Capital liberalization and the U.S. external imbalance

Elvira Prades and Katrin Rabitsch [*]

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Abstract

Differences in financial systems are often named as prime candidates for being responsible for the current state of world global imbalances. This paper argues that the process of capital liberalization and, in particular, the catching up relative to the US of other advanced and emerging market economies in terms of financial account openness can explain a substantial fraction of the current US external deficit. We assess this link in a simple two country one good model with an internationally traded bond. Capital controls are reflected in the presence of borrowing and lending constraints on that bond. A reduction in the foreign country's (RoW) constraint on capital outflows enables the domestic economy (US) to better insure against consumption risk and therefore decreases its motives for precautionary asset holdings relative to the rest of the world. As a result, the US runs a long run external deficit.

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Precautionary Savings, Net Foreign Asset Position
JEL-Codes: F32, F34, F41

1 Introduction

Among the most debated topics in international macroeconomics in recent years is the US current account deficit over the past years and the ongoing accumulation of US' net foreign debt since the mid eighties. At the end of 2006 the US net foreign asset position is standing at about minus 25% of its GDP, the current account deficit in 2006 stands at above 6% of GDP after being in the red for most of the last 25 years. The size and persistence of the US net external positions are challenging to the conventional wisdom of the standard theory of the current account and has led to a large debate -among academics and policy makers alike. Contents of this debate are 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 the current imbalances might create major financial turbulence, or at least 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, Giavazzi and Sa (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. Recently, attention has been put on cross-country differences in financial factors as a potential driving force behind the imbalances (Mendoza, Quadrini and Rios-Rull (2006), Caballero, Farhi and Gourinchas (2006)). We propose a mechanism that is related to this view, yet different. While we also stress the importance of financial factors, we focus less on the financial development within a country, but instead more on the role of differences in financial openness across countries. Arguably, the US is the economy that has had the most liberalized financial account already in the 1980s. We suggest that the catching up of other advanced and emerging market economies in terms of financial account openness may be partly responsible for the current global imbalances.

Figure 1 presents an index of financial openness developed by Chinn and Ito (2005) that is based on measures such as a country's controls on capital and current account transactions, the presence of multiple exchange rates within that country or requirements for the surrender of export proceeds. As it can be seen from this index, 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. We can observe that the index for Asian countries starts picking up in the late 1970s or early 1980s, for the group of Latin American emerging markets it increases in the early 1990s. The index for European countries shows a first increase in the early 1980s but picks up substantially also only in the early 1990s. Figure 2 plots the development of the US current account and its net foreign asset position. As can be seen the gradual decline in the US net external position begins somewhere in the mid 1980s, and was actually positive before.

A basic function of world capital markets is to allow countries with imperfectly correlated income risks to trade them. If world financial markets were complete countries would be able to largely reduce the cross-sectional variability in their per capital consumption levels. The empirical stylized facts just presented, indicate that, a quarter century ago, for most regions of the world other than the US the degree of financial openness was rather limited. At that time, because of controls on inflows and especially on outflows of capital in most emerging market countries as well as in many industrial countries world capital markets were far from complete. With international capital markets being only a limited means for involving in consumption smoothing in response to country specific shocks, a country's agents have an incentive to have some buffer asset holdings to insure against bad times in which consumption would be very low otherwise - there is a precautionary savings motive. We argue that while the US has had a very liberalized financial account already in the mid 1980s, long before the rest of the world (RoW), it nevertheless could not access world financial markets unrestrictedly, because the RoW had high controls on capital outflows. Effectively, this 'constrained' the US in its ability to borrow in international financial markets to involve in insuring against any risk of fluctuations in their consumption. When capital controls in the rest of the world started to be dismantled, this allowed the US to effectively borrow more easily at any point and decreased the importance for them to have precautionary asset holdings. It is the drop in the relative importance of precautionary savings that links the accumulation of US net foreign debt to the process of capital liberalization.

We address this question in a two country one good model and consider two cases: 1) an endowment economy, where outputs arrive stochastically each period, and, 2) a model with production and capital accumulation similar to Backus, Kehoe and Kydland (1992), which

is the standard workhorse model of international macroeconomics. The simple model is developed mainly to build intuition, whereas the model with capital accumulation allows for a more realistic description of actual economies. We assume that the representative agent in each country 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 agents have limited access to borrow and lend in international financial markets; there are limits beyond which they cannot borrow or lend. 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 achieve smoother consumption. The presence of the borrowing and lending constraints creates a role for a precautionary savings. The catching up of the rest of the world's (RoW) financial openness, that is, the financial account liberalization in the RoW is modeled as a one-time permanent relaxation of the upper limit of capital outflows of the foreign economy. Effectively, this improves also the domestic -US- ability to borrow. For any given level of risk it faces it can now better use the international bond for consumption smoothing purposes, 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 of the (relative) importance of the precautionary savings motive that endogenously makes the U.S. hold long run negative net foreign assets as it transitions to a new implied steady state.

There are several contributions in the literature that our paper connects to. As mentioned before, in recent work Mendoza et al. (2006) also refer to differences in financial factors as a potential explanation for the U.S. external imbalances. They emphasize the heterogeneity of financial systems within countries such as a country's credit markets and differences in the ability to borrow from collateral.[1] They propose a model in which agents face idiosyncratic risk from both endowments and investment technology, which has to be to be managed differently. In such a setup, differences in financial development between countries matter when economies open up to trade in international financial markets. The accompanied process of

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[1]Their paper also provides empirical evidence of a negative relationship between the state of development of a country's credit markets and its current account. The ratio of Private Credit to Domestic Sector as percentage of GDP from the World Development Indicators shows that the US is (and has been) world leader in terms of credit market development.

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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. Contrary to Mendoza et al. (2006) we focus on the effects of capital liberalization on cross-country risk sharing, and show that even in a model with aggregate risk only the implied imbalances of a change in financial openness can be substantial.

Caballero et al. (2006) argue that for emerging market economies, among them most prominently China, the development of local financial markets has not kept pace with the growth experiences of their economies. They argue, that for these countries, this has led to an inability to supply high quality financial assets. The high demand for quality assets on world financial markets, together with the process of capital liberalization has allowed emerging market economies to hold their savings in U.S. assets, or equivalently has allowed the U.S. to more easily hold foreign debt.

The explanation for what is driving the US external deficit that is suggested here, that is, the decrease in the US precautionary savings motive relative to the rest of the world is similar to the mechanism proposed by Fogli and Perri (2006). They claim that the 'great moderation' in business cycle volatility in the US (compared to the rest of the world) has led to a decrease in consumption volatility which is what is driving the US external imbalance. In our model it is the opening up of countries' financial accounts which allows the US to better smooth its consumption and which endogenously leads to the external deficit.

The paper is organized as follows. In section 2 we present the model framework, a simple two country endowment model that allows for constraints on capital in- and outflows. Section 3 explains in detail how financial openness and capital liberalization is modeled. Subsection 3.1 briefly describes the solution technique and discusses parametrization. In subsection 3.2 we present the results of the quantitative exercise for the simple model together with some sensitivity analysis. Section 4 proceeds with the discussion and results of the model with capital that can be calibrated. Section 5 concludes.

2 Endowment Economy

2.1 The model

The world economy consists of two countries, Home and Foreign, each inhabited by a large number of infinitely lived agents with mass n and $(1-n)$ 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

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t) \tag{1}$$

where β is the rate of time preference. The utility function $u(c)$ is assumed to be constant relative risk aversion $u(c) = (1/(1-\sigma))[c^{1-\sigma} - 1]$, where σ 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:

$$\begin{pmatrix} \ln(y_t) - \ln(\overline{y}) \\ \ln(y_t^*) - \ln(\overline{y}^*) \end{pmatrix} = A \begin{pmatrix} \ln(y_{t-1}) - \ln(\overline{y}) \\ \ln(y_{t-1}^*) - \ln(\overline{y}^*) \end{pmatrix} + \begin{pmatrix} \varepsilon_t \\ \varepsilon_t^* \end{pmatrix} \tag{2}$$

where $\overline{y}$ is mean income, A is a 2x2 matrix of coefficients describing the autocorrelation properties of the process, and $\mathbf{e} = (\varepsilon_t \quad \varepsilon_t^*)'$ is a vector of shocks from a bivariate normal distribution with mean zero and variance-covariance matrix $V(\mathbf{e})$, i.e. $\mathbf{e}_t \sim N(0, V(\mathbf{e}))$.

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 is the gross real interest rate. We can then write the domestic country's budget constraint as:

$$\frac{b_{t+1}}{r_t} = b_t + y_t - c_t \qquad \text{with } b_0 \text{ given} \tag{3}$$

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 domestic country's debt level cannot exceed some fraction $\underline{B}$ of the level of its current output:[2]

$$\frac{b_{t+1}}{y_t} \geq -\underline{B} \tag{4}$$

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

$$\frac{b_{t+1}}{y_t} \leq \overline{B} \tag{5}$$

The foreign country's budget constraint and the borrowing and lending constraints are equivalent versions of equations (3) and (4), replacing all variables with star-ed ones. The borrowing limit for the foreign country therefore is $\frac{b_{t+1}^*}{y_t^*} \geq -\underline{B}^*$ and the lending limit is $\frac{b_{t+1}^*}{y_t^*} \leq \overline{B}^*$.[3]

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 $[\mathbf{B}, \mathbf{B}^*]$, where $\mathbf{B} = \max\left(-\underline{B}y_t, -\overline{B}^* y_t^*\right)$ denotes the domestic country's *effective* borrowing constraint. Similarly, $\mathbf{B}^* = \min\left(\overline{B}y_t, \underline{B}^* y_t^*\right)$ denotes the foreign country's *effective* borrowing constraint.

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

1. c_t and b_{t+1} maximize (1) subject to (3)-(4)-(5)

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[2]In addition, there is a 'natural debt' limit as in Ayagari (1994) in 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, but on top of that countries face more restrictive debt limits. 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 interest rate is exogenous. In addition if one the constraint binds for one of the economies the interest rate differs for each agent, for a detailed discussion see Anagnostopoulos (2006). However, the debt limits we impose are generally stricter than the natural debt limit.

[3]In equilibrium, since bonds are held in zero net supply, the foreign country's borrowing constraint reads $\frac{b_{t+1}}{y_t} \leq \underline{B}^*$ and the lending constraint reads $\frac{b_{t+1}}{y_t} \geq -\overline{B}^*$.

2. c_t^* and b_{t+1}^* maximize the foreign version of (1) s.t. the foreign versions of (3)-(4)-(5)

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:[4]

$$c_t^{-\sigma} - r_t \lambda_t^{\underline{B}} + r_t \lambda_t^{\overline{B}} = \beta r_t E_t \left[c_{t+1}^{-\sigma} \right] \tag{6}$$

$$c_t^{*-\sigma} - r_t \lambda_t^{\underline{B}^*} + r_t \lambda_t^{\overline{B}^*} = \beta r_t E_t \left[c_{t+1}^{*-\sigma} \right] \tag{7}$$

$$\frac{b_{t+1}}{r_t} = b_t + y_t - c_t \tag{8}$$

$$-\frac{b_{t+1}}{r_t} = -b_t + y_t^* - c_t^* \tag{9}$$

$$\lambda_t^{\underline{B}} \left[\frac{b_{t+1}}{y_t} + \underline{B} \right] = 0 \tag{10}$$

$$\lambda_t^{\underline{B}^*} \left[-\frac{b_{t+1}}{y_t^*} + \underline{B}^* \right] = 0 \tag{11}$$

$$\lambda_t^{\overline{B}} \left[\overline{B} - \frac{b_{t+1}}{y_t} \right] = 0 \tag{12}$$

$$\lambda_t^{\overline{B}^*} \left[\overline{B}^* + \frac{b_{t+1}}{y_t^*} \right] = 0 \tag{13}$$

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

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[4]Where we have used the bond market clearing condition to substitute out b_t^*.

to zero, i.e. $\lambda_t^{\underline{B}} = \lambda_t^{\underline{B}^*} = 0$ and $\lambda_t^{\overline{B}} = \lambda_t^{\overline{B}^*} = 0$, and the Euler equations (6)-(7) reduce to their standard expressions.

2. The borrowing constraint binds for the domestic country, i.e. $b_{t+1} = -\underline{B}$. The Lagrange multiplier of the domestic borrowing constraint, $\lambda_t^{\underline{B}}$, which reflects the shadow value of relaxing the constraint marginally, is therefore positive.

3. The lending constraint binds for the domestic country, that is $b_{t+1} = \overline{B}$, and $\lambda_t^{\overline{B}} > 0$.

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

5. The lending constraint binds for the foreign economy, $b_{t+1} = -\bar{B}^*$, and $\lambda_t^{\overline{B}^*} > 0$.

3 The interpretation of financial openness and capital liberalization in the model

In the framework of the model we 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 choice 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, 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 country idiosyncratic consumption risk.[5]

The second special case is the scenario in which the bond can be freely traded across countries, that is $\overline{B}$, $\overline{B}^*$, $\underline{B}$ and $\underline{B}^*$ are sufficiently high, such that none of the constraints ever binds.[6] This case coincides with the standard case of what is known as the incomplete

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[5]In the endowment case therefore volatility of the endowment directly translates into the volatility of consumption. In the model with capital, the domestic country can even under financial autarky engage in at least some consumption smoothing through increasing or running down its capital stock.

[6]However, there still is a 'natural debt limit' and a 'No Ponzi' condition that needs to be satisfied.

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 Baxter and Crucini (1995)).

We interpret intermediate cases between financial autarky and no limits in borrowing and lending as reflecting intermediate stages of financial 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 we are able to generate large imbalances with our model. 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 policy functions.[7]

The experiment we undertake is the following. The initial borrowing constraints, denoted $\underline{B}^{BL}$ and $\underline{B}^{*BL}$ (BL stands for *'before liberalization'*) for the domestic and foreign country respectively and capital outflow limits, $\overline{B}^{BL}$ and $\overline{B}^{*BL}$, are initially set to some constant fraction of steady state world output, i.e. $\underline{B} = \frac{b}{y}$ and $\underline{B}^* = \frac{b^*}{y^*}$ and similarly for the capital outflow limit, $\overline{B} = \frac{b}{y}$ and $\overline{B}^* = \frac{b^*}{y^*}$. We model the RoW's reduction of controls on capital outflows as a relaxation of the lending constraint to a new level $\overline{B}^{*AL}$ (*'after liberalization'*), with $\overline{B}^{*AL} > \overline{B}^{*BL}$. Rather than modeling the process of liberalization as something that took place gradually over time, we make the simplifying assumption that liberalization occurs at once. That is, we consider a one-time permanent relaxation in the RoW's lending constraint, which the representative agents of both countries learn about instantly. If the capital outflow constraints for the RoW initially are tighter than the US borrowing constraint, $\overline{B}^{*BL} < \underline{B}^{BL}$, this implies that the US economy can achieve lower consumption volatility. It should be noted that, cleary, also the RoW is able to a better smooth its consumption in

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[7]As shown by Anagnostopoulos (2006) a global solution when there are relatively restrictive borrowing limits instead of a local approximation solution avoids the well-known problem of non-stationarity of bonds in the model.

response to the relaxation. The drop in US consumption volatility is bigger, however, since agents are more risk averse when consumption is rather low.[8] Accordingly, the US motive to hold precautionary assets decreases by more than the RoW's motive for buffer assets.

The modeling of financial markets, that is, the assumption that there only exists one internationally traded bond, is clearly overly simplistic. In particular, it cannot address questions of portfolio choice or give any rationale to why gross asset and liability positions have risen drastically. We however also see the simplicity of our model and the fact that the standard workhorse international macro-model is nested in our setup as an advantage. We show that even in a simple setup and with only aggregate (country specific) risk we can explain a sizable portion of the US net external deficits through effects of capital liberalization.

3.1 Model solution and parametrization

Solution method   To address the question 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 on agent's policy functions and that also allows treatment of occasionally binding inequality constraints.

We use time iteration techniques as described by Coleman (1990) and increased its speed by using the endogenous grid points method developed by Carroll (2006) which reduces the number of non-linear equations the the algorithm needs to solve. Time iteration has several advantages as compared to standard dynamic programming as it preserves the continuous nature of the state space since it relies on interpolation techniques, and it easily allows to take into account inequality constraints. In particular, we make guesses on the policy rules as functions of the economy's state variables. In the endowment economy we obtain policy rules for bond holdings and the interest rate as functions of last period bond holdings and the two endowment processes, $b''(b';y',y^{*'})$ and $r'(b';y',y^{*'})$. Further details about the solution technique are provided in the appendix.

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[8]That is, utility is concave.

Parameters values Table 1 presents our baseline parameter values for the quantitative experiments of our model economy, chosen such as to match U.S. quarterly data versus the rest of the world. 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 coefficient of risk aversion σ is set to 2, a very standard choice in macroeconomics. The discount factor β is set as to match a 4% annual interest rate in the non-stochastic steady state. The exogenous process follows a bivariate AR(1) with a coefficient of autocorrelation ρ of 0.98 (and no cross-correlation) and standard deviation of the exogenous process σ_ε set to 0.0075 as estimated by Fogli and Perri (2006) for the US economy.

The analysis of the endowment economy model is quite useful to build intuition we can show how borrowing and lending constraints and their relaxation matter for the equilibrium net foreign asset position. It is convenient to start with a completely symmetric initial parametrization. The two economies are equal in terms of country size (set to one-half), long term output levels ($\overline{y} = \overline{y}^* = 1$), as well as their initial borrowing and lending constraints, $\overline{B}^{BL} = \overline{B}^{*BL} = \underline{B}^{BL} = \underline{B}^{*BL} = .5$.

3.2 Main results

We now turn to the quantitative predictions of our model economy when we relax the effective borrowing constraint faced by the US. To build intuition we start from an initial setting where both economies are symmetric. Before discussing the experiment of the relaxation in the domestic country's borrowing constraint we want to comment on the general effect of borrowing constraints in a stochastic environment. The presence of borrowing constraints give households 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 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. Since both economies are initially symmetric and the bond must be held in zero net supply, this means that none of two countries can actually have positive holdings of the international bond. As first observed by Ayagari (1994), as a result of 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.

For displaying the mechanism of the model it does not matter whether the domestic country's ability to borrow is restricted because of its own actual constraints on borrowing, $b_{t+1} \geq -\underline{B}y_t$, or whether it is constrained because the foreign economy is restricted from holding the domestic country's financial assets, i.e. $b_{t+1} \geq \overline{B}^* y_t^*$. Since what matters is the domestic country's effective borrowing constraint, $\mathbf{B} = \max\left(-\underline{B}y_t, -\overline{B}^* y_t^*\right)$, we will conduct our experiment in terms of a relaxation of this effective constraint. We model the increase in financial openness of capital outflows for the ROW as a one-time permanent relaxation of the effective US' 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 $\mathbf{B}^{BL} = \mathbf{B}^{*BL} = 0.5$, and are equal to $\mathbf{B}^{*AL} = 0.5$ and $\mathbf{B}^{AL} = 1.0$) after liberalization. We

assume that the RoW economy still faces the same borrowing limit as before, as in practice the ability of obtaining external finance for many emerging market countries is still limited. Two reasons are behind this fact, first, these economies are financially less developed. Second, after the recurrent crises that some of the emerging markets have faced during the end of the 90's, where they suffered limitations in their ability to borrow internationally. With this parametrization we capture the asymmetry in borrowing in financial markets and therefore the differences in the ability to manage consumption uncertainty. We choose the mid 1980 as the date for the experiment which coincides with the start of the decline in the U.S. net foreign asset position.

Figure 3 shows the response of main macroeconomic variables in the face of the U.S. increased ability to borrow in international markets in comparison to RoW. Since the foreign

household's motive to engage in precautionary savings has remained unchanged and it therefore now has, relative to the US, a stronger desire for precautionary savings we observe (in panel 2 of figure 3) a U.S. current account deficit and a gradual decline in the U.S. net foreign asset position as the economy transitions to a new steady state.[9] Note that we measure the quantitative responses of the current account (and consumption) in relation to current output which since we used a quarterly calibration is in *quarters*, and are therefore different than in the data not annualized. On an annualized basis, the current account deficit to GDP is therefore substantially larger. After the relaxation of the domestic country's borrowing constraint, its desire to hold assets for precautionary savings has dropped for two reasons: on the one hand it can use the bond more freely in response to random output shocks and can achieve better consumption smoothing and therefore a lower consumption volatility for any given risk it faces. On the other hand, the borrowing constraint itself has softened, and therefore the probability that the constraint binds at any moment in time has decreased and the desire to hold assets as a buffer to avoid these eventualities decreases.

The decrease in the importance of U.S.' precautionary savings lowers its demand for the asset and, as a consequence, pushes up the interest rate (panel 4 of figure 3) which gives the RoW a motive to forgo consumption today. As interest rates increase the RoW finds it optimal to save and enjoy some higher consumption in the future. The consumption responses in panel 3 of figure 3 show that domestic consumers become relatively more impatient. The drop in the 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 U.S. consumption at the new steady state is at a lower level permanently.

It is important to note that figure 3 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 3 is entirely due to the decrease in the importance of the precautionary savings motive for the U.S. economy, that stems from the domestic coun-

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[9]In principle the responses shown in figure 3 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 we instead feed $\sigma_\varepsilon = 0$ in the 'simulation' (however, the policy functions themselves have, of course, been obtained from a stochastic setting with σ_ε as indicated in section 3.1).

try's improved ability to smooth consumption, and plots the expected path as the economy transitions to the new implied steady state.

Sensitivity Analysis Figure 4 presents some sensitivity analysis. The first column presents the equilibrium response of our baseline parametrization for values of the coefficient of relative risk aversion σ equal to 1, 2 (baseline) and 5, respectively. As can be seen, the higher is the degree of risk aversion, the smaller is the reduction of the importance of US' precautionary motives and therefore, the smaller is the accumulation of net foreign debt.

Given the difficulty to parameterize the borrowing limits, we consider it especially important to do sensitivity analysis on different values of the effective borrowing constraints. The quantitative response of net foreign assets to a relaxation depends on two things: one, the degree to which the constraints where initially restricting asset trade, and two, the amount by which the effective constraints are relaxed. The panels in the second and third 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 column 2 of figure 4 under varying degrees of 'initial financial market openness' and show the responses of the economic variables for three different parameterizations. The first assumes that initially international financial markets were very closed (the constraints change from $\mathbf{B}^{BL} = \mathbf{B}^{*BL} = 0.01$ to $\mathbf{B}^{*AL} = 0.01$ and $\mathbf{B}^{AL} = 0.5$), the second set of responses repeat the baseline case, and the third starts out in a situation where international financial markets were (relatively) open to begin with (from $\mathbf{B}^{BL} = \mathbf{B}^{*BL} = 1.0$ to $\mathbf{B}^{*AL} = 1.0$ and $\mathbf{B}^{AL} = 1.5$). 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.

The third column of figure 4 shows different cases for 'the extent of liberalization', that is, for different assumptions on by how much the effective borrowing constraint is relaxed.

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We show the baseline case, and the changes in the constraints from $\mathbf{B}^{BL} = \mathbf{B}^{*BL} = 0.5$ to $\mathbf{B}^{*AL} = 0.5$ and $\mathbf{B}^{AL} = 1.5$, and from $\mathbf{B}^{BL} = \mathbf{B}^{*BL} = 0.5$ to $\mathbf{B}^{*AL} = 0.5$ and $\mathbf{B}^{AL} = 2.5$.

Not surprisingly, the decline in the net foreign asset position is more pronounced the higher the extent of the relaxation.

We summarize the new stochastic steady states obtained 20 years after financial account liberalization in table 2. Taking in to account that the current level of US net foreign assets has achieved almost 25% of GDP the results obtained under our experiments are quite significant. In 2006 our baseline experiment for the endowment economy accounts for a net foreign debt of about -15 percent of domestic output. The new steady state level of net foreign assets of approximately -23% is reached at around 80 years later.

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. Column 2 of figure 5 plots the results of the great moderation. [10] Column 3 of figure 5 then incorporates both facts: capital liberalization plus 'great moderation'. The results from these experiments are reported for different values of the coefficients of relative risk aversion.

4 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 by making use of the international bond, that 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 in which the domestic representative agent is owner of the economy's capital stock which is used in production. This gives her another asset that can be used to smooth intertemporal consumption and to hold savings for precautionary reasons. Now, the domestic representative agent maximizes

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[10]Note that the model used by Fogli and Perri (2006) is different as they include capital accumulation in their model. We also include an additional asset in the next section.

eq. (1) 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:

$$c_t + x_t + \frac{b_{t+1}}{r_t} = \omega_t n + r_t^k k_t + b_t \tag{14}$$

$$k_{t+1} = (1 - \delta)k_t + x_t - \frac{\phi}{2}\left[\frac{k_{t+1} - k_t}{k_t}\right]^2 \tag{15}$$

where k_t is capital, w_t and r_t^k refers to the wage rate and the return of capital. To avoid a counterfactual volatile investment, x_t, there are adjustment costs to install new capital. Households are assumed to supply their labor inelastically. For simplicity, we continue to model the foreign country's output as an endowment process (or, implicitly, continue to hold the foreign capital stock fixed).[11]

Firms produce output according to a Cobb-Douglas production function and face a country specific productivity. They are assumed to be competitive such that profit maximization leads to factors being paid their marginal products.

$$\max \pi = (z_t k_t^\alpha n^{1-\alpha} - \omega_t n - r_t^k k_t) \tag{16}$$

Technologies are modeled as exogenous processes which follow a bivariate autoregressive process of order 1.[12]

$$\begin{pmatrix} \ln(z_t) - \ln(\overline{z}) \\ \ln(z_t^*) - \ln(\overline{z}^*) \end{pmatrix} = A \begin{pmatrix} \ln(z_{t-1}) - \ln(\overline{z}) \\ \ln(z_{t-1}^*) - \ln(\overline{z}^*) \end{pmatrix} + \begin{pmatrix} \varepsilon_t \\ \varepsilon_t^* \end{pmatrix} \tag{17}$$

where $\overline{z}$ is a parameter reflecting the mean productivity, A is a 2x2 matrix of coefficients describing the autocorrelation properties of the process, and $\mathbf{e} = (\varepsilon_t \quad \varepsilon_t^*)'$ is a vector of shocks from a bivariate normal distribution with mean zero and variance-covariance matrix $V(\mathbf{e})$, i.e. $\mathbf{e}_t \sim N(0, V(\mathbf{e}))$.

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[11]This is done mainly for ease of computation.
[12]this is the same assumption we made for the endowment model, just that the exogenous processes describe productivity instead of output.

The equilibrium of this economy is defined as a path of interest rates $r = \{r_t\}_{t=0}^{\infty}$ and input prices $w = \{w_t\}_{t=0}^{\infty}$ and $r^k = \{r_t^k\}_{t=0}^{\infty}$ together with consumption plans $c = \{c_t\}_{t=0}^{\infty}$ and $c^* = \{c_t^*\}_{t=0}^{\infty}$, capital accumulation plans $k = \{k_t\}_{t=0}^{\infty}$ and debt plans $b = \{b_t\}_{t=0}^{\infty}$ and $b^* = \{b_t^*\}_{t=0}^{\infty}$ such that households and firms solve their optimization problem and markets for bonds, consumption and capital clears in each market.

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 additional Euler equation with respect to the choice of the optimal capital stock, given by:

$$\left(1 + \frac{\phi}{k_t}\left(\frac{k_{t+1}}{k_t} - 1\right)\right)c_t^{-\sigma} = \beta E_t \left\{ c_{t+1}^{-\sigma}\left[(1-\delta) + \alpha z_{t+1}\left(\frac{k_{t+1}}{n}\right)^{\alpha-1} + \frac{\phi}{k_{t+1}}\left(\frac{k_{t+2}}{k_{t+1}} - 1\right)\frac{k_{t+2}}{k_{t+1}}\right]\right\}$$

(18)

Solution method and parameters values   The model is solved with the same technique as in the endowment economy model. In the full model with production we iterate on policy function guesses of b'', k'' and r' as functions of $(b', k'; z', z^{*'})$.

In the model with capital we have another set of standard parameters. Table 1 presents our baseline parameter values for the quantitative experiments of our model economy. The capital share α is set equal to 0.36. The quarterly depreciation rate, δ, is set to 2.5%. In order to avoid counterfactual volatile investment, we include quadratic capital adjustment costs with parameter ϕ equal to 8. The domestic economy's country size parameter n is taken to be 0.25 which corresponds approximately to the US population share in the OECD in 2007. The level of long run productivity in the US is taken to be slightly higher than in the RoW, with parameters $\overline{Z} = 1.01$ and $\overline{Z}^* = 1$.

For the model with capital we aim to capture a more realistic setting and allow for differences in country size and productivity, and, more importantly, differences in initial borrowing and lending constraints and the catching up of the RoW's financial account openness. We

claim that the US borrowing and lending constraints, $\underline{B}^{BL}$ and $\overline{B}^{BL}$, in the period *before liberalization* in the rest of the world are already relatively loose, and set these to 100% of US output. For the RoW, while for most countries capital was not being prevented from flowing into the country, there were tight controls on capital outflows. We assume, for simplicity, an equally loose borrowing constraint, $\underline{B}^{*BL}$, for the RoW up to 100% of its output. The outward capital controls reflect this in a relatively tight constraint on the RoW's lending, $\overline{B}^{*BL}$, which will be set to 50% of RoW's output level. We assume after capitals controls in the RoW have been dismantled, the bond holdings of the rest of the world can also take on 100% of its output level, $\overline{B}^{*AL} = \overline{y}^*$.

4.1 Responses to financial account liberalization in the full model with capital

In the previous section we have seen that large imbalances can result from changes in financial openness, reflected in changes in the effective borrowing constraint of the domestic economy. This may not seem surprising given that in the endowment economy the internationally traded bond is the only asset which can be used for agents' desired holding of buffer assets. Then, any change in the relative importance of the precautionary savings motive of the US vs. the RoW is necessarily expressed in (large) equilibrium responses of the long run external asset position.

In the model with capital the domestic agent is allowed another asset that can help her in the desire to achieve smooth consumption on the one hand, and for precautionary motives on the other hand. It is because of the latter that the long-run level of the capital stock in a stochastic equilibrium lies above the deterministic steady state capital stock, reflecting that also capital is held as a buffer against having to have very low consumption in bad states of the economy.

Figure 6 presents the equilibrium responses when the RoW is initially facing a high level of capital controls and is therefore very much restricted from holding foreign assets. After capital liberalization takes place in the RoW, the foreign lending constraint softens which also relaxes the US' effective borrowing constraint. In particular, we parameterize the initial

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constraints the US is facing such that it would be able to borrow and lend up to 50% of its current output level, that is, $\overline{B}^{BL} = \underline{B}^{BL} = 0.5$. For the RoW, before capital liberalization, the initial constraint on capital outflows is set to $\overline{B}^{*BL} = 0.01$, essentially entirely preventing the RoW from taking their financial wealth abroad. Controls on capital inflows were much less prevalent even before liberalization, and we assume the RoW's borrowing constraint initially to be $\underline{B}^{*BL} = 0.5$. After liberalization, when capital controls in the RoW have been dismantled, the RoW's lending constraint is also at 50% of its output level, $\overline{B}^{*AL} = 0.5$. We can observe that the US net foreign asset position before the onset of capital liberalization in the rest of the world is slightly positive[13] and then starts its subsequent decline. Our model is therefore able to rationalize the stylized facts we observe in the data -which were presented in figure 1 and figure 2- as a result of the process of capital liberalization. As figure 6 shows, the drop in the US net foreign asset position remains substantial in the capital model, despite the fact that part of the decrease of buffer stock holdings that result from lower precautionary motives of the US is expressed by lowering investment, and therefore, by a decrease in the economy's long-run capital stock level. The experiment of the capital model also gives a quantitative indication on these effects. While the drop in domestic variables (investment, capital stock) 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.

5   Conclusions

Since the mid 80's we have observed a persistent decline in the US net foreign asset position. Contrary to conventional wisdom, where an adjustment was expected, the US continues to be the main world net borrower. In this paper we have quantitatively explored the role of the process of capital liberalization and risk aversion in driving the US net foreign asset position into deficit. For doing so we used a stylized two country one good model with borrowing and lending constraints.

We have shown that the current US net external imbalance can be a natural outcome

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[13]In fact, with our choice of initial constraints, it would be even more positive if the long run productivity levels across the two countries were equal.

of the catching up process of other advanced and emerging market economies in terms of financial account openness in the last 25 years.

6 Appendix

The models in section 2.1 are solved by making policy function guesses combined with the method of endogenous grid points. Below we briefly outline the steps of the algorithm used:

- We discretize the exogenous process following Adda and Cooper (2003). We use the Adda Cooper method instead of the more conventional Tauchen and Hussey (1991) since, as shown by Floden (2007), the accuracy of the discretization in terms of the unconditional variance of y and y^* (z and z^*) is better under this method when the degree of autocorrelation is high and when there are only few discretization nodes. In the following, we denote t+1 variables with a prime (accordingly b'' is b_{t+2}). We construct a grid of endogenous state variables at time $t+1$. For the endowment economy we therefore have, for each combination of y' and $y^{*\prime}$, a one-dimensional grid in b' which consists of nb grid points and ranges from $\min(-\underline{B}, \overline{B^*})$ to $\max(\overline{B}, -\underline{B^*})$. For the capital economy we construct, for each combination of z' and $z^{*\prime}$, a 2-dimensional grid in k', b' consisting of $nk * nb$ grid points. The range for k' is set from .7 to 1.3 times the non-stochastic steady state level of the capital stock.

- Set counter equal to 1. We make initial policy function guesses using the log-linear solution as starting point. In the endowment economy guesses are made for $b''(b'; y', y^{*\prime})$ and $r'(b'; y', y^{*\prime})$. In the capital economy initial guesses are made for $b''(k', b'; z', z^{*\prime})$, $k''(k', b'; z', z^{*\prime})$, and $r'(k', k^{*\prime}, b'; z', z^{*\prime})$.

- Using these initial policy function guesses, and using the discretized states and transition matrix for the exogenous processes, the conditional expectations in the Euler Equations can be computed. In particular, in both economies, we compute $E\left[c'^{-\sigma}\right]$ and $E\left[c^{*\prime-\sigma}\right]$ from equations (6)-(7). For the capital economy we also derive an expression for $E\left[c'^{-\sigma}\left(f_{k'} + 1 - \delta + \Phi_{k'}\right)\right]$ from equation (18).

- Using the so computed expressions for the conditional expectations, the values of b (or, respectively, the values of k and b) are found for each grid-point b' (combination of grid-points k' and b') by using a nonlinear equations solver.

- Finally, the policy function guesses are updated using interpolation methods. As the function $b'(b; y, y^*)$ and $r(b; y, y^*)$ (or, in the capital economy, $k'(k, b; z, z^*)$, $b'(k, b; z, z^*)$ and $r(k, b; z, z^*)$) are known, one can obtain the updated guesses by interpolating b'' and r' at points $(b'; y', y^{*\prime})$ (or, in the capital economy, k'',b'' and r' at points $(k', b'; z', z^{*\prime})$).

- The above steps are repeated until convergence is achieved.

Table 1: Baseline parameter values

		economy with capital	
σ	5	α	0.36
β	.9895	δ	0.0255
$\overline{y}$	1	ϕ	8
ρ	.98	n	0.25
σ_ε	.0075	$\overline{Z},\overline{Z}^*$	1.01,1

Table 2: Sensitivity analysis

Sensitivity analysis

Risk aversion, σ

	$\sigma = 2$	$\sigma = 5$	$\sigma = 8$
Financ. dev.	-12.94	-11.83	-10.11

Borrowing constraints: changes in differences

	$\bar{B}_{BL} = \bar{B}^*_{BL} = 0.01$ $\to \bar{B}_{AL} = 0.5$	$\bar{B}_{BL} = \bar{B}^*_{BL} = 0.5$ $\to \bar{B}_{AL} = 1.0$	$\bar{B}_{BL} = \bar{B}^*_{BL} = 1$ $\to \bar{B}_{AL} = 1.5$
Ext. Imb.	-12.94	-20.87	-26.02

Borrowing constraints: changes in level

	$\bar{B}_{BL} = \bar{B}^*_{BL} = 0.5$ $\to \bar{B}_{AL} = 1$	$\bar{B}_{BL} = \bar{B}^*_{BL} = 0.5$ $\to \bar{B}_{AL} = 1.5$	$\bar{B}_{BL} = \bar{B}^*_{BL} = 0.5$ $\to \bar{B}_{AL} = 2.0$
Ext. Imb.	-20.58	-12.94	-7.46

Table 3: Impact on external imbalances as percentage of GDP to different parameter values

Table 4: BASELINE ALGORITHM PARAMETERS

1. Endowment economy

Number of gridpoints

bonds		$nodes_b$	31
output		$nodes_y$	5

Size of the grid

output			
	max	$y_{\max}, y^*_{\max}=$	-0.032
	min	$y_{\min}, y^*_{\min}=$	0.032
bonds			
	before		
	max	$b_{\max}, b^*_{\max}=$	-0.500
	min	$b_{\min}, b^*_{\min}=$	0.500
	percentage of st.st output		50%
	”		50%
	after		
	max	$b_{\max}, b^*_{\max}=$	-1.000
	min	$b_{\min}, b^*_{\min}=$	0.500
	percentage of st.st output		100%
	”		50%

2. Capital economy

Number of gridpoints

bonds		$nodes_b$	31
capital		$nodes_k$	31
technology		$nodes_z$	3

Size of the grid

technology			
	max	$z_{\max}, z^*_{\max}=$	1.042
	min	$z_{\min}, z^*_{\min}=$	0.959
capital			
	max	$k_{\max}=$	8.540
	min	$k_{\min}=$	15.859
bonds			
	before		
	max	$b_{\max}, b^*_{\max}=$	-0.013
	min	$b_{\min}, b^*_{\min}=$	0.633
	percentage of st.st output		1%
	”		50%
	after		
	max	$b_{\max}, b^*_{\max}=$	-0.633
	min	$b_{\min}, b^*_{\min}=$	0.633
	percentage of st.st output		50%
	”		50%

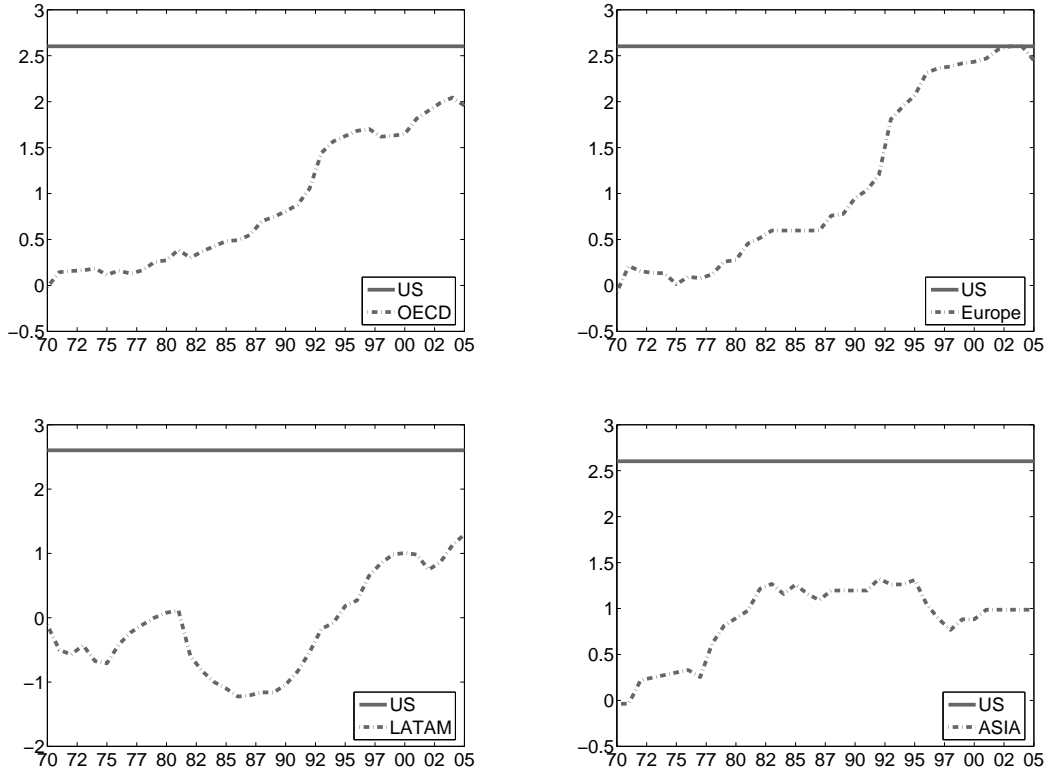# Financial Openness Index

Figure 1: Average financial openness index compiled by Chinn and Ito (2005) for different groups of countries compared with US
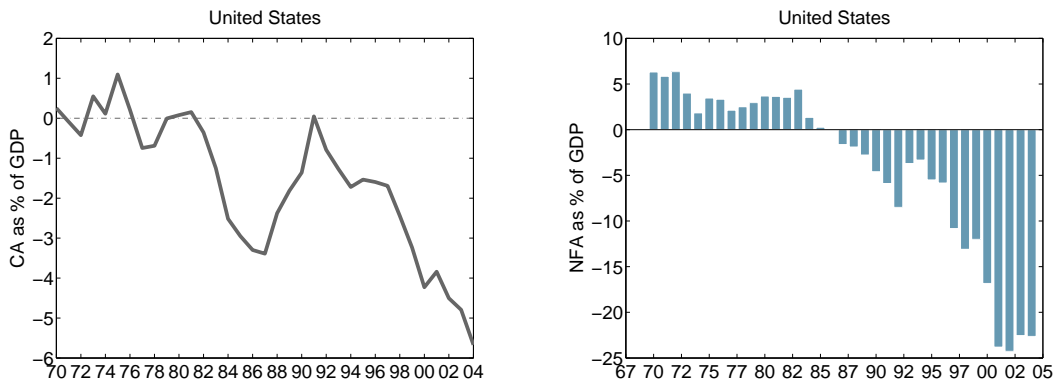

Figure 2: US current account and net foreign assets as percentage of GDP. Source: IMF statistics, Lane and Milesi-Ferretti database and World Development Indicators
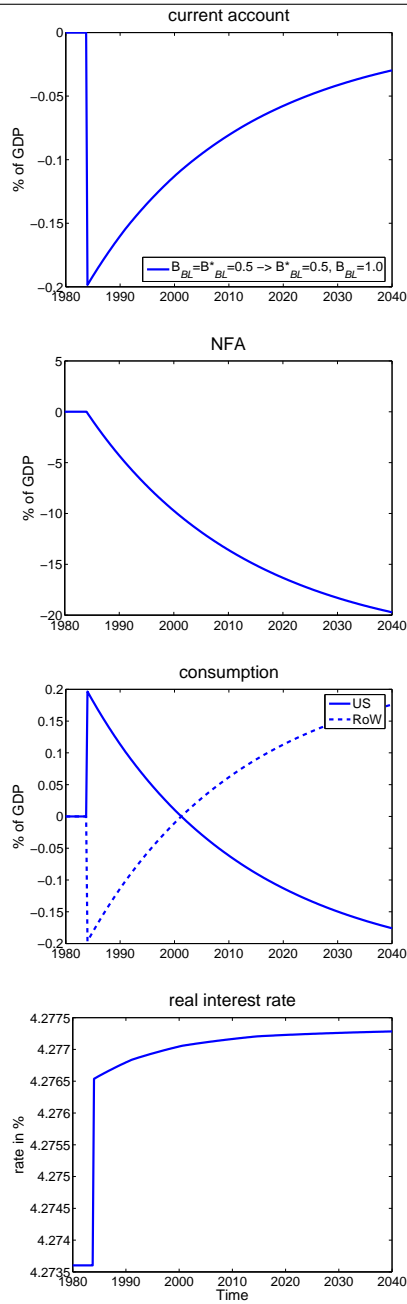
Capital Liberalization

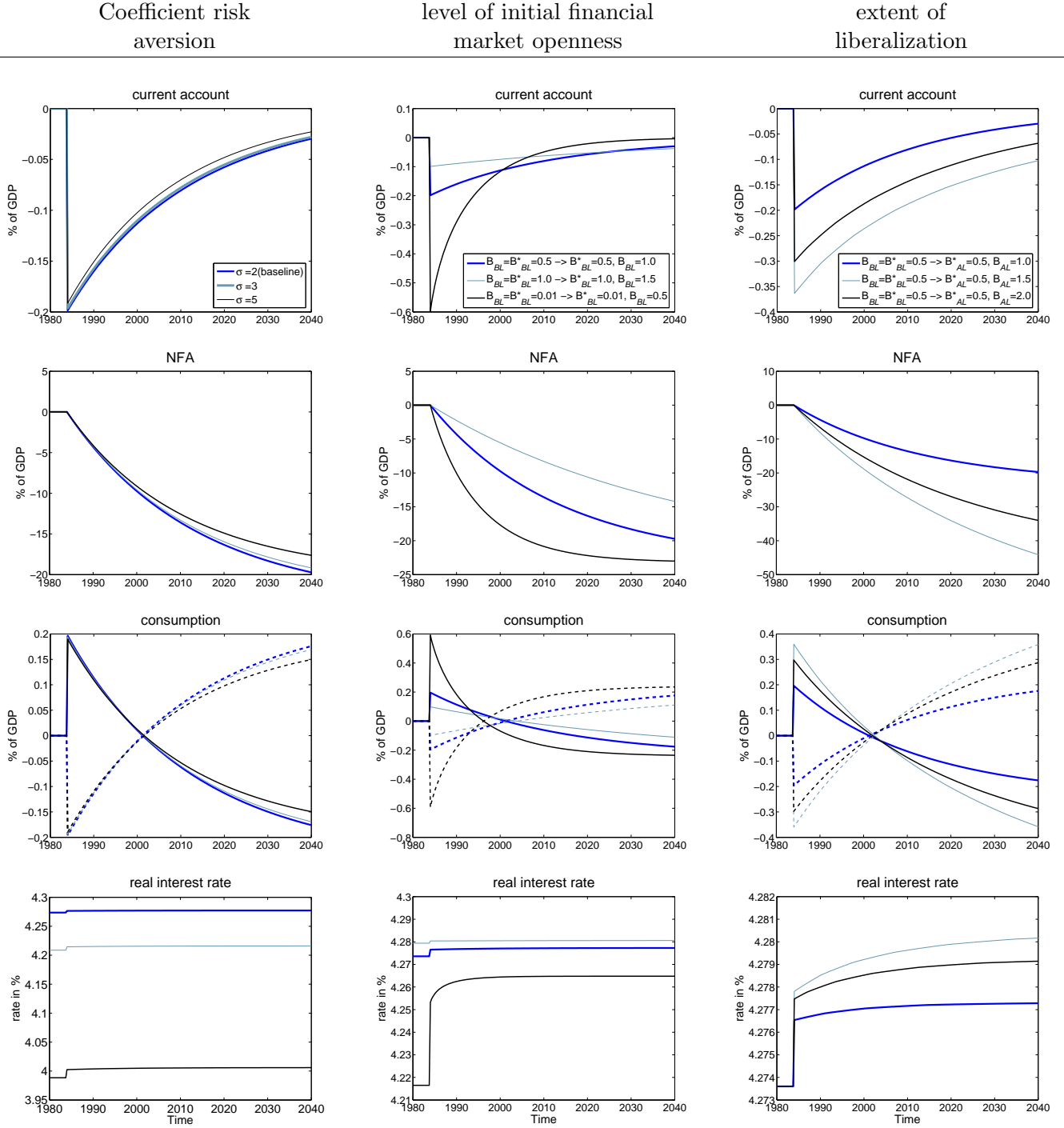Figure 3: Response to a relaxation in the US effective borrowing constraint

Figure 4: Response to a relaxation in the US effective borrowing constraint: column 1) different coefficients of risk aversion, column 2) different initial levels of debt limits and, column 3) and different sizes of relaxation
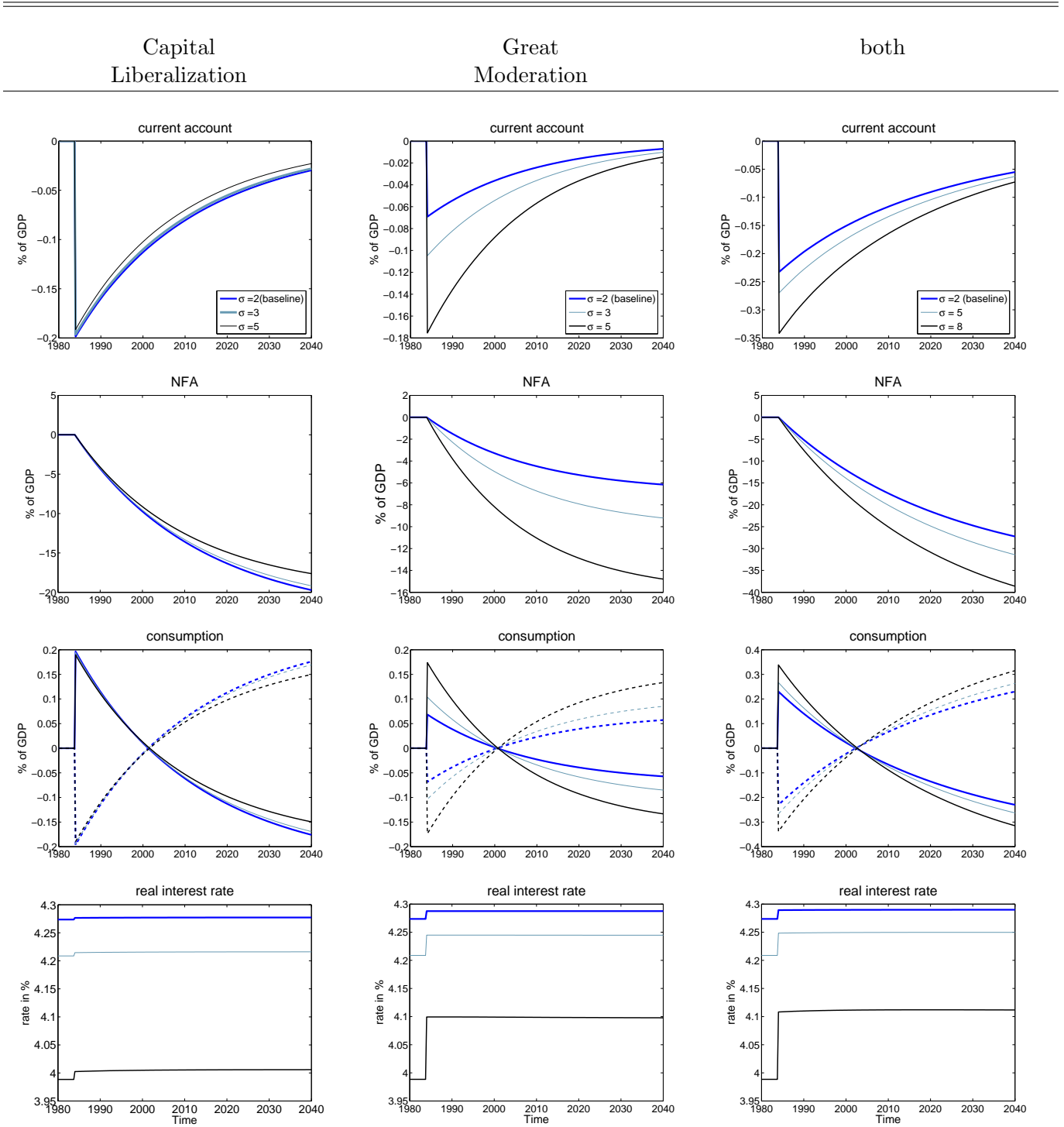
Figure 5: Response to a relaxation in the US effective borrowing constraint: Column 1) different coefficients of risk aversion, Column 2) great moderation in US income volatility and, Column 3) great moderation and US borrowing limit relaxation
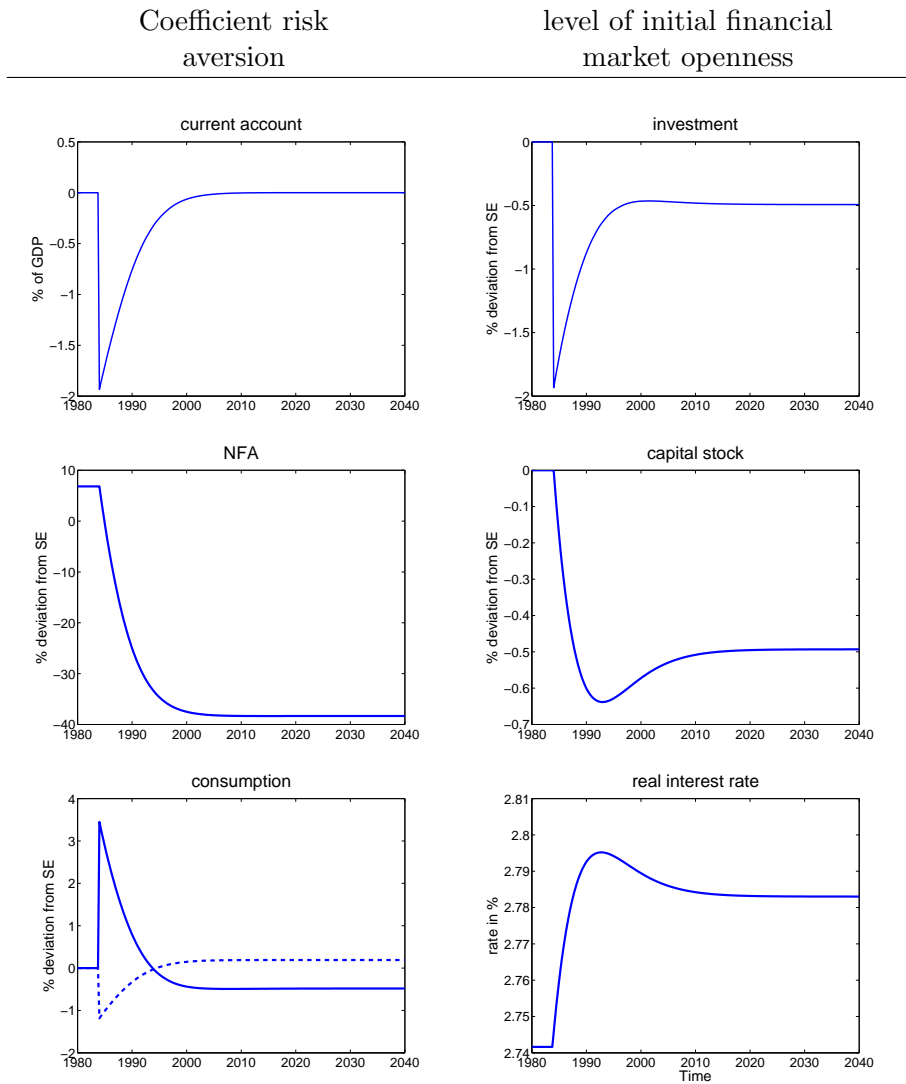
Capital Liberalization in the RoW

Coefficient risk
aversion

level of initial financial
market openness

Figure 6: Response to an relaxation of controls on capital outflows in the RoW

References

Adda, J. and Cooper, R. (2003), 'Dynamic economics', *MIT Press* .

Anagnostopoulos, A. (2006), 'Consumption and debt dynamics with (rarely binding) borrowing constraints', *mimeo* .

Ayagari, R. (1994), 'Uninsured idiosyncratic risk and aggregate savings', *Quarterly Journal of Economics* (59(3)), 659–84.

Backus, D., Kehoe, P. and Kydland, F. (1992), 'International real business cycles', *Journal of Political Economy* (100), 745–775.

Baxter, M. and Crucini, M. (1995), 'Business cycles and the asset structure of foreign trade', *International Economic Review* (36(4)).

Blanchard, O., Giavazzi, F. and Sa, F. (2005), 'The u.s. current account and the dollar', *NBER Working Paper* (11137).

Caballero, R., Farhi, E. and Gourinchas, P.-O. (2006), 'An equilibrium model of 'global imbalances' and low interest rates', *NBER Working Paper* (11996).

Carroll, C. D. (2006), 'The method of endogenous gridpoints for solving dynamic stochastic optimization problems', *Economics Letters* (91(3)), 312–320.

Chinn, M. and Ito, H. (2005), 'A new measure of financial openness', *University of Wisconsin mimeo* .

Coleman, W. J. (1990), 'Solving the stochastic growth model by policy-function iteration', *Journal of Business and Economic Statistics* .

Floden, M. (2007), 'A note on the accuracy of markov-chain approximations to highly persistent ar(1) processes', *SSE/EFI Working Paper Series in Economics and Finance* (656).

Fogli, A. and Perri, F. (2006), 'The 'great moderation' and the us external balance', *NBER Working Paper* .

Mendoza, E., Quadrini, V. and Rios-Rull, J. V. (2006), 'Financial integration, financial deepness and global imbalances', *mimeo* .

Obstfeld, M. and Rogoff, K. (2004), 'The unsustainable us current account position revisited', *NBER Working Paper* (10869).

Roubini, N. and Setser, B. (2005), 'Will the bretton woods 2 regime unravel soon? the risk of a hard landing in 2005-2006', *Unpublished Manuscript* .

Tauchen, G. and Hussey, R. (1991), 'Quadrature-based methods for obtaining approximate solutions to nonlinear asset pricing models', *Econometrica* (59), 371–396.