Financial Integration, Financial Deepness and Global Imbalances [1]

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Abstract

Large and persistent global financial imbalances need not be the harbinger of a world financial crash. Instead, we show that these imbalances can be the outcome of financial integration when countries differ in financial markets deepness. In particular, countries with more advanced financial markets accumulate foreign liabilities in a gradual, long-lasting process. Differences in financial deepness also affect the composition of foreign portfolios: countries with *negative* net foreign asset positions maintain *positive* net holdings of non-diversifiable equity and FDI. Abstracting from the potential impact of globalization on financial development, liberalization leads to sizable welfare gains for the more financially-developed countries and losses for the others. Three empirical observations motivate our analysis: (1) financial deepness varies widely even amongst industrial countries, with the United States ranking at the top; (2) the secular decline in the U.S. net foreign asset position started in the early 1980s, together with a gradual process of international capital markets liberalization; (3) net exports and current account balances are negatively correlated with indicators of financial development.

1 Introduction

At the end of 2006 the current account deficit of the United States reached 2 percentage points of the world's GDP and the country's net foreign liabilities reached 8 percent of global output. The IMF (2006) expects the U.S. current account to remain in the red through 2011. By then, U.S. net foreign liabilities will be about 15 percent the size of the global economy. The composition of the US foreign portfolio has also changed during the last two decades: While net foreign liabilities have reached one-third of the U.S. GDP, portfolio equity and FDI have climbed to one-tenth of GDP.

These imbalances are fueling heated debates in academic and policy circles. On the one hand there is the view that, unless major policy actions are taken, the imbalances will generate global financial turbulence and, possibly, a world economic crisis.[1] On the other hand, there is the view that the imbalances are the harmless outcome of various events such as differences in productivity growth or business cycle volatility, demographic dynamics, a 'global saving glut', or valuation effects. This view is summarized in Backus, Henriksen, Lambert & Telmer (2005).[2]

This paper proposes an explanation of global imbalances that has not been explored in this debate. We argue that both the large, persistent global imbalances and their portfolio composition could be the result of international financial integration among countries with heterogeneous domestic financial markets. The far-reaching reforms that liberalized international capital markets during the 1980s and 1990s were predicated on the benefits that financial integration would have for efficient resource allocation and risk-sharing across countries. But these arguments generally abstracted from the fact that financial systems differed substantially across countries, and those differences have remained largely unaltered despite the globalization of capital markets. In short, financial integration was a global phenomenon but financial development was not.

The motivation for studying global imbalances from this perspective derives from three observations:

[1] See, for example, Summers (2004), Obstfeld & Rogoff (2004), Roubini & Setser (2005), Blanchard, Giavazzi & Sa (2005), Krugman (2006).

[2] See also Bernanke (2005), Croke, Kamin and Leduc (2005), Gourinchas and Rey (2005), Hausmann & Sturzenegger (2005), Henriksen (2005), Lane and Milesi-Ferretti (2005), Caballero, Farhi & Gourinchas (2006), Cavallo and Tille (2006), Engel and Rogers (2006), Fogli and Perri (2006), Ghironi, Lee and Rebucci (2006).

1. Measures of financial development or financial deepness differ sharply across countries, even across industrialized countries, and the differences have changed little during the past 10 years (Figure 1).

2. The net foreign asset position of the country with the highest level of financial development—the United States—shows a secular decline starting in the early 1980s, at roughly the same time when many countries started to liberalize their capital accounts (Figures 2 and 3).

3. Net exports and current account balances, as a share of GDP, are negatively correlated with proxies for the degree of financial development (Figure 5).

These empirical observations raise three important questions that this papers seeks to answer. First, if countries involved in the process of financial integration are characterized by different financial structures, do we expect to see the type of imbalances and portfolio composition we observe in the data? Second, are the imbalances temporary or permanent? Third, are policies aiming at correcting the imbalances desirable?

We address these questions with a multi-country dynamic general equilibrium model with incomplete asset markets. Countries are inhabited by a continuum of ex-ante identical consumers who face two types of idiosyncratic shocks: endowment and investment shocks. 'Financial development' is defined by the extent to which financial contracts are enforceable. This can range from the case of perfect enforceability—allowing for the full insurance of the idiosyncratic risk (complete markets)—to the case in which enforcement is so limited that the only mechanism for consumption smoothing is the accumulation of non-contingent assets.

Analytical characterizations as well as numerical simulations of a two-country version of the model show that, if country U (say the United States) is more financially developed than country E (Europe or emerging economies), financial integration causes U's net foreign asset position to decline sharply in the long-run. In fact, moderate differences in financial deepness can easily lead to net foreign asset positions larger than domestic production. Moreover, this is a gradual and long-lasting process that can take more than 30 years.

The model also predicts that countries with different financial markets characteristics choose different compositions for their foreign asset portfolios, in a pattern that broadly resembles the portfolio compositions observed in the data. In particular, country U invests in foreign risky assets and finances

this investment with debt, so its net foreign asset position features a large negative position in riskless bonds and a positive position in risky assets. This is in line with the structure of the U.S. external position documented by Gourinchas and Rey (2005) and Lane and Milesi-Ferretti (2005).[3]

Large and persistent global imbalances in our model are fully consistent with intertemporal solvency conditions and do not lead to a financial crash or a 'Sudden Stop'. The model's welfare implications, however, suggest that capital markets liberalization is not always beneficial for all countries. In particular, countries with less developed financial markets experience welfare losses. Our model, however, ignores other potential gains from capital markets liberalization such as the transfer of technology, speedier financial markets development and risk-sharing benefits. With the consideration of these other benefits, the net welfare consequences of financial globalization could still be positive for all countries.

There are few papers that investigate global imbalances with quantitative dynamic models. Among these are Chapter 1 of IMF (2005), Hunt and Rebucci (2005) and Faruqee, Laxton, Muir & Pesenti (2005). These studies conduct simulations based on multi-country, multi-sector models with nominal rigidities, in line with the New Open Economy Macroeconomics. Their main focus is on the analysis of alternative policy scenarios for the unwinding of the imbalances, rather than explaining the imbalances themselves. Global imbalances emerge as the outcome of a combination of exogenous shocks, such as a permanent increase in the U.S. fiscal deficit, a permanent decline in the rate of time preference in the U.S., and a permanent increase in foreign demand for U.S. financial assets. In contrast, the model developed in this paper predicts a reduction in U.S. savings and an increase in the foreign demand for U.S. assets endogenously, after financial integration, because of the different characteristics of the U.S. financial system. This occurs even if all countries have identical preferences, resources and production technologies.

The premise that differences in domestic asset markets can produce external imbalances has precedent in the literature. Willen (2004) studied the qualitative predictions of a two-period endowment-economy model with ex-

[3]According to the March 2006 version of the Lane-Milesi database, the U.S. net foreign asset position fell from a share of GDP of 4 percent in 1980 to -23 percent in 2004. This resulted from a sustained widening in the net debt position, from near zero to about -32 percent, and an increase in the net position in portfolio equity and FDI, from 3.7 to 9 percent. In contrast, in the1970s, the decade before financial integration started, the U.S. net foreign asset position and its components remained relatively stable.

ponential utility, heterogenous agents, and normal-i.i.d. shocks. He showed that, under incomplete markets, trade imbalances emerge due to reduced savings by the agents residing in countries with 'more complete' asset markets. Our model embodies this mechanism but also differs in two key respects. First, we allow for endogenous production with 'production risks,' which is crucial for explaining the composition of asset portfolios in addition to net foreign asset positions. Second, we study an infinite horizon model with standard constant-relative-risk-aversion preferences and serially-correlated shocks, exploring both the qualitative and quantitative predictions of the model as well as its welfare implications.

The study by Caballero et al. (2006) also emphasizes the role of heterogeneous domestic financial systems in explaining global imbalances, but using a model in which financial imperfections are captured by a country's ability to *supply* assets in a world without uncertainty. In our framework, instead, financial imperfections have a direct impact on savings, and therefore, on the *demand* for assets. Uncertainty is crucial in our framework: without risk there are no imbalances even if financial markets are heterogeneous. The two papers also differ in the main driving forces for global imbalances. In Caballero et al. the imbalances are generated by differential shocks to productivity growth and/or to the financial structure of countries. Our explanation, instead, relies on the international integration of capital markets, given the differences in the characteristics of domestic financial markets. These differences started to matter for global imbalances after the liberalization of the 1980s and 1990s.

Some recent studies emphasize the role of demographic differences for the emergence of the imbalances. Henriksen (2005) shows that a two-country model calibrated to the population dynamics of the U.S. and Japan can capture the observed magnitude and persistence of current account imbalances between these two countries. Attanasio, Kitao & Violante (2006) focus instead on the demographics dynamics of developing countries. Although demographic differences is a compelling mechanism for capturing differences in saving patterns, they do not account for the international portfolio composition outlined above. The ability to explain the portfolio composition of observed foreign asset positions is a key feature that distinguishes our theory from other theories.

The rest of the paper is organized as follows: Section 2 reviews the empirical motivation of the paper. Section 3 describes the model and defines the competitive equilibrium under autarky and under free mobility of capi-

tal. Section 4 characterizes analytically the key properties of both equilibria. Section 5 conducts the quantitative analysis. Section 6 extends the model by introducing capital accumulation. Section 7 concludes.

2 Empirical motivation

The first fact that motivates our analysis is the observation that countries differ significantly in the deepness of their financial markets, even industrial countries. A recent study by the International Monetary Fund (IMF (2006)) constructs an index of financial markets development for industrial countries. The index combines information from three core sub-indexes: an index of traditional bank intermediation, an index of new financial intermediation (i.e. intermediation through direct market instruments, such as asset-backed securities and derivatives, and/or non-bank intermediaries, such as hedge funds) and an index of general characteristics of financial markets (e.g. stock market turnover, investor protection, bond market capitalization, etc.). Countries with a higher index undertake a larger volume of financial intermediation through direct market instruments, and thus are viewed as having attained a higher degree of financial development. Figure 1 shows that the United States has the highest score and that the gaps of other countries relative to the the U.S. have not changed substantially during the last decade.

The second key observation motivating our work relates to international financial integration. Chinn and Ito (2005) compiled an index of the degree of capital account openness for 163 countries from 1970 to 2004. The index is based on binary dummy variables that codify the tabulation of restrictions on cross-border financial transactions reported in the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions* (AREAER). The dummy variables reflect the four major categories of restrictions: multiple exchange rates, restrictions on current account transactions, restrictions on capital account transactions, and requirements for the surrender of export proceeds. The index is the first standardized principal component of these four variables and it takes higher values for countries that are more open to cross-border capital transactions.

Figure 2 shows the Chinn-Ito financial openness index for the United States, the group of industrialized countries excluding the U.S., and all countries except the U.S. The indices are computed as means of individual country indices, weighted by GDP. Although the U.S. has always been open during the last three decades, most of the other countries have been opening their

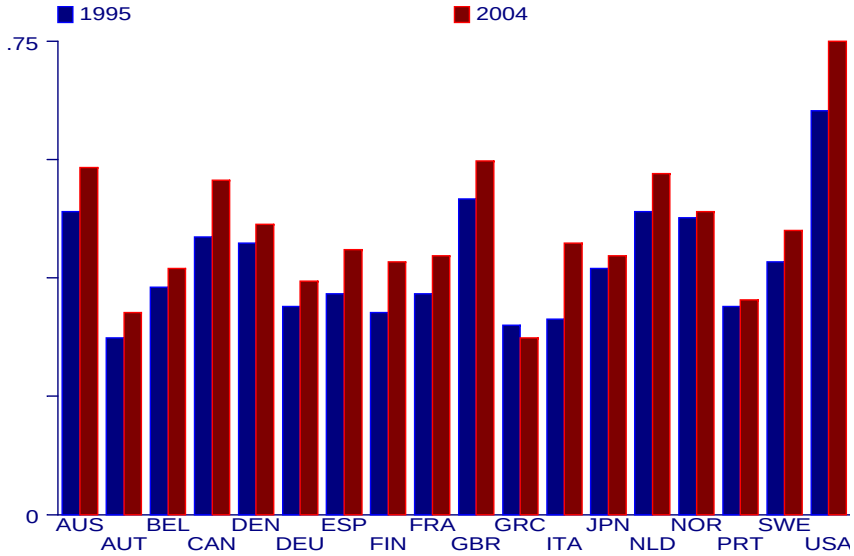


Figure 1: Financial index score for advanced economies. Source: IMF (2006).

capital accounts gradually since the beginning of the 1980s, starting first with the industrial countries and moving on to emerging economies in the 1990s. What is remarkable is that the timing of the gradual, but sustained, capital account liberalization coincides with the deterioration of the U.S. foreign asset position, as shown in the next figure.

Figure 3 plots the net foreign asset positions as a share of GDP for the United States, the group of industrialized countries excluding the U.S., and the group of emerging economies using the Lane-Milesi-Ferretti database. Clearly, the deterioration of the U.S. external position is not a recent phenomenon: It has been declining almost uninterrupted since the first half of the 1980s. This is right after industrial countries started to liberalize their capital accounts, as show in Figure 2. In addition, Figure 4 shows that the decline in the U.S. net foreign asset position has been accompanied by a change in the portfolio composition of foreign assets. In particular, while the net position in debt instruments has declined sharply, the net position in FDI and portfolio equity has increased.

The third fact that motivates our paper is the negative relation between international flow imbalances and financial development. As a proxy for the latter we use 'Domestic Credit to the Private Sector.' This is the proxy often used in the finance-development literature (see, for example, Demirguc-Kunt

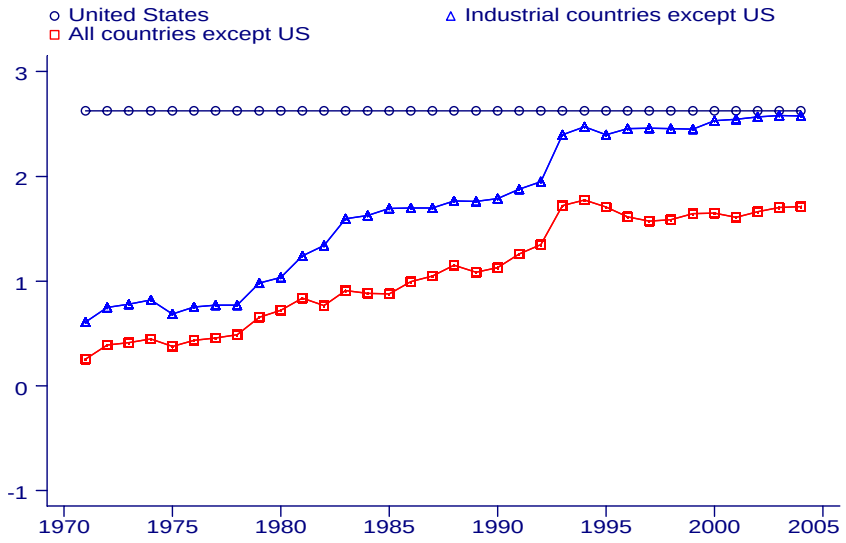


Figure 2: Financial openness index, 1970-2004. Source: Chinn and Ito (2005) and www.ssc.wisc.edu/~mchinn/research.html.

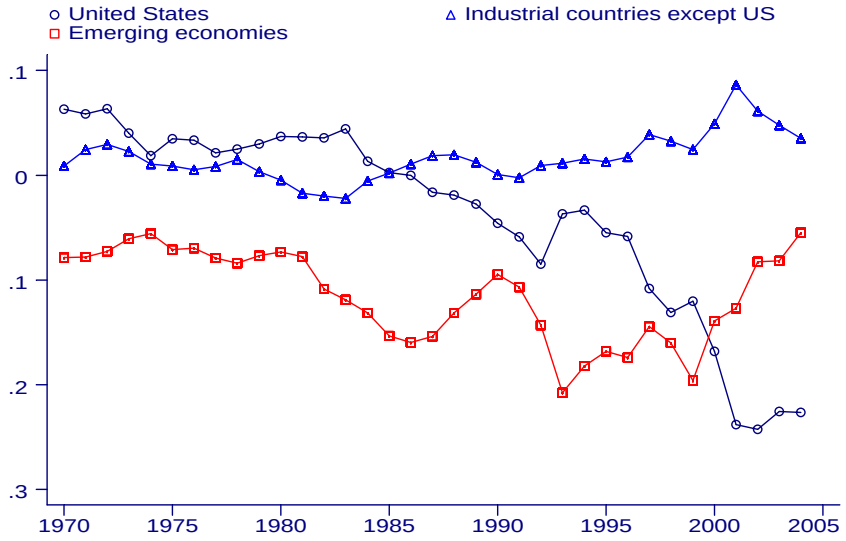


Figure 3: Net foreign asset position relative to GDP, 1970-2004. Source: Lane and Milesi-Ferretti (2006).

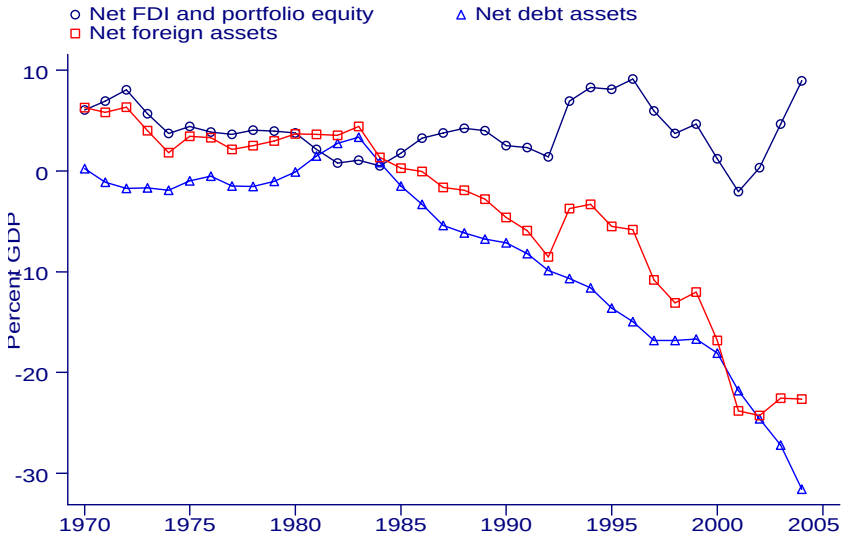


Figure 4: Composition of US foreign assets: Net positions in FDI and equities, and debt instruments, 1970-2004. Source: Lane and Milesi-Ferretti (2006).

and Levine (2001)), and is defined as the financial resources provided to the private sector, such as loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment. We study whether private credit is correlated with international flow imbalances, either 'Net Exports of Goods and Services' or the 'Current Account Balances'. To this end, we run the following regression:

$$NEX_{it} = \alpha_0 + \alpha_1 \cdot CREDIT_{it} + \alpha_2 \cdot CGDP_{it} + \varepsilon_{it} \tag{1}$$

where NEX is net exports (or current account) in percentage of GDP; $CREDIT$ is domestic credit to the private sector also in percentage of GDP; $CGDP$ is per-capita GDP. The subscripts identify country and year. The inclusion of per-capita GDP controls for the stage of economic development. We would like to emphasize that in running this regression we are not trying to establish a causal link. We are simply looking for conditional correlations.

We use yearly data for OECD countries for the period 2000-2004. The results are reported in the first column of Table 1. Figure 5 shows that the conditional correlation between domestic credit and net exports is negative and statistically significant. This suggests that countries with deeper

Table 1: Financial deepness and foreign imbalance in OECD countries

	Net Exports			**Current Account**		
	2000-2004	*1995-2004*	*1990-2004*	*2000-2004*	*1995-2004*	*1990-2004*
Pooled regression						
$CREDIT$	-0.0598	-0.0509	-0.0457	-0.0349	-0.0269	-0.0224
	*(0.0088)**	*(0.0068)**	*(0.0056)**	*(0.0099)**	*(0.0069)**	*(0.0055)**
$CGDP$	0.00063	0.00058	0.00054	0.00041	0.00039	0.00035
	*(0.00004)**	*(0.00003)**	*(0.00003)**	*(0.00005)**	*(0.00004)**	*(0.00003)**
$CONSTANT$	-8.287	-7.589	-6.867	-7.053	-6.713	-6.073
	*(0.950)**	*(0.688)**	*(0.539)*	*(1.121)**	*(0.722)**	*(0.538)**
R^2	0.633	0.525	0.468	0.353	0.318	0.285
Obs.	144	289	432	145	289	428
Fixed effect regression						
$CREDIT$		-0.0406	-0.0448		-0.0370	-0.0505
		*(0.0085)**	*(0.0066)**		*(0.0092)**	*(0.0077)**
$CGDP$		0.00029	0.00043		-0.00003	0.00014
		*(0.00006)**	*(0.00004)**		*(0.00006)*	*(0.00005)**
$CONSTANT$		-1.620	-4.442		3.897	0.913
		(1.191)	*(0.833)**		*(1.304)**	*(1.028)*
R^2 (within)		0.121	0.233		0.079	0.099
R^2 (between)		0.541	0.543		0.100	0.010
R^2 (overall)		0.472	0.461		0.049	0.013
Obs.		289	432		289	428

Notes: Data is from the World Bank, *World Development Indicators*. The countries included in the sample are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherland, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

* Significant at 1 percent level.

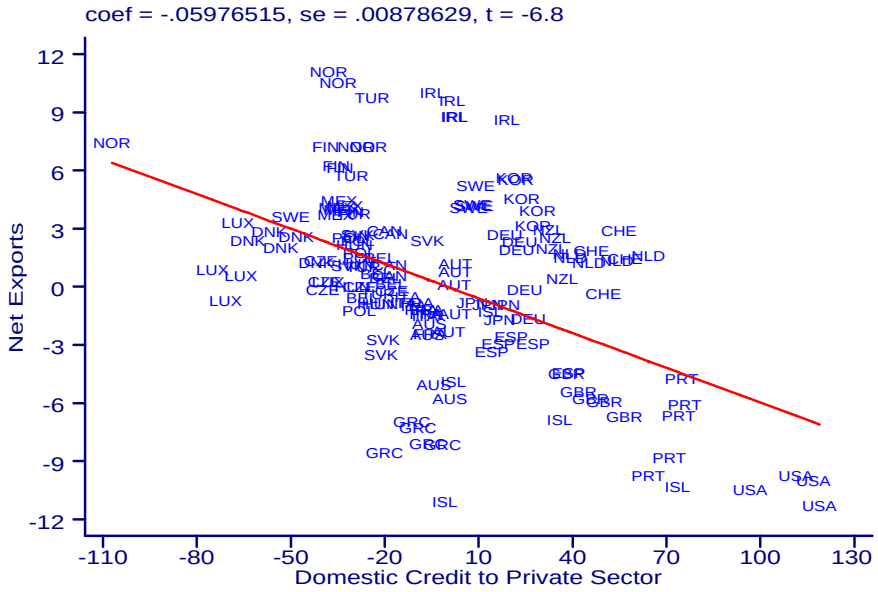


Figure 5: Net exports and domestic credit in OECD countries, 2000-2004. Source: See notes on Table 1.

financial markets tend to experience trade deficits while countries with lower financial deepness experience trade surpluses. Given the resource identity $S = I + NEX$, this can be restated as saying that countries with deeper financial markets save less than their domestic investment while countries with lower financial deepness save more. The variation of net exports accounted by domestic credit and per-capita GDP is quite high (R^2 above 60 percent).

The finding that countries with more developed financial markets tend to experience larger external deficits (i.e. the negative cross-country correlation between domestic credit and net exports) is robust to several changes in the estimation shwon in Table 1. First, we re-estimate equation 1 for 1995-2004 and 1990-2004 and obtain similar results, although the R^2 tends to decline as we extend the sample to earlier years. Second, the results are robust to the use of the current account as a measure of foreign imbalances. Finally, we estimate equation 1 with country fixed effects and largely confirm the findings from the pooled regression. The fixed effects results for 2000-2004 are not shown because of the short sample.

3 The model

Consider an economy composed of I countries or regions, indexed by i, all with identical characteristics except for the deepness of domestic financial markets. Financial deepness is captured by a parameter ϕ^i as specified below.

Each country is populated by a continuum of agents of total mass 1 who maximize expected lifetime utility $E\sum_{t=0}^{\infty}\beta^t U(c_t)$, where c_t is consumption at time t and β is the intertemporal discount factor. The utility function is strictly increasing and concave with $U(0) = -\infty$ and $U'''(c) > 0$.

Each country is endowed with unit supply of a non-reproducible, internationally immobile asset, traded at price P_t^i. The asset can be used by each individual agent in the production of a homogeneous good. The production function is $y_{t+1} = z_{t+1}k_t^{\nu}$, where k_t is the quantity of the asset used at time t, z_{t+1} is an *idiosyncratic* shock and y_{t+1} is the output produced at time $t+1$. We will refer to z_{t+1} as the *investment* shock as it determines the return on the investment k_t. Because the productive asset is internationally immobile, when agents buy the foreign asset they have to produce abroad.

In addition to production/investment income, agents receive an *idiosyncratic* stochastic endowment, w_t, that follows a discrete Markov process. Therefore, there are two types of uncertainty or risk: from endowment and from investment shocks.

One key difference between endowment and investment risks is that the first is beyond the control of the agent while the second can be avoided by choosing not to produce, that is, by choosing not to purchase the productive asset. The consideration of investment shocks allows us to distinguish risky from riskless investments so that agents face a nontrivial portfolio choice. We can then study not only how financial markets heterogeneity affects net foreign asset positions but also their composition.

It is important to emphasize that production is individually run and shocks are idiosyncratic. There are no aggregate shocks. Therefore, cross-country risk-sharing is not an issue here. Also notice that there is no aggregate accumulation of capital. This assumption is relaxed in Section 6 and we find that our key findings remain unaltered.

Let $s_t \equiv (w_t, z_t)$ be a pair of endowment and investment shocks and $g(s_t, s_{t+1})$ their conditional probability distribution. Agents can buy contingent claims, $b(s_{t+1})$, that depend on the next period's realizations of these shocks. Because there is no aggregate uncertainty, the price of one unit of consumption goods contingent on the realization of s_{t+1} is $q_t^i(s_t, s_{t+1}) =$

$g(s_t, s_{t+1})/(1 + r_t^i)$, where r_t^i is the equilibrium interest rate.

Define a_t as the end-of-period net worth before consumption. The budget constraint is:

$$a_t = c_t + k_t P_t^i + \sum_{s_{t+1}} b(s_{t+1}) q_t^i(s_t, s_{t+1}) \tag{2}$$

The net worth evolves according to:

$$a(s_{t+1}) = w_{t+1} + k_t P_{t+1}^i + z_{t+1} k_t^\nu + b(s_{t+1}) \tag{3}$$

If asset markets were complete (i.e. without restrictions on the set of feasible claims), agents would be able to perfectly insure against the endowment and investment risks. Because of market frictions, however, the set of feasible claims is constrained in each country. We consider two types of constraints. First, an enforceability constraint that is derived from the assumption that shocks are not verifiable and agents can divert part of the incomes from endowment and production. Agents loose a fraction ϕ^i of the income they divert, so ϕ^i measures the degree of enforcement of financial contracts in country i. Second, a limited liability constraint: contracts are not exclusive and there is limited liability. This implies that the end-of-period net worth cannot be negative. Appendix A shows that, under these conditions, incentive-compatibility imposes the following constraints:

$$a(s_j) - a(s_1) \geq (1 - \phi^i) \cdot \left[(w_j + z_j k_t^\nu) - (w_1 + z_1 k_t^\nu) \right] \tag{4}$$

$$a(s_j) \geq 0 \tag{5}$$

for all $j \in \{1, ..., N\}$. Here N denotes the number of possible realizations of the two shocks and s_1 is the lowest (worse) realization.

The first condition requires that the variation in net worth, $a(s_j) - a(s_1)$, cannot be smaller than the variation in income, scaled by $1 - \phi^i$. When ϕ^i is sufficiently large, agents are able to maintain constant consumption (full insurance). When $\phi^i = 0$—implying that income can be diverted without losses—only non-state-contingent claims are feasible. The second constraint imposes limited liability.

Two key points of this setup are worth emphasizing. First, ϕ^i pertains to the residency of the agents, regardless of the geographic location of the assets they own. In particular, if asset markets are globally integrated, domestic agents can buy foreign productive assets and receive foreign income, but still

their feasible claims are determined by the domestic, not the foreign ϕ. This assumption implies that the ability of an agent to divert investment incomes generated abroad depends on the institutional, legal and contractual environment of the residence country.[4] Second, what is crucial for our results is the limited ability to insure idiosyncratic risks, and not the specific source of markets incompleteness. We chose here a setup based on limited verifiability of shocks and limited liability because of its analytical simplicity. Other frictions, such as information asymmetries, would lead to similar results as long as they limit the agents' ability to insure away idiosyncratic risk.

3.1 Optimization problem and equilibrium

Let $\{P^i_\tau, q^i_\tau(s_\tau, s_{\tau+1})\}^\infty_{\tau=t}$ be a (deterministic) sequence of prices in country i. A single agent's optimization problem can be written as:

$$V^i_t(s,a) = \max_{c,k,b(s')} \left\{ U(c) + \beta \sum_{s'} V^i_{t+1}\Big(s', a(s')\Big) g(s,s') \right\} \tag{6}$$

subject to

$$(2), (3), (4) \text{ and } (5)$$

where we have used the convention of denoting current 'individual' variables without subscript and next period 'individual' variables with the prime superscript. Notice that this is the optimization problem for any deterministic sequence of prices, not only steady states. This motivates the time subscript in the value function.

The solution to the agent's problem provides the decision rules for consumption, $c^i_t(s,a)$, productive assets, $k^i_t(s,a)$, and contingent claims $b^i_t(s,a)(s')$. These rules determine the evolution of the distribution of agents over s, k and b, which we denote by $M^i_t(s,k,b)$. The definition of equilibria with and without international mobility of capital are as follows:

Definition 1 (Autarky) *Given the financial deepness, ϕ^i, and initial distributions, $M^i_t(s,k,b)$, for $i \in \{1,..,I\}$, a general equilibrium without mobility is defined by sequences of: (i) policies $\{c^i_\tau(s,a), k^i_\tau(s,a), b^i_\tau(s,a)(s')\}^\infty_{\tau=t}$;*

[4] One way to think about this assumption is that agents repatriate the incomes earned abroad. Once the incomes are transferred back to the home country, the verifiability of these incomes is determined by the local institutions.

(ii) value functions $\{V_\tau^i(s,a)\}_{\tau=t}^\infty$*; (iii) prices* $\{P_\tau^i, r_\tau^i, q_\tau^i(s,s')\}_{\tau=t}^\infty$*; (iv) distributions* $\{M_\tau^i(s,k,b)\}_{\tau=t+1}^\infty$*. Such that: (i) the policy rules solve problem (6) and* $\{V_\tau^i(s,k)\}_{\tau=t}^\infty$ *are the associated value functions; (ii) prices satisfy* $q_\tau^i = g(s,s')/(1+r_t^i)$*; (iii) asset markets clear,* $\int_{s,k,b} k_\tau^i(s,a) M_\tau^i(s,k,b) = 1$*,* $\int_{s,k,b,w'} b_\tau^i(s,a)(w') M_\tau^i(s,k,b) g(s,s') = 0$ *for all* $\tau \geq t$ *and in each country* $i \in \{1,..,I\}$*; (iv) the sequence of distributions is consistent with the initial distribution, the individual policies and the idiosyncratic shocks.*

Definition 2 (Financial integration) *Given the financial deepness,* ϕ^i*, and initial distributions,* $M_t^i(s,k,b)$*, for* $i \in \{1,..,I\}$*, a general equilibrium with mobility of capital is defined by sequences of: (i) agents' policies* $\{c_\tau^i(s,a), k_\tau^i(s,a), b_\tau^i(s,a)(s')\}_{\tau=t}^\infty$*; (ii) value functions* $\{V_\tau^i(s,a)\}_{\tau=t}^\infty$*; (iii) prices* $\{P_\tau^i, r_\tau^i, q_\tau^i(s,s')\}_{\tau=t}^\infty$*; (iv) distributions* $\{M_\tau^i(s,k,b)\}_{\tau=t+1}^\infty$*. Such that: (i) the policy rules solve problem (6) and* $\{V_\tau^i(s,k)\}_{\tau=t}^\infty$ *are the associated value functions; (ii) prices satisfy* $q_\tau^i = g(s,s')/(1+r_t^i)$*,* $P_\tau^i = P_\tau$ *and* $r_\tau^i = r_\tau$*, for all* $i \in \{1,..,I\}$*; (iii) asset markets clear,* $\sum_i \int_{s,k,b} k_\tau^i(s,a) M_\tau^i(s,k,b) = I$*,* $\sum_i \int_{s,k,b,s'} b_\tau^i(s,a)(s') M_\tau^i(s,k,b) g(s,s') = 0$ *for all* $\tau \geq t$*; (iv) the sequence of distributions is consistent with the initial distribution, the individual policies and the idiosyncratic shocks.*

The only difference in the two definitions is that with financial integration there is a global market for assets, and hence asset prices are equalized across countries (conditions (ii) and (iii)). This also implies that the assets owned by a country are no longer equal to the assets located in the country. Therefore, foreign asset positions are not necessarily zero. Also notice that one country may hold a larger share of the world productive asset than its domestic share. In this case a fraction of this country's agents will be producing abroad. However, the set of feasible claims still depends on the domestic ϕ^i.

4 Characterization of the equilibrium

This section characterizes the properties of the equilibrium with and without international financial integration. To illustrate these properties, it is convenient to consider first the special cases with only endowment or investment risks. This clarifies the different role played by these two shocks.

4.1 Endowment shocks only

Consider first the case in which z is not stochastic, that is, $z = \bar{z}$ and the only source of idiosyncratic uncertainty is the endowment w. Denote by $\bar{\phi}$ a sufficiently high value of the enforcement parameter so that the enforcement constraint (4) is not binding. When shocks are iid, this is obtained by setting $\bar{\phi} = 1$. With persistent shocks, however, $\bar{\phi}$ must be strictly greater than 1. To show the importance of financial deepness, we compare the limiting cases of complete markets ($\phi = \bar{\phi}$) and non-state-contingent assets only ($\phi = 0$). First we look at the autarky regime and then the regime with financial integration.

When $\phi = \bar{\phi}$, constraint (4) is not binding by definition. Therefore, the first-order conditions with respect to k and $b(w')$ are:

$$U'(c) = \beta(1 + r_t)U'(c(w')) + (1 + r_t)\lambda(w'), \qquad \forall\, w' \tag{7}$$

$$U'(c) = \beta R_t(k, \bar{z})EU'(c(w')) + R_t(k, \bar{z})E\lambda(w') \tag{8}$$

where $\lambda(w')$ is the Lagrange multiplier associated with the limited liability constraint (5) and $R_t(k, \bar{z}) = (P_{t+1} + \nu\bar{z}k^{\nu-1})/P_t$ is the gross marginal return from the productive asset. Notice that $R_t(k, \bar{z})$ is strictly decreasing in k.

The first condition holds for any realization of w', which implies that next period consumption, $c(w')$, must be the same for all w' (full insurance).[5]

The second condition, together with the first, implies $R_t(k, \bar{z}) = 1 + r_t$, that is, the marginal return from the productive asset is equal to the interest rate. Because $R_t(k, \bar{z})$ is strictly decreasing in k, this implies that all agents choose the same input of the productive asset, that is, $k = 1$. Given that the supply of the productive asset is fixed, total output is also fixed. The following lemma establishes that the equilibrium must satisfy $\beta(1 + r_t) = 1$.

Lemma 1 *Consider the autarky regime and assume $\phi = \bar{\phi}$. Then the interest rate and the price of the asset are constant and equal to $r = 1/\beta - 1$ and $P = \nu\bar{z}/r$.*

Proof 1 *If $\beta(1 + r_t) = 1$ is not satisfied, condition (7) implies that the consumption growth of all agents will be either positive or negative. This cannot be an equilibrium because aggregate output is constant. Therefore, $r_t =$*

[5] This is obvious when the limited liability constraint is not binding so that $\lambda(w') = 0$. It can be shown that this also holds when $\lambda(w') > 0$.

$1/\beta - 1$. *Using the fact that all agents use the same units of the productive asset,* $k = 1$, *conditions (7) and (8) imply* $(P_{t+1} + \nu\bar{z})/P_t = 1 + r_t$. *The only stationary solution for this difference equation is* $P_t = P_{t+1} = \nu\bar{z}/r_t$. *Q.E.D.*

This establishes that with $\phi = \bar{\phi}$ we are in an economy with complete markets. Let's look now at the other limiting case in which $\phi = 0$. The enforceability constraint (4) imposes that $b(w_1) = ... = b(w_N) = b$, that is, claims cannot be state-contingent. The first-order conditions are:

$$U'(c) = \beta(1 + r_t)\, EU'(c(w')) + (1 + r_t)E\lambda(w') \tag{9}$$

$$U'(c) = \beta R(k, \bar{z})EU'(c(w')) + R(k, \bar{z})E\lambda(w') \tag{10}$$

In this case we have again that $R_t(k, \bar{z}) = 1 + r_t$ and the input of the productive asset is the same for all agents. Individual consumption, however, is not constant but depends on the realization of the endowment. This is a standard Bewley (1986) economy with uninsurable endowment risks. Because all agents use the same input of the productive asset, which is in limited supply, they get the same investment income. As it is known from the savings literature (see Huggett (1993), Ayagari (1994) and Carroll (1997)), the uninsurability of the idiosyncratic risk generates precautionary savings and in the steady state $\beta(1 + r_t) < 1$.

Lemma 2 *Consider the autarky regime and assume* $\phi = 0$. *Then the interest rate satisfies* $r_t < 1/\beta - 1$ *and the steady state price is* $P = \nu\bar{z}/r$.

Proof 2 *Suppose that* $\beta(1 + r_t) \geq 1$. *Because* $U'(.)$ *is convex, condition (7) implies that, for all agents, the expected next period consumption is bigger than current consumption. Therefore, next period aggregate consumption will also be greater than today consumption. This cannot be an equilibrium because aggregate income is constant. Therefore,* $r_t < 1/\beta - 1$. *Using the fact that all agents employ the same productive asset,* $k = 1$, *conditions (7) and (8) imply* $(P_{t+1} + \nu\bar{z})/P_t = 1 + r_t$. *In the steady state the price and the interest rate are constant. Therefore,* $P = \nu\bar{z}/r$. *Q.E.D.*

Lemmas 1 and 2 establish that in autarky the economy with lower financial deepness ($\phi = 0$) has a lower interest rate and, at least in the steady

state, a higher price for the asset. Let's consider now the regime with capital mobility between two countries with different financial deepness. Suppose that country 1 has $\phi^1 = \bar{\phi}$ and country 2 has $\phi^2 = 0$. The following proposition characterizes the steady state equilibrium with capital mobility.

Proposition 1 *Suppose that $\phi^1 = \bar{\phi}$ and $\phi^2 = 0$. In the equilibrium with financial integration, $r_t < 1/\beta - 1$ and country 1 accumulates a negative net foreign asset position but holds a zero net position in the productive asset.*

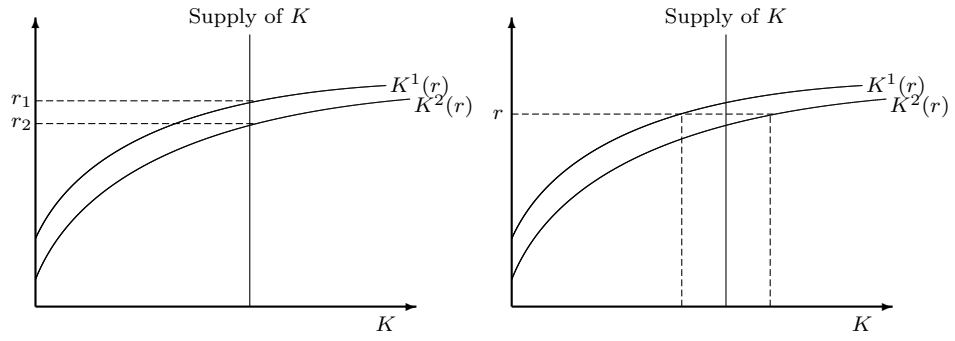
Proof 1 *Appendix B.*

The case with $\phi^1 = \bar{\phi}$ and $\phi^2 = 0$ allowed us to establish analytical results. From these results we can infer the properties of the equilibrium for intermediate values of ϕ. In general, lower values of ϕ increase precautionary savings and reduce the equilibrium interest rate. Figure 6 shows the equilibrium of the model under autarky and under financial integration. The figure plots the aggregate demand for assets (i.e. savings) in each country as an increasing, concave function of r.[6] Country 1 has deeper financial markets ($\phi^1 > \phi^2$), and hence lower asset demand for each interest rate. Because the supply of the productive asset is fixed, aggregate net savings (in terms of the productive asset) must be zero under autarky in each country. This requires a higher autarky interest rate in country 1 ($r^1 > r^2$).

When the countries become financially integrated, the prices of the productive asset and the interest rates are equalized. Compared to autarky, the interest rate and the demand for assets (in units of K) fall in country 1 and rise in country 2, and hence the country with deeper financial markets ends up with a negative foreign asset position.

A similar result is obtained by Willen (2004) in a two-period endowment economy with incomplete asset markets and trade, but without investment shocks. However, as stated in Proposition 1, endowment shocks alone cannot generate differences in portfolio composition between financial and productive assets. As we will see in the next section, it is the presence of investment shocks that generates differences in portfolio composition.

[6]The asset demand curves in Figure 6 correspond to the well-known average asset demand curve from the closed-economy heterogenous agents literature (e.g. Aiyagari (1994)). Average asset demand diverges to infinity as the interest rate approaches the rate of time preference from below, because agents need an infininte amount of precautionary savings as they aim to attain non-stochastic consumption while their income remains stochastic.



a) Autarky *b*) Mobility

Figure 6: Steady state equilibria with heterogeneous financial conditions.

To summarize, the analysis of this section shows that the economy with only endowment shocks can generate nonzero foreign asset positions but cannot account for differences in the composition of foreign portfolios. For this we need investment shocks.

4.2 Investment shocks only

We now consider the case in which the productivity z is stochastic while the endowment is constant, that is, $w = \bar{w}$. The assumption that investment income is stochastic allows us to distinguish debt instruments from risky investments such as FDI. Also in this case it will be convenient to compare the limiting cases of $\phi = \bar{\phi}$ and $\phi = 0$, starting with autarky.

When $\phi = \bar{\phi}$, the first order conditions are:

$$U'(c) = \beta(1 + r_t)U'(c(z')) + (1 + r_t)\lambda(z'), \qquad \forall\, w' \tag{11}$$

$$U'(c) = \beta E R_t(k, z')U'(c(z')) + E\lambda(z')R_t(k, z') \tag{12}$$

The first condition holds for any realization of z'. Therefore, the next period consumption, $c(z')$, must be the same for all realizations of z' (full insurance). Because next period consumption is not stochastic, conditions (11) and (12) imply that $ER_t(k, z') = 1 + r_t$. Therefore, there is no marginal premium for investing in the productive asset and k is the same for all agents. Thus, Lemma 1 also applies here and the only equilibrium is characterized

by $\beta(1+r_t)=1$. Intuitively, because agents can insure perfectly against the idiosyncratic risk, there are no precautionary savings and in equilibrium the interest rate must be equal to the intertemporal discount rate.

Let's look now at the case with $\phi=0$. The incentive-compatibility constraint (4) imposes that $b(z_1)=...=b(z_N)=b$, that is, claims cannot be state contingent. The first order conditions are:

$$U'(c) = \beta(1+r_t)\,EU'(c(z')) + (1+r_t)E\lambda(z') \tag{13}$$

$$U'(c) = \beta EU'(c(z'))R_t(k,z') + E\lambda(z')R_t(k,z') \tag{14}$$

Lemma 2 also applies here, that is, the equilibrium interest rate is smaller than the intertemporal discount rate when $\phi=0$. This can be proved by following the same steps of the proof of Lemma 2. The main difference with the case of endowment shocks is that now there is a premium over the interest rate for the expected marginal return from the risky asset. To see this, consider the case in which the borrowing limit is not binding. Then conditions (13) and (14) imply:

$$(1+r_t)EU'(c(z')) = ER_t(k,z')EU'(c(z')) + \mathrm{Cov}\Big(R_t(k,z')\,,\,U'(c(z'))\Big)$$

Because $U'(c(z'))$ is in general negatively correlated with $R_t(k,z')$, the last term on the right-hand-side is negative. Therefore, $ER_t(k,z')>1+r_t$, that is, there is a marginal premium for investing in the risky asset.

Now suppose that the two countries become financially integrated. The first country has $\phi^1=\bar{\phi}$ and the second $\phi^2=0$. The following proposition characterizes the new steady state equilibrium with capital mobility.

Proposition 2 *Suppose that $\phi^1=\bar{\phi}$ and $\phi^2=0$. In the steady state with financial integration, $r<1/\beta-1$. Country 1 has a negative net foreign asset position but a positive position in the productive asset. The average return of country 1's foreign assets is larger than the cost of its liabilities.*

Proof 2 *Appendix B.*

The proposition shows that, with investment shocks, countries with deeper financial markets invest in foreign (high return) assets and finance the investment with foreign debt. In the particular case in which the most developed

country has $\phi^1 = \bar{\phi}$, this country ends up with a negative net foreign asset position. The negativity of the net position, however, cannot be generalized to any values of ϕ. Intuitively, if country 1 has a greater ability to insure than country 2 but the insurance is not perfect, then it will continue to buy some of the foreign risky asset. By purchasing more of the risky asset, however, agents take more risk. This in turn may generate enough precautionary savings up to the point in which the foreign borrowing of country 1 becomes smaller than the value of the risky assets held abroad. Still, the foreign position in productive assets is always positive, so this is a general result.[7]

Another important point is that, if country 1 cannot insure perfectly against the investment risk, there will be a marginal risk premium also for country 1. This further increases country 1's return from the foreign investment relative to the cost of its foreign liabilities.

4.3 Both endowment and investment shocks.

With both endowment and investment shocks, the first order conditions with $\phi = \bar{\phi}$ and $\phi = 0$ are also given by (11)-(14). The only difference is that next period consumption depends on both shocks, that is, $c(s')$. Lemmas (1) and (2) also apply to this case. We then have the following proposition.

Proposition 3 *Suppose that $\phi^1 = \bar{\phi}$ and $\phi^2 = 0$. In the steady state with capital mobility, $r < 1/\beta - 1$. Country 1 has a negative net foreign asset position but a positive position in the foreign productive asset. The average return of country 1 foreign ownership is bigger than the cost of its liabilities.*

Proof 3 *Same as in Proposition 2.*

This is a restatement of proposition 2. In the extreme case of $\phi^1 = \bar{\phi}$ and $\phi^2 = 0$, the addition of endowment shocks does not change the main properties of the equilibrium. Some of these properties, however, cannot be generalized to any value of $\phi^1 < \phi^2$. In particular, while it is always true that the steady state interest rate is smaller than the intertemporal discount rate and country 1 always acquires a positive net position in foreign productive

[7]The concavity of the production function, $\nu < 1$, is crucial here. With a linear technology, as in Angeletos (2006), the most developed country would own all of the world's risky asset. This implies that the less developed country does not face any risk, and therefore, has no incentive to save.

assets, its total net foreign asset position is not necessarily negative. This depends on the relative importance of the two shocks: as long as the endowment shock is sufficiently large, compared to the investment shock, country 1 holds a negative net foreign asset position.

5 Quantitative analysis

In this section we parameterize the model and show its quantitative properties. The analysis is limited to two countries: the first is representative of the United States while the second aggregates all other countries.

5.1 Calibration

We calibrate the model to match the U.S. share of world GDP, which is about 30 percent. The model can be calibrated to reflect this fact in two ways: by fixing the population size and supply of the productive asset in country 1 to 30 percent of the worldwide quantities, or by setting the average endowment and productivity of country 1 to 30 percent of the worldwide values. These two approaches lead to the same results, but the first approach is easier to work with because differences in size matter only for the market-clearing conditions.[8]

The stochastic endowment takes two values, that is, $w = \bar{w}(1 \pm \Delta_w)$, with symmetric transition probability matrix. The investment shock also takes two values, that is, $z = \bar{z}(1 \pm \Delta_z)$ but it is assumed to be *iid*. Interpreting w as labor income and y as net capital income, we set $\bar{w} = 0.85$ and then we parameterize the production function so that $y = \bar{z}k^{\nu} = 0.15$. Because per-capita assets are $k = 1$, this requires $\bar{z} = 0.15$. The return to scale parameter is set to $\nu = 0.75$.

For the calibration of the stochastic component of the endowment we follow recent estimates of the U.S. earning process and set the persistence probability to 0.95 and $\Delta_w = 0.6$. These values imply an autocorrelation coefficient of 0.9 and a standard deviation of log-earnings of 0.30. This is in the ranges of values estimated by Storesletten, Telmer & Yaron (2004). The

[8]Let μ^i be the share of country i and define B^i and K^i as the per-capita financial claims and productive assets owned by agents in country i. The worldwide market clearing conditions are $B^1\mu^1 + B^2\mu^2 = 0$ and $K^1\mu^1 + K^2\mu^2 = 1$. With productivity differences the per-capita aggregates B^i and K^i would be rescaled by the relative productivity.

variation in the investment shock is set to $\Delta_z = 2.5$. With this parameterization, the return on the productive asset fluctuates between -6% and 15%. This approximates the observed volatility of firm-level profits.

Next we choose the parameters of the financial structure, ϕ^1 and ϕ^2. Several indicators, such as those reported in Figure 1, suggest that financial markets are significantly different across countries. However, it is difficult to derive a direct mapping from these indicators to actual values of ϕ^i. Given these difficulties, we take a pragmatic approach. We begin by assigning $\phi^1 = 0.4$ and $\phi^2 = 0$ but then we conduct a sensitivity analysis. These values imply that contingent claims are not feasible in country 2 while they are partially feasible in country 1. The equilibrium allocation in country 1 is similar to the allocation that would be achieved if contingent claims were not available but the volatility of the endowment was 40 percent lower. In this sense we can say that the financial structure of country 1 is about 40 percent more advanced than country 2.[9]

The utility function is CRRA with the coefficient of risk aversion set to $\sigma = 2.5$. The intertemporal discount rate is chosen to obtain a worldwide wealth-to-income ratio of 3.5 in the steady state with financial integration. This is the approximate value resulting from survey data such as the Survey of Consumer Finances for the US. The required value of β is 0.915.

5.2 Results

Table 2 reports some key variables in the steady state equilibria before and after international financial integration. Three cases are considered: A) the baseline model with both shocks, B) endowment shocks only, and C) investment shocks only. The transition dynamics following capital markets liberalization are plotted in Figures 7 and 8. For the description of the computational procedure see the appendix.

5.2.1 Case A: Both Shocks

Long Run Properties. The stationary equilibrium with capital mobility is characterized by country 1 having a positive position in productive assets

[9] According to the data shown in Figure 1, the difference between the financial index for the US and the average index for all other advanced economies is about 40 percent. Therefore, it seems reasonable to start with $\phi^1 = 0.4$ and $\phi^2 = 0$.

but a much larger negative position in riskless bonds. The country net position in bonds is measured as the sum of the claims b of all agents in the country. As a percent of income, country 1's debt position is nearly -168 percent and its position in foreign risky assets is 117 percent. As a result, the net foreign asset position is negative and quite large, at about -50 percent of income. Because of the higher return from the foreign holdings of risky assets, country 1 receives positive factor payments, equivalent to 0.27 percent of income, despite the negative net foreign asset position. Moreover, these large changes in asset positions are accompanied by small changes in asset prices and the risk free interest rates. The interest rate in country 1 falls by just 70 basis points relative to its autarky value. Interestingly, Warnock and Warnock's (2006) estimated the effect of foreign purchases on the yield for 10-year U.S. Treasury bills and showed that foreign purchases have contributed to a decline of about 50 basis points on average between 1984 and 2005. Thus, the model is consistent with the data in that the large decline in the U.S. net foreign assets coincided with the globalization of capital markets, and with a negative but small effect of foreign inflows on the U.S. risk-free interest rate.

Transition after liberalization. Figure 7 plots the dynamics of several variables. Before financial integration, both countries were in the autarky steady state and the opening of world capital markets is not anticipated. As can be seen from the first panel, the decline in the net foreign asset position of country 1 is a slow, gradual process. The current account drops to a deficit of 4 percent of output on impact and remains in deficit for many periods until it balances in the limit.

The pattern of a large initial deficit followed by gradual recovery is a consequence of the particular exercise we are conducting, where capital markets are fully integrated overnight. In reality, the process of financial integration has been gradual (see Figure 2). With gradual integration, the current account dynamics would been more in line with the U.S. data.[10]

Figure 7 also plots the composition of foreign assets and the current

[10]In the data, there are also well-known shocks driving U.S. current account deficits, such as oil price shocks and the collapse of investment rates in Asia after the 1997-98 Sudden Stops. However, the goal of our analysis is not to track the cyclical pattern of the U.S. current account, but to explain the secular decline in its net foreign assets since the mid 1980s. Because flows are usually more volatile than stocks, we believe that understanding the dynamics of net foreign assets is a more fundamental question.

Table 2: Steady state with and without capital mobility.

	Autarky		**Capital mobility**	
	Country 1	*Country 2*	*Country 1*	*Country 2*
A) Both shocks				
Asset price	3.24	3.69	3.54	3.54
Interest rate	3.08%	2.30%	2.56%	2.56%
Return on risky asset	4.57%	3.94%	3.89%	4.28%
Foreign asset position	-	-	-50.31%	21.31%
Foreign bonds	-	-	-167.62%	70.98%
Foreign risky asset	-	-	117.31%	-49.68%
Net exports	-	-	-0.27%	0.11%
Net factor payments	-	-	0.27%	-0.11%
B) Endowment shocks only				
Asset price	3.08	3.44	3.33	3.33
Interest rate	3.66%	3.27%	3.38%	3.38%
Return on risky asset	4.87%	4.36%	4.50%	4.50%
Foreign asset position	-	-	-45.85%	19.65%
Foreign bonds	-	-	-45.85%	19.65%
Foreign risky asset	-	-	0.00%	0.00%
Net exports	-	-	1.55%	-0.66%
Net factor payments	-	-	-1.55%	0.66%
C) Investment shocks only				
Asset price	1.23	1.17	1.20	1.20
Interest rate	8.31%	7.02%	7.58%	7.58%
Return on risky asset	12.18%	12.66%	11.54%	12.99%
Foreign asset position	-	-	-17.78%	7.51%
Foreign bonds	-	-	-62.43%	26.36%
Foreign risky asset	-	-	44.64%	-18.85%
Net exports	-	-	-0.42%	0.18%
Net factor payments	-	-	0.42%	-0.18%

Notes: Foreign asset positions, current account, net exports and net factor payments are in percentage of domestic income (endowment plus domestic dividends).

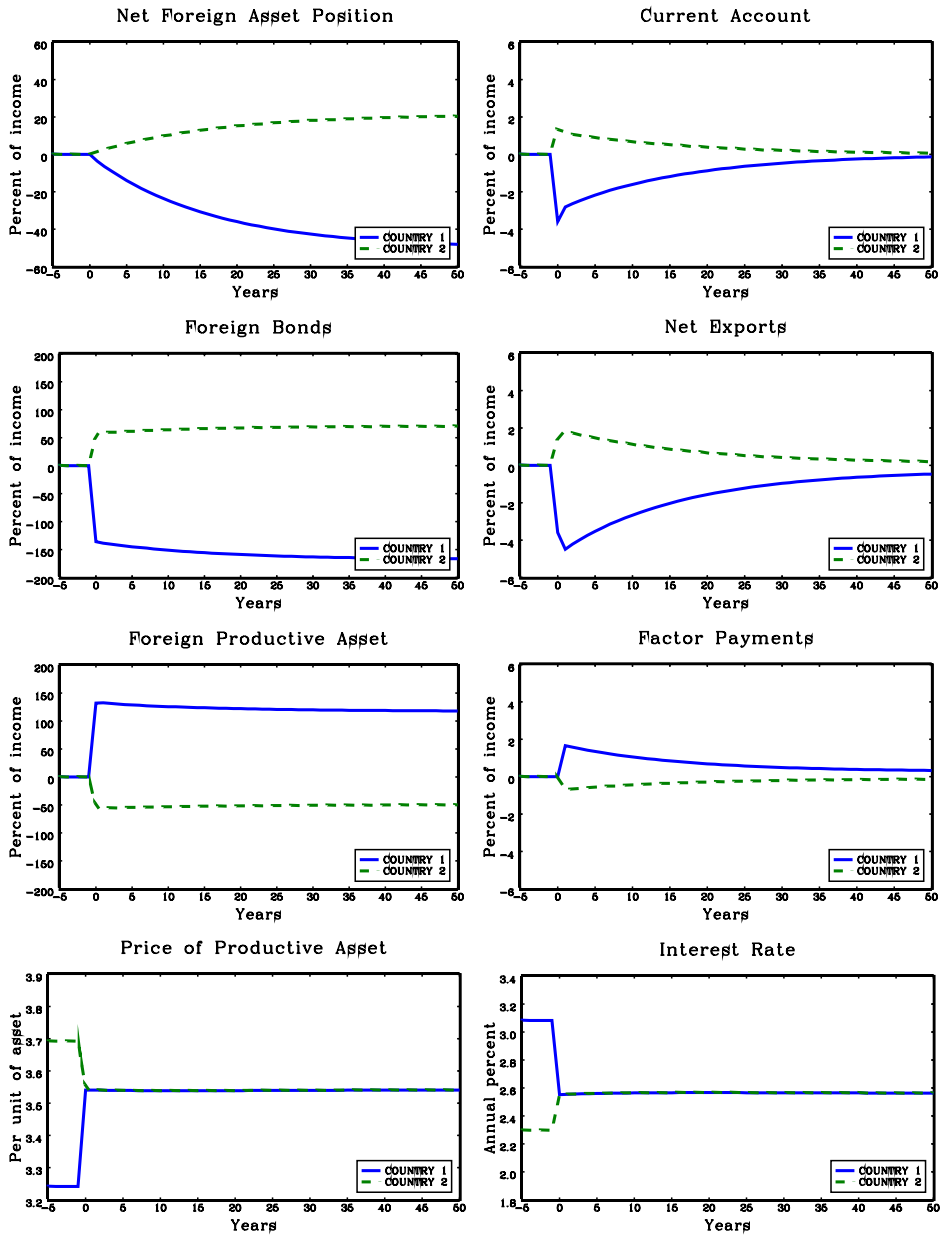


Figure 7: Transition dynamics after capital markets liberalization.

account. Immediately after financial integration, country 1 purchases a large quantity of foreign productive assets financed with foreign debt. As the country's wealth declines (due to lower savings), the foreign exposure to the risky investment is partially reduced. Despite the negative foreign asset position, country 1 receives net factor payments from abroad due to the higher return on the productive assets. These payments, however, are more than compensated by negative net exports and thus the country experiences current account deficits until it reaches the steady state. Notice that the portfolio adjustment is very drastic. The reallocation of the portfolio across debt and risky investments would be smoother if there were adjustment costs and/or the liberalization of capital markets was gradual.

In summary, the results for case A) highlight three important points. First, the country with deeper financial markets takes a positive position in foreign risky assets. Because this position is more than compensated by foreign borrowing, the country's net foreign asset position is negative. Still, the higher return from the risky assets allows this country to receive net positive factor payments from abroad. Second, the magnitude of the total net foreign liabilities can be large, about half the value of domestic production. Third, the formation of the external imbalances is a gradual process that takes a long period of time: only 2/3 of the long-run net foreign asset position is accumulated in the first 15 years.

5.2.2 Cases B and C: One shock only

Long Run Properties. Endowment shocks alone can produce a large negative foreign asset position (of roughly -46 percent of output). However, they cannot explain the observed shift in the composition of the portfolios of foreign assets. By contrast, the setup with only investment shocks does produce a portfolio with a substantial increase in debt and a positive position in foreign risky assets. However, the total net foreign asset position at steady state (-18 percent of output) is small compared to what we see in U.S. data.

Transition after liberalization. Figure 8 plots the transition dynamics in country 1 following financial integration in cases A), B), and C). As can be seen, the dynamics with only one shock are qualitatively similar to those with both shocks. They only differ in magnitude.

In summary, as anticipated in Section 4, the economy with only endowment shocks generates large net foreign asset positions but cannot capture

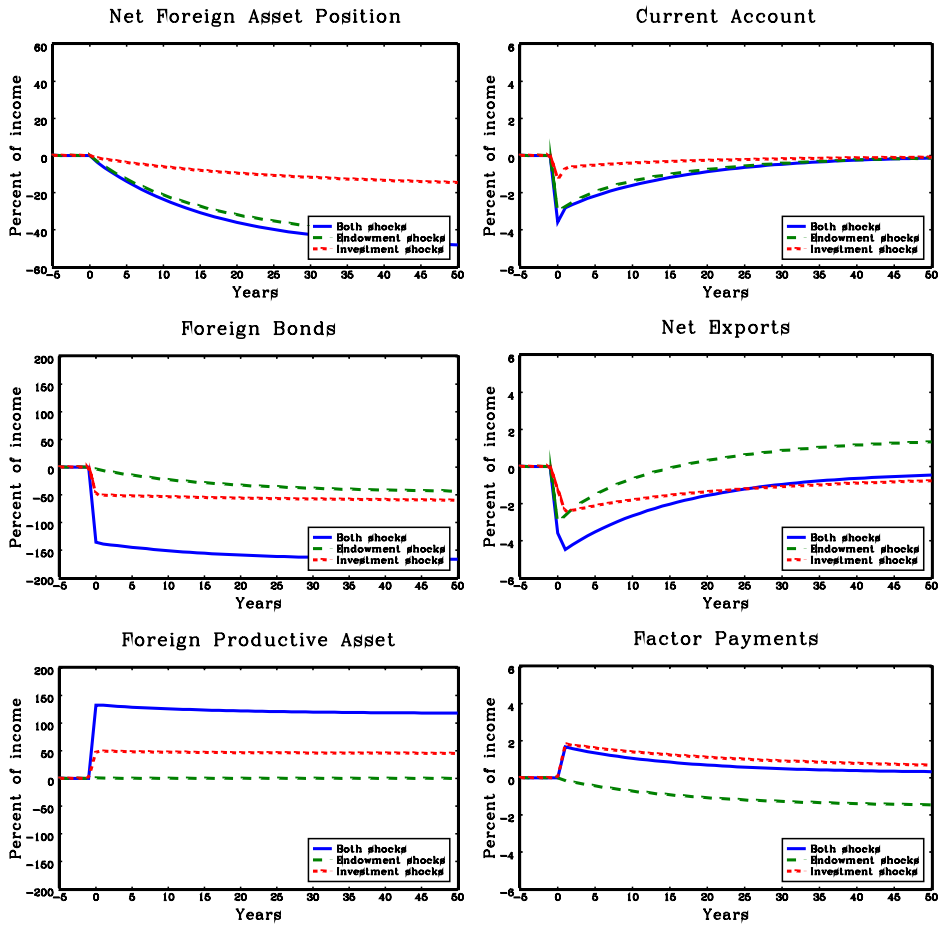


Figure 8: Transition dynamics in country 1 for different type of risks.

the fact that a share of US foreign holdings are in high-return assets in the form of portfolio equity and FDI. On the other hand, the economy with only investment shocks accounts for the US foreign ownership of high-return assets but it generates a small net foreign asset position.[11] By combining endowment and investment shocks, we can capture both features of the US

[11]For some parameterizations, country 1 may accumulate positive asset positions. This seems to contradict Proposition 2. This proposition, however, applies only to the case with $\phi^1 = \bar{\phi}$. As remarked in Section 4.2, the country with better financial markets invests more in the risky asset. By doing so, it also takes more risk which increases the incentive to save. As a result, the country may end up accumulating a positive net foreign asset position.

international asset position: large net foreign liabilities and a portfolio composition tilted toward high-return assets.

5.3 Welfare consequences of financial integration

We examine next the normative implications of the model. We are interested in answering two questions: Is international financial integration welfare enhancing for the participating countries?, and how are the welfare effects distributed amongst the population of each country?

Figure 9 plots the welfare consequences of financial integration in countries 1 and 2 as a function of net worth, a, and for different realizations of the endowment.[12] We show the results for the same three cases reported in Table 2: the model with endowment and investment shocks, endowment shocks alone and investment shocks alone. The welfare effects are computed as the percentage increase in consumption in the autarky steady state that makes agents indifferent between remaining in autarky and shifting to the regime with financial integration.

All three charts show that agents with lower initial wealth gain in country 1 and lose in country 2. This is a consequence of the changes in interest rates after financial integration. The interest rate falls in country 1, and this is beneficial for poorer agents because they are net borrowers and harmful for wealthy agents because they are net lenders. The opposite is true in country 2 where the interest rate increases after financial integration.

The aggregate welfare effects are computed using an equally weighted welfare function. Because all agents are weighted equally, the aggregate welfare effects depend on the initial distribution over net worth and endowments. The equally-weighted welfare effects are reported in Table 3. Because most of the agents are concentrated on the left-hand side of the distribution, the aggregate welfare effects are dominated by the effects on poorer agents. As a result, country 1 gains on average while country 2 is worse off independently of the types of shocks affecting the economy. For the economy with both shocks, country 1's welfare increases by 2.7 percent of consumption while country 2 experiences a welfare loss of 1.0 percent.

The fact that country 1 gains and country 2 loses on average can be explained as follows. Without financial integration, aggregate savings must be zero because our model is essentially a Lucas-tree economy without capital

[12] The current realization of the endowment is a state variable because endowment shocks are persistent. Investment shocks, instead, can be ignored because z is iid.

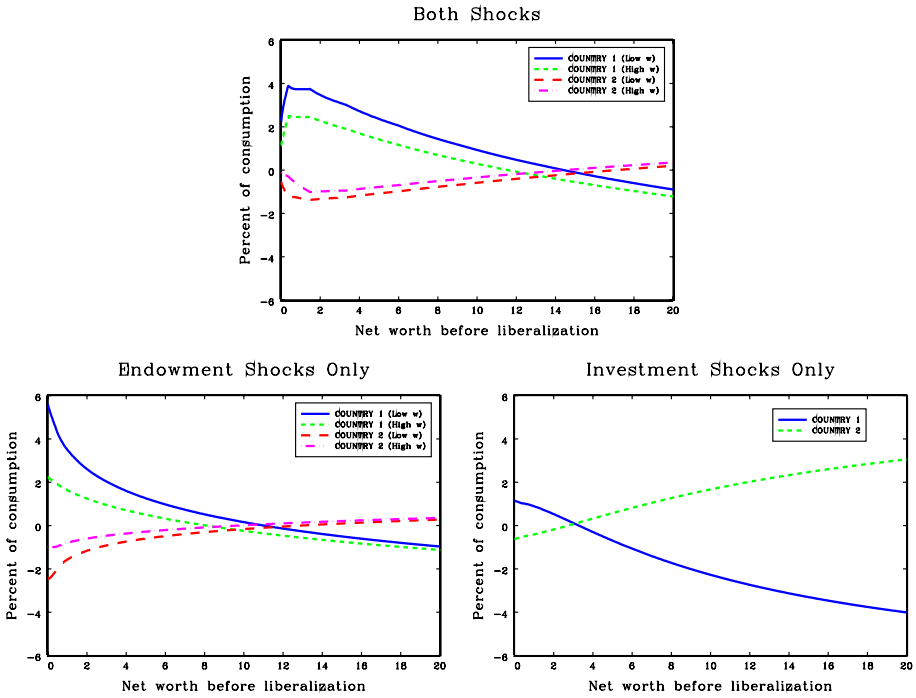


Figure 9: Welfare effects of financial integration.

accumulation. The interest rate will adjust so that this holds at equilibrium. With financial integration, however, each country can access the global asset markets. In particular, country 2 can access higher returns by lending to country 1. The higher return induces country 2' agents to save more. But each individual agent does not internalize that, by saving more, the initial interest rate received from country 1 is going to fall. This will move the 'terms of trade' in favor of country 1 as this country can now borrow at a cheaper price (lower interest rate).[13]

It is important to emphasize that in this model financial integration has only a secondary effect on efficiency. Although country 2 can benefit from

[13]This can be easily seen in a simple example that can be solved analytically. Suppose that there are only two periods and agents in both countries receive the same sequence of non-stochastic endowments. Differential incentives to save are generated by assuming that in each country there is a different saving subsidy, γ^i. This subsidy generates similar effects on savings as income uncertainty. Further assume that $\gamma^2 > \gamma^1 \geq 1$. It can then be shown that financial liberalization generates welfare gains for country 1 and losses for country 2.

Table 3: Equally weighted welfare gains (percent of consumption).

	Country 1	Country 2
Economy with both risks	2.71	-1.00
Economy with endowment risks	2.86	-1.33
Economy with investment risks	0.47	-0.18

disinvesting in the risky asset, and therefore, from the lower risk, this is more than compensated by the lower investment income. Thus, if one country gains, the other must lose. It should be noticed, however, that we are abstracting from possible dynamic gains that may arise with capital markets integration such as those associated with technological adoption, risk-sharing, capital accumulation, and efficient re-allocation of factors of production. In addition, capital markets integration may contribute to deepen financial markets in countries where they are less developed. The effects reported above were derived keeping constant the financial structure before and after liberalization. For these reasons, the results of our welfare analysis should not be taken as suggesting that financial globalization is detrimental for countries with less developed financial markets. Still, the results do suggest that, in order to argue that financial globalization is welfare improving for all participating countries, one has to show that the dynamic gains not captured in our analysis are large.

5.4 Sensitivity analysis: changes in financial deepness

Table 4 reports steady state values for different parameterizations of ϕ^1 and ϕ^2. In the top section of the table we reduce ϕ^1 from 0.4 to 0.2, keeping ϕ^2 at the original value of zero (i.e. we narrow the gap between ϕ^1 and ϕ^2 to 0.2). In the second panel we increase ϕ^1 to 0.8 with ϕ^2 still at zero (i.e. the gap between ϕ^1 and ϕ^2 widens to 0.8). In the third panel we study what happens if financial integration implies an increase in ϕ^2 from 0 to 0.2.

The impact of these changes on the equilibrium outcomes is as expected. More (less) heterogeneity in financial deepness leads to larger (smaller) global imbalances. In particular, the country with more advanced financial markets accumulates larger (smaller) positions in the productive asset and borrows more (less) from abroad. The welfare effects also become bigger (smaller).

Table 4: Steady state with and without capital mobility. Sensitivity analysis.

	Autarky		**Capital mobility**	
	Country 1	*Country 2*	*Country 1*	*Country 2*
A) $\phi^1 = 0.2$, $\phi^2 = 0.0$				
Asset price	3.46	3.69	3.62	3.62
Interest rate	2.68%	2.30%	2.42%	2.42%
Return on risky asset	4.25%	3.94%	3.90%	4.10%
Foreign asset position	-	-	-22.74%	9.68%
Foreign bonds	-	-	-81.89%	34.86%
Foreign risky asset	-	-	59.16%	-25.18%
Welfare gains	-	-	1.23%	-0.48%
B) $\phi^1 = 0.8$, $\phi^2 = 0.0$				
Asset price	2.81	3.69	3.37	3.37
Interest rate	3.92%	2.30%	2.88%	2.88%
Return on risky asset	5.33%	3.94%	3.95%	4.69%
Foreign asset position	-	-	-121.54%	51.13%
Foreign bonds	-	-	-330.47%	139.03%
Foreign risky asset	-	-	208.94%	-87.90%
Welfare gains	-	-	6.72%	-2.09%
A) $\phi^1 = 0.4$, $\phi^2 = 0.2$				
Asset price	3.24	3.46	3.39	3.39
Interest rate	3.08%	2.68%	2.81%	2.81%
Return on risky asset	4.57%	4.25%	4.22%	4.41%
Foreign asset position	-	-	-26.84%	11.43%
Foreign bonds	-	-	-78.03%	33.24%
Foreign risky asset	-	-	51.19%	-21.80%
Welfare gains	-	-	1.34%	-0.53%

Notes: Foreign asset positions, current account, net exports and net factor payments are in percentage of domestic income (endowment plus domestic dividends).

Still, even in the case with $\phi^1 = 0.2$ and $\phi^2 = 0$, financial integration results in sizable global imbalances, with country 1 holding a net foreign asset position of -23 percent of GDP, a debt position of -82 percent, and a position in foreign risky assets of 60 percent. The welfare gain for country 1 remains large at 1.23 percent of consumption. Note that introducing differences in the variance of income fluctuations across countries would have analogous effects. Countries with more volatile income profiles will look similar to countries with lower values of ϕ (i.e., they would be countries with stronger precautionary needs).

The results reported at the bottom of Table 4, where $\phi^1 = 0.4$ and $\phi^2 = 0.2$, are similar to those reported in the top section of the Table (which assumes $\phi^1 = 0.2$ and $\phi^2 = 0$). This shows that differences in the values of ϕ are more important than the absolute values. Hence, as long as one country, or group of countries, are more financially developed than the rest, the model predicts that financial globalization produces a large decline in net foreign assets for the most financially developed area and a welfare loss for the less financially developed area.

The case with $\phi^1 = 0.4$ and $\phi^2 = 0.2$ can be interpreted as capturing the situation in which financial integration facilitates financial development in country 2. The idea is that country 2 starts with $\phi^2 = 0$ but, after liberalization, the enforcement parameter increases to $\phi^2 = 0.2$. We can see that the consequences of liberalization are smaller but still significant.

6 Global imbalances with capital accumulation

The model studied so far abstracts from the aggregate accumulation of capital. The goal of this section is to extend the model to allow for the endogenous supply of productive assets (i.e. the capital stock).

We make the following changes. First, we assume that production requires both capital and labor. Without the input of labor, the cross-country location of capital would not be determined.[14] The production function is $y_{t+1} = z_{t+1}(k_t^\theta l_t^{1-\theta})^\nu$, where k_t is the input of capital and l_t is the efficiency units of labor. Both capital and labor are chosen one period in advance, and therefore, before observing the shock. Capital depreciates at rate δ. Because capital is reproducible, its price is $P_t = 1$.

[14]New capital could be allocated at home or abroad. Without the labor input, the return from the investment is independent of the international location. By having labor as a complementary input of production, the returns from investments depend on wages. This guarantees that the aggregate cross-country location of capital will be determined.

The second change is that the previous endowment shocks are now interpreted as shocks to the efficiency units of labor. The price of labor—the wage rate—will be determined in equilibrium to clear the labor market.

Denote the efficiency units of labor and the wage rate by ε_t and w_t^i respectively. The idiosyncratic shocks are $s_t = (\varepsilon_t, z_t)$ with conditional probability distribution $g(s_t, s_{t+1})$. The agent's problem is:

$$V_t^i(s,a) = \max_{c,l,k,b(s')} \left\{ U(c) + \beta \sum_{s'} V_{t+1}^i\Big(s', a(s')\Big) g(s,s') \right\} \tag{15}$$

subject to

$$\begin{aligned} a &= c + k + \sum_{s'} b(s') q_t^i(s,s') \\ a(s') &= \varepsilon' w_{t+1}^i + (1-\delta)k + z'(k^\theta l^{1-\theta})^\nu - l w_{t+1}^i + b(s') \\ a(s_j) - a(s_1) &\geq (1-\phi^i) \cdot \left[(\varepsilon_j - \varepsilon_1) w_{t+1}^i + (z_j - z_1)(k^\theta l^{1-\theta})^\nu \right] \\ a(s') &\geq 0 \end{aligned}$$

Given the sequence of wages and interest rates, the problem solved by each individual agent is similar to the problem solved in the previous setup. The only difference is that now there is also a choice for the input of labor. However, because the optimal capital-labor ratio only depends on the wage and the interest rate, the individual problem is analogous to (6).

The definition of equilibria provided in Section 3.1 requires only two minor changes: instead of the price for the productive asset we now have the price for labor (the wage rate) and the market-clearing condition for the productive asset is replaced with the market-clearing condition in the labor market.

6.1 Quantitative results

The parametrization of the model uses, when possible, the same parameters used in the previous model. The risk aversion is $\sigma = 2.5$ and the efficiency units of labor follow the same stochastic process as the previous endowment.

In the production function we set $\nu = 0.75$ so that at the individual level production has the same returns to scale as in the previous model. Then we choose θ to have an average capital income share of 0.36. The variability in the investment shock, Δ_z, is set to 0.5. This leads to similar volatility

of capital returns as in the previous model. The targeted wealth-to-income ratio can now be achieved by choosing either β or δ (in the previous model there was no depreciation). We proceed by fixing β to 0.94 and then we choose δ so that the wealth-to-income ratio in the economy with mobility is 3.5. This requires $\delta = 0.024$.

Table 5 compares stationary equilibria before and after financial integration for the three cases examined in Table 2. Qualitatively, the properties of the model are similar with and without endogenous accumulation of capital. Because the capital-labor ratio is the same in the two countries, country 1 owns part of the capital located in country 2. At the same time, country 1 borrows heavily from country 2 and the net foreign asset position is negative. Although not reported, country 1 receives positive factor payments from abroad because of the much higher return from risky capital.

Quantitatively, the economy with both investment and earning shocks generates a negative net foreign asset position in country 1 that is nearly twice as large as the one obtained with the previous model without capital accumulation. The positions in bonds and risky capital are both smaller with capital accumulation than without (-130 instead of -168 percent for debt and 33 instead of 117 percent for risky capital), but since the difference is larger, the net foreign asset position falls more. The welfare consequences are still sizable: the welfare gain for country 1 measures 2.1 percent and the loss for country 2 is almost 0.6 percent. Notice that, with capital accumulation, liberalization does not generate capital gains or losses as in the previous model. This also contributes in differentiating the welfare consequences between the two models. Finally, the combination of the two shocks is still crucial for reproducing the fact that the large negative foreign asset position of country 1 features a portfolio composed of a large debt position and a positive position in foreign risky capital. In short, our main findings are robust to the introduction of capital accumulation.

We do not report the transition dynamics because they are similar to those for the economy without capital accumulation. The only important difference is that in the first period after financial integration, there is a large reallocation of capital from country 2 to country 1. This is because the stock of capital of country 1 in the autarky equilibrium is smaller than in country 2. Because factor prices are equalized immediately, so does capital. The reallocation of capital in the first period implies a trade deficit and a jump in net foreign liabilities for country 1 above 20 percent of GDP. Of course, changing the cross-country location of installed capital may be costly. So it

Table 5: Steady state with endogenous accumulation of capital.

	Autarky		**Capital mobility**	
	Country 1	*Country 2*	*Country 1*	*Country 2*
A) Both shocks				
Wage	0.702	0.693	0.697	0.697
Interest rate	1.56%	0.55%	0.83%	0.83%
Return on risky capital	11.63%	9.19%	9.24%	10.19%
Foreign asset position	-	-	-97.10%	40.33%
Foreign bonds	-	-	-129.76%	53.90%
Foreign risky capital	-	-	32.66%	-13.57%
Welfare gains	-	-	2.07%	-0.58%
B) Endowment shocks only				
Wage	0.704	0.710	0.708	0.708
Interest rate	2.68%	2.32%	2.43%	2.43%
Return on risky capital	14.23%	13.06%	13.40%	13.40%
Foreign asset position	-	-	-33.75%	14.46%
Foreign bonds	-	-	-33.75%	14.46%
Foreign risky capital	-	-	0.00%	0.00%
Welfare gains	-	-	0.41%	-0.17%
C) Investment shocks only				
Wage	0.657	0.643	0.649	0.649
Interest rate	4.77%	3.07%	3.60%	3.60%
Return on risky capital	22.59%	19.12%	19.13%	20.79%
Foreign asset position	-	-	-81.92%	34.06%
Foreign bonds	-	-	-98.41%	40.91%
Foreign risky capital	-	-	16.48%	-6.85%
Welfare gains	-	-	1.14%	-0.28%

Notes: Foreign asset positions, current account, net exports and net factor payments are in percentage of domestic income (endowment plus domestic dividends).

would make sense to assume the presence of adjustment costs. This would make the transition to the steady state equilibrium smoother.

7 Conclusion

This paper shows that international financial integration can lead to large and persistent global imbalances when countries differ in the degree of domestic financial development. Financial integration induces countries with deeper financial markets to reduce savings and accumulate a large stock of net foreign liabilities in a long and gradual process. Financial heterogeneity also affects the composition of the portfolio of net foreign assets. Countries with deeper financial markets borrow heavily from abroad and invest in high-return foreign risky assets. As a result, they may receive positive factor payments even if the net foreign asset position is negative. These patterns are consistent with the features of the U.S. external imbalances observed since the beginning of the 1980s. Moreover, we can explain these facts solely as the outcome of financial integration in a world with heterogeneity in domestic financial markets, even if the income process of all countries is the same, the agents' preferences are identical, and the structure of domestic asset markets remains unchanged.

Our explanation of large and persistent global imbalances implies that these imbalances are consistent with intertemporal solvency conditions, so our analysis predicts that the large negative net foreign asset position of the U.S. is fully 'sustainable' and does not lead to a worldwide financial crisis. Yet, we also find that financial integration could be undesirable for countries with poorly developed financial systems. We estimated nontrivial welfare costs for these countries, and the costs are larger for their poorer residents. However, if financial globalization promotes financial development and allows for other benefits we abstracted from (e.g., technological diffusion, risk sharing, resource allocation), then the integration of world capital markets can still be beneficial for all participating countries.

A Appendix: Set of feasible contingent claims

Suppose that agents have the ability to divert part of their income. Diversion is observable but not verifiable in a legal sense. If an agent diverts x, he or she retains $(1-\phi)x$ while the remaining part, ϕx, is lost. We allow ϕ to be greater than 1. This can be interpreted as a fine or additional punishment. A similar assumption is made in Castro, Clementi & MacDonald (2004) but in an environment with information asymmetry.

Contracts are signed with financial intermediaries in a competitive environment. Financial contracts are not exclusive, meaning that agents can always switch to another intermediary from one period to the other. The set of state-contingent claims that an intermediary is willing to offer must be incentive-compatible.

Let $V_t(s,a)$ be the value function for an agent with current realization of endowment and investment shocks s, and current net worth a. The net worth is before consumption. After choosing the contingent claims $b(s_j)$, the next period value is $V_t(s_j, a(s_j))$, where $a(s_j) = w_j + z_j k^\nu + kP_{t+1} + b(s_j)$. In case of diversion, the agent would claim that the realizations of the endowment and productivity were the lowest levels s_1 and divert the difference $w_j - w_1 + (z_j - z_1)k^\nu$. In this process the agent retains $(1-\phi)[w_j - w_1 + (z_j - z_1)k^\nu]$ and receives $b(s_1)$. Therefore, the net worth after diversion is:

$$\begin{aligned} &w_1 + z_1 k^\nu + (1-\phi)\cdot[w_j - w_1 + (z_j - z_1)k^\nu] + kP_{t+1} + b(s_1) \;= \\ &a(s_1) + (1-\phi)\cdot[w_j - w_1 + (z_j - z_1)k^\nu] \end{aligned}$$

and the value of diversion is:

$$V_t\Big(s_j\,,\, a(s_1) + (1-\phi)\cdot[w_j - w_1 + (z_j - z_1)k^\nu]\Big)$$

Incentive-compatibility requires:

$$V_t\Big(s_j\,,\, a(s_j)\Big) \geq V_t\Big(s_j\,,\, a(s_1) + (1-\phi)\cdot[w_j - w_1 + (z_j - z_1)k^\nu]\Big)$$

which must hold for all $j = 1, .., N$.

It is important to emphasize that the financial intermediary can tell whether the agent is diverting but there is no court that can verify this and force the repayment of the diverted funds. Compared to the standard model with information asymmetries, this assumption is convenient because it simplifies the contracting problem when shocks are persistent. Also convenient

is the assumption that financial contracts are not exclusive and agents can switch to other intermediaries without a cost. This further limits the punishments available to the current intermediary. Also notice that, although the new level of wealth after diversion is verifiable when a new contract is signed, this does not allow the verification of diversion because the additional resources could derive from lower consumption in previous periods, which is not observable and verifiable. Again, the intermediary knows that the additional resources come from diversion but it cannot legally prove it.

The last assumption is limited liability for which agents renegotiate negative values of net worth, and therefore, $a(s_j) \geq 0$. The agent's problem can be written as:

$$\begin{aligned} V_t(s,a) &= \max_{c,k,b(s')} \left\{ U(c) + \beta \sum_{s'} V_{t+1}\Big(s', a(s')\Big) g(s,s') \right\} \\ & \quad \text{subject to} \\ a &= c + \sum_{s'} b(s') q(s,s') \\ a(s') &= w' + z' k^{\nu} + k P_{t+1} + b(s') \\ V_t\Big(s_j\,,\, a(s_j)\Big) &\geq V_t\Big(s_j\,,\, a(s_1) + (1-\phi)\cdot [w_j - w_1 + (z_j - z_1)k^{\nu}]\Big) \\ a(s_j) &\geq 0 \end{aligned}$$

Using standard arguments for recursive problems, we can prove that there is a unique solution and the function $V_t(s,a)$ is strictly increasing and concave in a.[15] The strict monotonicity of the value function implies that the incentive-compatibility constraint can be written as:

$$a(s_j) \geq a(s_1) + (1-\phi)\cdot \Big[w_j - w_1 + (z_j - z_1)k^{\nu}\Big]$$

for all $j = 1, .., N$. This is the constraint we imposed on the original problem.

We shall remark that we arrived at this simple formulation of the constraints because of the particular environment. With the alternative assumption of information asymmetries and persistent shocks, the characterization

[15]The proof is facilitated by defining the variable $x = k^{\nu}$. After making the change of variables $k = x^{1/\nu}$, it can be easily proved that this is a standard concave problem.

of the optimal contract becomes more complicated. Because the qualitative properties are similar to the model considered here (see, for example, Fernandes and Phelan (2000)), we opted for the simpler route.

B Appendix: Analytical proofs

Proof of Proposition 1 In both economies we have that $R(k, \bar{z}) = 1 + r_t$. Because with capital mobility there is a single worldwide interest rate, all agents employ the same input of capital $k = 1$. Therefore, the net position in the productive asset is zero. We want to show now that the interest rate is smaller than the intertemporal discount rate. Suppose, on the contrary, that $\beta(1 + r_t) \geq 1$. Under this condition agents in country 1 will have non-negative consumption growth (see Lemma 1) and agents in country 2 will have positive consumption growth (see Lemma 2). This implies that worldwide consumption growth is positive which cannot be an equilibrium because aggregate income is constant. Therefore, the equilibrium must satisfy $\beta(1 + r_t) < 1$. Under this condition, agents in country 1 will experience negative consumption growth (see again Lemma 1). Therefore, consumption in country 1 keeps falling until the limited liability constraint (5) binds for all agents, that is, the net worth becomes zero. Because country 1 holds the whole amount of domestic productive asset, the zero net worth implies that the foreign liabilities are equal to the value of the domestic asset. Therefore, the net foreign asset position of country 1 is negative. *Q.E.D.*

Proof of Proposition 2 Suppose that $\beta(1 + r) \geq 1$. Under this condition agents in country 1 will have non-negative consumption growth and agents in country 2 will have strictly positive consumption growth (Lemmas 1 and 2 apply also to the case with only investment shocks). This implies that worldwide consumption growth is positive which cannot be a steady state equilibrium. Therefore, $\beta(1 + r_t) < 1$. Under this condition agents in country 1 will experience negative consumption growth (see again Lemma 1). Therefore, consumption keeps falling until the limited liability constraint (5) binds for all agents. This implies that the net foreign asset position of country 1 will be negative.

To show that country 1 has a positive net position in the productive asset, consider again the first order conditions (11)-(14). From these conditions we have that $ER_t(k, z') = 1 + r$ in country 1 and $ER_t(k, z') > 1 + r$ in country 2.

The monotonicity of R_t with respect to k implies that the productive asset used by agents in country 1 must be greater than the productive asset used by any agent in country 2. Because the supply is the same, country 1 must own part of the productive asset of country 2.

What remains to be shown is that for country 1 the average return from the foreign productive investment is higher than the cost of its foreign liabilities. Even thought the marginal return from the productive asset is equalized to the interest rate, the concavity of the production function implies that the average return is higher than the interest rate (liability cost). *Q.E.D.*

C Appendix: Computational procedure

We show first that the economy with contingent claims is equivalent to an alternative economy where contingent claims are not allowed but agents face a different process for the exogenous shocks. We can then solve this equivalent economy where the agents' problem is a standard portfolio choice between risky and riskless assets. After showing this, we describe the computational procedures used to solve for the steady state and transitional equilibria of the equivalent economy.

C.1 Equivalent economy

Let $\bar{b}_t$ be the expected next period value of contingent claims, that is, $\bar{b}_t = \sum_{s_{t+1}} b(s_{t+1})g(s_t, s_{t+1})$. Then a contingent claim can be rewritten as $b(s_{t+1}) = \bar{b}_t + x(s_{t+1})$ where, by definition, $\sum_{s_{t+1}} x(s_{t+1})g(s_t, s_{t+1}) = 0$. The variable $\bar{b}_t$ can be interpreted as a non-contingent bond and the variable $x(s_{t+1})$ is the pure insurance component of contingent claims.

The law of motion for the next period assets becomes:

$$a(s_{t+1}) = w_{t+1} + z_{t+1}k_t^{\nu} + k_t P_{t+1} + \bar{b}_t + x(s_{t+1}) \tag{16}$$

Consider the incentive compatibility constraint. Because agents choose as much insurance as possible, the incentive-compatibility constraint will be satisfied with equality, that is,

$$a(s_j) = a(s_1) + (1-\phi)\cdot\left[w_j - w_1 + (z_j - z_1)k_t^{\nu}\right]$$

Using the law of motion for a, the constraint can be rewritten as:

$$x(s_j) - x(s_1) = -\phi\cdot\left[w_j - w_1 + (z_j - z_1)k_t^{\nu}\right]$$

which must hold for all $j > 1$. The variables $x(s_j)$ must also satisfy the zero-profit condition, that is,

$$\sum_j x(s_j) g(s_t, s_j) = 0$$

Therefore, we have N conditions and N unknowns. We can then solve for all the N values of x. The solution can be written as:

$$x(s_j) = -\phi \cdot W_j(s_t) - \phi \cdot Z_j(s_t) \cdot k_t^{\nu}$$

where $W_j(s_t)$ and $Z_j(s_t)$ are exogenous variables defined as

$$\begin{aligned} W_j(s_t) &= w_j - \sum_i g(s_t, s_i) w_i \\ Z_j(s_t) &= z_j - \sum_i g(s_t, s_i) z_i \end{aligned}$$

Notice that these variables depend on the current shocks which affect the probability distribution of next period shocks. We made this explicit by writing the variables as functions of s_t.

Define the following variables:

$$\begin{aligned} \tilde{w}_j(s_t) &= w_j - \phi \cdot W_j(s_t) \\ \tilde{z}_j(s_t) &= z_j - \phi \cdot Z_j(s_t) \end{aligned}$$

These are transformations of the shocks. Using these new shocks, the law of motion for next period assets can be written as:

$$a(s_j) = \tilde{w}_j(s_t) + \tilde{z}_j(s_t) k_t^{\nu} + k_t P_{t+1} + \bar{b}_t$$

where now agents no longer choose state contingent assets. Therefore, by redefining the new shocks $\tilde{w}_j(s_t)$ and $\tilde{z}_j(s_t)$, the problem becomes a standard portfolio choice between a risky asset, k_t, and a riskless asset, $\bar{b}_t$. Differences in financial deepness are captured by difference in the stochastic properties of the transformed shock. So, for example, if $\phi = 0$, we go back to the original shock because contingent claims are not feasible. If $\phi = 1$ and shocks are iid, the transformed shock becomes a constant. We are in the case of full insurance. Any intermediate values allow only for partial insurance. In the computation we will solve the portfolio choice of the transformed model.

C.2 Steady state equilibrium

1. Choose a grid for asset holdings a.

2. Guess the steady state values of the interest rate, r, and the price P.

3. Using the first-order conditions, solve for the optimal portfolio choices at each grid point of a and for each s, by iterating on the policy rules. The solutions are combined using piece-wise linear functions.

4. Find the steady state distribution of agents using the decision rules and compute the clearing conditions for the risky and riskless assets.

5. Update the guesses for the interest rate and the price of the productive asset (step 2) until the market clearing conditions are satisfied.

C.3 Transitional equilibrium

1. Solve for the initial and final steady states (autarky and mobility).

2. Choose the number of transition periods T. This number should be sufficiently large to allow the economy to reach, approximately, the new steady state in T periods.

3. Guess transition sequences for the interest rates, $\{r_t\}_{t=1}^{T}$, and for the price of the productive asset $\{P_t\}_{t=1}^{T}$.

4. Using the first-order conditions, solve for the optimal portfolio choices backward starting from T. This provides the sequence of optimal decision rules at $t = 1, 2, .., T$.

5. Using the optimal decision rules, find the sequence of distributions and compute the market-clearing conditions at time $t = 1, 2, .., T$.

6. Update the guess for the sequences of the interest rates and the prices of the productive asset (step 3) until the market-clearing conditions are satisfied at all points in time $t = 1, 2, .., T$.

References

Angeletos, G.-M. (2007). "Uninsured Idiosyncratic Investment Risk and Aggregate Saving". *Review of Economic Dynamics*, 10(1), 1-30.

Attanasio, O., Kitao, S., Violante, G. (2006). "Quantifying the Effects of the Demographic Transition in Developing Economies". *The B.E. Journal of Macroeconomics (Advances)*, 6(1), Article 2.

Backus, D., Henriksen, E., Lambert, F., & Telmer, C. (2005). "Current Account Fact and Fiction". Unpublished manuscript, New York University.

Bernanke, B. S. (2005). "The Global Saving Glut and the U.S. Current Account Deficit". Speech at the Sandridge Lecture, Virginia Association of Economists, March 10, 2005.

Bewley, T. F. (1986). "Stationary Monetary Equilibrium with a Continuum of Independent Fluctuating Consumers". Contributions to Mathematical Economics in Honor of Gerard Debreu, Werner Hildenbrand and Andreu Mas-Colell editors, North-Holland, Amsterdam.

Blanchard, O., Giavazzi, F., & Sa, F. (2005). "The U.S. Current Account and the Dollar". NBER Working Paper No. 11137, February 2005.

Caballero, R. J., Farhi, E., & Gourinchas, P. O. (2006). "An Equilibrium Model of "Global Imbalances" and Low Interest Rates". NBER Working Paper No. 11996, February 2006.

Carroll, C. D. (1997). "Buffer-Stock Saving and the Life Cycle/Permanent Income Hypothesis". *Quarterly Journal of Economics* CXII(1), 1-56.

Castro, R., Clementi, G., & MacDonald, G. (2004). "Investor Protection, Optimal Incentives, and Economic Growth". *Quarterly Journal of Economics*, Vol. 119(3), 1131-75.

Cavallo, M. and Tille, C. (2006). "Could Capital Gains Smooth a Current Account Rebalancing?" Federal Reserve Bank of New York Staff Report 237, January 2006.

Chinn, M. and Ito, H. (2005), "What Matters for Financial Development? Capital Controls, Institutions, and Interactions", NBER Working Paper No. 11370.

Croke, H., Kamin, S. B., & Leduc, S. (2005). "Financial Market Developments and Economic Activity during Current Account Adjustments in Industrial Economies". International Finance Discussion Papers No. 827, Board of Governors of the Federal Reserve System, February 2005.

Demirguc-Kunt, A. and Levine, R. (2001). "Financial Structure and Economic Growth". MIT Press, Cambridge, Massachusetts.

Engel, C. and Rogers, J.H. (2006), "The U.S. Current Account Deficit and the Expected Share of World Output," Board of Governors of the Federal Reserve System, International Finance Discussion Papers No. 856, April 2006.

Faruqee, H., Laxton, D., Muir, D., & Pesenti, P. (2005)."Smooth Landing or Crash? Model-Based Scenarios of Global Current Account Rebalancing", in Clarida, Richard, editor, G7 Current Account Imbalances: Sustainability and Adjustment, University of Chicago Press, forthcoming.

Fernandes, A. and Phelan, C. (2000). "A Recursive Formulation for Repeated Agency with History Dependence". *Journal of Economic Theory*, 91(2), 223-247.

Fogli, A. and Perri, F. (2006). "The great moderation and the US external imbalance," mimeo, Department of Economics, University of Minnesota.

Ghironi, F., J. Lee, and A. Rebucci (2006), "The Valuation Channel of External Adjustment," mimeo, Research Department, International Monetary Fund.

Gourinchas, P. O. and Rey, H. (2005). "From World Banker to World Venture Capitalist: US External Adjustment and the Exorbitant Privilege". NBER Working Paper No. 11563, August 2005.

Hausmann, R. and Sturzenegger, F. (2005), "U.S. and Global Imbalances: Can Dark Matter Prevent a Big Bang?". Center for International Development, Harvard University, Working Paper No. 124, January 2006.

Henriksen, E. R. (2004), "A Demographic Explanation of U.S. and Japanese Current Account Behvaior." mimeo, Carnegie-Mellon University.

Huggett, M. (1993). "The Risk Free Rate in Heterogeneous-Agents, Incomplete Markets Economies". *Journal of Economic, Dynamics and Control*, 17(5/6), 953-70.

Hunt, B. and Rebucci A. (2005), "The US Dollar and the Trade Deficit: What Accounts for the Late 1990s?," *International Finance* 8:3, 2005: pp. 399–434.

IMF (2005). "Global Imbalance: A Saving and Investment Perspective" World Economic Outlook, Chapter 2, September 2005.

IMF (2006). "How Do Financial Systems Affect Economic Cycles?" World Economic Outlook, Chapter 4, September 2006.

Krugman, P. (2006), "Will there be a Dollar crisis?," mimeo.

Lane, P. R. and Milesi-Ferretti, G. M. (2005). "A Global Perspective on External Position". NBER Working Paper No. 11589, September 2005.

Lane, P. R. and Milesi-Ferretti, G. M. (2006). "The External Wealth of Nations Mark II: Revised and Extended Estimates of Foreign Assets and Liabilities, 1970-2004". IMF Working Paper 06/69.

Obstfeld, M. and Rogoff, K. (2004). "The Unsustainable US Current Account Position Revisited". NBER Working Paper No. 10869, November 2004.

Quinn, D. P., Inclan, C., & Toyoda, A. M. (2001). "How and Where Capital Account Liberalization Leads to Economic Growth". Unpublished manuscript, Georgetown University.

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, New York University and Oxford University.

Storesletten, K., Telmer, C. I. and Yaron A. (2004). "Cyclical dynamics in idiosyncratic labor market risk" *Journal of Political Economy*, 112 (3), 695-717.

Summers, L. H. (2004). "The United States and the Global Adjustment Process". Speech at the Third Annual Stravos S. Niarchos Lecture, Institute for International Economics, March 23, 2004.

Warnock, F.E. and Warnock V.C. (2006). "International Capital Flows and U.S. Interest Rates," NBER Working Paper 12560, National Bureau of Economic Research.

Willen, P. S. (2004). "Incomplete Markets and Trade". Working Paper Series No. 04-8, Federal Reserve Bank of Boston.