that adding such dimension to the model does not alter out main conclusions with respect to the impact of differences in the level of δ across different regions of the world. While adding multiple goods allows us to generate exchange rate patterns from our shocks that resemble those observed in recent data —in particular, the appreciation of U in the short run following a collapse in δ^R and the persistent but gradual depreciation at later stages— the behavior of capital flows and interest rates remain largely unchanged.

5.1 Preliminaries

Let us return to the framework in Section 2, without an investment margin, but extend it to consider differentiated goods. Each region i produces one type of good X^i, while its consumers have the following constant elasticity preferences (CES):

$$C^i = \left(\sum_j \gamma_{ij}^{\frac{1}{\sigma}} x^{j\,\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{27}$$

where σ represents the –constant– elasticity of substitution between the goods from any two regions. The coefficients γ_{ij} measure the strength of preferences for the various goods and satisfy $\sum_j \gamma_{ij} = 1$. Assumption 7 below imposes that agents have a preference for their home good. This assumption is well-established empirically. It also generates relative demand effects that will be important for exchange rate dynamics.

Assumption 7 *(Consumption Home Bias) Each agent has a preference for the home good:* $\gamma_{ii} \equiv \gamma > 0.5$.

Let X^U be the numeraire good and define q^j as the price of good j in terms of good U (with the convention $q^U = 1$). Given (27), the Fisher-ideal price indices are:

$$P^i = \left(\sum_j \gamma_{ij} q^{j(1-\sigma)} \right)^{1/(1-\sigma)}$$

and the real exchange rate between regions i and k is

$$\lambda^{ik} = \frac{P^k}{P^i} = \left(\frac{\sum_j \gamma_{kj} q^{j(1-\sigma)}}{\sum_j \gamma_{ij} q^{j(1-\sigma)}} \right)^{1/(1-\sigma)}$$

This expression highlights the importance of consumption home bias for exchange rate movements: if $\gamma_{ij} = \gamma_{kj}$ for all j, then purchasing power parity obtains and the real exchange rate is equal to 1.

Given CES preferences, the demand for good j by residents of region i satisfy:

$$x^{ij} = \gamma_{ij} C^i \left(\frac{q^j}{P^i} \right)^{-\sigma}, \ \forall i, j$$

and equilibrium in the goods market imposes

$$\sum_i x_{ij} = X_j, \ \forall j.$$

Substituting $P^i C^i = \theta W^i$ (where domestic wealth is now measured in terms of U's good), the equilibrium condition for good i can be rewritten as:

$$\theta \sum_i \gamma_{ij} \frac{W^i}{P^i} \left(\frac{q^j}{P^i} \right)^{-\sigma} = X^j, \ \forall j.$$

5.2 A Drop in δ^R

Consider now the interaction between U and R. As before, let's consider a scenario where R's ability to capitalize financial assets drops from δ^U to $\delta^R < \delta^U$ while $g^R = g^U = g$.

Following the same steps as before, we obtain:

$$V_t = W_t = \frac{X_t}{\theta}$$

where $X_t = X_t^U + q_t^R X_t^R$, $V_t = V_t^U + V_t^R$ and $W_t = W_t^U + W_t^R$. The instantaneous rate of return now satisfies:

$$r_t = r_{aut}^U + x_t^R \left(\frac{\dot{q}_t^R}{q_t^R} - \theta(\delta^U - \delta^R) \right)$$

which is similar to equation (15), except for the rate of change of the terms of trade.

Proposition 6 *: Under Assumptions 3 and 7, if δ drops in R to $\delta^R < \delta^U$, then U's real exchange rate initially appreciates, then depreciates and stabilizes in the long run. The current account of U turns into a deficit at impact and remains in deficit thereafter, with CA_t^U / X_t^U converging to a strictly negative limit. The interest rate falls permanently below r_{aut}^U.*

Proof. On impact, home bias in asset holdings implies that U-residents are richer and R-residents are poorer following the collapse in δ^R. Combined with home-bias in consumption, this implies that relative demand for U-goods rises in the short run, leading to an appreciation in U's real exchange rate (a decline in q^R). On the other hand, in the long run, since output growth is the same in both countries, we have $\dot{q}_t^R/q_t^R = 0$. Substituting the latter condition into the expression for r_t, we obtain the asymptotic interest rate:

$$\lim_{t\to\infty} r_t = r_\infty^+ = r_{aut}^U - x_\infty^R(\delta^U - \delta^R)\theta < r_{aut}^U$$

where x_∞^R represents the asymptotic share of R's output. Now Lemma 1 applies, so that

$$\frac{V_t^R}{q_t^R X_t^R} \underset{t\to\infty}{\to} \frac{\delta^R}{r_\infty^+ - g}; \qquad \frac{V_t^U}{X_t^U} \underset{t\to\infty}{\to} \frac{\delta^U}{r_\infty^+ - g},$$

$$\frac{W_t^R}{q_t^R X_t^R} \underset{t\to\infty}{\to} \frac{1-\delta^R}{\theta + g - r_\infty^+}; \qquad \frac{W_t^U}{X_t^U} \underset{t\to\infty}{\to} \frac{1-\delta^U}{\theta + g - r_\infty^+}$$

and the asymptotic current account satisfies

$$\frac{CA_t^U}{X_t^U} \underset{t\to\infty}{\to} g\left(\frac{1-\delta^U}{\theta + g - r_\infty^+} - \frac{\delta^U}{r_\infty^+ - g}\right) < 0.$$

Since $r_{aut}^U > r_\infty^+$, U runs a permanent current account deficit. ■

The results of Proposition 1 carry through with one exception: the asymptotic output share x_∞^R may differ from the initial output share x_0^R. It is immediate that the current account deficit will be larger if $r_\infty^+ < r^+$, or, from the formula for r_∞^+, if

$$x_\infty^R > x_0^R.$$

Since $x_t^R = q_t^R X_0^R / \left(q_t^R X_0^R + X_0^U\right)$, this is equivalent to $q_\infty^R > q_0^R$ or $\lambda_\infty > \lambda_0$. If the real exchange rate depreciates asymptotically, which it does in our simulations, the asymptotic current account worsens, compared to the single good case.

The conventional rebalancing channel has implications for exchange rate movements but does not affect the core story for capital flows, which lies somewhere else in global asset markets.[31] In fact, although small for our calibrated parameters, adding the exchange rate dimension allows U to run larger asymptotic current account deficits and hold larger net foreign liabilities. The reason is that the long run depreciation reduces U's share of output $(1 - x_\infty^U)$. This is equivalent to a further reduction in the global supply of assets and pushes world interest rates lower (Panel C), reducing U's borrowing costs.

Figure 6 presents the results of a simulation similar to Figure 4.[32] Panel E demonstrates that the real

[31] The rebalancing channel refers to the mechanism whereby the rapid accumulation of claims on U by R residents, together with the consumption home bias assumption requires a future a depreciation of the real exchange rate.

[32] To generate figure 6, we need to calibrate the elasticity of substitution σ and the preference for the home good γ. Feenstra (1994) finds a value of 4 for σ while Broda and Weinstein (2006) report estimates ranging from 17 at 7-digit between 1972-1988 to 4 for 3-digit goods in 1990-2001. Obstfeld and Rogoff (2004) use an elasticity of 2 while Obstfeld and Rogoff (2000) used a value of 6. We adopt a value of $\sigma = 4$. Obstfeld and Rogoff (2004) use a weight on domestic tradeable of 0.7. But they also assume a share of expenditure on non-tradeable equal to 0.75. This corresponds to a share of domestic consumption on domestic goods γ of 0.925, not far from our 0.9.

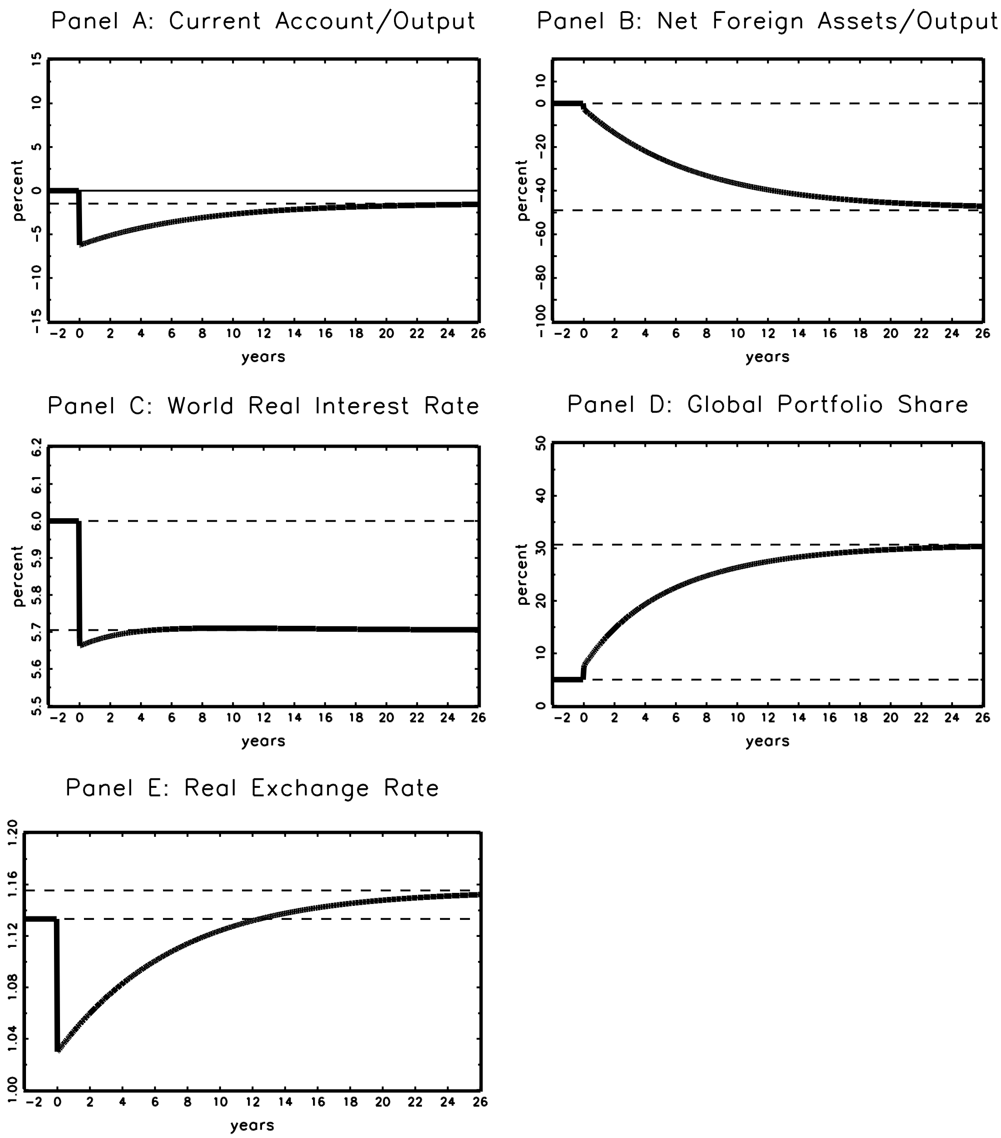


Figure 6: A Collapse in δ^R in the two-good model

exchange rate appreciates on impact by 9.5 percent, then depreciates slowly, returning to λ_{0^-} in 12 years, then depreciating by another 1.6 percent. Given the previous discussion, the long run depreciation of the real exchange rate implies that the asymptotic current account deficits are (slightly) larger than in the single good model (-1.56 percent versus -1.47 percent in the single good model) with a correspondingly higher permanent accumulation of net foreign liabilities (49% of output versus 48%). Panel C shows that our conclusion with respect to the decline in interest rates from the single good model remains largely unchanged.

6 Final Remarks

In this paper we have proposed a framework to analyze the effects of different structural shocks on global capital flows, portfolio shares and interest rates. The framework highlights the central role played by the heterogeneity in countries' ability to produce financial assets for global savers.

We used the framework to discuss different financial shocks and trends that we view as particularly relevant in explaining recent "global imbalances" and the "interest rate conundrum." These include the collapse in asset markets in Japan in the early 1990s, the emerging market crash in the late 1990s, as well as secular process of global integration and fast growth by China and other emerging markets. All these effects point in the same direction: To a sustained reallocation of savings toward U and to lower interest rates.

The framework is flexible enough to explore a variety of experiments and issues that have been postulated in the "global imbalances" debate. For example, in an earlier version of this paper (Caballero et al. (2006b)), we showed how the growth gap that developed between the US and Continental Europe during the 1990s generates patterns in our model which are consistent with the data. One could also model some of the aspects of fiscal deficits in the US as an increase in θ^U. This would indeed lead to current account deficits in U but it would increase rather than reduce interest rates, and hence it is probably not the main factor behind current "global imbalances." Instead, this angle offers a better representation of the current account deficits of the US during the 1980s.

Finally, a word of caution. Our framework also highlights that the current configuration of global asymmetries is likely to continue building the already large net external liabilities of U. Leverage always comes with risks. A substantial growth speed up in Europe and Japan, or a sudden shift in R's appetite for its own financial assets (as could happen with the emergence of local bubbles), would lead to a sharp reversal in capital flows, interest rates and exchange rates. One could also go outside the model and add a credit-risk concern with U's liabilities to generate a more harmful reversal. Our model has little to say about the latter possibility, although it seems remote. Moreover, one of our main points has been that such risk does *not* follow as an unavoidable outcome of the current configuration in global imbalances, as the latter are consistent with global asymmetries in financial development and needs.

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A Proofs

A.1 Proof of Lemma 1

We have

$$\begin{aligned}
V_t &= \int_t^\infty \delta X_s e^{-\int_t^s r_u du} ds = \delta X_t \int_t^\infty e^{-\int_t^s (r_u - g) du} ds \\
W_t &= W_0 e^{\int_0^t (r_s - \theta) ds} + \int_0^t (1-\delta) X_s e^{\int_s^t (r_u - \theta) du} ds \\
&= (1-\delta) X_t \left[\frac{W_0}{(1-\delta) X_t} e^{\int_0^t (r_s - \theta) ds} + \int_0^t e^{\int_s^t (r_u - \theta - g) du} ds \right]
\end{aligned}$$

The Lemma follows from the fact that

$$\begin{aligned}
\lim_{t \to \infty} \int_t^\infty e^{-\int_t^s (r_u - g) du} ds &= \frac{1}{r-g} \\
\lim_{t \to \infty} \int_0^t e^{\int_s^t (r_u - \theta - g) du} ds &= \frac{1}{g + \theta - r}
\end{aligned}$$

and

$$\lim_{t \to \infty} \frac{W_0}{(1-\delta) X_t} e^{\int_0^t (r_s - \theta) ds} = 0$$

when $g < r < g + \theta$.

A.2 Proof of proposition 2

The first inequality of the first statement follows directly from $(\delta - \delta^R) > 0$, as in Proposition 2. The second inequality follows from the fact that x_t^U declines over time. Asymptotically, r_t converges to r_{aut}^R.

From Lemma 1, we know that

$$\frac{CA_t^U}{X_t^U} \underset{\substack{t \to \infty \\ g^R > g}}{\longrightarrow} -g \frac{r_{aut}^U - r_{aut}^R}{\left(g + \theta - r_{aut}^R\right)\left(r_{aut}^R - g\right)} < 0$$

On the other hand, from Proposition 1 we have that

$$\frac{CA_t^U}{X_t^U} \underset{\substack{t \to \infty \\ g^R = g}}{\longrightarrow} -g \frac{r_{aut}^U - r^+}{\left(g + \theta - r^+\right)\left(r^+ - g\right)} < 0$$

where $r^+ = r_{aut}^U - \theta\left(1 - x_0^U\right)\left(\delta - \delta^R\right)$ (see (16)). From assumption 4, $r^+ > r_{aut}^R$ and the second statement in the proposition now follows since

$$\frac{r - r_{aut}^U}{(g + \theta - r)(r - g)} = \frac{1-\delta}{g + \theta - r} - \frac{\delta}{r - g}$$

is increasing with respect to r.

A.3 Proof of equation (18)

The wealth accumulation and asset pricing equations are

$$\dot{W}_t^i = r_t W_t^i + (1-\delta)\, X_t^i - \theta^i W_t^i \tag{28}$$

and

$$r_t V_t^i = \delta X_t^i + \dot{V}_t^i \tag{29}$$

These dynamics can be integrated to

$$\begin{aligned} \dot{W}_t &= r_t W_t + (1-\delta)\, X_t - \sum_i \theta^i W_t^i \\ r_t V_t &= \delta X_t + \dot{V}_t \end{aligned}$$

Equilibrium requires that $V_t = W_t$ so that

$$X_t = \sum_i \theta^i W_t^i \tag{30}$$

and the world interest rate is given by

$$r_t = \frac{\dot{W}_t}{W_t} + \delta \frac{X_t}{W_t}.$$

Deriving (30) with respect to time and substituting in the budget constraint, we get:

$$\begin{aligned} \dot{X}_t &= \sum_i \theta^i \dot{W}_t^i = \sum_i \theta^i \left[r_t W_t^i + \left(1-\delta^i\right) X_t^i - \theta^i W_t^i \right] \\ &= r_t X_t + \sum_i \theta^i \left(1-\delta^i\right) X_t^i - \sum_i \theta^{i2} W_t^i \end{aligned}$$

Hence

$$\begin{aligned} r_t &= g - \sum_i \theta^i \left(1-\delta^i\right) \frac{X_t^i}{X_t} + \sum_i \theta^{i2} \frac{W_t^i}{X_t} \\ &= \sum_i x_t^i r^i + \sum_i \theta^i \left(\theta^i W_t^i / X_t^i - 1\right) x_t^i \end{aligned}$$

A.4 Proof of proposition 4

Let us first focus on the first claim in the proposition. In situation 1, we have

$$\begin{aligned} \dot{W}_t &= \left(1-\kappa x_t^U\right) \frac{\dot{X}_t}{\theta} - \kappa \dot{x}_t^U \frac{X_t}{\theta} \\ &= \frac{X_t}{\theta} \left[g^n x_t^U + g^z - \kappa x_t^U g \right] \end{aligned}$$

Substituting into the asset equation we solve for the interest rate:

$$r_t = g^z + \frac{\theta\bar{\delta}_t}{1-\kappa x_t^U} + \frac{g^n x_t^U}{1-\kappa x_t^U}\left[1-\kappa-\theta\frac{V_t^U}{X_t^U}\right]$$

where $\bar{\delta}_t = \delta x_t^U + \delta^R x_t^R$. Comparing the interest rate at time 0 when there is no investment collapse ($r_0 = g^z + \theta\bar{\delta}_0/(1-\kappa)$) and where there is an investment collapse, the difference in interest rates is

$$\Delta r_0 = -\kappa\theta\bar{\delta}_0\frac{1-x_0^U}{\left(1-\kappa x_0^U\right)(1-\kappa)} + \frac{g^n x_0^U}{1-\kappa x_0^U}\left[1-\kappa-\theta\frac{V_0^U}{X_0^U}\right]$$

and this is negative because each term is negative (since U is a borrower, we know that $\kappa X_0^U + \theta W_0^U = I_0^U + C_0^U > X_t^U$). This proves the first claim in the proposition.

Let us now prove the second claim in the proposition. To distinguish variables under our counterfactual situation 2, we adopt the convention to underline those variables. We have

$$\begin{aligned} V_{0^+} &= (1-\kappa\frac{X_0^U}{X_0})\frac{X_0}{\theta} \text{ and} \\ V_{0^+}^R &= \frac{\delta^R X_0^R}{\delta^R X_0^R + \delta X_0^U} V_{0^+}. \end{aligned}$$

Similarly

$$\begin{aligned} \underline{V}_{0^+} &= (1-\kappa)\frac{X_0}{\theta} = V_{0^+} - \kappa\frac{X_t^R}{\theta} \text{ and} \\ \underline{V}_{0^+}^R &= \frac{\delta^R X_0^R}{\delta^R X_0^R + \delta X_0^U}\underline{V}_{0^+}. \end{aligned}$$

Hence

$$\begin{aligned} V_{0^+}^R - \underline{V}_{0^+}^R &= \frac{\delta^R X_0^R}{\delta^R X_0^R + \delta X_0^U}(\underline{V}_{0^+} - V_{0^+}) = \frac{\delta^R X_0^R}{\delta^R X_0^R + \delta X_0^U}\kappa\frac{X_0^R}{\theta} \\ &= \frac{V_{0^+}^R}{V_{0^+}}\kappa\frac{X_0^R}{\theta} \end{aligned}$$

Let us first consider situation 1. Assuming extreme home bias, at $t = 0^+$, we have,

$$TB_{0^+}^U = CA_{0^+}^U = \theta W_{0^+}^R - X_0^R = \theta V_{0^+}^R - X_0^R$$

Let us now analyze situation 2.

$$\begin{aligned} \underline{TB}_{0^+}^U &= \underline{CA}_{0^+}^U = \theta\underline{W}_{0^+}^R - (1-\kappa)X_0^R = \theta\underline{V}_{0^+}^R - (1-\kappa)X_0^R \\ &= \theta(V_{0^+}^R - \kappa\frac{X_0^R}{\theta}\frac{V_{0^+}^R}{V_{0^+}}) - (1-\kappa)X_0^R \\ &= \theta V_{0^+}^R - X_0^R(1-\kappa(1-\frac{V_{0^+}^R}{V_{0^+}})) \end{aligned}$$

Hence

$$CA_{0^+}^U < \underline{CA}_{0^+}^U$$

and

$$TB_{0^+}^U < \underline{TB}_{0^+}^U$$

This proves the second claim in the proposition.

A.5 Proof of proposition 5

Let us assume that enough time has passed so that the output of the old R trees is negligible relative to the total output produced by trees planted in R by U. We have:

$$(r_t + g^n)V_t^i = \delta^U X_t^i + \dot{V}_t^i$$

$$(r_t + g^n)V_t = \delta^U X_t + \dot{V}_t$$

$$\dot{W}_t^U = (r_t - \theta)W_t^U + (1-\delta^U)X_t^U + g^n V_t - (I_t^U + I_t^R) - P_t.$$

$$\dot{W}_t^R = (r_t - \theta)W_t^R + (1-\delta^U)X_t^R + P_t.$$

$$\dot{W}_t = (r_t - \theta)W_t + (1-\delta^U)X_t + g^n V_t - I_t \tag{31}$$

so that:

$$W_t = V_t = (1-\kappa)\frac{X_t}{\theta}.$$

and

$$r = r_{aut}^U = g^z + \frac{\delta\theta}{1-\kappa} \tag{32}$$

It follows from derivations analogous to those in previous sections that:

$$\frac{W_t^U}{X_t^U} \to \frac{(1-\delta^U-\kappa) + g^n \frac{\delta^U}{r_{aut}^U - g^z} + g^n \frac{\delta^U x^R/x^U}{r_{aut}^U - g^z} - (\kappa+\kappa_P)\, x^R/x^U}{\theta + g - r_{aut}^U}$$

and since $TB_t^U = -\theta W_t^U - I_t^U + X_t^U$, we have that:

$$\begin{aligned}
\frac{TB_t^U}{X_t^U} &\to -\theta \frac{(1-\delta^U-\kappa) + g^n \frac{\delta^U}{r_{aut}^U - g^z} + g^n \frac{\delta^U x^R/x^U}{r_{aut}^U - g^z} - (\kappa+\kappa_P)\, x^R/x^U}{\theta + g - r^{U,aut}} + (1-\kappa) \\
&= -\theta \frac{x^R}{x^U} \frac{g^n \frac{\delta^U}{r_{aut}^U - g^z} - (\kappa+\kappa_P)}{\theta + g - r_{aut}^U} < 0.
\end{aligned}$$

That is, the trade balance is in deficit in the long run as long as there is an intermediation rent, which is ensured by Assumption 6.

A.6 Derivation of the dynamics in section 4.2

Define v_t^{Ro} the value of an old R tree, v_t^{Rn} the value of a new R tree and v_t^U the value of a U tree. The asset equation for each tree follows (note that the capitalized share of output for old R trees is δ^R).

$$\begin{aligned}
r_t v_t^{Ro} &= \delta^R Z_t^R + \dot{v}_t^{Ro} \\
r_t v_t^{Rn} &= \delta Z_t^R + \dot{v}_t^{Rn} \\
r_t v_t^U &= \delta Z_t^U + \dot{v}_t^U
\end{aligned}$$

The aggregate value of U trees is $V_t^U = N_t^U v_t^U$ and satisfies

$$r_t V_t^U = \delta X_t^U + \dot{V}_t^U - g^n V_t^U$$

The aggregate value of new trees in R is $V_t^{Rn} = \left(N_t^R - N_0^R\right) v_t^{Rn}$ and satisfies

$$\begin{aligned} r_t V_t^{Rn} &= \delta \left(N_t^R - N_0^R\right) Z_t^R + \left(N_t^R - N_0^R\right) \dot{v}_t^{Rn} \\ &= \delta X_t^{Rn} + \dot{V}_t^{Rn} - g^n N_t^R v_t^{Rn} \end{aligned}$$

Finally, define the aggregate value of the old trees in R as $V_t^{Ro} = N_0^R v_t^{Ro}$. It satisfies:

$$r_t V_t^{Ro} = \delta^R X_t^{Ro} + \dot{V}_t^{Ro}$$

Aggregate wealth then evolves according to

$$r_t V_t = \delta \left(X_t^U + X_t^{Rn}\right) + \delta^R X_t^{Ro} + \dot{V}_t - g^n V_t^U - g^n N_t^R v_t^{Rn}$$

Let's now consider the wealth accumulation equations:

$$\begin{aligned} \dot{W}_t^U &= \left(r_t - \theta\right) W_t^U + \left(1 - \delta\right) X_t^U + g^n V_t^U + g^n N_t^R v_t^{Rn} - P_t - I_t \\ \dot{W}_t^R &= \left(r_t - \theta\right) W_t^R + \left(1 - \delta\right) X_t^{Rn} + \left(1 - \delta^R\right) X_t^{Ro} + P_t \end{aligned}$$

Aggregating, we obtain:

$$\dot{W}_t = \left(r_t - \theta\right) W_t + \left(1 - \delta\right) \left(X_t^U + X_t^{Rn}\right) + \left(1 - \delta^R\right) X_t^{Ro} + g^n V_t^U + g^n N_t^R v_t^{Rn} - I_t$$

In equilibrium, $W = V$ from which we infer:

$$\theta W_t = X_t \left(1 - \kappa\right)$$

and the interest rate satisfies:

$$\begin{aligned} r_t &= \frac{\dot{X}_t}{X_t} + \theta \left[\delta \left(x_t^U + x_t^{Rn}\right) + \delta^R x_t^{Ro}\right] / \left(1 - \kappa\right) - \frac{\theta}{1 - \kappa} g^n \frac{V_t^U + N_t^R v_t^{Rn}}{X_t} \\ &= \frac{\dot{X}_t}{X_t} - g^n + \theta \left[\delta \left(x_t^U + x_t^{Rn}\right) + \delta^R x_t^{Ro}\right] / \left(1 - \kappa\right) - \frac{\theta}{1 - \kappa} g^n \frac{N_0^R \left[v_t^{Rn} - v_t^{Ro}\right]}{X_t} \end{aligned}$$

while aggregate output growth satisfies:

$$\frac{\dot{X}_t}{X_t} = g^n + g^z$$

substituting output growth $\dot{X}_t / X_t = g^n + g^z$, and using $v_t^{Ro} / v_t^{Rn} = \delta^R / \delta$, and defining $\hat{v}_t^{R_0} = V_t^{R_0} / X_t^{R_0}$, we obtain:

$$r_t = g^z + \theta \left[\delta \left(x_t^U + x_t^{Rn}\right) + \delta^R x_t^{Ro}\right] / \left(1 - \kappa\right) - \frac{\theta}{1 - \kappa} g^n \hat{v}_t^{Ro} x_t^{R_0} \left[\delta / \delta^R - 1\right]$$

The last term makes clear that the interest rate will initially be lower with FDI since $\delta / \delta^R > 1$. The reason is that $g^n \left(V^U + N_t^R v_t^{Rn}\right) > g^n V_t$ so the asset demand in U increases more when there is FDI. This depresses even more interest rates.

Asymptotically, the last term disappears (since v_t^{Rn} and v_t^{Ro} grow at rate g^z while X grows at rate $g > g^z$) and x_t^{Ro} tends to 0, so that

$$r_\infty = g^z + \frac{\theta\delta}{1-\kappa} = r_{aut}$$

Since $v_t^{Rn} > v_t^{Ro}$ and $\delta^R x_t^{Ro} \leq \delta x_t^{Ro}$, we have:

$$r_t \leq r_\infty$$

To solve this problem, note that $\hat{v}_t^{Ro}$ satisfies:

$$\frac{d\hat{v}_t^{Ro}}{dt} = (r_t - g^z)\,\hat{v}_t^{Ro} - \delta^R$$

while x_t^{Ro} follows simple dynamics:

$$\dot{x}_t^{Ro} = -g^n x_t^{Ro}$$

Substituting, we obtain a single equation for $d\hat{v}_t^{Ro}/dt$ with a forcing term x_t^{Ro} :

$$\frac{d\hat{v}_t^{Ro}}{dt} = \frac{\theta}{1-\kappa}\left[\delta\left(1 - x_t^{Ro}\right) + \delta^R x_t^{Ro} - g^n \hat{v}_t^{Ro} x_t^{Ro}\left(\delta/\delta^R - 1\right)\right]\hat{v}_t^{Ro} - \delta^R$$

We can solve this differential equation by '*reversing time*'. Since $r_t \to r_{aut}$, $\hat{v}_t^{Ro}$ settles to:

$$\hat{v}_\infty^{Ro} = \frac{\delta^R}{\delta}\frac{1}{\theta}$$

We start at $t = \infty$ with x^{Ro} very close to 0 and $\hat{v}^{Ro} = \hat{v}_\infty^{Ro}$ then move 'back' in time until $x^{Ro} = x_0^{Ro}$.

Finally, after we find the value of $\hat{v}_{0+}^{R_0}$, we integrate forward the budget constraint using $w_t^U = W_t^U/X_t^U$ and

$$\begin{aligned}
\dot{w}_t^U &= \frac{(r_t - \theta)\,W_t^U + (1-\delta)\,X_t^U + g^n V_t^U + g^n N_t^R v_t^{Rn} - P_t - I_t}{X_t^U} - g w_t^U \\
&= (r_t - \theta - g)\,w_t^U + \left(1 - \delta - \frac{\kappa}{x_t^U}\right) + g^n\left(\frac{1-\kappa}{\theta}\frac{1}{x_t^U} - \hat{v}_t^{Ro}\frac{x_t^{Ro}}{x_t^U}\left(1 - \frac{\delta}{\delta^R}\right) - \kappa_p\frac{x_t^{Rn}}{x_t^U}\right)
\end{aligned}$$

A.7 Solving the Model with Exchange Rates

We use a shooting algorithm to solve for the initial terms of trade q_{0+}^i and asset values V_{0+}^i after the shock. Define $w_t = W_t^U/X_t^U$ and $x_t = X_t^U/\sum_i q_t^i X_t^i$. The system (w_t, x_t, q_t^i) satisfies:

$$\dot{w}_t = (r_t - \theta - g)w_t + (1-\delta) \tag{33}$$

$$1 = \theta\gamma w_t P_t^{U(\sigma-1)} + (1-\gamma)\left(\frac{1}{x_t} - \theta w_t\right)P_t^{i(\sigma-1)} \tag{34}$$

$$\dot{x}_t = x_t\,(1 - x_t)\left(g - g^i - \frac{\dot{q}_t^i}{q_t^i}\right) \tag{35}$$

$$r_t = x_t\,(g + \delta\theta) + (1 - x_t)\left(g^i + \frac{\dot{q}_t^i}{q_t^i} + \delta^i\theta\right) \tag{36}$$

Equation (33) is the wealth dynamics for country i. Equation (34) is the equilibrium condition on the market for good U. Equation (35)characterizes the law of motion of relative output. Unlike the one-good model, the path for future interest rates depends upon the future sequence of terms of trade, which depends upon the current and future asset values.

We start with a guess for the asset values V^i_{0+} immediately after the shock. Given the initial portfolio allocation, we infer the initial wealth distribution W^i_{0+}. We then use (34) to solve for the initial terms of trade q_{0+}. Finally, we integrate (33)-(36) forward to construct the path of future interest rates and terms of trade r_t, q_t consistent with equilibrium on the goods markets. We then use

$$\begin{aligned} V^i_{0+} &= \delta^i \int_0^\infty q^i_t X^i_t e^{-\int_0^s r_u du} ds \\ &= q^i_0 X^i_0 \delta^i \int_0^\infty e^{-\theta \int_0^s \bar{\delta}_u du} \frac{x^i_s}{x^i_0} ds \end{aligned}$$

to update our guess for V^i_{0+}, where $\bar{\delta}_t = \sum_i x^i_t \delta^i$ is the average (time-varying) capitalization ratio.

B Non-Ricardian environments

In this appendix, we show how two standard non-Ricardian models – Blanchard's model and Weil's model – generate an aggregate consumption function of the form

$$C_t = \tilde{\theta}(W_t + H_t)$$

where W_t is aggregate tradeable financial wealth in the economy and H_t is the aggregate nontradeable wealth of agents *currently alive*. In those models, $H_t < N_t$ where N_t is the net nontradeable wealth of agents *currently alive and to be born in the future.* The quantity $N_t - H_t$ is then the net non tradeable wealth that cannot be pledged or consumed against by agents currently alive. Our model in the main text is simply one in which $H = 0$, which we show to be a special case of expanded versions of Blanchard (1985) and Weil (1987)'s models.

B.1 Blanchard's model

In this section, we modify the preferences and demographics of our model and adopt the specification in Blanchard (1985). Agents have log utility with discount factor $\tilde{\theta}$ and face a constant probability of death per unit of time p At any instant in time, a new cohort whose size is normalized to p is born.

We keep the production side of our model unaltered: We consider a continuous-time endowment economy, where the aggregate endowment at date t is X_t and grows at rate g. There is one asset in the economy: It pays a dividend δX_t every period. The rest is paid as non capitalizable income.

There is a competitive life-insurance sector: agents may contract to make or receive payments contingent on their death. In the absence of a bequest motive, and if negative bequests are prohibited, agents with *tradeable financial* wealth w enter in a contract which transfers their tradeable wealth to the insurance company contingent on their death. In equilibrium, contracts are actuarially fair: a contract pays w to the insurance companies if the agent dies, and pays the agent pw if he lives.

Under these conditions, aggregate consumption is given by

$$C_t = (p + \tilde{\theta})(W_t + H_t)$$

where H_t represents the *non-capitalizable* wealth of agents *currently alive*.

Aggregate (financial) wealth W_t evolves according to

$$\dot{W}_t = r_t W_t + (1 - \delta) X_t - (p + \tilde{\theta})(W_t + H_t) \tag{37}$$

The value of the tradeable asset, V_t, evolves according to:

$$r_t V_t = \dot{V}_t + \delta X_t$$

and the asset market clears if and only if $W_t = V_t$.

The only difference between this model and the model in the main text is the presence of the term H_t on the right hand side of (37). The determination of H_t depends on how the aggregate income from the nontradeable asset $(1 - \delta) X_t$ is distributed.

We first consider the case where $(1 - \delta) X_t$ is distributed over time, as in Blanchard (representing labor income in his case). In that case, H_t evolves according to:

$$\dot{H}_t = (r_t + p) H_t - (1 - \delta) X_t$$

while the evolution of N_t is:

$$\dot{N}_t = r_t N_t - (1 - \delta) X_t.$$

These two expression differ as long as $p > 0$, and it follows from them that in this case $N > H$ throughout.

Finally, we consider the case where $(1 - \delta) X_t$ is given as an initial endowment to agents born at date t. In that case, H_t is zero (while N_t remains unchanged), and we recover exactly the same differential equations for aggregate wealth as in the model in the main text if we replace θ in the main text in place of $p + \tilde{\theta}$, the effective discount rate.

$$\begin{aligned} \dot{W}_t &= (r_t - \theta) W_t + (1 - \delta) X_t \\ C_t &= \theta W_t \end{aligned}$$

B.2 Weil's model

It is important to realize that what matters is that $N > H$, *not* that agents have a finite horizon. This point can be highlighted with Weil (1987) model. In this model, population size grows at rate n_t. Agents of each generation are infinitely-lived log-utility consumers.

Weil shows that aggregate consumption is given by

$$C_t = \tilde{\theta}(W_t + H_t)$$

Aggregate wealth W_t evolves according to

$$\dot{W}_t = r_t W_t + (1-\delta)X_t - \tilde{\theta}(W_t + H_t) \tag{38}$$

The value of assets V_t evolves according to

$$r_t V_t = \dot{V}_t + \delta X_t$$

and the asset market clears if and only if $W_t = V_t$.

The only difference between Weil's model and the model in the main text is the presence of non tradeable wealth H_t on the right hand side of (38). The determination of H_t depends on the way the aggregate annuity income $(1-\delta)\,X_t$ is distributed.

As Blanchard, Weil considers the case where $(1-\delta)X_t$ is split equally among agents. In that case, aggregate nontradeable wealth H_t evolves according to

$$\begin{aligned} H_t &= \int_t^{\infty} (1-\delta)\,X_u \exp\left[-\int_t^u n_v dv\right] R\,(t,u)\,du \\ \dot{H}_t &= (r_t + n_t)\,H_t - (1-\delta)\,X_t \end{aligned}$$

Again, this contrasts with the corresponding expressions for N_t:

$$\begin{aligned} N_t &= \int_t^{\infty} (1-\delta)\,X_u R\,(t,u)\,du \\ \dot{N}_t &= r_t N_t - (1-\delta)\,X_t \end{aligned}$$

It is apparent that $N_t > H_t$ as long as $n > 0$.

Alternatively, we can consider the case where $(1-\delta)X_t$ is given exclusively as an initial endowment to agents born at date t. In that case, H_t is zero, and we recover exactly the same differential equations for aggregate wealth as in the model in the main text (with $\tilde{\theta} = \theta$)

$$\dot{W}_t = \left(r_t - \tilde{\theta}\right) W_t + (1-\delta)X_t$$

B.3 The Meltzer Diagram

B.3.1 Blanchard's model

Consider the Blanchard model summarized above, assuming that non-tradeable asset income $(1-\delta)X_t$ is distributed across agents as a flow. Imagine a small open economy growing at rate g and facing a constant interest rate $g + p + \tilde{\theta} > r > g + \tilde{\theta}$. On the balanced growth path:

$$\begin{aligned} \lim_{t\to\infty} \frac{W_t}{X_t} &= \frac{\left(r - g - \tilde{\theta}\right)(1-\delta)}{(p + r - g)\,(p + \tilde{\theta} + g - r)} && (39) \\ \frac{V_t}{X_t} &= \frac{\delta}{r-g} && (40) \\ \frac{H_t}{X_t} &= \frac{1-\delta}{r+p-g} \\ \frac{N_t}{X_t} &= \frac{1-\delta}{r-g} \end{aligned}$$

The asset demand curve (39) is increasing in r and decreasing in δ. While the expression for the interest rate has no closed form solution in this case, the conclusions are qualitatively similar to the ones we stress as long as $p > 0$.[33]

The asset supply curve (40) is decreasing in r and increasing in δ. Since for a given interest rate, V_t/X_t goes up with δ, this implies that the autarky interest rate defined implicitly in the following equation is increasing in δ :

$$\frac{(r_{aut} - g)\left(r_{aut} - g - \tilde{\theta}\right)}{(p + r_{aut} - g)(p + \tilde{\theta} + g - r_{aut})} = \frac{\delta}{1 - \delta}$$

For $r \neq r_{aut}$, we can express the current account deficit on the balanced growth path:

$$\frac{CA_t}{X_t} = g\left[\frac{\left(r - g - \tilde{\theta}\right)(1 - \delta)}{(p + r - g)(p + \tilde{\theta} + g - r)} - \frac{\delta}{r - g}\right]$$

Hence we can perform a Metzler diagram analysis as in the main text of the paper: the current account is increasing in r, and decreasing in δ.

What is novel is that we can now distinguish between the role of $\tilde{\theta}$ and p. The asset supply curve is invariant with respect to these parameters. The asset demand curve is decreasing in p and in $\tilde{\theta}$. Hence a shortening of the time horizon or a higher discount rate are forces for a current account deficit.

B.3.2 Weil's model

Consider the Weil model summarized above, assuming that non tradable asset income $(1-\delta)X_t$ is distributed as a flow over time. Imagine a small open economy growing at rate g and facing a constant interest rate r, such that $r + n > g + \tilde{\theta} > r > g$. Then, on the balanced growth path,

$$\begin{aligned}
\lim_{t\to\infty} \frac{W_t}{X_t} &= \frac{r + n - g - \tilde{\theta}}{g + \tilde{\theta} - r}\frac{(1 - \delta)}{r + n - g} \\
\frac{V_t}{X_t} &= \frac{\delta}{r - g} \\
\frac{H_t}{X_t} &= \frac{1 - \delta}{r + n - g} \\
\frac{N_t}{X_t} &= \frac{1 - \delta}{r - g}
\end{aligned}$$

As above, the asset supply curve is decreasing in r and increasing in δ, while the asset demand curve is increasing in r and decreasing in δ. The latter is again a consequence of the non-Ricardian feature of this environment.

The asset market clears if and only if r is given by:

$$\frac{n - (g + \tilde{\theta} - r_{aut})}{g + \tilde{\theta} - r_{aut}}\frac{r_{aut} - g}{r_{aut} - g + n} = \frac{\delta}{1 - \delta}$$

[33] Note that $p > 0$ captures the non-Ricardian feature of this model. When p converges to zero, r converges to $g + \tilde{\theta}$ and no longer depends on δ.

When $n = 0$, we find the usual condition $r = g + \tilde{\theta}$. With $n > 0$, r depends positively on δ.

The current account is given by:

$$\frac{CA_t}{X_t} = g \left[\frac{r + n - g - \tilde{\theta}}{g + \tilde{\theta} - r} \frac{(1 - \delta)}{r + n - g} - \frac{\delta}{r - g} \right]$$

Hence we can perform a Metzler diagram analysis as in the main text of the paper: the current account is increasing in r, and decreasing in δ.