The Triffin Dilemma and the Saver's Curse*

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Abstract

Have US dollar assets delivered the benefits that the rest of the world is looking for in international liquidity? US government debt has been liquid, safe and it has been supplied in sufficient quantity. But it has given a low (and in fact negative) return to the countries that accumulated the most reserves. I argue in this paper that the countries that accumulate foreign assets through current account surpluses should expect a low return in terms of their own consumption. The only way that an international monetary reform could change that fact is by reducing the current account balances associated with the accumulation of reserves.

[PRELIMINARY. COMMENTS WELCOME.]

JEL codes: F36, F43

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1 Introduction

The international monetary system, viewed from a very high altitude, could be described as follows. There is a center and there is a periphery. The periphery uses safe and liquid assets of the center as reserve assets. There are three necessary conditions for the system to be viable (i.e., to deliver satisfactory outcomes for its participants):

(i) the international asset must be liquid and safe;

(ii) it must be provided in sufficient quantity and;

(iii) it must deliver an appropriate return.[1]

But to which extent can these conditions be simultaneously satisfied? There are debates about the role of the US dollar in the international monetary system and in particular, about its performance as a stable international store of value. A number of policymakers have criticized the current system on the grounds that the value of the dollar is determined by the domestic objectives of the US authorities rather than a concern to provide a stable store of value for the rest of the world (most notably Zhou (2009)). This has led to debates about the current system, which remains based primarily based on the US dollar as a reserve currency, should be replaced by a more multipolar system with a greater role for the euro and perhaps (in the longer term), the renminbi, or the SDR (Eichengreen (2011)).

Recent debates have seen the resurgence of an old question, which is whether an international monetary system that relies the currency and the assets of a particular country to provide international liquidity is sustainable. Triffin (1960) famously pointed to an internal contradiction that was undermining the Bretton Woods fixed exchange rate system. The quantity of dollars that the US needed to create in order to satisfy the rest of the world's demand for international liquidity grew at a faster rate than the US gold reserves, so that the fixed parity between the dollar and gold would be increasingly difficult to maintain. Triffin's

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[1]In addition, if there are fixed exchange rates, the monetary policy of the center must be acceptable to the periphery. With floating exchange rates this not as important, although a minimum of stability is necessary to make the nominal assets of the center safe.

argument was mainly about the problem of maintaining a fixed peg to gold but it is now being updated and applied *mutatis mutandis* to today's system of floating exchange rates. A *fiscal* variation on the Triffin dilemma theme has been proposed by Fahri, Gourinchas and Rey (2011) and Obstfeld (2011). Those authors argue that as reserves are composed of US public debt, and the share of the US in the global economy is shrinking, the US progressively loses its fiscal capacity to satisfy the rest of the world's demand for liquid assets.

I propose in this paper another variation on this theme. The internal tension that is highlighted in this paper involves the relationship between current account imbalances, exchange rates and interest rates. I argue that, to the extent that the US assets are accumulated by the rest of the world through current account surpluses rather than the financial account, those assets *must* deliver a low return. This is because the accumulation of foreign assets moves interest rates and exchange rates in a way that endogenously reduce their return. The periphery's accumulation of US assets has several effects in equilibrium. First, there is a current account deficit in the US, which lowers the US interest rate ("global savings glut" effect). Second, the dollar appreciates when the assets are accumulated, and depreciates when the current account imbalances unwind. So periphery countries apply the opposite of the investor's adage "buy low, sell high". They buy dollar assets when the dollar is high and sell (or stop buying) it when it is low. It follows that the three conditions listed above are indeed inconsistent: accumulating large quantity of US assets decreases the return on those assets, and the countries that accumulate the most foreign assets will have the lowest return (whence the "saver's curse" in the title)

This point is explained and quantified with the help of a simple theoretical framework. I consider a world with many countries (the center country and periphery countries), one tradable good and a range of nontradable goods. By assumption, periphery countries wish to hold a certain quantity of the center's assets and a certain fraction of those assets are accumulated through the current account. I then look at the return that periphery countries

receive on their foreign assets *in terms of their own consumption.* The own-consumption rate of return is what matters for welfare, and it is not the same for all countries. Then I use the model to understand how the own-consumption returns that periphery countries receive on their foreign assets depend on various factors such as the size and growth rate of the center relative to the periphery, or the extent to which the reserves are accumulated through the current account, etc.

I then use this framework to define and measure the "fundamental equilibrium return on foreign assets" (FERFA). This concept is defined by analogy with that of fundamental equilibrium exchange rates developed by Williamson (1994). The FERFA is the own-consumption return that periphery countries can expect to receive on their foreign assets after the interest rates and exchange rates have adjusted to put their current accounts on a sustainable path. The "FERFA gap" is defined as the differential between the FERFA and the normal or long-return return.

The model is then calibrated to estimate the FERFA gap on the US assets held by the three non-oil-exporting economies that have accumulated the most reserves between 2000 and 2007 (China, India and Brazil). I find that the return gap is large and negative: it is -14.8 % on average, and it is -19.2 % for China. A small part of this is due to a fall in the US interest rate, but most of it is due to an expected appreciation of the renminbi. And most of this appreciation is due to high growth in China and the Balassa-Samuelson effect, not to factor external to China. In fact, the only way China could avoid having a low return on its foreign assets is if it imported foreign capital through a current account deficit, as basic neoclassical theory suggests it should do given its high growth rate (see Gourinchas and Jeanne (2007)).

So there seems indeed to be a dilemma for periphery countries between accumulating large amounts of net foreign assets and receiving a decent return on those assets. Can this dilemma be resolved? I use the model to discuss two approaches. First, what if one

increases the size of the center? I find that this would mitigate the dilemma, but only by a small amount. Second, what about the SDR? The answer really depends on how the SDR is used for. For the SDR to have a large impact, it would have to make periphery countries reduce their accumulation of reserves through the current account. This is consistent with proposals to use the SDR in global financial safety nets—if one believes that reserves are accumulated primarily for precautionary reasons.

The paper is structured as follows. Section 2 presents a review of the recent experience of the dollar as a reserve currency, with a special focus on the own-consumption return that it yielded to the countries that accumulated the most reserves. Section 3 presents the FERFA concept and some estimates. Section 4 discusses policy implications and section 5 concludes.

2   Recent experience with the US dollar as a reserve currency

The dollar, with a share of about 60 percent of global reserves, remains the main reserve currency. The purpose of this section is to assess the performance of the dollar in the 2000s from the perspective of the three criteria stated at the beginning of the introduction. Did dollar assets provide liquidity and safety? Were dollar assets provided in sufficient quantity? And did it deliver an appropriate return?

There is little doubt that US financial markets have provided liquidity, safety and abundance of assets, at least until the crisis. This is especially true of US treasury bonds, the main asset of investment for international reserves, and the US Treasury has benefited from this by paying a lower interest rate on its debt. Krishnamurthy and Vissing-Jorgensen (2007) estimate a demand for Treasury bonds akin to a money demand function and find that as a result of superior liquidity and safety, Treasury yields are reduced by 72 basis points below corporate bonds on average over the period 1926-2008.

Has this perception changed during the crisis? It has certainly changed for the asset
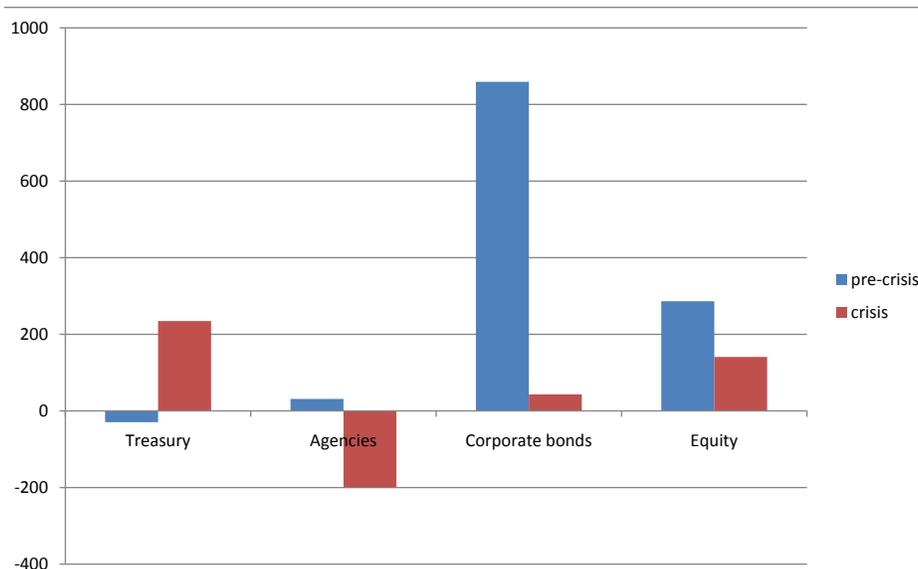
Figure 1: Net securities flows to US ($ bn)

classes that were most directly affected by the crisis such as asset-backed securities or the debt of the Government Sponsored Agencies (Fannie Mae and freddy Mac). But the pre-crisis perception did not change for Treasury bonds, which have in fact successfully served their function of "safe haven" during the crisis (McCauley and McGuire (2009)). This can be seen in the decomposition of the net securities flows to the US reported in Figure 1. The figure shows the net purchase of different classes of US securities by foreign private investors before the crisis (2006Q1 to 2007Q2) and during the crisis (2007Q3 to 2008Q4). The pre-crisis and crisis periods last the same time (6 quarters) and so the flows shown in the figure are comparable. Before the crisis, foreign investors were investing massively in US corporate bonds and reducing their investment in US Treasury bonds. The crisis is associated with a large shift in the composition of foreign flows, toward US Treasury debt and away from all other categories (with Agency debt turning sharply negative).

Second, was dollar liquidity provided in sufficient quantity before and during the crisis? This is not an easy question, absent a clear benchmark about the appropriate level of reserves and how liquidity should be distributed in a crisis. Emerging market economies have not

"run out of reserves" during the crisis: they reduced their stock of reserves, but not by very much and certainly not down to zero (Aizenman and Sun (2009)). However, the provision of swaps by the US Fed in the Fall of 2008 was probably important in restoring confidence in the global banking system. The fact that those swaps were perceived to be important to restore confidence even in countries that had a comfortable buffer stock of reserves raises important questions about what is the appropriate level of international reserves, and the extent to which international reserves can provide a good substitute to the Fed acting as international lender of last resort. These question have been actively discussed in the debates about global financial safety nets since the crisis. The problem revealed by the crisis, however, is not so much a shortage of safe and liquid US dollar assets as the fact that the global banking system needs the Fed to act sometimes as international lender of last resort, and the existence of uncertainties about the Fed willingness or ability to play that role in the future.[2]

The fiscal version of the Triffin dilemma holds that a shortage of US government debt might become a problem in the future (even though it was not during the crisis). Figure 2 shows global international reserves (excluding gold) together with the stock of US government debt, both expressed as shares of global non-US GDP. We observe that the gap between the two was narrowing before the crisis and that global reserves were going to exceed the stock of US government debt in 2010 if one extrapolated the pre-crisis trends. However, the US government debt started to increase after the crisis. Overall, the problem is not so much a decrease in US supply of government debt to the rest of the world as a dramatic increase in the rest of the world's demand for reserves. In particular, one cannot attribute the fiscal Triffin dilemma to the fact that the US economy is shrinking relative to the rest of the world. The US economy would probably be able to maintain a level of government debt in excess of 20 percent of the rest of the world's GDP for some time, which would be sufficient if the rest of the world's demand for reserves had remained at the 2000 level (about 10 percent of

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[2]This also applies to the ECB, which might be even more reluctant to play that role.
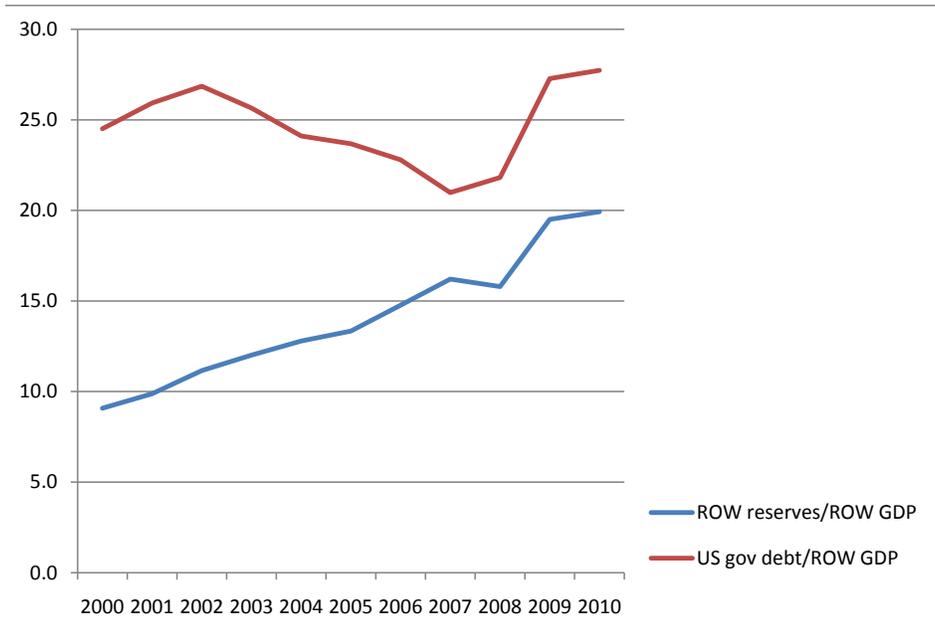
Figure 2: Global reserves and US government debt as shares of the rest of the world's GDP (%)

GDP). But the rest of the world doubled its stock of reserves in terms of its own GDP over the past decade.

The third question is whether dollar reserves have provided an appropriate return to their holders. I look at the three non-oil-exporting emerging market countries that have accumulated the most international reserves over the period 2000-10: China, India and Brazil. As shown in Table 1, China is the country that accumulated the most reserves by far. I estimated the return that these countries received on their dollar assets in terms of their own consumption between 2000 and 2010. If a country invests 100 hundred units of domestic consumption in dollar assets in January 2000, how many units of domestic consumption can the country purchase by selling those assets at a later date? The answer is given in Figure 3. For each country, the purchasing power of the dollar assets in terms of domestic consumption was computed by cumulating the country's own-consumption return on dollar assets defined as,

$$r_t = r_{\$t} + \Delta s_{t+1} - \Delta p_{t+1}.$$

The consumption own rate of interest on dollar assets is equal to the dollar interest rate, plus the rate of nominal depreciation of the domestic currency relative to the dollar, minus the domestic CPI inflation rate. It was computed using monthly data, and taking the three-month US Tbill interest rate for the dollar interest rate.[3] We started from a base of 100 in January 2000 for all three countries. A country has a positive (negative) own-consumption return on its dollar foreign assets between 2000 and a given year if the index is above (below) 100 in that year. For example, the fact that the index fell to 83.0 in December 2010 for China, means that investing 100 units of Chinese consumption in 2000 in dollar reserves gives the equivalent of 83 units of Chinese consumption ten years later. As shown in Figure 3, all three countries had a negative consumption own return on dollar assets at the end of the decade. The cumulative return before the crisis (between 2000 and 2007) is reported in the second column of Table 1.

Table 1. Reserve accumulation and consumption-based real return on US dollar assets for selected economies

Country	Total Reserve Accumulation (2000-2010)	Cumulated cons.-based real return on US dollar (2
China	$2,337bn	-4.9%
India	$236.5bn	-21.4%
Brazil	$191.5bn	-27.8%

Source: IMF BOP database, World Development Indicators (WDI); FRED database, and author's computations.

These results suggest that there is something to the view that the dollar has not performed well as a store of value. The US dollar has yielded a negative real return in terms of the country's own consumption on average over the last decade. The return is lower for India

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[3]The investment in dollar assets was assumed to be staggered over time, with one third of the foreign assets reinvested every month
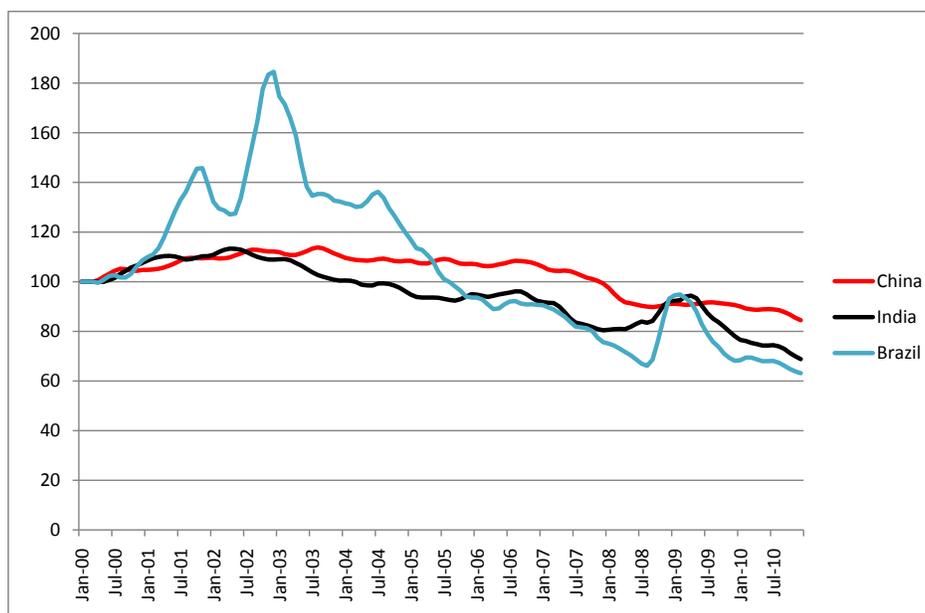
Figure 3: Own-consumption payoff on dollar foreign assets

and Brazil than for China, because China has limited more the appreciation of its currency relative to the dollar.

The estimates reported in Table 1 are interesting but they raise as many questions as they answer. First, the results are heavily influenced by the real exchange rate between those countries' currencies and the dollar, which is (for the countries that do not peg to the dollar) a volatile variable. To which extent are the low returns observed during this decade due to "low-frequency noise" in the real exchange rate? Second, these estimates do not take into account the real exchange rate adjustments that we may expect to take place in the future given the trade balances and net foreign asset positions that were observed during that period. For example, China may have a certain level of pent-up appreciation "in the pipeline" to implement in the future. Third, are returns low by chance, or is there a fundamental reason that they should be low?

I address these questions with a model.

3 Fundamental Equilibrium Return on Foreign Assets

The purpose of the model is to understand how the return on foreign assets is determined and to estimate those returns for a few selected economies that have accumulated a lot of reserves and foreign assets in the recent period.

3.1 Theory

I consider a world composed of n countries indexed by $i = 1, ..., n$. Country 1 has a special status: it is the center of the international monetary system and I will call it the center country or "Center". The other countries are the periphery countries (or, taken collectively, the "Periphery"). Time is continuous and denoted by t.

There are $n + 1$ goods: one tradable good, which is consumed in all countries, and n nontradable goods, one for each country. For simplicity, we assume that there is no productive capital or investment (or to put it in another way, we take the investment decisions as exogenous). No real restriction of generality, as there are productivity paths that would make the model equivalent to this one?

The output levels are exogenous. Each country i receives exogenous endowments of tradable and nontradable goods, respectively denoted by $Y_{Ti}(t)$ and $Y_{Ni}(t)$. Each country consumes its endowment of nontradable goods but may run a surplus or a deficit in tradable good. The external budget constraint of country i can be written in terms of domestic consumption as,

$$A_i'(t) + C_i(t) = Y_i(t) + r_i(t)A_i(t), \tag{1}$$

where $A_i(t)$ is the country's level of net foreign assets, $r_i(t)$ is the consumption own rate of interest (or consumption-based real interest rate), and domestic consumption is given by the CES index:

$$C_i(t) = \left[(1 - \eta)^{1/\sigma} C_{Ni}(t)^{(\sigma-1)/\sigma} + \eta^{1/\sigma} C_{Ti}(t)^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}. \tag{2}$$

We define the real exchange rate of country i as the price of Center consumption in terms of country i's consumption, and denote it by q_i. An decrease in q_i, thus, means a real appreciation in country i relative to the Center. The equilibrium of the global financial markets implies,

$$\sum_{i=1}^{n} q_i(t) A_i(t) = 0,$$

where the real exchange rate of the Center relative to itself, $q_1(t)$, is equal to 1. The absence of arbitrage in perfect foresight implies that the home and foreign interest rates satisfy the interest parity condition,

$$r_i(t) = r_1(t) + \frac{q_i'(t)}{q_i(t)}. \tag{3}$$

The accumulation of foreign assets by periphery countries will be taken as exogenous. The equilibrium interest rate at the Center will be at the level that induces the Center to provide the assets demanded by periphery countries. That level results from the intertemporal consumption/saving choice of the Center. I will assume, for simplicity, that the Center is populated by an infinitely-lived consumer with a utility for consumption that is intertemporally separable and with a constant elasticity of intertemporal substitution. The real interest rate, thus, must satisfy the Euler equation,

$$\frac{C_1'(t)}{C_1(t)} = g + \epsilon \left(r_1(t) - r \right), \tag{4}$$

where ϵ is the Center's elasticity of intertemporal substitution of consumption, and g and r are respectively the long-run (or "normal") rate of growth and rate of interest. r is the level of the Center country's consumption-based rate of interest such that consumption grows at rate g.[4]

I will consider equilibria in which periphery countries increase their ratio of foreign assets

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[4]Another way to put it is that the consumer's discount rate is equal to $r - g/\epsilon$.

to GDP,

$$a_i(t) = \frac{A_i(t)}{Y_i(t)}. \tag{5}$$

This could be the case, for example, because periphery countries wish to increase their level of international reserves and reserve accumulation is achieved (to some extent) through the current account rather than the financial account. A periphery country could also accumulate foreign assets in order to depreciate (or resist the appreciation of) its currency. It is not necessary to know the reasons that periphery countries increase their foreign assets in order to estimate the return on those assets, and those reasons are left outside of the model.

Equation (5) expressed the level of foreign assets in terms of GDP. Taking GDP as denominator is purely a matter of normalization. In particular, there is no assumption that output is the appropriate denominator from the point of view of normative theory of reserves adequacy. For the purpose of reserves adequacy the appropriate denominator could be another variable, such as short-term external debt or a monetary aggregate like M2 (Jeanne (2007)).

I will consider the equilibrium after some time t_0. I assume that after some time $t_1 > t_0$ the global economy is in a balanced growth path. So the return r_i differs from the normal level r during the finite time interval $[t_0, t_1]$. Time t_1 could be arbitrarily large so there is little restriction in this assumption.

I define the *fundamental equilibrium return on foreign assets* (FERFA) as the cumulated return on the country's foreign assets between time t_0 and time t_1,

$$R_i = \int_{t_0}^{t_1} r_i(t)dt.$$

The FERFA gap is defined as the difference between the FERFA and the "normal" cumulated return that the country should receive in a balanced growth path,

$$\Delta R_i = \int_{t_0}^{t_1} \left(r_i(t) - r\right)dt. \tag{6}$$

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I will also call this the "return gap" to avoid repeating the same acronym. The advantage of looking at the return gap (rather than the level) is that it does not depend on an assumption about the "normal" level of the interest rate, which is necessarily somewhat arbitrary. For a periphery country, the return gap is a measure of the extent to which the return exceeds the normal level. For the Center, it is the amount by which the cost of borrowing abroad exceeds the normal level. The return gap will typically be negative in the data.

Using the interest parity condition (3) one can decompose the return gap for country i as the sum of the gap for the Center and a term that depends on the periphery country's real exchange rate:

$$
\begin{aligned}
\Delta R_i &= \int_{t_0}^{t_1} \left(r_1(t) + \frac{q_i'(t)}{q_i(t)} - r \right) dt, \\
&= \Delta R_1 + \log \left(\frac{q_i(t_1)}{q_i(t_0)} \right).
\end{aligned}
\tag{7}
$$

The first term reflects the impact of the center country's interest rate on the return received by the periphery country on its foreign assets. The second term reflects the valuation change on the periphery country's coming from the change in its real exchange rate relative to the Center. There is a valuation loss if the currency of the periphery country appreciates in real terms relative to the Center $(q_i(t_1) < q_i(t_0))$.

Using the Euler equation (4) the center country's return gap can in turn be written

$$
\Delta R_1 = \int_{t_0}^{t_1} \frac{1}{\epsilon} \left(g - \frac{C_1'(t)}{C_1(t)} \right) dt = \frac{1}{\epsilon} \log \left(\frac{C_1(t_0) e^{g(t_1 - t_0)}}{C_1(t_1)} \right).
\tag{8}
$$

This gap is positive if and only if the center country's consumption grows by more than g between time t_0 and time t_1. For simplicity I shall assume that output grow at rate g in the Center. Let us denote by x_1 the ratio of Center net exports to Center GDP, so that $C_1 = (1 - x_1)Y_1$. Then we have

$$
\Delta R_1 = \frac{1}{\epsilon} \log \left(\frac{1 - x_1(t_1)}{1 - x_1(t_0)} \right).
$$

$x_1(t_1)$ is the net-exports-to-GDP ratio that puts the center country's economy on a balanced growth path from year t_1 onwards. It can be derived from the ratio of the center country's net foreign assets to GDP $a_1(t_1)$, using the steady-state relationship

$$x_1(t_1) = -(r - g)a_1(t_1).$$

It follows that the center country's return gap can also be written

$$\Delta R_1 = \frac{1}{\epsilon} \log\left(\frac{1 + (r - g)a_1(t_1)}{1 - x_1(t_0)}\right). \tag{9}$$

The center country's real interest rate is reduced by a decrease in its ratio of net foreign assets to GDP. This is because the center country must reduce its ratio of consumption to GDP between time t_0 and time t_1 in order to service its larger debt.

The real exchange rate component can also be decomposed as follows. Let us denote by $\widetilde{q}_i$ the real exchange rate that one would observe if country i and the center country both had a zero trade balance. As shown in the appendix, if $\sigma = 1$ this counterfactual real exchange rate is given by

$$\widetilde{q}_i = \left(\frac{Y_{Ni}/Y_{Ti}}{Y_{N1}/Y_{T1}}\right)^{1-\eta}.$$

This expression shows how the real exchange rate is determined by the relative supply of tradable good and nontradable good in the two countries, exactly like in the Balassa-Samuelson model. As we know from the Balassa-Samuelson model, an increase in the relative supply of tradable good in country i appreciates the currency of that country.

As shown in the appendix, the real exchange rate is equal to the balanced-trade level times a factor that depends on both countries' trade balances,

$$q_i = \widetilde{q}_i f(\overset{+}{x_i}, \overset{-}{x_1}).$$

An increase in country i's net exports to GDP ratio is associated with a depreciation of its

currency that makes the tradable good more expensive in terms of nontradable good. An increase in the center country's net exports to GDP ratio is associated with a depreciation of the center currency (and so a depreciation of country i's currency).

Putting things together, country i's return gap can be written in reduced form as,

$$\Delta R_i = \Delta R(a_i \overset{-}{(t_1)}, a_1 \overset{+}{(t_1)}, \frac{\widetilde{q}_i \overset{+}{(t_1)}}{\widetilde{q}_i(t_0)}).$$

Other things equal, country i's return gap is decreasing in country i's ratio of net foreign assets to GDP and increasing in the ratio of the center country's ratio of net foreign assets to GDP. Thus, the accumulation of net foreign assets by periphery countries (which must be associated with an accumulation of foreign liabilities in the center country) decreases the own-consumption return on the periphery foreign assets. This is because the changes in foreign assets lead to a real appreciation of periphery currencies relative to the center currency.

The return gap of country i is increasing in the rate of "technological depreciation", $\widetilde{q}_i(t_1)/\widetilde{q}_i(t_0)$. Thus, a country in which the tradable sector develops at a high pace will have a low return on its foreign assets.

3.2   Estimates

The US will be taken as the center country (and so "US" will be used instead of "1" as the subscript for the Center from now on). I estimate the FERFA gap on the net foreign assets of China, India and Brazil over the seven-year period between t_0=2000 and t_1=2007. These estimates will not be the same as the returns that were *observed* over that period (reported in 2) because they will be based on the assumption that the real exchange rates and trade balances adjust in 2007 to levels that put those countries on balanced growth paths from 2007 onwards. That is, I estimate the total return on the countries' foreign assets between

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2000 and 2007, taking into account the exchange rate and interest rate adjustments that would have to take place for those economies to be on a balanced growth path after 2007.

I focus on a period that stops before the global financial crisis. Although one could see the crisis as part of the adjustment toward a balanced growth path, it involves unemployment in the US whereas the model (implicity) assume full employment. Unemployment and output gaps might bias the results. The fall in the US trade deficit observed after 2007 will be interpreted by the model as a fundamental real appreciation of the dollar (since the dollar needs to depreciate by less to achieve fundamental balance.) even though it is due mostly to low demand and a negative output gap in the US..

In order to do estimate the return gaps we must calibrate the structural model. We use the following benchmark calibration (sensitivity analysis later).

Table 2. Benchmark calibration

η	σ	ϵ	$r - g$
0.25	1	0.5	0.005

The values for the elasticity of substitution between the tradable and the nontradable good, σ, and the share of the tradable good in total consumption, η, are taken from Obstfeld and Rogoff (2005). The intertemporal elasticity of substitution of consumption is set to $\epsilon = 0.5$ (which is in the range assumed in the literature). The value of 0.5 percent for the interest-growth differential was derived as follows. The average US growth rate between 1960 and 2010 is 3.1 percent. There are theoretical reasons to believe that the interest-growth differential is positive but it is difficult to find strong evidence of a positive differential in the data, at least in the case of the US. For example, taking the difference between the average one-year nominal interest rate and the average CPI inflation rate between 1960 and 2010 yields a real interest rate level of 1.8 percent, which is lower than the average real growth rate over the same period. Considering longer maturities (three or five years) raises the measured level of the real interest rate somewhat, but only marginally so. However, there

are periods during which the interest-growth differential was positive. During the 1990s, the differential between the average 5-year ex post real interest rate and the growth rate was 0.4 percent. Given the theoretical prior that the interest-growth differential is positive, we set it to a positive (but small) level of half a percentage point in the calibration. As we will see, the precise value assumed for this differential does not affect our results very significantly.

For a given country i the FERFA gap ΔR_i can be decomposed in two terms, the US gap and the exchange rate term. The US return gap is the same for all countries i and can be computed using equation (9). The ratio of the US trade balance to US GDP was equal to -3.8% in 2000. This gives $x_{US}(t_0) = -0.038$. The net foreign asset position of the US as estimated by Lane and Milesi-Ferretti is $a_{US}(t_1) = -17.1\%$ in 2007.[5] This implies $x_{US}(t_1) = 0.1\%$, that is, the US would have to show a trade surplus of 0.1 percent of its GDP for its economy to be on a balanced growth path after 2007. In principle, we should adjust this level for the valuation effects resulting from the real exchange rate adjustment assumed in the counterfactual. (Since the US foreign liabilities are primarily in dollars and its foreign assets are primarily in foreign currency, a real devaluation would improve the net foreign asset position of the US.) But the interest-growth differential being very small, this adjustment would have a small quantitative impact.

Under these assumptions we find that the US return gap is $R_{US} = -3.3\%$ over a period of seven years, that is a reduction of about half a percentage point in the average annual return. This estimate is obviously very sensitive to ϵ. As a benchmark for comparison, Krishnamurthy and Vissing-Jorgensen (2007) find that if the foreign official sector were to sell its holdings of Treasury bonds the short-term yield on those bonds would increase by 60 basis points relative to corporate bonds.[6]

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[5] We take the net foreign assets data from the updated and extended version of the External Wealth of Nations Mark II database of Lane and Milesi-Ferretti (2007). Using the country's net international investment position (NIIP) from the IMF BOPS and IFS does not significantly affect the results.

[6] In-sample estimates of the impact of the global savings glut on US interest rates are likely to underestimate the long-run impact because they do not take into account that US consumption will have to grow at a rate lower than g in the transition to the balanced growth path.

The second component of the return gap, $\log(q_i(t_1)/q_i(t_0))$, is country specific. We consider the CPI-based real exchange rate with the US between 2000 and 2007, taking a basis of $q_i(t_0) = 100$ in January 2000. However, the value for $q_i(t_1)$ that we must use in formula (7) is not the real exchange rate measured at the end of 2007, it is the counterfactual real exchange rate that would be observed in 2005 in a balanced growth path, taking as given the observed net foreign asset positions of country i (and of the US). A formula for this counterfactual real exchange rate is derived in the appendix.

Table 3 reports our estimates. The first column gives the total return gap R_i, and the second column gives the contribution of the real exchange rate change term, $\log(q_i(t_1)/q_i(t_0))$. Most of the return gap comes from the exchange rate appreciation. The return gap is the highest (in absolute value) for China because it is estimated to have the highest fundamental appreciation given its high trade surplus in 2007.

Table 3. Fundamental Equilibrium Return gaps (2000-07)

Country	Return gap	Exchange rate contribution
China	-19.2%	-15.9%
India	-8.5%	-5.2%
Brazil	-16.7%	-13.3%

4 Discussion (sketch)

How can periphery countries increase the return on their foreign assets?

A first approach is diversification. Instead of accumulating exclusively the debt of the center country, periphery countries could accumulate equity or even real assets (e.g., natural resources). It would be easy to introduce more assets in the model. This would raise the return on periphery countries' foreign assets to the extent (but only to the extent) that the

diversification involves non-center assets. The center would accumulate less foreign liabilities, which would reduce the depreciation of the center currency relative to the periphery currencies. But this effect would be small because the real exchange rate is not very sensitive to the center's accumulation of foreign liabilities.

For the same reason, increasing the size of the center would raise the return that the periphery receives on its foreign assets, but only by a very small amount. To illustrate, Figure [tba] shows how the return gap of a periphery country depends on the center's ratio of foreign assets to GDP at the end of the accumulation period (time t_1). Doubling the size of the center (as would be the case, for example, if the euro area were added to the US at the center) reduces the size of the foreign liabilities that the center needs to accumulate (in terms of its GDP) by a factor 2. This reduces (in absolute value) the return gap from []% to [.]%

Most of the return gap is due to the exogenous technological rate of appreciation, which itself is exogenous to the international monetary and financial system. Countries in which the tradable sector grows at a high rate must have a low return on their foreign assets. The only way that the return on their foreign assets can be substantially increased is by reducing their accumulation of foreign assets. Ideally, those countries should run current account deficits and accumulate net foreign liabilities, so that the low return becomes a low interest rate on their liabilities.

For the SDR to have a large impact, it would have to allow periphery countries to reduce the share of their accumulation of reserves that comes from the current account. This is consistent with proposals to use the SDR in global financial safety nets (see, e.g.,Obstfeld (2011)). This is true, however, only if one believes that reserves are accumulated primarily for precautionary (rather than mercantilist) reasons.

5   Conclusion (sketch)

The model could be extended in several directions, for example by adding productive capital and investment. The Periphery's demand for liquidity could be endogenized in the context of a precautionary savings model.

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TECHNICAL APPENDIX

We express the real exchange rate of country i as a function of the consumption level of tradable good. The tradable good will be used as the numeraire. Let us denote by p_i the price of country i's nontradable good in terms of tradable good. Then we have

$$q_i = \left[\frac{(1-\eta)p_1^{1-\sigma} + \eta}{(1-\eta)p_i^{1-\sigma} + \eta} \right]^{1/(1-\sigma)},$$

and

$$q_i = \left(\frac{p_1}{p_i} \right)^{1-\eta},$$

if $\sigma = 1$. Then using the fact that,

$$\frac{C_{Ni}}{C_{Ti}} = \frac{1-\eta}{\eta} p_i^{-\sigma}, \tag{10}$$

and $C_{Ni} = Y_{Ni}$ we have

$$q_i = \left[\frac{(1-\eta)(C_{T1}/Y_{N1})^{(1-\sigma)/\sigma} + \eta}{(1-\eta)(C_{Ti}/Y_{Ni})^{(1-\sigma)/\sigma} + \eta} \right]^{1/(1-\sigma)}. \tag{11}$$

In a steady-growth path, the equilibrium can be derived from the ratio $a_i = A_i/Y_i$ as follows. The steady-growth budget constraint for country i implies

$$\frac{C_i}{Y_i} = 1 + (r-g)a_i.$$

Since $C_i = (1 - x_i)Y_i$ one has

$$x_i = -(r-g)a_i.$$

Then using

$$\frac{C_i}{Y_i} = \frac{C_{Ti} + p_i Y_{Ni}}{Y_{Ti} + p_i Y_{Ni}}, \tag{12}$$

and using (10) to substitute out p_i we obtain

$$1 + (r-g)a_i = \frac{C_{Ti} + \left(\frac{1-\eta}{\eta} \frac{C_{Ti}}{Y_{Ni}} \right)^{1/\sigma} Y_{Ni}}{Y_{Ti} + \left(\frac{1-\eta}{\eta} \frac{C_{Ti}}{Y_{Ni}} \right)^{1/\sigma} Y_{Ni}}. \tag{13}$$

Given a_i, this equation can be solved for C_{Ti}, which then allows one to compute the other endogenous variables.

In the case where $\sigma = 1$, equation (13) can be solved in closed form to give

$$C_{Ti} = [1 - x_T(a_i)] Y_{Ti},$$

where

$$x_T(a) = -\frac{(r-g)a}{\eta - (1-\eta)(r-g)a},$$

is the ratio of net exports to tradable GDP that can be sustained in steady state with a net foreign assets ratio of a. We have $x_T(0) = 0$ and $x_T(\cdot)$ is decreasing with a. It then follows from (10) that

$$q_i = \left(\frac{p_1}{p_i}\right)^{1-\eta} = \left(\frac{C_{T1}/C_{N1}}{C_{Ti}/C_{Ni}}\right)^{1-\eta} = \left(\frac{Y_{Ni}/Y_{Ti}}{Y_{N1}/Y_{T1}}\frac{1-x_{T1}}{1-x_{Ti}}\right)^{1-\eta}.$$

This equality holds in any period t, and not only in a balanced growth path. In a balanced growth path one has

$$q_i = \left(\frac{Y_{Ni}/Y_{Ti}}{Y_{N1}/Y_{T1}}\frac{1-x_T(a_1)}{1-x_T(a_i)}\right)^{1-\eta}.$$

These expressions involve x_T but one observes x in the data. Using (12) and $C_T/\eta = pC_N/(1-\eta)$, one can derive a relationship between x and x_T:

$$\frac{Y}{C} = \frac{1}{1-x} = 1 - \eta + \eta\frac{Y_T}{C_T} = 1 - \eta + \eta\frac{1}{1-x_T},$$

so that,

$$\frac{1-x_{T1}}{1-x_{Ti}} = \frac{(1-x_i)^{-1} - (1-\eta)}{(1-x_1)^{-1} - (1-\eta)}.$$

Let us denote by $q_i(t_{1-})$ the real exchange rate observed at t_1 before the adjustment. Then the post-adjustment real exchange rate is given by,

$$q_i(t_1) = \left[\frac{1 - x_T(a_1(t_1))}{1 - x_T(a_i(t_1))}\frac{(1-x_1(t_1))^{-1} - (1-\eta)}{(1-x_i(t_1))^{-1} - (1-\eta)}\right]^{1-\eta} q_i(t_{1-}).$$

For each country i, this can be computed using the observed real exchange rate relative to the US, $q_i(t_{1-})$, and the observed net-foreign-assets-to-GDP ratios ($a_i(t_1)$ and $a_1(t_1)$), and net-exports-to-GDP ratios ($x_i(t_1)$ and $x_1(t_1)$).