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Capital liberalization and the US external imbalance

Elvira Prades† Katrin Rabitsch ‡

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Abstract

Differences in financial systems are often named as a prime candidate for the current state of global imbalances. This paper focuses on cross-country heterogeneity in access to international financial markets that derives from the presence of capital controls and argues that the process of capital liberalization over the past decades can explain a substantial fraction of US net external liabilities. We present a simple two-country model with an internationally traded bond, in which capital controls are reflected in the presence of borrowing and lending constraints on that bond. In a US versus the rest of the world (RoW) scenario, we perform experiments that are largely consistent with countries’ liberalization experiences. A reduction in the RoW’s controls on capital outflows and/or a tightening in the RoW’s borrowing constraint enables the US economy to better insure against consumption risk relative to the rest of the world, and therefore decreases its motives for precautionary asset holdings relative to the rest of the world. As a result of these asymmetric shifts in countries’ barriers to capital mobility, the US runs a long run external deficit.

Keywords: Capital Liberalization, External Imbalances, Net Foreign Asset Position Precautionary Savings, Borrowing and Lending Constraints

JEL-Codes: F32, F34, F41

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1 Introduction

In recent years the US net external liabilities stand at close to 20% of its GDP, the current account has been in deficit for most of the last 25 years. The fact that the US is an external borrower, and the size and persistence of its net external position is challenging to the conventional wisdom of standard economic theory and has led to a large debate on the sustainability of these imbalances, whether and when adjustment needs to take place or how painful it is going to be for the world economy. A number of authors have argued that major policy actions need to be taken to avoid a painful worldwide rebalancing process (e.g. Obstfeld and Rogoff (2004), Roubini and Setser (2005), Blanchard et al. (2005)). On the other hand, a number of papers have emphasized that before policy advice can be given as to how adjustment of the current global imbalance should take place, it is important to understand how these imbalances have arrived in the first place.

We suggest that part of the US imbalance can be rationalized by noting that countries differ in their degree of openness to international financial markets and differ in their liberalization experiences over recent decades. Arguably, the US is the economy that has had the most liberalized capital account already in the 1980s while in most other regions of the world capital controls were much more prevalent. In the rest of the world the process of capital liberalization has, over the last decades, led on the one hand to a reduction of controls on capital outflows, as a result of the catching up of other advanced and emerging market economies in terms of capital account openness. On the other hand, many emerging market economies that have experienced crises after an initial liberalization of their capital accounts, have subsequently faced increased limitations in their ability to borrow internationally. We argue that, over these two developments, capital liberalization has led to asymmetric changes in countries’ ability to borrow and lend internationally, which has brought about differences in their ability to manage consumption uncertainty. In particular, it has improved, relative to the rest of the world (RoW), the US’s ability to make better use of international financial markets to smooth their consumption and therefore has lowered their motives for precautionary asset holdings relative to RoW. As a result, the US runs an external deficit.

We address this question in a stylized two-country one good model of consumption and saving choice. We consider an endowment economy, where outputs arrive stochastically each period. The home economy is taken to be the US while the foreign economy stands for the
rest of the world. We assume that there is a representative agent in each country that can 
trade a non-contingent bond to smooth consumption in response to country specific shocks, 
but that she cannot do so unrestrictedly. In particular, in each country the agent has limited 
access to borrow and lend in international financial markets; there are limits beyond which 
capital cannot flow in or out. We think of the presence of capital controls as being reflected in 
the tightness of these borrowing and lending constraints. When the limits are set to zero, such 
that the bond holdings are not only constrained but cannot be used at all, the economies are 
in financial autarky. As the constraints get more and more relaxed, it becomes increasingly 
easier to smooth consumption.

The setup of the model provides us with a novel framework in which to study the implica-
tions of capital controls for the international macroeconomy. We use this model framework to 
analyze the effect of changes in countries’ degree of financial openness that have resulted from 
the process of capital liberalization. In particular, we use the model to perform two experi-
ments: The catching up of the RoW’s financial openness is modeled as a one-time permanent 
relaxation of the upper limit of capital outflows of the foreign economy. On the other hand, 
the limitations that some emerging market countries faced in their ability to borrow interna-
tionally in response to crisis experiences is modeled as a tightening in the RoW’s borrowing 
constraint. Effectively, both these channels improve the US ability to borrow in international 
financial markets relative to the rest of the world. For any given level of risk it faces it can 
now better use the international bond to achieve smooth consumption, and the implied drop 
in consumption volatility means that it has less of a motive to hold assets as a buffer for 
times of low consumption. It is this drop in the (relative) importance of the precautionary 
savings motive that endogenously makes the US hold long run negative net foreign assets as 
it transitions to a new implied steady state.

We conduct extensive sensitivity analysis for crucial parameters, most importantly for the 
initial level of financial openness and the extent of liberalization assumed. We also consider a 
model with production and capital accumulation, thereby allowing for an additional (internal) 
asset that the change in precautionary asset demand can fall on. The model allowing for 
capital accumulation is essentially the framework of Backus et al. (1992), which is a standard 
workhorse model of international macroeconomics. In all specifications, we show, that our 
model framework implies that differences in financial openness and the process of capital
liberalization can contribute to rationalizing the sizeable observed imbalances and can help explain the puzzle of the direction of net flows, within a standard neoclassical model.

There are several contributions in the recent literature that our paper connects to, which also stress the importance of differences in precautionary motives of the US and other countries as a potential driving force behind the imbalances. It is important to note, however, that the source of these precautionary motives is different.

Mendoza et al. (2009, hereafter MQRR), and previously Willen (2004), emphasize the heterogeneity in the level of development of countries’ local financial systems, such as the domestic credit market and differences in the ability to borrow from collateral. In their model agents face idiosyncratic risk from both endowments and investment technologies, which has to be managed differently. In this relatively rich model setup, differences in financial development between countries matter when economies open up to trade in international financial markets. The accompanied process of factor equalization – less developed economies face an increase in the interest rate relative to its autarky interest rate, therefore an incentive to save – leads to capital flows from less developed financial markets into the US economy.

While both our contribution and MQRR emphasize cross-country heterogeneity in financial factors, the type of heterogeneity and the mechanism generating imbalances are different. Contrary to MQRR the different strength of precautionary assets derives not from differences in the level of development of domestic financial markets; in our model the representative agent assumption implies that financial markets within each of the two countries are complete. The differences in precautionary asset holdings arrive solely from the fact that the financial globalization experience was heterogenous across countries: while the US was unrestricted, both in borrowing from abroad or in investing abroad, the process of capital liberalization has removed barriers to capital mobility in the RoW, largely lifting restrictions that prevented the RoW from investing abroad. At the same time, because of market reactions to the liberalization experiences of emerging economies may not have seen an equivalent change in how easily the RoW can borrow in international financial markets. Another important distinction

\footnote{Caballero et al. (2006) also relate the US imbalance to heterogenous domestic financial systems, but their proposed channel is of rather different nature, focusing on an asset supply channel: they argue that, in emerging market economies, the development of local financial markets has not kept pace with the growth experiences of their economies which has resulted in an inability to supply the high quality financial assets savers may seek.}
with respect to MQRR is that also the type of risk that matters for the respective financial market heterogeneity differs; while it is idiosyncratic risk that matters for the financial market heterogeneity MQRR emphasize, the model in our paper focuses on country specific, aggregate risk.

Another mechanism that rationalizes part of the observed US imbalance as an equilibrium outcome of differences in precautionary savings across countries is suggested by Fogli and Perri (2006). They emphasize that the 'great moderation' in business cycle volatility has been disproportionately strongly experienced by the US (compared to the rest of the world), which has led to a decline not only in absolute, but also in relative consumption volatility. While the mechanism of our paper is similar in that the US imbalance also derives from a lower relative consumption volatility, this is a result of the opening up of countries’ capital accounts which allows the US to make disproportionally better use of international financial markets.

Durdu et al. (2009) use a small open economy model to suggest that the motive for emerging market economies’ precautionary asset holdings may stem from either changes in business cycle volatility, from financial globalization, or from self-insurance against sudden stops. In the line of thought of a self-insurance motive, we obtain similar effects from our experiment of modeling the increased difficulty to borrow internationally.

The rest of the paper is organized as follows. Section 2 discusses how financial openness and capital liberalization is measured in the data. In section 3 we present the model framework, a simple two-country endowment model that allows for constraints on capital in- and outflows. Subsection 3.2 explains in detail how financial openness and capital liberalization is modeled. Subsection 3.3 discusses parametrization. In section 4 we present the results of our 'capital liberalization' exercise for the simple model together with extensive sensitivity analysis, while section 5 discusses results for the model with capital accumulation. Section 6 concludes.
2 Empirical Motivation

2.1 The US External Position

Figure 1 plots the development of the US current account and its net foreign asset (NFA) position. At the end of 2007 they stand, respectively, at -5.2% and -15.2% of GDP. As can be seen the gradual decline in the US net external position begins in the mid 1980s, and was actually positive before. As we will show in the next section, the beginning of this downward trend in the US NFA position coincides with major liberalization periods in terms capital account openness in the rest of the world.

Figure 1: US current account and net foreign assets as percentage of GDP

Source: Bureau of Economic Analysis. 2008 is based on preliminary data.

2.2 Measurement of Financial Openness and Capital Liberalization

A large literature has studied the effect of financial integration on growth and volatility, with mixed conclusions. While the focus of this paper is a different one – in particular, we focus on the effect of financial integration on countries’ net foreign asset positions –, we draw from this literature in terms of how it treats the measurement of financial openness. In general, one can distinguish two types of measures of financial openness, *de jure* and *de facto* measures.

The majority of papers studying the effects of capital account liberalization rely on ‘de jure’ measures, which reflect legal restrictions on capital movements (or lack thereof). These are rule-based indices on various types of capital controls, in the largest number of cases based on the IMF’s *Annual Reports on Exchange Rate Arrangements and Exchange Restrictions*.
A shortcoming of de jure measures is the fact that they just capture whether there are controls or not, but not how stringent these controls are. In addition to the problem of measuring the intensity of legal capital controls, there is generally also a lack of systematic information on how strongly these legal restrictions are enforced.

De facto measures of financial integration typically look at actual data on cross-country capital flows (or interest rate differentials) to draw conclusions about the degree of capital mobility. Observed flows do, however, not necessarily capture the correct degree of capital mobility. In practice it is difficult to distinguish whether capital does not flow across countries because of actual restrictions or because of other factors unrelated to the level of capital restrictions.

Figure 2 documents the evolution of three types of de jure indices for the United States, for the group of industrial countries other than the US, and for emerging economies, over the period of 1983-2004. We focus on de jure indices since these most closely reflect the prevailing level and evolution of restrictions on capital flows, that we will be interested in for our theoretical model. The line with diamond-signs displays the evolution of a country-average over a binary indicator on 'restrictions on payments for capital account transactions' published in the pre-1996 editions of the IMF’s AREAER, which takes on value 1 if there are restrictions or value 0 if there are no restrictions. As noted by Eichengreen (2001) this simple dummy accounts only for controls on capital outflows. Because of the obvious limitations of a dichotomic dummy the IMF changed reporting procedures starting with the 1996 edition of the AREAER. In the category of restrictions on payments for capital account transactions, the 'new' AREAER provides dummies in not one but 13 subcategories of transactions, some of which are even further disaggregated. Miniane (2004) uses the post-1996 disaggregated capital account information and extends the indices back to 1983 for a representative sample of countries. This index is given by the line with circle-signs in figure 2. While the disaggregated indices generally do a better job than the pre-1996 single dummy in reflecting global trends.
toward capital account liberalization, the index unfortunately does not distinguish between controls on capital inflows and outflows.\textsuperscript{5} Finally, the third line presented in figure 2 plots the inverse of an index of financial openness developed by Chinn and Ito (2005), which is given by the line with crosses.\textsuperscript{6} Chinn and Ito’s index is a broader measure in the sense that it incorporates information not only on countries’ restrictions on capital account transactions, but also on restrictions on current account transactions, the presence of multiple exchange rates within that country or requirements for the surrender of export proceeds.

As can be seen from these indices, the US has always been financially open over the last three decades, and most other regions have been liberalizing gradually since the beginning of the 1980s. The IMF dummy indicates that the US were not imposing any restrictions on its capital outflows over the entire period. The Chinn and Ito index also appraises the US the highest financial openness over the entire period. Only Miniane’s index indicates that the US has also been liberalizing its capital account, however, starting from a low level of restrictions already in the mid 1980s.

Figure 2: Indices of Capital Restrictions

Sources: AREAER (IMF, various editions), Miniane (2004), Chinn and Ito (2005)

The indices for the group of industrial countries other that the US also paint a clear picture. Initially, in the mid 1980s, because of controls on capital inflows and especially on

\textsuperscript{5}While the ‘new’ AREAER editions after 1996 now makes a distinction between capital inflows and capital outflows, this information is not available for earlier periods.

\textsuperscript{6}As the original index is an index of openness we plot the inverse of it (and rescale the index to the 0 to 1 interval) to make it comparable with the other measures of capital restrictions.
outflows in many industrial countries world capital markets were far from complete. With the end of the Bretton Woods system and the move towards flexible exchange rate regimes, the national monetary authorities of most advanced countries were increasingly freed from balance of payment constraints, which thus permitted them to relax capital controls. While for many countries capital was not being prevented from flowing into the country, controls on capital outflows often were much tighter. Johnston and Tamirisa (1998) provide evidence that, for countries at an early liberalization stage, capital outflow controls are more prevalent than controls on inflows on most types of transactions. Similar findings can be reached from the literature that measures capital mobility from data on interest rate differentials, which will be reviewed below. The evolution of the IMF dummy indicates that starting in the mid 1980s controls on capital outflows for the group of industrial countries other than the US have been largely eliminated. Also the other indices suggest that industrial countries have largely caught up with the US in terms of capital account openness.

For the group of emerging countries the picture is somewhat less clear. One thing to point out is the general higher level of restrictions on capital flows to begin with, when compared to industrial countries. On the other hand, the removal of restriction seems to have occurred also at a lower pace. Nevertheless, liberalization of capital accounts did take place to some degree, often as a result of pressure from the industrialized world. For the IMF index we observe, after an initial spike, a steady reduction of restrictions on capital outflows. The Miniane index displays a lesser degree of liberalization. This may be partly due to the fact that after recurrent crisis that some of the emerging market economies have faced during the end of the 1990s, they suffered limitations in their ability to borrow internationally.

Because of the obvious difficulties in interpreting the intensity of capital controls from the de jure measures above, and their lack of distinction between capital inflow and capital outflow controls, it is useful to take a tour into another stream of the literature that can say something more in this direction: the literature that interprets onshore-offshore interest rate differentials and deviations from covered interest parity as resulting from capital controls.

---

7 As Obstfeld and Taylor (1998) argue, in an open economy countries face a ‘macroeconomic trilemma’, in the sense that they cannot simultaneously target the exchange rate, use monetary policy in pursuit of other domestic objectives, and have free capital mobility.

8 A drawback of this approach is that interest differentials tend to be available only for a limited number of countries and years – specifically, for countries that are important enough to have well-developed offshore markets and advanced enough financially to have well-developed forward currency markets. Also, the measurement of interest rate differentials is typically confined to a consideration of short-term assets only.
The presence of capital controls generally drives a wedge between these interest rates, resulting in large deviations from covered interest parity, and in a high volatility of these deviations. Moreover, the sign of the interest differential is able to reflect the type of capital controls, whether outflow or inflow restrictions dominate. On the one hand, governments may restrict resident purchases of foreign assets – such outwards controls, which often are designed to prop up a weak currency, lead to a covered interest differential favoring the foreign market. Alternatively, governments may restrict nonresident purchases of domestic assets in order to reduce pressures toward appreciation of the domestic currency. Such inward controls may lead to an interest differential favoring the domestic market.

The liberalization experiences of advanced countries in the late 1970s and 1980s are well reflected in several empirical studies on covered interest parity. An illustrative example is the case of British controls, as documented by, e.g., Frankel (1989) and Marston (1993, 1995). Despite the fact that London already was an important financial center, the British government maintained a system of controls on resident outflows until as late as June 1979. The presence of controls led to large interest differentials in the period until 1979 – moreover, the asymmetric nature of the controls, which inhibited outward flows but not inward flows was reflected in the fact that these sizable differentials of the British (onshore) interest rate over the Eurosterling (offshore) rate were found to be negative. Once capital outflow controls were fully removed in 1979, covered interest parity was found to hold. Several other studies suggest that the vast majority of countries restricted mainly outward capital flows, captured by negative interest differentials vis-a-vis the Eurocurrency market (see, e.g. Frankel and MacArthur (1988), and Voth (2003)). Only a few countries like Germany, Switzerland, and Japan have resorted to inward controls, where Japan’s controls were affecting both inward and outward flows (see, e.g., Marston (1995)). The Japanese government maintained a system of capital controls throughout most of the 1970s, although the regulations varied in intensity and effect. Until June 1974, for example, tight controls on the outflow of funds led to a Japanese (Gensaki) interest rate falling far below the Euroyen rate. Between June 1977 and January 1979, in contrast, the controls were generally binding in the opposite direction, limiting inflows of funds to Japan, leading to a positive Gensaki-Euroyen differential. Frankel (1989) documents that during the period of May 1979 to November 1983, the differential fell

9In particular, Frankel and MacArthur (1988) report, for the time period of 1982-87, negative interest differentials for all small European countries, and for all of the LDC’s in the sample, except Hong Kong.
sharply in absolute size and turned negative again. He interprets the fact that the differential was actually somewhat negative during this period as evidence that the controls that remained were working to discourage outflow more than inflow. In the period 1985-88, (after the Yen/Dollar agreement of of May 1984), the differential was essentially zero, showing evidence of complete liberalization. This period also marks the beginning of Japan’s role as a world external creditor.

More recently, several studies study interest differentials of emerging economies, capturing the more recent capital control and liberalization experiences of this country group. We focus our attention, in particular, on the group of Asian emerging economies, some of which have become net external creditors more recently. Ma et al. (2004), Ma and McCauley (2008), and Cheung and Qian (2010) study empirical determinants of the Chinese renminbi covered interest differential. They find evidence of onshore interest rates that are substantially lower than offshore rates in the period of 1999-2002, suggesting that outward controls dominate. In the period after 2002, however, onshore interest rates are found much higher than offshore; the authors attribute this finding to a shift in China’s policy away from being more restrictive on capital outflows towards more inward controls.¹⁰ Ma et al. (2004) document such pattern not only for China, but also for India, and, somewhat less pronounced, also for Taiwan and Indonesia, suggesting that also other Asian emerging economies liberalized outflow controls and/or tightened their inflow controls.

We make use of the stylized facts just presented in that they inspire the experiments we perform in our theoretical model: on the one hand we will analyze the effects of a reduction on capital outflows in the RoW, which can be thought of stemming mostly from the group of other industrial countries. On the other hand, we will consider an experiment of increased difficulties in borrowing for the RoW, incorporating the experiences of some emerging economies.

This section has shown that the measurement of the existence and intensity of capital controls is empirically very challenging, and as a result the effect of restrictions to capital mobility on economic variables is sometimes difficult to establish. We believe that even more

¹⁰Liu and Otani (2005) divide the period 1999-2005 into 3 subperiods: 1999-2000 is characterized by Chinese authorities’ intention to discourage capital outflows coinciding with the period when capital flight away from China was great and the forward exchange rate showed a discount. 2001 constitutes a transition period moving gradually to policy of encouraging capital outflows. The third period 2002-2005 clearly shows the authorities’ desire to encourage capital outflows to ward off appreciative pressures on the renminbi.
so we need a theory of how financial flows relate to the presence of capital controls in a framework of the models we use in modern macroeconomics.

3 The Model

3.1 Model Setup

The world economy consists of two countries, Home and Foreign, which are taken to be the US and the rest of the world respectively. We will assume that all idiosyncratic risk is perfectly insured among residents of a country, i.e. within-country financial markets are complete. We can therefore think of a representative consumer in each country that maximizes the expected sum of future discounted utilities from consumption, $c_t$:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t),$$

where $\beta$ is the discount factor. The utility function $u(c_t)$ is assumed to be of the constant relative risk aversion form, $u(c_t) = (1/(1-\sigma)) [c_t^{1-\sigma} - 1]$, where $\sigma$ is the coefficient of relative risk aversion. The foreign representative agent faces an equivalent problem, where foreign variables are denoted with an asterisk. Agents of each country receive an exogenous endowment $y_t$ or $y_t^*$ respectively in every period $t$. Exogenous outputs are assumed to follow a bivariate autoregressive process of order 1:

$$
\begin{pmatrix}
\ln(y_t) - \ln(\bar{y}) \\
\ln(y_t^*) - \ln(\bar{y}^*)
\end{pmatrix} =
\begin{pmatrix}
\rho & \psi \\
\psi & \rho
\end{pmatrix}
\begin{pmatrix}
\ln(y_{t-1}) - \ln(\bar{y}) \\
\ln(y^*_{t-1}) - \ln(\bar{y}^*)
\end{pmatrix} +
\begin{pmatrix}
\varepsilon_t \\
\varepsilon_t^*
\end{pmatrix},
$$

where $\bar{y}$ is mean income, $\rho$ and $\psi$ are coefficients describing the autocorrelation and spillover properties of the process, and $\varepsilon_t$ and $\varepsilon_t^*$ are normally distributed mean-zero shocks with variance $\sigma_\varepsilon$ and correlation $\rho_\varepsilon$.

Asset markets are incomplete in the sense that countries are only allowed to trade in a one-period risk-free bond, $b_t$, which promises one unit of consumption the next period and trades at price $\frac{1}{r_t}$, where $r_t$ is the gross real interest rate. We can then write the home country’s budget constraint, given $b_0$, as:
Even though agents are assumed to be able to trade a risk-free bond in order to smooth their consumption, they cannot do so unrestrictedly. In particular, we assume that the home country’s debt level cannot exceed some fraction $B$ of the level of its steady state output:\footnote{In principle, there is also a ‘natural debt’ limit as in Aiyagari (1994) according to which both countries will not borrow more than the minimum value that the endowment can take at period $t+1$ discounted to period $t$ prices. To compute the natural debt limit in a two country model, where the interest rate is endogenous, is more difficult than in a partial equilibrium model where the interest rate is exogenous. In addition if one of the constraint binds for one of the economies the interest rate generally differs for each agent (for a detailed discussion see Anagnostopoulos (2006)). However, the debt limits we impose here are generally stricter than the natural debt limit.}

\[
\frac{b_{t+1}}{y_t} = b_t + y_t - c_t. \tag{3}
\]

Due to capital outflow controls international asset holdings are also limited by an upper bound.

\[
\frac{b_{t+1}}{y_t} \leq \bar{B} \tag{5}
\]

The foreign country’s budget constraint and the borrowing and lending constraints are equivalent versions of equations (3), (4) and (5), replacing all variables with starred ones. The borrowing limit for the foreign country is therefore given by $\frac{b_{t+1}^*}{y} \geq -B^*$ and the lending limit is given by $\frac{b_{t+1}^*}{y} \leq \bar{B}^*$.

Due to symmetry and the fact that bond holdings must be in zero net supply, only two of the four constraints on borrowing and lending effectively matter. More precisely, the limit that is imposed on up to how much one country can borrow is determined by either its own borrowing constraint or by the other country’s lending constraint – whichever of the two is stricter. Formally, the range over which the international bond can effectively be traded is given by the interval $[B, B^*]$, where $B = \max \left(-\frac{B^* y^*}{y}, -\frac{B y}{y}\right)$ denotes the home country’s effective borrowing constraint. Similarly, $B^* = \min \left(\frac{\bar{B} y}{y}, \frac{\bar{B^*} y^*}{y}\right)$ denotes the foreign country’s effective borrowing constraint.

The equilibrium of this economy is defined as a path of interest rates \( \{r_t\}_{t=0}^{\infty} \) together
with consumption plans \( \{c_t\}_{t=0}^{\infty} \) and \( \{c^*_t\}_{t=0}^{\infty} \) and debt plans \( \{b_t\}_{t=0}^{\infty} \) and \( \{b^*_t\}_{t=0}^{\infty} \) such that:

1. \( c_t \) and \( b_{t+1} \) maximize (1) subject to (3)-(4)-(5), for all \( t \), and \( b_0 \) given,

2. \( c^*_t \) and \( b^*_{t+1} \) maximize the foreign version of (1) s.t. the foreign versions of (3)-(4)-(5), for all \( t \), and \( b^*_0 \) given,

3. the real interest rate clears the bond market, \( b_t + b^*_t = 0 \), for all \( t \),

4. the goods market also clears (due to Walras’ Law), \( c_t + c^*_t = y_t + y^*_t \), for all \( t \).

The equilibrium conditions can then be summarized as:\(^1\)\(^2\)

\[
\begin{align*}
\lambda^B_t \left[ b_{t+1} + B \bar{y} \right] &= 0 \\
\lambda^B_t \left[ y_{t+1} - b_t \right] &= \beta \bar{r} E_t \left[ u_{c,t+1} \right] \tag{6}
\end{align*}
\]

\[
\begin{align*}
\lambda^{B^*}_t \left[ b^*_{t+1} + B^* \bar{y}^* \right] &= 0 \\
\lambda^{B^*}_t \left[ y^*_{t+1} - b^*_t \right] &= \beta \bar{r} E_t \left[ u_{c^*,t+1} \right] \tag{7}
\end{align*}
\]

\[
\begin{align*}
\frac{b_{t+1}}{r_t} &= b_t + y_t - c_t \\
\frac{b^*_{t+1}}{r_t} &= b^*_t + y^*_t - c^*_t \tag{8}
\end{align*}
\]

\[
\begin{align*}
\frac{y_{t+1} - b_t}{r_t} &= \beta \bar{r} E_t \left[ u_{c,t+1} \right] \tag{9}
\end{align*}
\]

\[
\begin{align*}
\lambda^B_t \left[ b_{t+1} + B \bar{y} \right] &= 0 \\
\lambda^{B^*}_t \left[ y_{t+1} - b_t \right] &= \beta \bar{r} E_t \left[ u_{c^*,t+1} \right] \tag{10}
\end{align*}
\]

\[
\begin{align*}
\lambda^B_t \left[ y_{t+1} - b^*_t \right] &= 0 \\
\lambda^{B^*}_t \left[ b^*_{t+1} + B^* \bar{y}^* \right] &= 0 \tag{11}
\end{align*}
\]

\[
\begin{align*}
\lambda^B_t \left[ y^*_{t+1} - b^*_t \right] &= 0 \\
\lambda^{B^*}_t \left[ b^*_{t+1} + B^* \bar{y}^* \right] &= 0 \tag{12}
\end{align*}
\]

\[
\begin{align*}
\lambda^B_t \left[ y^*_{t+1} + b_t \right] &= 0 \\
\lambda^{B^*}_t \left[ b^*_{t+1} + B^* \bar{y}^* \right] &= 0 \tag{13}
\end{align*}
\]

\(^1\)\(^2\)Where we have used the bond market clearing condition to substitute out \( b^*_t \).
Equation (6) is the combination of the first order conditions for $c_t$ and $b_{t+1}$ and states that the marginal benefit from using debt to increase consumption at time $t$ must be greater than or equal to the expected marginal loss at time $t + 1$ arising from the additional debt. Equation (8) is the Home country’s budget constraint, stating that current consumption and outstanding debt have to be financed either from current output or by issuing new debt. Equations (10) and (11) are the complementary slackness condition with $\lambda^B_t$ and $\lambda^F_t$ being the multipliers on the inequality constraints (4) and (5). Finally, equations (7), (9), (10) and (11) are the foreign equivalents to the equations just discussed.

We can distinguish five cases that are summarized by equilibrium conditions (6)-(13):

1. The case where no borrowing or lending constraint is binding for either country. In this case the Lagrange multipliers associated to the borrowing and lending limits are equal to zero, i.e. $\lambda^B_t = \lambda^F_t = 0$ and $\lambda^B_t = \lambda^F_t = 0$, and the Euler equations (6)-(7) reduce to their standard expressions.

2. The borrowing constraint binds for the home country, i.e. $\frac{b_{t+1}}{y} = B^*$. The Lagrange multiplier of the home borrowing constraint, $\lambda^B_t$, which reflects the shadow value of relaxing the constraint marginally, is therefore positive.

3. The lending constraint binds for the home country, that is $\frac{b_{t+1}}{y} = B^*$, and $\lambda^B_t > 0$.

4. The borrowing constraint binds for the foreign country, $\frac{b_{t+1}}{y} = B^*$ and $\lambda^F_t > 0$.

5. The lending constraint binds for the foreign economy, $\frac{b_{t+1}}{y} = -B^*$, and $\lambda^F_t > 0$.

3.2 The Interpretation of Financial Openness and Capital Liberalization in the Model

The framework of the model allows us to think of financial market openness as being reflected in the tightness of the respective borrowing and lending constraints the countries are facing. Therefore, a relaxation of a country’s lending or borrowing constraints can be interpreted as a reduction of capital controls on that country’s capital outflows or inflows. Before we discuss the parameter choices of these constraints in our model, let us first consider two special cases that are nested in our model setup and correspond to the more standard cases analyzed.
previously in the literature, known as the ‘financial autarky’ case and as the incomplete markets ‘bond economy’ case.

First, if $\overline{B} = \overline{B}^* = \underline{B} = \underline{B}^* = 0$ then the world is in financial autarky. In this case there is no international consumption risk sharing – the bond cannot be used at all to insure against idiosyncratic, country-specific risk.

Second, in the case when $\overline{B}$, $\overline{B}^*$, $\underline{B}$, and $\underline{B}^*$ are sufficiently high, such that the constraints would hardly ever bind, the bond can be very freely traded across countries. This case coincides with the standard case of what is known as the incomplete markets ‘bond economy’ case. It is well known that under this case, even though markets are incomplete, the outcome is very close to the perfect risk sharing case under complete markets, where consumption in both economies perfectly co-moves (see, e.g., Baxter and Crucini (1995)).

We interpret intermediate cases between financial autarky and no limits in borrowing and lending as reflecting intermediate stages of capital account openness, with the state of liberalization being more advanced as $\overline{B}$ and $\overline{B}^*$, and $\underline{B}$ and $\underline{B}^*$ increase. The presence of limits in bond holdings in these intermediate cases makes it hard for the countries’ economic agents to perfectly insure against country specific shocks. Since agents dislike the possibility of being left without any consumption at any point in time, they have an incentive to build up a buffer stock of savings to facilitate consumption smoothing, that is, they have precautionary savings motives. This will be the crucial mechanism with which the model is able to generate external imbalances. As long as borrowing constraints are not ‘too’ relaxed, such that consumption smoothing is not too close to perfect risk sharing, precautionary savings motives have a significant impact on the equilibrium bond holding policy functions.

We use our model to study a ‘before’ and an ‘after’ capital liberalization scenario. The initial borrowing constraints, denoted $\overline{B}^{BL}$ and $\overline{B}^{*BL}$ (BL stands for ‘before liberalization’) for the home and foreign country, and capital outflow limits, $\overline{B}^{BL}$ and $\overline{B}^{*BL}$, are initially set to some constant fraction of bond holding to the countries’ steady state output, i.e. $\overline{B} = \frac{b}{y}$ and $\overline{B}^* = \frac{b^*}{y'}$ and similarly for the capital outflow limit, $\overline{B} = \frac{b}{y}$ and $\overline{B}^* = \frac{b^*}{y'}$. From the evidence given in section 2 it is safe to assume that the US’ constraints have always been looser than the RoW’s constraints. Effectively, this means that the RoW’s constraints determine how easily both countries can access international financial markets and make use of the bond for their consumption smoothing purposes.
We can use the model to perform two experiments of the effects of capital liberalization. In the first experiment, the catching up of the rest of the world’s financial openness in the RoW is modeled as a one-time permanent relaxation of the upper limit of capital outflows of the foreign economy. As indicated, this reflects the dismantling of restrictions on controls on capital outflows especially in industrial countries, but to some degree also in emerging economies. We model the RoW’s reduction of controls on capital outflows as a relaxation of the lending constraint to a new level $B_{AL}^*$ ($AL$ stands for ‘after liberalization’), with $B_{AL}^* > B_{BL}^*$. The left column of figure 3 provides a graphical representation of this model experiment. The upper left panel describes the initial level of openness to international financial markets, before liberalization. It can be seen that the US constraints (‘Home constraints’) are looser than the RoW’s constraints (‘Foreign constraints’), and as a result the permissible region over which the internationally traded bond can be used is pinned down by the latter, and is given by what we call ‘effective constraints’. Liberalization relaxes the RoW’s constraint on capital outflows and, as a result, also implies an outward shift of the effective constraint, $B = \max \left(-B y, -B_{AL}^* y^*\right)$. After liberalization, the permissible region over which the bond can be held has become larger, international financial markets have become more accessible. As a result both countries are now better able to use the internationally traded bond for their consumption smoothing purposes and are able to achieve, for any given output volatility, a lower consumption volatility. This reduces the incentives for precautionary savings in both countries. However, because the reduction in the RoW’s controls on capital outflows has led to a relaxation of the effective US borrowing constraint, and countries care more about smoothing out the downside risk of consumption uncertainty, the US’ precautionary savings motives will fall by more than the precautionary savings motives in the RoW.

In a second experiment, we capture the limitations that some emerging market countries faced in their ability to borrow internationally in response to financial turbulence and crisis experiences by modeling it as a tightening in the RoW’s borrowing constraint. The nature of what produces the shift in our second experiment is somewhat different than before. While, in the previous experiment, the relaxation of the RoW’s outflow constraint stems from the removal of actual regulatory restrictions on capital movements, the model experiment of the tightening of the RoW’s borrowing constraint is understood not so much as the result of actual policies of imposing new restrictions on capital inflows, but rather as an endogenous market
Figure 3: Changes in capital controls and permissible region of bond holding

relaxation of RoW’s constraint on capital outflows

BEFORE LIBERALIZATION

Effective Constraints
\[ B = \max \left( -B_y, -B^*_y \right) \]
Foreign Constraints
\[ k_{t+1} \leq -B_y \rightarrow k_{t+1} \geq -B^*_y \]

AFTER LIBERALIZATION

Effective Constraints
\[ B = \max \left( -B_y, -B^*_y \right) \]
Foreign Constraints
\[ k_{t+1} \leq -B_y \rightarrow k_{t+1} \geq -B^*_y \]

tightening of RoW’s constraint on capital inflows

BEFORE LIBERALIZATION

Effective Constraints
\[ B^* = \min \left( B_y, B^*_y \right) \]
Foreign Constraints
\[ k_{t+1} \geq -B^*_y \rightarrow k_{t+1} \leq -B^*_y \]

AFTER LIBERALIZATION

Effective Constraints
\[ B^* = \min \left( B_y, B^*_y \right) \]
Foreign Constraints
\[ k_{t+1} \geq -B^*_y \rightarrow k_{t+1} \leq -B^*_y \]
reaction that is not explicitly modeled here. Modeling the causes of this differential access to international capital markets of emerging economies would be an interesting extension, which is, however, beyond the scope of this paper. Instead, we focus our analysis on the consequences for countries’ external positions. Our experiment is summarized graphically in the right column of figure 3. Such a shift decreases the permissible region over which the bond can be held in response to shocks to income. While this implies that the precautionary savings motives of both countries are going to increase, it is important to emphasize that the precautionary savings motives of the US increase by less than those of the RoW, such that the precautionary savings motive of the US relative to the RoW actually goes down.

In our experiments we make two simplifying assumptions. One, rather than modeling the process of liberalization as something that took place gradually over time, we make the simplifying assumption that it occurs at once. And two, the modeling of financial markets, that is, the assumption that there only exists one internationally traded bond, is clearly overly simplistic. In particular, it only allows us to analyze the effects of financial globalization on countries net external positions, but cannot address questions of portfolio choice or give any rationale to why gross asset and liability positions have risen drastically. Despite the simple setup of the model, we believe that the experiments of our model framework can provide useful insights into the effects of capital control on the international macroeconomy.

### 3.3 Parameterization and Model Solution

Table 1 presents our baseline parameter values for the experiments of our model economy, chosen such as to match US quarterly data. For simplicity, and to isolate the effects of differences in financial openness, we consider a symmetric specification for all parameters other than the capital control parameters. This way, the predictions of our model can be understood as stemming entirely from changes in countries degree of financial openness.

Most parameter choices are relatively standard in the literature, which we briefly outline first. We then discuss the choice of the borrowing and lending constraints, for which there is no previous (nor obvious) choice. The discount factor $\beta$ is set to 0.9895, such as to match an annualized interest rate of about 4% in the non-stochastic steady state. The coefficient of risk aversion $\sigma$ is set to 2, a common choice in macroeconomics. To obtain the parameters of the exogenous process, we estimate a simple AR(1) on detrended US real GDP data, covering
Table 1: Baseline Parameter Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient of relative risk aversion</td>
<td>$\sigma$ 2</td>
</tr>
<tr>
<td>Discount factor</td>
<td>$\beta$ 0.9895</td>
</tr>
<tr>
<td>Steady state level of output</td>
<td>$\bar{y}, \bar{y}^*$ 1</td>
</tr>
<tr>
<td>Persistence of exogenous process</td>
<td>$\rho$ 0.99</td>
</tr>
<tr>
<td>Spillover of exogenous process</td>
<td>$\psi$ 0</td>
</tr>
<tr>
<td>Standard deviation of exogenous shock</td>
<td>$\sigma_\varepsilon$ 0.01</td>
</tr>
</tbody>
</table>

the period from 1947:Q1 to 2009:Q1. The estimates result, approximately, in a coefficient of autocorrelation $\rho$ of 0.99 and a standard deviation of $\sigma_\varepsilon = 0.01$. We abstract from spillovers or cross-country correlation of the shocks, which, however, do not turn out to be crucial for our results.

The parameter choice for the level of the constraints on capital in- and outflows is more challenging. Unfortunately, there is no empirical counterpart that tells us what exactly the choice of these constraints should be. We do not know how to relate regulatory measures such as the de jure indices presented in section 2 to the quantitative measures we have in our model, where constraints are expressed as a fraction of NFA to a country’s output. On the other hand, neither can we use actual observed capital flows as a guideline in setting the parameter of our constraints, as we would like to explain actual flows as resulting from changes in the constraints. We approach these difficulties by starting with some initial parameters for the constraints, but then performing extensive sensitivity analysis on a) the level of initial constraints and b) the size of the relaxation of the constraints.

We set the initial (‘before liberalization’) constraints for the home economy to 100 percent of its steady state output ($B^{BL} = B^{BSL} = 1$), reflecting the fact that the US economy was very little constrained already in the 1980s. The initial constraints for the RoW are set such that the RoW is initially much less financially open than the US. We set the constraint on both inflows and outflows to 50 percent of output initially ($B^{\ast BL} = B^{\ast SBL} = 0.5$).\(^ {13}\)

Finally, we want to comment briefly on the model solution. To address the questions we are interested in, local approximation techniques like log-linearization around the non-stochastic

\(^{13}\)As argued in section 2, the initial constraint on capital outflows is likely to have been stricter, as many economies did not restrict capital from flowing into the economy as much as they prevented it from flowing out of their economies. We could have incorporated this by parameterizing the initial constraints as $B^{\ast BL} > B^{\ast SBL}$. To clearly lay out the mechanism of how the presence of international liquidity constraints affect the model variables, we instead focus on a setup of initially equal controls on capital inflows and outflows.
steady state cannot be used. Instead, we need to use a global solution technique that can explicitly account for the influence of second moments and occasionally binding inequality constraints on agent’s policy functions. Further details about the solution technique are provided in the appendix.

4 Results of the Baseline Model

This section outlines our main results. Before discussing the capital liberalization experiments we comment on the general effect of borrowing constraints in a stochastic environment. As discussed previously, the presence of borrowing constraints give the agents of both countries an incentive to engage in precautionary saving, to store away some extra assets in the ‘good’ states of nature for the ‘bad’ states in which the constraint may bind and in which they may not be able to borrow as much as they would desire in world markets. In our endowment economy the only asset available to be used as a buffer is the bond. Therefore, at most one of the two countries can have a positive position at any point in time. Because initial constraints are such that both countries can borrow and lend up to the same amount (and the parameterization is symmetric otherwise), it turns out that, on average, none of the two countries has positive holdings of the international bond initially. As first observed by Aiyagari (1994), as a result of these motives to hold precautionary buffer assets, when the (gross) real interest rate would be at their certainty equivalent level, $\frac{1}{\beta}$, there would be an excess demand for savings. Under uncertainty, therefore, the asset price needs to be higher relative to its non-stochastic level to clear the bond market, or, equivalently, the real interest rate needs to be lower than in a non-stochastic world.

We now turn to our experiments of how the process of capital liberalization affects the economic variables of our model, and in particular, how it affects the US net foreign asset position. The first experiment of the catching up of the RoW in terms of its financial openness, that is, the dismantling of controls on its capital outflows is modeled as a one-time permanent relaxation of $\overline{B}^{BL}$ from 0.5 to $\overline{B}^{AL} = 1$. Because the US are initially more financially open (such that $\overline{B}^{*BL} < B^{BL}$), the relaxation of the RoW’s constraint on capital outflows translates also into a relaxation of the US’ effective borrowing constraint from 50% of its current output level to 100% of its output. This means that before capital liberalization the effective borrowing constraints are $B^{*BL} = 0.5$, but are equal to $B^{*AL} = 0.5$ and
B^{AL} = 1.0 after liberalization. We choose the mid 1980 as the date for the experiment which
coincides with the start of the decline in the US net foreign asset position and the start of a
major liberalization period.

The left column of figure 4 shows the expected paths of main macroeconomic variables in
the face of the US' increased ability to borrow in international markets in comparison to RoW.
In principle the responses shown in the figure need to be derived from averages over a large
number of simulations, such that the stochastic behavior of the economy can be 'aggregated
away' and only the deterministic change in the policy functions – that reflects the change in
the importance of precautionary savings – is left over. To save computational time and to
isolate the expected paths of the model's variables we instead feed $\sigma_\varepsilon = 0$ in the 'simulation'
(the policy functions themselves have, of course, been obtained from a stochastic setting with
$\sigma_\varepsilon$ as indicated in section 3.3).

With the relaxation of the US' effective borrowing constraint the probability that the
constraint binds at any moment in time decreases. Both regions are now able to better
smooth consumption in response to shocks and to achieve a lower consumption volatility, and
as a result, the motives to hold precautionary assets in both countries decreases. The drop in
the US consumption demand for precautionary assets is larger, however, since home agents
can now better insure against times when their consumption is rather low. Accordingly,
the US motive to hold precautionary assets decreases by more than the RoW’s motive for
buffer assets. As a result we observe (in the first two panels on the left column of figure 4) a
US current account deficit and a gradual decline in the US net foreign asset position as the
economy transitions to a new steady state. At the end of 2007, our experiment implies US net
foreign liabilities as a ratio of output of 3.1%, which means that our proposed channel could
explain roughly one fifth of the empirically observed US external position. The decrease in
the importance of US’ precautionary savings also lowers its demand for the asset and, as a
consequence, pushes up the interest rate (panel 4 of figure 4) which gives the RoW a motive
to forgo consumption today. As interest rates increase the RoW finds it optimal to save and
enjoy higher consumption only in the future. The consumption responses in panel 3 of figure
4 show that home consumers implicitly become relatively more impatient. The drop in the

\[ \text{That is, with concave utility, marginal utility of consumption is higher for low levels of consumption. Therefore agents benefit more from being able to smooth consumption through borrowing when their consumption is low than from lending when their consumption is high.} \]
Figure 4: Response to a) a relaxation in the RoW’s constraint on capital outflows, and b) to a tightening in the RoW’s borrowing constraint.
precautionary savings motive leads them to consume more relative early on at the expense of consumption in future periods, such that the long run value of US consumption at the new steady state is at a lower level permanently.

The right column of figure 4 shows the evolution of the model’s variables in response to the second experiment we perform, a tightening of the RoW’s constraint on capital inflows. As outlined before, this can be thought of as modeling the fact that many emerging countries in practice continue to have limitations in the ability of obtaining external finance, and, after the recurrent crises that some of the emerging markets have faced during the end of the 1990s, have suffered limitations in their ability to borrow internationally. We assume that the RoW’s borrowing constraint shifts from an initial value of $B^{BL} = 0$ to $B^{AL} = 0.25$. We observe that the responses of the current account, the net foreign asset position and consumption resemble, at least qualitatively, the case of the first experiment. This again is due to a shift in the relative importance of precautionary assets across countries: in particular, it results in a higher precautionary savings motive in the RoW relative to the US. The crucial difference is, however, that the tightening in the RoW’s effective borrowing constraint has led to a lower ability to use the bond for consumption smoothing, which increases demand for precautionary assets. As precautionary asset demand increase relatively more in the RoW, we observe net flows from the RoW to the US. The higher worldwide asset demand also decreases the interest rate.

It is important to note that figure 4 does not plot the responses to a particular shock, nor did we assume that the mean or variance of the endowment processes has changed at any point in time. The response in figure 4 is entirely due to the decrease in the importance of the precautionary savings motive for the US economy as coming from the shift in international liquidity constraints, and plots the expected path as the economy transitions to the new implied steady state.

4.1 Sensitivity Analysis with respect to Capital Control Parameters

Figure 5 presents some sensitivity analysis. Given the difficulty to parameterize the borrowing limits, we consider it especially important to perform sensitivity analysis on different values of the effective borrowing constraints. For displaying the results of our sensitivity analysis we focus throughout on effective constraints, $B$ and $B^*$. The quantitative response of net foreign
assets to a relaxation depends on two things: one, on the degree to which the constraints where initially restricting asset trade, and two, on the amount by which the effective constraints are relaxed. The panels in the first and second columns therefore show variations in the assumptions on these constraints, either before or after capital liberalization.

We plot the first set of sensitivity experiments with respect to the borrowing constraints in the left column of figure 5, showing the effect of varying the degree of 'initial financial market openness'. We keep the size of the relaxation of the home effective borrowing constraint constant at 0.5 (that is, \( B^{AL} - B^{BL} = 0.5 \)), and show the responses of the economic variables for three different initial parameterizations. The first set of responses repeat the baseline case, the second assumes that initially international financial markets were very closed (the constraints change from \( B^{BL} = B^{*BL} = 0.01 \) to \( B^{*AL} = 0.01 \) and \( B^{AL} = 0.5 \)), and the third starts out in a situation where international financial markets were relatively open to begin with (from \( B^{BL} = B^{*BL} = 1.0 \) to \( B^{*AL} = 1.0 \) and \( B^{AL} = 1.5 \)). Since precautionary motives are highest when financial markets can hardly be accessed as a means to engage in consumption smoothing, the drop in the net foreign asset position is strongest in the case where international financial markets are initially very closed. In this case the implied NFA response at the end of 2007 is -5.0% in comparison to -3.1% in the baseline case, while it is only -2.0% in the case of initially rather open international financial markets.

The right column of figure 5 shows different cases for 'the extent of liberalization', that is, for different assumptions on by how much the effective borrowing constraint is relaxed. We show the baseline case, and the changes in the constraints from \( B^{BL} = B^{*BL} = 0.5 \) to \( B^{*AL} = 0.5 \) and \( B^{AL} = 1.5 \), and from \( B^{BL} = B^{*BL} = 0.5 \) to \( B^{*AL} = 0.5 \) and \( B^{AL} = 2 \). Not surprisingly, the decline in the net foreign asset position is more pronounced the higher the extent of the relaxation, in which US net foreign assets in year 2007 stand at -5.1% (in case 2) or -6.5% (in case 3) respectively.

4.2 Further Sensitivity Analysis

We also conduct sensitivity analysis of our results with respect to a number of other parameters or modeling assumptions. For sake of space, we report only the implied 2007 NFA position of the US which we focus on as the most important quantitative measure of sensitivity for the results. Table 2 summarizes our findings.
Figure 5: Sensitivity analysis for responses to a relaxation in the US effective borrowing constraint

level of initial financial market openness *

extent of liberalization **

---

* different initial tightness of debt limits
** different extents of relaxation
<table>
<thead>
<tr>
<th></th>
<th>$\sigma = 1$</th>
<th>$\sigma = 2$ (baseline)</th>
<th>$\sigma = 5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma = 1$</td>
<td>-3.1</td>
<td>-3.1</td>
<td>-2.9</td>
</tr>
<tr>
<td>$\rho = 0.95$</td>
<td>-3.0</td>
<td>-3.1</td>
<td>-3.0</td>
</tr>
<tr>
<td>$\sigma_e = 0.0075$</td>
<td>-2.5</td>
<td>-3.1</td>
<td>-4.3</td>
</tr>
<tr>
<td>quadratic utility</td>
<td></td>
<td>CRRA utility (baseline)</td>
<td></td>
</tr>
<tr>
<td>Great Moderation</td>
<td>-0.8</td>
<td>-3.1</td>
<td></td>
</tr>
<tr>
<td>Capital Liberalization (baseline)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The parameter choices of the coefficient of relative risk aversion and the persistence of the exogenous process were found not to be crucial for the quantitative results of our experiment, affecting the outcome only little. The size of the disturbance of the exogenous shock, on the other hand, seem more important for the quantitative model predictions. Changing the standard deviation of the shock of the output processes to $\sigma_e = 0.02$, produces an imbalance in 2007 of $-4.3\%$. On the other hand, with $\sigma_e = 0.0075$, the implied imbalance would be considerably smaller at only $-2.5\%$.

Carroll and Kimball (2006) distinguish between incentives for buffer asset holdings that derive from uncertainty and those that derive from liquidity constraints – both of which have similar effects because they lead to a concave consumption function. Since our paper concentrates on the effects of buffer asset holdings that derive from (changes in) liquidity constraints, we consider the use of quadratic instead of CRRA utility, which isolates the role of precautionary savings motives from the presence of international liquidity constraints by eliminating any inherent precautionary savings motive coming from the preference-implied curvature of marginal utility. This way, by finding that our results are insensitive to this functional form of preferences, we are able to verify that the channel featuring most prominently in our model is indeed the effect of international liquidity constraints as a source for precautionary asset holdings.

Finally, in order to compare the results obtained with our approach with the recent contribution of Fogli and Perri (2006) we also run the experiment of the ‘great moderation’ in US business cycle volatility. In their experiment they consider a decrease in the volatility of
US aggregate productivity of one third. The final row of Table 2 reports the results of the 'great moderation' experiment. We find that both capital liberalization in the RoW and the great moderation of business cycle volatility can contribute to explaining the US net foreign asset position. At the end of 2007, the process of capital liberalization has led to a net foreign asset position of -3.1% of output, while the great moderation can contribute to explaining another -0.8%.

5 A Model with Production and Capital Accumulation

It can be argued that in a setup in which agents’ only option to save and to smooth consumption intertemporally is through the use of the international bond, the effects of changes in the strength of precautionary savings motives across countries have an unrealistically strong impact on the external position. We therefore now turn to a model setup, building on Backus et al. (1992), in which the representative agents in both countries are also owners of the economy’s capital stock which is used in production. This gives the agents another asset that can be used to smooth intertemporal consumption and to hold savings for precautionary reasons. Now, the home representative agent maximizes $E_0 \sum_{t=0}^{\infty} \beta^t u [c_t, (1 - n_t)]$ with respect to borrowing constraint (4) and lending limit (5). As in the endowment economy, international asset markets can therefore be used only incompletely for consumption smoothing purposes. The budget constraint under this set-up and the law of motion for capital are:

$$c_t + x_t + \frac{b_{t+1}}{r_t} = \omega_t n_t + r_t^k k_t + b_t$$

(14)

$$k_{t+1} = (1 - \delta)k_t + x_t - \frac{\phi}{2} \left[ \frac{k_{t+1} - k_t}{k_t} \right]^2$$

(15)

where $k_t$ is capital, $n_t$ is labor, and $w_t$ and $r_t^k$ refer to the wage rate and the return of capital respectively. To avoid a counterfactual volatile investment, $x_t$, there are adjustment costs to install new capital. The instantaneous utility function is given by $u [c_t, (1 - n_t)] = \left[ c_t (1 - n_t)^{\theta} \right]^{1-\sigma} / (1 - \sigma)$.

Firms produce output according to a Cobb-Douglas production function and face a country specific productivity, $y_t = z_t f (k_t, n_t) = z_t k_t^\alpha n_t^{1-\alpha}$. They are assumed to be competitive such that profit maximization leads to factors being paid their marginal products.
Technologies are modeled as exogenous processes which follow a bivariate autoregressive process of order 1:

\[
\begin{pmatrix}
\ln(z_t) - \ln(\bar{z}) \\
\ln(z^*_t) - \ln(\bar{z}^*)
\end{pmatrix} = 
\begin{pmatrix}
\rho & \psi \\
\psi & \rho
\end{pmatrix}
\begin{pmatrix}
\ln(z_{t-1}) - \ln(\bar{z}) \\
\ln(z^*_{t-1}) - \ln(\bar{z}^*)
\end{pmatrix} + 
\begin{pmatrix}
\varepsilon_t \\
\varepsilon^*_t
\end{pmatrix}
\]

(16)

where \(z_t\) is a parameter reflecting the mean productivity, \(\rho\) and \(\psi\) are coefficients describing the autocorrelation and spillover properties of the process, and \(\varepsilon_t\) and \(\varepsilon^*_t\) are normally distributed mean-zero shocks with variance \(\sigma_\varepsilon\) and correlation \(\rho_\varepsilon\).

The equilibrium of this economy is defined as a path of interest rates \(\{r_t\}_{t=0}^\infty\) and input prices \(\{w_t\}_{t=0}^\infty\) together with consumption plans \(\{c_t\}_{t=0}^\infty\) and \(\{c^*_t\}_{t=0}^\infty\), plans for hours worked \(\{n_t\}_{t=0}^\infty\) and \(\{n^*_t\}_{t=0}^\infty\), investment plans \(\{x_t\}_{t=0}^\infty\) and \(\{x^*_t\}_{t=0}^\infty\), capital accumulation plans \(\{k_t\}_{t=0}^\infty\) and \(\{k^*_t\}_{t=0}^\infty\), and debt plans \(\{b_t\}_{t=0}^\infty\) and \(\{b^*_t\}_{t=0}^\infty\) such that households and firms solve their optimization problems, and goods, assets and factor markets clear.

The equilibrium conditions of the full model are given by the set of equilibrium conditions of the endowment model, equations (6)-(13) – where the budget constraints are replaced by their versions of equation (14) – plus the capital laws of motion, the additional Euler equations with respect to the choice of the optimal capital stock, and the labor market equilibrium condition, given by equations (15), (17) and (18) and their foreign equivalents:

\[
\frac{c_t^{-\sigma} (1 - n_t)^{\theta(1-\sigma)}}{1 + \phi \frac{k_{t+1}}{k_t} (\frac{k_{t+1}}{k_t} - 1)} = \beta E_t \left\{ \begin{array}{c} 
\frac{c_{t+1}^{-\sigma} (1 - n_{t+1})^{\theta(1-\sigma)}}{(1 - \delta) + \alpha z_{t+1} \left( \frac{k_{t+1}}{n} \right)^{\alpha-1} \\
+ \frac{\phi}{k_{t+1}} \left( \frac{k_{t+2}}{k_{t+1}} - 1 \right) \left( \frac{k_{t+2}}{k_{t+1}} \right)^{\alpha-1} \end{array} \right\}
\]

(17)

\[
\theta \frac{c_t}{1 - n_t} = (1 - \alpha) z_t k_t^\alpha n_t^{-\alpha}.
\]

(18)

5.1 Parameters Values

In the model with capital we have a number of additional parameters. Following Backus et al. (1992), the capital share \(\alpha\) is set equal to 0.36, and the quarterly depreciation rate, \(\delta\), is set to 2.5%. In order to avoid counterfactual volatile investment, we include quadratic capital adjustment costs and chose its parameter such that model’s investment series is about 3 times as volatile as output, which corresponds to \(\phi = 30\). Parameter \(\theta\) is chosen such as...
to insure that households devote about one third of their time to market activities. In our choice of parameters for the exogenous technology process we follow Fogli and Perri (2006), who estimate an AR(1) process on US quarterly data. The process is symmetrically specified, featuring an autocorrelation coefficient of $\rho = 0.98$, no technological spillovers, and a mean zero disturbance with standard deviation, $\sigma = 0.0075$ and shock correlation $\rho = 0.4$.

5.2 Responses to Capital Liberalization in the Full Model with Capital

Figure 6 presents the same kind of equilibrium responses as for our baseline experiment in the simple model when the RoW is initially facing a high level of capital controls. We continue to perform our experiment of relaxing the RoW’s constraint on capital outflows from $B^{BL} = 0.5$ to $B^{AL} = 1$. After capital liberalization takes place in the RoW, the foreign lending constraint softens which also relaxes the US’ effective borrowing constraint. As in the endowment model, we can observe that the US net foreign asset position before the onset of capital liberalization in the rest of the world is initially zero, and then starts its subsequent decline to reach a NFA position of -3.2% in 2007. Decomposing the current account into its two components, saving minus investment, we see that the current account moves into deficit despite of a large decrease in investment because of an even larger drop in savings. As before, US consumers have become relatively more impatient and prefer consuming more early on at the expense of decreases in consumption in the future. Similarly, they also prefer more leisure early on, therefore initially decreasing hours worked at the cost of having to work more later on. The decrease in the US precautionary savings motive and decrease in hours worked lead to a temporary decrease in the marginal product of capital, that is, in the rate of return to capital. This, on impact, leads to a drop in investment and a decline in the US capital stock. The long-run response of the capital stock is, however, dominated by the latter effect; as in the long-run the higher amount of hours worked in the US drives up the rate of return on capital, we actually observe a slight long-run increase in the capital stock, despite the lower relative precautionary motives.

As figure 6 shows, the drop in the US net foreign asset position remains substantial in the capital model, despite the fact that we could expect part of the decrease of buffer stock holdings that result from lower precautionary motives of the US to fall on the economy’s capital stock level. Moreover, it is interesting to note, that while the change in domestic variables
Figure 6: Response to an relaxation of controls on capital outflows in the RoW
(investment, capital stock, consumption, hours worked) are relatively small quantitatively, the effects on the external position are quite substantial – a model prediction that is in line with the experience of the US economy.

6 Conclusions

Since the mid 1980’s we have observed a persistent decline in the US net foreign asset position who has become the world’s main net borrower. Not only is the size and persistence of the US NFA position puzzling, it is contrary to the conventional wisdom of neoclassical theory, which predicts that capital would flow from rich to poor countries. Among the most notable changes in the world between the mid 1980s and today is the rapid process of dismantling of controls on international capital flows. In this paper we have explored the role of the process of capital liberalization in driving the US net foreign asset position into deficit. For doing so, we used a stylized model of consumption and savings choice across countries, enriched with borrowing and lending constraints that proxy for the presence of controls on capital in- and outflows. In an extension we also considered a model with capital accumulation, which is essentially the two-country one model good of Backus et al. (1992), a workhorse model in international macroeconomics.

In all cases, we have shown that part of the current US net external imbalance can be a natural outcome of the financial liberalization experiences of other advanced and emerging economies in terms of their financial openness over the last 25 years.
A Appendix: Solution Technique

To address the questions we are interested in, local approximation techniques like log-linearization around the non-stochastic steady state cannot be used. Instead, we need to use a global solution technique that can explicitly account for the influence of second moments and the presence of inequality constraints on agent’s policy functions. The endowment model of section 3 as well as the model with capital accumulation of section 5 are solved by an iterative algorithm to find the conditional expectations of the model’s equilibrium conditions. Below we briefly outline the steps of the algorithm used:

- We follow the methodology of Tauchen and Hussey (1991) to discretize the exogenous processes. We construct a grid over the model’s state variables at time \( t \). In the following, we denote \( t+1 \) variables with a prime, e.g. \( b = b_t, b' = b_{t+1} \), and accordingly, \( b'' = b_{t+2} \). For the endowment economy we therefore have, for each combination of \( y \) and \( y^* \), a one-dimensional grid in \( b \) which consists of \( n_b \) grid points and ranges from \( \min( -B_y, B^*_y y^*) \) to \( \max( -B_y, B^*_y y^* ) \). For the capital economy we construct, for each combination of \( z \) and \( z^* \), a 3-dimensional grid in \( k, k^*, b \) consisting of \( n_k n_k^* n_b \) grid points. The range for \( k \) and \( k^* \) is set from .6 to 1.4 times the non-stochastic steady state level of the capital stock. The number of gridpoints was chosen to be \( n_b = 15 \) and \( n_y = n_{y^*} = 15 \). For the full model with capital, we used \( n_b = n_k = n_{k^*} = 11 \) and \( n_z = n_{z^*} = 9 \).

- Set counter equal to 1. We make initial guesses on the model’s conditional expectations by using the log-linear solution as starting point. In the endowment economy guesses are made for the conditional expectations of the bond Euler equations, \( CE_{BEE}(b; y, y^*) \equiv E\{u_{c'}\} \) and \( CE^*_{BEE,t}(b; y, y^*) \equiv E\{u_{c^*}\} \), at each grid point \( (b; y, y^*) \). In the capital economy initial guesses are similarly made for \( CE_{BEE}(k, k^*, b; z, z^*) \), \( CE^*_{BEE}(k, k^*, b; z, z^*) \), as well as for the conditional expectations of the two capital Euler equations, \( CE_{CEE}(k, k^*, b; z, z^*) \equiv E_t\{u_{c'} [(1 - \delta) + z' f_{k'} + \Phi_{k'}] \} \) and \( CE^*_{CEE}(k, k^*, b; z, z^*) \equiv E_t\{u_{c^*'} [(1 - \delta) + z'^* f_{k'^*} + \Phi_{k'^*}] \} \), at each grid point for \( (k, k^*, b; z, z^*) \).

- Using the guesses for the conditional expectations, the endogenous variables \( b', c, c^*, r, \lambda^B, \lambda^B^*, \lambda^F \), and \( \lambda^F \) (plus \( k', k'^*, n' \) and \( n'^* \) in the capital economy) can be computed at each gridpoint, by using the set of equilibrium conditions outlined in section 3.1 (or for the capital economy, by using the set of equilibrium conditions outlined in section 3.2).
economy, in section 5 respectively). Having in hand the guesses of the conditional ex-
pectations as functions of \((b; y, y^*)\) (respectively, \((k, k^*, b; z, z^*)\)), we use interpolation
methods to find \(CE_{BEE}', CE_{BEE}''\) (and \(CE_{CEE}', CE_{CEE}''\)), which in turn can be used
to obtain \(b''', c', c'^*, r', \lambda_B', \lambda_{B'}, \lambda_{B''}, \lambda_{B'''}\) (plus \(k'', k^*'', n''\) and \(n^*''\) in the capital
economy).

- With the found values of \(c', c'^*\) \((n', n^*, k'', k^*''\)), together with the discretized states
  and transition matrix for the exogenous processes, we can compute expected future
  marginal utility and expected future rates of return on capital which we can use to
  obtain updated guesses of the conditional expectations in the Euler Equations.

- The above steps are repeated until convergence is achieved.
References


