

International Liquidity Rents

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Abstract

This paper presents a model of global liquidity shortages. Liquid claims are enforceable promises that play a transaction role. Since developed economies have a comparative advantage in creating liquidity, they export liquid claims to emerging economies, resulting in a permanent current account deficit. This model suggests

that unrestricted liquidity flows are (a) welfare reducing for emerging economies and (b) Pareto inefficient. The inefficiency results both from excessive investment for the purpose of creating collateral-backed liquid claims, and from excessive global fragility with respect to collateral shocks.

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1 Introduction

The behavior of international capital flows is puzzling from a neoclassical perspective: while standard considerations would suggest that capital should flow from steady-state developed economies to converging emerging economies, there are large net capital flows in the opposite direction (commonly referred to as “global imbalances”). The persistent decline in interest rates in the US is also a puzzling trend, as, given the high returns to capital in emerging economies, the neoclassical model would predict that financial integration should increase the returns to savings in global markets.

In their seminal work, Caballero et al. [2008] present a highly stylized model of global asset shortages that can help explain these puzzles. Their model features overlapping generations with an inelastic demand for saving. Developed economies have a comparative advantage in creating assets, and, in equilibrium, export assets to emerging economies.

In this paper, I attempt to embed this stylized intuition in a standard neoclassical growth model, generating a demand for assets from a need for liquidity. This focus is in line with the findings in Gourinchas and Rey [2007] who show that US external liabilities are predominantly composed of liquid claims which carry a significant liquidity premium. I then use the model to revisit the welfare implications of financial integration, as well as the implications for consumption, investment and volatility. The model illustrates that, despite a growing consumption path and high returns to capital, emerging economies may be net lenders in equilibrium; in this case, financial integration is welfare-reducing for emerging economies. In contrast, developed economies are made better off by financial integration as they enjoy rents from liquidity supply. Even though developed economies gain from financial integration, it is possible to show that financial integration is Pareto inefficient, and, in some cases, welfare inferior to autarky. The inefficiency is a result of excessive capital accumulation in the developed economy and unnecessary fragility with respect to collateral shocks.

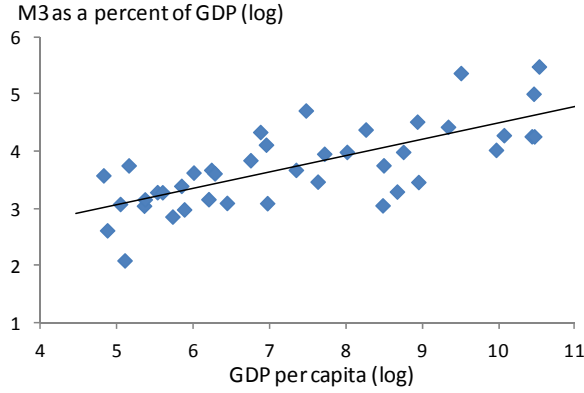
The starting point of the model is the assumption that, compared to emerging economies, developed economies have a comparative advantage in creating liquid claims. This assumption is consistent with figure 1, that shows that the average level of broad money (M3) as a fraction of nominal GDP is positively correlated with income. To generate a need for liquidity, I assume a transaction role for *liquid claims*. In the spirit of Neumeyer and Perri [2005], this transaction role is modeled as a “working capital” constraint in the labor market: labor is unable to enforce payment ex-post, and must be paid in advance with liquid claims (which are easily enforceable).

In emerging economies, there is not enough liquidity to finance the unconstrained wage bill. Consequently, the autarkic wage is depressed relative to the marginal product of labor. In the integrated equilibrium, this wedge creates an incentive to buy liquid claims issued by foreigners. However, the purchase of foreign-issued liquid claims is associated with a pecuniary externality, as “imported” liquidity bids up wages.¹ Since liquidity is expensive, the increase in labor income is not enough to offset the fall in firms’ profits.² Aggregate domestic income is lower than in the autarkic counterfactual, as payments for liquidity services are sent abroad.

These “liquidity rents” incentivize agents in developed economies to explore innovative ways to create more liquidity. A high liquidity premium increases the private return to physical capital, as it can be used as collateral to back liquid claims. This is Pareto inefficient for two reasons: first, it leads to excessive capital accumulation in the developed economy. Second, equilibrium reliance on collateral-backed liquid claims exposes the economy to unnecessary fragility, as collateral shocks change the incentives to accumulate physical capital.

¹This result is broadly consistent with the empirical findings in Chari et al. [2012], who show that financial integration in emerging economies is associated with an increase in wages.

²The way that financial integration changes domestic income shares is in the spirit of Antras and Caballero [2009]: the returns to liquidity decline, as liquidity can be imported more cheaply from abroad, allowing labor to absorb a higher share of output.



Source: World Development Indicators, 2013: Liquid liabilities (M3) as % of GDP, and GDP per capita (constant 2000 US\$).

Figure 1: A positive cross-country correlation between the ratio of M3 and nominal GDP ($\frac{M3}{PY}$) and income per capita (in the year 2000). A 1% increase in income per capita is associated with a 0.3% increase in real balances.

The general principle underlying the welfare analysis in this paper is that agents are willing to undertake costly measures to relax binding constraints, even when doing so is socially inefficient. For emerging economies, this takes the form of buying liquid claims issued by foreigners. Privately, each firm thinks it can increase its profits by importing liquidity and increasing its labor inputs. In general equilibrium, foreign-issued liquidity merely bids up the wage rate, leaving firms worse off as they face higher wages and must make payments to foreign liquidity suppliers. For developed economies, the inefficiency takes the form of accumulating collateral. Privately, each agent stands to profit from creating collateral-backed liquid claims; however, in general equilibrium, this merely reduces the liquidity premium and wastes valuable resources.

2 Related literature

The global equilibrium view expressed in this paper is closely related to the “asset shortage” view, summarized in Caballero [2006] and Caballero et al. [2008]. Subsequent work such as Caballero and Krishnamurthy [2009] and Maggiori [2008] observe that the surplus of emerging economies is composed primarily of treasuries and other safe assets, and relate the demand for assets to a demand for safety. In this paper, safety is de-emphasized and replaced with liquidity. Of course, the views are not mutually inconsistent as safety and liquidity often go together (see Krishnamurthy and Vissing-Jorgensen [2012] for the case of treasuries). However, the focus on liquidity is key for the welfare implications explored here.

The welfare implications are conceptually related to the idea of international seigniorage, as in Matsuyama et al. [1993] and Eden [2009]. In the monetary literature, the fact that foreigners use dollars allows the US central bank to collect seigniorage payments from abroad. An implication of this is that the foreigners would be better off if using dollars were illegal, as the only seigniorage payments would be collected by the domestic government and consumed domestically. The results here are of similar flavor: in the autarkic emerging economy, there are rents to liquidity supply, but they are consumed domestically. Under financial integration, the developed economy extracts some liquidity rents, which reduces aggregate domestic income in emerging economies.

This paper is related to others that emphasize inefficient pecuniary externalities in constrained environments, including Korinek [2011], Lorenzoni [2008] and Eden [2012]. Most closely related is Eden [2012], in which I consider a closed economy with pledgeability constraints in which the price of production inputs is determined in equilibrium. Producers are willing to pay an “intermediation cost” to relax their pledgeability constraint, but in equilibrium this only raises the price of inputs and generates an inefficiency. This pecuniary externality is the key ingredient in both models. The main

difference between the papers is in their focus. Here, I focus on the welfare implications of international liquidity flows and on the distribution of surplus between emerging and developed economies, as well as the implications of collateral shocks in this context. In Eden [2012] I focus on the general equilibrium costs of financial intermediation in a closed economy context.

The idea that in liquidity-scarce environments collateral shocks can translate into liquidity shocks appears also in Midrigan and Philippon [2011]. Midrigan and Philippon [2011] consider a general equilibrium monetary model, in which the Friedman rule is not implemented and “cash in advance” constraints bind in equilibrium. The ability to borrow against housing wealth in order to relax the “cash in advance” constraint increases the private return to housing. Thus, shocks to the collateral value of housing reduce the incentives to invest in new houses. The mechanism here is similar: the economy can issue liquid claims against the “collateralizable” part of its capital stock. Shocks to the collateral value of capital reduce the incentives for capital accumulation. While the mechanism is similar, the suggested interpretation is somewhat different: capital-backed liquid claims are interpreted not only as mortgage loans, but also as securities with favorable liquidity properties (for example, MBS or ABS that can be used as collateral in the repo market).

This paper contributes to the theoretical literature on the welfare implications of financial integration in emerging economies, including (among others) Gourinchas and Jeanne [2006] and Levine [2001]. Mendoza et al. [2007] similarly consider the welfare implications of financial integration for a financially underdeveloped economy. Similarly, the conclusion is that financial integration is welfare reducing. However, the mechanism is very different.³

³In Mendoza et al. [2007], the welfare effects operate through the domestic distributional implications. Relatively poor households are equilibrium borrowers that are made worse off by higher equilibrium interest rates. In this model, there is no household heterogeneity and all emerging market households are net lenders in equilibrium. The welfare effects operate through the pecuniary externality on wages, which makes it more difficult for domestic producers to finance production.

3 Setup

I consider a discrete time infinite horizon model, where time periods are indexed by $t = 0, 1, 2, \dots$

Technology. There is a unit measure of identical firms indexed $i \in [0, 1]$. The production technology is time invariant and given by:

$$F_i(k_{i,t}, l_{i,t}) = A_i k_{i,t}^\alpha l_{i,t}^{1-\alpha} \quad (1)$$

Where A_i is the firm's productivity, $l_{i,t}$ is the labor employed by firm i and $k_{i,t}$ is firm i 's physical capital.

Physical capital. Physical capital is owned by firms. The final good can be invested and turned into physical capital, to be used in the next period. Capital depreciates at the rate δ . This implies the standard capital accumulation equation (where $i_{i,t}$ is investment):

$$k_{i,t+1} = (1 - \delta)k_{i,t} + i_{i,t} \quad (2)$$

Paying labor. To generate a role for liquidity, I assume that firms need to pay labor with enforceable promises on post-production output, prior to production. Enforceable promises are transferable "IOU notes" which I will refer to as *liquid claims*.⁴

There are two types of liquid claims: publicly-backed liquid claims and collateral-backed liquid claims (which will also be referred to as privately-backed liquid claims).

⁴This simplified modeling of liquid claims captures two important aspects of liquidity. First, it can easily be used for transaction purposes (here, purchasing labor). Second, liquid claims can be enforced without any expertise or enforcement power, a property that is necessary for liquid claims to be widely acceptable. See Holmstrom and Tirole [2011], Holmstrom [2008] and Kurlat [2010] for a more rigorous discussion of the necessary attributes of liquid claims.

Publicly backed liquid claims. The government can guarantee a firm’s promises up to m units of output. Publicly guaranteed claims are tradable IOU notes that are issued by the firm, and enforced by the government.⁵ I assume for simplicity that the limit on publicly backed claims is proportional to output:

$$m_t = \theta \int_0^1 F_i(k_{i,t}, l_{i,t}) di \quad (3)$$

The proportion coefficient θ captures the economy’s aptitude for creating publicly backed liquid claims. Publicly backed liquid claims should be interpreted as traditional forms of liquidity, such as government bonds or money. A government bond is a claim on domestic output, backed by the government’s ability to collect tax revenues; similarly, money is a claim on output, its purchasing power guaranteed by the the commitment of the central bank not to inflate the currency. The parameter θ captures attributes such as the government’s ability to commit future tax revenues and the central bank’s commitment to low inflation.

Collateral backed liquid claims. In addition, firms can privately back their promises against a fraction γ of their capital stock.⁶ These privately backed liquid claims should be interpreted as less traditional forms of liquidity, such as MBS or ABS.

There are two important differences between publicly backed claims and collateral backed claims. First, publicly backed claims are *undistortive*, in the sense that the firm does not internalize the effect of its capital accumulation decisions on the amount of publicly backed claims that it can issue; rather, firms take the amounts m_t as exogenous. In contrast, the ability to use capital to issue collateral backed claims is internalized by the firm in its investment

⁵These claims are in the spirit of “money” in Caballero and Krishnamurthy [2005].

⁶The distinction between “publicly backed” and “privately backed” liquid claims is in the spirit of Farhi and Tirole [2011], who similarly distinguish between “inside” and “outside” liquidity.

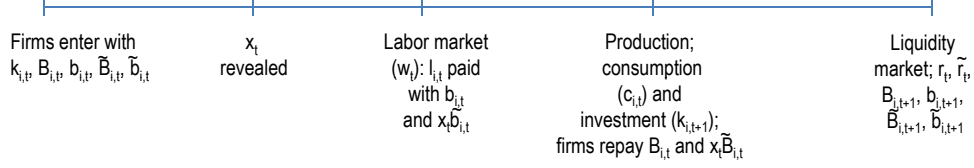


Figure 2: The within-period timing of the model.

decisions.

Second, unlike publicly backed claims, collateral backed claims are (potentially) risky: there is a random variable $x_t \in [0, 1]$ that determines the fraction of collateral backed claims can be enforced. The use of collateral backed claims therefore may expose the economy to aggregate “enforceability” risk. Denote by S^T the history of the realizations of x_t up to time T ($S^T = (x_1, x_2, \dots, x_T)$). To simplify, this is the only source of uncertainty that I will consider.

Realistically, there is a sense that collateral-backed claims are less liquid than publicly-backed claims. To capture this, I will assume that collateral backed claims are *specialized*, in the sense that they are not enforceable across borders. While, in principle, wage bills in one country can be paid with publicly backed claims issued in another country, collateral backed claims are only enforceable domestically. This captures the idea that collateral backed claims are more specialized, and, in some sense, serve as “inside money” within a domestic financial system. This assumption will not be essential for any of the theoretical results, but will play a role in the numerical simulation.⁷

To summarize, let $B_{i,t}$ denote the total amount of publicly backed liquid claims that firm i can issue, and let $\tilde{B}_{i,t}$ denote the total amount of privately

⁷In the numerical simulation, this assumption affects the wage dynamics associated with an enforceability shock. Specifically, if emerging markets hold privately-backed liquid claims issued by developed economies, part of the instantaneous adjustment in wages would take place in emerging economies.

backed liquid claims that firm i can issue. These amounts are bounded by:

$$B_{i,t} \leq m_t \quad (4)$$

$$\tilde{B}_{i,t} \leq \gamma k_{i,t} \quad (5)$$

Liquidity markets. After production takes place and investment decisions are made, firms issue liquidity that can be used in period $t+1$ (the choices of B_{t+1} and $\tilde{B}_{i,t+1}$ are made at the end of period t). There is a liquidity market, in which firms can buy and sell liquid claims. The price of publicly backed liquid claims in terms of goods is $\frac{1}{1+r_t}$: one good can purchase $1+r_t$ publicly backed liquid claims, that can be used to hire labor for production in period $t+1$. Similarly, the price of collateral backed liquid claims is $\frac{1}{1+\tilde{r}_t}$.

Denote by $b_{i,t}$ the amount of publicly backed liquid claims that firm i holds at the beginning of period t , and let $\tilde{b}_{i,t}$ denote the amount of collateral backed liquid claims that firm i holds at the beginning of period t (these quantities are determined in the liquidity market at the end of period $t-1$). The amount of labor that firm i can hire is bounded by these quantities, and the aggregate state x that determines the extent to which collateral-backed claims are enforceable:

$$w_t l_{i,t} \leq b_{i,t} + x_t \tilde{b}_{i,t} \quad (6)$$

This constraint, which resembles a “cash in advance” constraint on labor purchases, will be referred to as the *liquidity constraint*.

Households. There is a unit measure of households indexed $i \in [0, 1]$. For simplicity, I assume that each household owns one firm (but cannot supply its own labor to its firm). Household i 's preferences over state-contingent consumption sequences $\{c_{i,t}(S^t)\}_{t,S^t}$ are represented by:

$$U(\{c_{i,t}(S^t)\}_{t,S^t}) = E\left(\sum_{t=0}^{\infty} \beta^t u(c_{i,t}(S^t))\right) \quad (7)$$

Where $u(\cdot)$ satisfies the standard assumptions: $u'(c) > 0$, $u''(c) < 0$. Households supply $l_{i,t} = l$ units of labor inelastically. As I will focus primarily on steady state analysis, l should be interpreted as the long-run level of labor supply; the assumption is consistent with the widely-held view that long-run labor supply is inelastic.⁸

Household i (that owns firm i) faces the following optimization problem:

$$\max_{\{c_{i,t}(S^t), k_{i,t+1}(S^t), l_{i,t}(S^t), b_{i,t+1}(S^t), B_{i,t+1}(S^t), \tilde{b}_{i,t+1}(S^t), \tilde{B}_{i,t+1}(S^t)\}_{t,S^t}} E\left(\sum_{t=0}^{\infty} \beta^t u(c_{i,t}(S^t))\right) \quad (8)$$

s.t. (for any S^t):

$$c_{i,t} + k_{i,t+1} + \frac{b_{i,t+1}}{1+r_t} + \frac{\tilde{b}_{i,t+1}}{1+\tilde{r}_t} = F_i(k_{i,t}, l_{i,t}) - w_t l_{i,t} \quad (9)$$

$$+(1-\delta)k_{i,t} + b_{i,t} - B_{i,t} + x_t(\tilde{b}_{i,t} - \tilde{B}_{i,t}) + w_t l + \frac{B_{i,t+1}}{1+r_t} + \frac{\tilde{B}_{i,t+1}}{1+\tilde{r}_t} \\ k_{i,t+1} \geq 0 \quad (10)$$

And the inequalities in equations 4, 5 and 6.

The productivity parameters A_i and the initial conditions $k_{i,0}$, $B_{i,0}$, $b_{i,0}$, $\tilde{B}_{i,0}$, $\tilde{b}_{i,0}$ are identical across firms within a country. As households are identical (and subject to the same aggregate risk), it follows that consumption and capital accumulation are the same across households and firms in all periods.

At time t , households have seven choice variables: household consumption ($c_{i,t}$), labor demand ($l_{i,t}$), next-period capital levels ($k_{i,t+1}$), demand for next-period's publicly backed claims ($b_{i,t+1}$), demand for next-period's privately backed claims ($\tilde{b}_{i,t+1}$), supply of next-period's publicly backed claims ($B_{i,t+1}$) and supply of next-period's privately backed claims ($\tilde{B}_{i,t+1}$).

Equation 9 is the household's budget constraint. The household's income

⁸Long run labor supply is typically thought of as being inelastic, as permanent changes in the wage rate have both an income and substitution effect that roughly cancel out. See, for example, Basu and Kimball [2002].

is composed of dividend income, labor income, and revenue from selling liquid claims (issued against next period's output). This income is divided between consumption, the accumulation of physical capital, and the purchase of liquid claims. Equation 10 states that capital cannot be negative (this will not be binding).

Wage setting. For simplicity, I assume that w_t is set at time t so that the labor market clears (there is no wage stickiness and no unemployment).

Timing. Figure 2 summarizes the timing of the model. The within-period timing of the model is as follows:

1. Firms enter period t with $k_{i,t}$ units of physical capital, $b_{i,t}$ units of publicly backed liquid claims and $\tilde{b}_{i,t}$ units of collateral backed liquid claims. They also enter with $B_{i,t}$ publicly backed outstanding obligations and $\tilde{B}_{i,t}$ collateral backed outstanding obligations, that they are to repay at the end of the period.
2. The aggregate enforceability state, x_t , is revealed.
3. Firms use their enforceable liquid claims to hire labor ($l_{i,t}$). The wage (w_t) is set so that the labor market clears.
4. After production takes place, firms repay their enforceable outstanding obligations ($B_{i,t} + x_t \tilde{B}_{i,t}$). Households (who are shareholders) decide how much to invest in next period's physical capital ($k_{i,t+1}$), and how much to consume.
5. Firms issue liquid claims against next period's output and capital ($B_{i,t+1}$ and $\tilde{B}_{i,t+1}$) and sell them in the liquidity market. Firms buy liquid claims to be used in the next period ($b_{i,t+1}$ and $\tilde{b}_{i,t+1}$).

3.1 Global environment

There are two countries: an emerging economy (em) and a developed economy (d). The size of the emerging economy relative to the developed economy is ρ (in the emerging economy, there is a measure ρ of households-firms, and in the developed economy there is a measure 1 of households-firms). As household-firms are identical within a country, with a slight abuse of notation I will use the subscript i to denote country variables ($i = d, em$).

The countries differ both in their ability to create publicly backed liquid claims and in their ability to create collateral backed liquid claims. The emerging economy is assumed to be unable to create collateral backed liquid claims:

$$\gamma^{em} = 0 \tag{11}$$

The emerging economy is also not particularly good at creating publicly backed liquid claims: the fraction of output that the government can guarantee, θ , is such that the liquidity constraint is binding in equilibrium. Recall that given the Cobb-Douglas production technology, the wage bill in an unconstrained economy is a fraction $1 - \alpha$ of output. Thus, the following restriction guarantees that in the autarkic emerging economy, the liquidity constraint is binding in equilibrium:

$$\theta^{em} < 1 - \alpha \tag{12}$$

The developed economy is superior to the emerging economy both in its ability to create publicly backed liquid claims and in its ability to create privately backed liquid claims. I assume that in the developed economy, a positive fraction of capital can be used as collateral:

$$\gamma^d = \gamma > 0 \tag{13}$$

In addition, the government is able to back enough claims to finance the

autarkic wage bill:

$$\theta^d \geq 1 - \alpha \quad (14)$$

I also allow for cross country differences in productivity levels and in initial conditions (A_i , $k_{i,0}$, $B_{i,0}$, $\tilde{B}_{i,0}$, $b_{i,0}$ and $\tilde{b}_{i,0}$ for $i = d, em$).

4 Efficient allocations

It is useful to consider the social planner's problem. Consider a social planner, facing the following problem:

$$\max_{\{c_{i,t}(S^t), k_{i,t+1}(S^t)\}_{i \in \{d, em\}}} U(\{c_{d,t}(S^t)\}) + \Psi U(\{c_{em,t}(S^t)\}) \quad (15)$$

s.t.:

$$\begin{aligned} c_{d,t}(S^t) + \rho c_{em,t}(S^t) + k_{d,t+1}(S^t) + \rho k_{em,t+1}(S^t) = \\ \rho F_{em}(k_{em,t}(S^{t-1}), l) + F_d(k_{d,t}(S^{t-1}), l) + (1 - \delta)(\rho k_{em,t}(S^{t-1}) + k_{d,t}(S^{t-1})) \end{aligned} \quad (16)$$

Where $k_{em,0}$ and $k_{d,0}$ are given.

The social planner chooses consumption and investment to maximize a weighted sum of developed and emerging market utilities, given the aggregate budget constraint. The parameter Ψ is the Pareto weight that the planner puts on emerging economies. Note that the standard equivalence applies here: any Pareto efficient allocation corresponds to the solution to the planner's problem, for some value of Ψ . In other words, if an allocation does not correspond to the planner's solution for some value of Ψ , both emerging and developed economies can be made better off by switching to an allocation that does.

While the planner's problem allows for state-contingent consumption and investment sequences, it is easy to see that the solution is deterministic. This is because the shock x_t only affects the ability to issue collateral-backed liquid claims against capital; as the planner is not subject to any liquidity

constraint, this shock is irrelevant. The planner's solution corresponds to the efficient allocation in a standard open economy neoclassical growth model.

Lemma 1 *The solution to the planner's problem satisfies the following equations:*

$$\frac{\partial F_{em}(k_{em,t+1}, l)}{\partial k_{em}} = \frac{\partial F_d(k_{d,t+1}, l)}{\partial k_d} \quad (17)$$

$$u'(c_{d,t}) = \Psi u'(c_{em,t}) \quad (18)$$

$$u'(c_{d,t}) = \beta u'(c_{d,t+1}) \left(\frac{\partial F(k_{d,t+1}, l)}{\partial k} + 1 - \delta \right) \quad (19)$$

$$c_{d,t} + k_{d,t+1} + \rho(c_{em,t} + k_{em,t+1}) = \quad (20)$$

$$F_d(k_{d,t}, l) + (1 - \delta)k_{d,t} + \rho(F_{em}(k_{em,t}, l) + (1 - \delta)k_{em,t})$$

The planner's solution converges to a steady state in which:

$$\frac{1}{\beta} = \frac{\partial F_d(k_d^{ss}, l)}{\partial k} + 1 - \delta = \frac{\partial F_{em}(k_{em}^{ss}, l)}{\partial k} + 1 - \delta \quad (21)$$

$$c_d^{ss} + \rho c_{em}^{ss} = F_d(k_d^{ss}, l) - \delta k_d^{ss} + \rho(F_{em}(k_{em}^{ss}, l) - \delta k_{em}^{ss}) \quad (22)$$

The proof of this lemma, together with other omitted proofs, is in the appendix.

5 Closed economy equilibrium

This section characterizes the autarkic equilibrium. In this economy, the autarkic equilibrium is defined as follows:

Definition 1 *An equilibrium of the closed economy is a sequence of interest rates $\{r_t(S^t), \tilde{r}_t(S^t)\}_{t,S^t}$, a sequence of wages $\{w_t(S^t)\}_{t,S^t}$, a sequence of labor demands $\{\{l_{i,t}(S^t)\}_{t,S^t}\}_{i \in [0,1]}$, a sequence of physical capital stocks $\{\{k_{i,t+1}(S^t)\}_{t,S^t}\}_{i \in [0,1]}$, a sequence of liquidity demands $\{\{b_{i,t+1}(S^t), \tilde{b}_{i,t+1}(S^t)\}_{t,S^t}\}_{i \in [0,1]}$, a sequence of liquidity supplies $\{\{B_{i,t+1}(S^t), \tilde{B}_{i,t+1}(S^t)\}_{t,S^t}\}_{i \in [0,1]}$ and a set of*

consumption paths $\{\{c_{i,t}(S^t)\}_{t,S^t}\}_{i \in [0,1]}$ that jointly satisfy the following conditions:

1. Given the sequence of interest rates and the wage sequence, the consumption sequences, the labor demand sequences, the sequences of liquidity demands and liquidity supplies, and the capital sequences solve the optimization problem of household i (owner of firm i).
2. Given the wage $w_t(S^t)$, the labor market clears:

$$l_{i,t}(S^t) = l \quad (23)$$

3. Given the interest rates $r_t(S^t)$ and $\tilde{r}_t(S^t)$, the liquidity market clears:

$$b_{i,t+1}(S^t) = B_{i,t+1}(S^t) \quad (24)$$

$$\tilde{b}_{i,t+1}(S^t) = \tilde{B}_{i,t+1}(S^t) \quad (25)$$

The last condition states that the liquidity market clears domestically; there is no international trade in publicly backed liquid claims, so the domestic r may be different across countries. This implies that in an autarkic equilibrium, the entire wage bill is financed by domestically issued claims.

Assume that initial conditions satisfy $b_0 = B_0 = m_0$ and $\tilde{b}_0 = \tilde{B}_0 = \gamma k_0$. The following lemma characterizes the closed economy equilibrium:

Lemma 2 1. The equilibrium is characterized by the following equations.

The consumption and capital sequences are given by:

$$u'(c_{i,t}) = \beta u'(c_{i,t+1}) \left(\frac{\partial F_i(k_{i,t+1}, l)}{\partial k} + 1 - \delta \right) \quad (26)$$

$$c_{i,t} + k_{i,t+1} = F_i(k_{i,t}, l) + (1 - \delta)k_{i,t} \quad (27)$$

For $i = em, d$.

Equilibrium wages are given by:

$$w_{d,t} = \frac{\partial F_d(k_{d,t}, l)}{\partial l} \quad (28)$$

$$w_{em,t} = \frac{\theta^{em} F_{em}(k_{em,t}, l)}{l} \quad (29)$$

Equilibrium $r_{i,t}$ are given by:

$$u'(c_{d,t}) = \beta(1 + r_{d,t})u'(c_{d,t+1}) \quad (30)$$

$$u'(c_{em,t}) = \beta(1 + r_{em,t}) \frac{\frac{\partial F(k_{em,t+1}, l)}{\partial l}}{w_{em,t+1}} u'(c_{em,t+1}) \quad (31)$$

Equilibrium $\tilde{r}_{i,t}$ are given by $\tilde{r}_{em,t} = -1$ and:

$$u'(c_{d,t}) = \beta(1 + \tilde{r}_{d,t}) E_t(x_{t+1}) u'(c_{d,t+1}) \quad (32)$$

2. The autarkic equilibrium converges to a steady state, in which r , k , w and c are constant. Steady state consumption and capital are pinned down by:

$$\frac{1}{\beta} = \frac{\partial F_i(k_i^{ss}, l)}{\partial k} + 1 - \delta \quad (33)$$

$$c_i^{ss} = F_i(k_i^{ss}, l) - \delta k_i^{ss} \quad (34)$$

For $i = em, d$.

Steady state wages are:

$$\frac{\partial F_d(k_d^{ss}, l)}{\partial l} = w_d^{ss} \quad (35)$$

$$w_{em}^{ss} = \frac{\theta^{em} F_{em}(k_{em}^{ss}, l)}{l} \quad (36)$$

Steady state r_i are:

$$1 + r_d^{ss} = \frac{1}{\beta} \quad (37)$$

$$1 + r_{em}^{ss} = \frac{w_{em}^{ss}}{\beta \frac{\partial F_{em}(k_{em}^{ss}, l)}{\partial l}} \quad (38)$$

As for \tilde{r}_i , $\tilde{r}_{em}^{ss} = -1$ and $\tilde{r}_{d,t}$ may depend on S^t and need not converge to a steady state.

The developed economy has enough publicly backed claims so that the liquidity constraint is never binding, and there is no liquidity premium. Consequently, the return to investment is unaffected by liquidity motives, and unchanged by the shock x_t . Equilibrium capital accumulation is given by equation 26, which is the standard Euler equation. Enforceability shocks have no effect on the equilibrium path.

Equation 28 states that, in the autarkic developed economy, the wage is equated with the marginal product of labor. This standard equilibrium condition implies that producers are indifferent with respect to hiring an additional unit of labor: the marginal productivity of labor exactly offsets its cost. This indifference is evidence that the liquidity constraint is not binding: a producer endowed with another unit of liquidity would be indifferent between using it or not.

The closed economy equilibrium of the emerging economy is different in nature. In the autarkic emerging economy, there are not enough liquid claims to finance the unconstrained wage bill, and the liquidity constraint is binding. The wage bill is constrained by the aggregate amount of liquidity, and thus given by $wl = \theta^{em} F(k_{em,t}, l)$. At this equilibrium wage, the firm's liquidity constraint is binding: an additional liquid claim could purchase $\frac{1}{w}$ units of labor, which, at the margin, produce $\frac{\partial F(k_{em,t}, l)}{\partial l} > w$ units of output each. The return to liquidity is positive, reflected in a liquidity premium in r .

Importantly, while the liquidity constraint is binding from the firm's perspective, it is not binding from an aggregate perspective: since labor is sup-

plied inelastically, even though each firm would like to hire more workers at the equilibrium wage, from an aggregate perspective, all labor is already employed in its most efficient use.⁹ The shortage in liquidity changes the distribution of surplus between labor and the firm's profits, but does not change *aggregate* income.

Consequently, similar to the unconstrained developed economy, equations 26 and 27 fully characterize the consumption and capital sequences in the emerging economy. The assumption that $\gamma^{em} = 0$ implies that, even though there is a liquidity premium, the binding liquidity constraint does not affect the incentive to accumulate physical capital; capital accumulation is undistorted and follows the same path as in the unconstrained equilibrium.

Corollary 1 *When initial capital levels are given by their steady state values ($k_{i,0} = k_{i,0}^{ss}$ for $i = d, em$), the closed economy equilibrium is Pareto efficient.*

To see this, note that in this case, the autarkic equilibrium corresponds to the solution to the planner's problem with $\Psi = \frac{u'(c_d^{ss})}{u'(c_{em}^{ss})}$.

Of course, under the more realistic assumption of $k_{em,0} < k_{em}^{ss}$ and $k_{d,0} = k_d^{ss}$, the autarkic equilibrium is not Pareto efficient, as there are gains from intertemporal trade between the two countries. In particular, it is optimal for the emerging economy to borrow from the developed economy in order to smooth consumption and speed up capital accumulation.

6 Integrated equilibrium

In the open economy, it is no longer required that the market for liquidity clears domestically: foreigners and domestic firms can trade publicly-backed

⁹The assumption that labor is supplied inelastically is important for the efficiency result: absent this assumption, the depressed wage would affect labor supply and generate an inefficiency. The assumption that firms are identical is not important: in the presence of domestic liquidity markets, the wedge between the marginal product of labor and the wage would be equated across firms. Thus, the marginal product of labor would be equated across firms and labor would be allocated efficiently.

liquid claims in a global liquidity market.

The definition of an equilibrium in the integrated economy is analogous to the definition of the autarkic equilibrium, with a single departure: rather than requiring that the market for publicly backed liquid claims clears domestically, it requires that the rate of return on publicly backed claims is equated across countries. Formally, the equilibrium condition in equation 24 is replaced with:

$$\rho b_{em,t}(S^t) + b_{d,t}(S^t) = \rho B_{em,t}(S^t) + B_{d,t}(S^t) \quad (39)$$

The other equilibrium conditions remain unchanged.

The following parametric restriction guarantees that in the autarkic steady state, the aggregate amount of liquidity is insufficient to finance the unconstrained wage bill in the integrated economy:

Assumption 1 *Let k_i^{ss} denote the autarkic steady state capital level in country i , and assume the following parametric restriction:*

$$\theta_i^d F_d(k_d^{ss}, l) + \rho \theta^{em} F_{em}(k_{em}^{ss}, l) + \gamma k_d^{ss} < (1 - \alpha)(F_d(k_d^{ss}, l) + \rho F_{em}(k_{em}^{ss}, l)) \quad (40)$$

The left hand side is the aggregate amount of liquidity in the autarkic steady state, given $x_t = 1$. The right hand side is the aggregate unconstrained wage bill at the autarkic steady state (which is a fraction $1 - \alpha$ of steady state output in each country).

Characterizing the integrated equilibrium is less straightforward than characterizing the autarkic equilibrium, because there may be occasionally binding constraints. However, it is possible to prove the following key result:

Proposition 1 *The integrated equilibrium is Pareto inefficient.*

There are two sources of inefficiency in the integrated equilibrium. First, there is excessive capital accumulation in the developed economy, driven by

an incentive to create collateral backed liquid claims. To see this, note that the household's first order condition with respect to the accumulation of physical capital (the Euler equation) is given by:

$$u'(c_{d,t}) = \beta E_t(u'(c_{d,t+1}) (\frac{\partial F(k_{d,t+1}, l)}{\partial k} + 1 - \delta)) + \gamma \lambda_{t+1, \tilde{B}} \quad (41)$$

Where $\lambda_{t, \tilde{B}}$ is the Lagrange multiplier on equation 5 (the constraint on issuing collateral-backed liquid claims, \tilde{B}). Under autarky, the incentive to create private liquidity is muted, since there are enough publicly backed liquid claims to insure that the liquidity constraint never binds. Thus, $\lambda_{t+1, \tilde{B}} = 0$ and the above condition amounts to the standard Euler equation. In the integrated equilibrium, there is a global liquidity shortage driven by the excess demand for liquidity in emerging economies. This results in a liquidity premium on internationally traded publicly backed liquid claims; consequently, there is also a liquidity premium on privately-backed liquid claims, that can be used to substitute for publicly-backed claims domestically. Thus, in the integrated equilibrium, $\lambda_{t+1, \tilde{B}} > 0$, and the incentive to create privately backed liquid claims enters into the developed economy's capital accumulation decision. From the planner's perspective, this is inefficient.

The second source of inefficiency is that reliance on collateral-backed liquid claims creates vulnerability with respect to enforceability shocks. In the autarkic equilibrium, enforceability shocks have no effect on the incentive to accumulate capital: when $\lambda_{t+1, \tilde{B}} = 0$, expectations regarding x_{t+1} do not enter the condition in equation 41. However, when $\lambda_{t+1, \tilde{B}} > 0$, expected changes in enforceability can affect the incentives to accumulate capital. The value of $\lambda_{t+1, \tilde{B}}$ depends on the expected transformation of physical capital into *enforceable* collateral-backed claims. Thus, changes in the expectation of x_{t+1} will change the incentives to accumulate physical capital, which results in inefficient volatility in capital accumulation.

Of course, the fact that the integrated equilibrium is Pareto inefficient

does not necessarily imply that it is welfare inferior to autarky, as given realistic initial conditions (for example, $k_{em,0} < k_{em}^{ss}$ and $k_{d,0} = k_d^{ss}$), the autarkic equilibrium is Pareto inefficient as well. Standard considerations would suggest that financial integration can be associated with welfare gains: emerging markets can borrow from developed economies to implement a smoother consumption path and faster capital accumulation. A natural question is: in the presence of liquidity motives for borrowing and lending, are these gains from financial integration still relevant?

It turns out that these standard considerations are relevant only when k_{em} is sufficiently small. At this range, the emerging economy borrows from the developed economy in order to increase investment and implement a smoother consumption path. Given these efficiency gains, financial integration may be welfare superior to autarky, and benefit both emerging and developed economies.

However, when capital levels are close to their autarkic steady state levels, this is no longer the case: in this range, the emerging economy starts to *lend* to the developed economy, even if $k_{em} < k_{em}^{ss}$ and $k_d \geq k_d^{ss}$. The reason for lending has nothing to do with differential returns to capital or consumption smoothing, but rather with liquidity shortages. Recall that, faced with binding liquidity constraints, producers in emerging economies stand to make strictly positive profits from additional units of liquidity: with an additional liquid claim, producers can purchase $\frac{1}{w}$ units of labor, which, at the margin, produce a return of $\frac{\partial F(k_{em,t}, l)}{\partial l} > w$. Anticipating their constraint in the next period, producers in emerging economies find it optimal to buy liquid claims in global liquidity markets. Importantly, when producers decide to buy foreign issued liquid claims, they do not internalize the pecuniary externality on wages. At the aggregate level, since labor is supplied inelastically, “imported” liquidity does not increase employment but translates entirely into higher wages. At this range, the emerging economy is made worse off by financial integration, as the economy must spend resources on importing

foreign liquidity.

Proposition 2 *Assume that there is no enforceability risk ($x_t = 1$ for all t).*

1. *There exists a unique integrated equilibrium steady state in which:*
 - (a) *The capital level in the emerging economy is equal to its autarkic steady state level;*
 - (b) *The capital level in the developed economy is higher than its autarkic steady state level;*
 - (c) *The emerging economy lends to the developed economy ($b_{em}^{ss} - B_{em}^{ss} > 0$).*
2. *For $k_{em,0}$ and $k_{d,0}$ sufficiently close to their autarkic steady state levels, financial integration reduces equilibrium welfare for emerging economies. Developed economies are made better off by financial integration (regardless of initial conditions).*

The first part of the proposition describes the steady state of the integrated equilibrium. The capital level in the emerging economy is the same as its autarkic level; however, the incentive to create privately-backed liquid claims implies a higher steady state capital level in the developed economy. At the steady state, the emerging economy lends to the developed economy in every period. This is because the steady state wage bill in emerging economies is too high to be financed with domestically issued liquid claims; effectively, emerging economies “import” liquidity in order to finance inflated production expenses.

The second part of the proposition summarizes the discussion above: when initial conditions in emerging economies are very different from initial conditions in developed economies, emerging economies may gain from financial integration through standard channels. However, when initial conditions are *sufficiently close*, financial integration reduces welfare for emerging economies, as it creates inefficient dependence on foreign liquidity. The

numerical example in the next section illustrates that, in this context, “sufficiently close” need not be very close: even when the initial capital stock of the emerging economy is 15% of its steady state level (and $k_{d,0}$ is at its autarkic steady state), it is a net lender in every period and made worse off by financial integration.

Interestingly, regardless of initial conditions, developed economies are always made weakly better off by financial integration. In this model, this conclusion holds true even in the presence of enforceability risk. For agents in developed economies, the autarkic consumption sequence is always feasible under financial integration, as they always have enough publicly backed liquid claims to finance the autarkic level of employment. For emerging economies this is not the case, because given equilibrium wages, domestically issued liquidity is insufficient to finance autarkic production.

7 Numerical example

This section presents two quantitative exercises. First, abstracting away from enforceability shocks, I compare the autarkic equilibrium with the integrated equilibrium. Second, I consider the implications of a permanent enforceability shock.

I assume that the intertemporal elasticity of substitution is 1, or $u(c) = \ln(c)$. The choice of parameters is summarized in table 1. The first three parameters, β , δ , and α , are standard. The choice of $l = 1$ and $A_d = 1$ are convenient normalizations. The productivity of the emerging market is calibrated based on Hsieh and Klenow [2009], who estimate manufacturing productivity in the US to be about 150% higher than in India and China.¹⁰ The value of θ^d was chosen to match the value of M3 over GDP in the US. The value of θ^{em} was calibrated to roughly match M3 over GDP in emerging

¹⁰I chose to calibrate TFP differences based on the differences in manufacturing productivity, which are relatively small compared to current differences in TFP levels. This reflects some expected convergence in TFP in the long run.

Table 1: Calibration parameters

Notation	Variable	Value
β	Discount factor	0.97
δ	Depreciation rate	0.1
α	Capital share in production	0.33
A_d	Productivity: developed economies	1
A_{em}	Productivity: emerging economies	0.4
ρ	Size of emerging market (relative to developed)	10
l	Labor supply	1
θ^d	Public backing as a share of output: developed economies	0.7
θ^{em}	Public backing as a share of output: emerging economies	0.35
γ	Private liquidity as a share of capital: developed economies	0.078
$k_{d,0}$	Initial capital level: developed economies	3.97
$k_{em,0}$	Initial capital level: emerging economies	0.15

economies, in particular China and India.¹¹ The value of ρ was chosen to roughly match the population of BRIC countries (Brazil, Russia, India and China) relative to the US.

I use the following procedure to calibrate γ . According to Gorton et al. [2012], privately backed claims (including MBS, ABS, corporate bonds and loans) accounted for about 25% of the supply of liquid claims in the US in 2006. I choose γ to match this proportion in the integrated steady state. Importantly, this proportion approaches its steady state level quite quickly: at $t = 4$ (the timing of the calibrated “shock”), this share is already 23%. Thus, the calibration of γ would be roughly the same if I were to choose γ to match this proportion at $t = 4$.

¹¹For the US, the average value of M3 as a percent of nominal GDP is about 70% between 1960-2011. It is worth noting that $\frac{M3}{PY}$ in the US is essentially trend-less in this period, despite the fact that the US has experienced high GDP growth. This feature of the data is consistent with the assumption that θ is a time invariant parameter that does not change with GDP. Unfortunately, data for China is available only for the years 1977-1982. For these years, M3 was 30% of nominal GDP on average. More data is available for India. Between 1977 and 1992, the average M3 over nominal GDP in India was 38%. Source: World Development Indicators.

The initial capital level in the developed economy is chosen as the autarkic steady state level. In the emerging economy, the initial capital level is chosen to match a 10% growth rate (under autarky). The other initial conditions are given by the autarkic equilibrium levels, $B_{i,0} = b_{i,0} = \theta^i F_i(k_{i,0}, l)$ and $\tilde{B}_{i,0} = \tilde{b}_{i,0} = \gamma^i k_{i,0}$.

7.1 Financial integration

To illustrate the workings of the model, I present a quantitative comparison between the autarkic equilibrium and the integrated equilibrium, abstracting away from any enforceability risk ($x_t = 1$ for all t).

Given the chosen parameters, the model suggests that, in developed economies, financial integration is associated with welfare gains equivalent to a 12% permanent increase in consumption, while, in emerging economies, financial integration is associated with a welfare loss equivalent to a 6.5% permanent reduction in consumption.

Steady state analysis. The steady state values of the autarkic and open equilibria, given the calibrated parameters in table 1, are summarized in the first two columns of table 2 (the third column presents steady state values for a permanent enforceability shock studied in the next section).

In this numerical example, steady state consumption in emerging economies is about 5.3% lower in the financially integrated equilibrium, while steady state consumption in developed economies is about 16.1% higher.

The last two rows are net exports as a fraction of GDP. Notice that, in this model, the trade balance is equal to the current account. These parameters suggest that, in the steady state, the emerging market exports roughly 4.2% of its GDP to the developed economy, as payment for liquidity services. At the same time, the developed economy enjoys a steady state flow of imports equal to 9.7% of its GDP.

Table 2: Steady state comparison

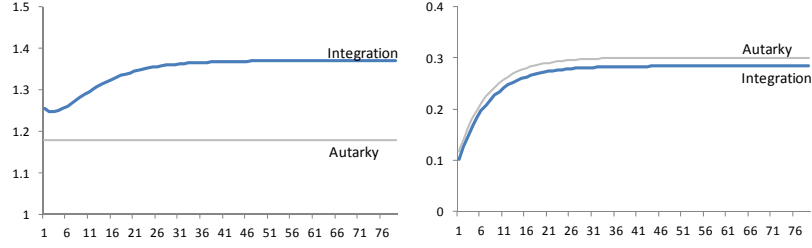
Variable	Autarky	Open	Shock	$\frac{\text{Open}}{\text{Autarky}}$	$\frac{\text{Shock}}{\text{No shock}}$
c_{em}	0.3	0.284	0.283	0.947	0.996
c_d	1.179	1.369	1.357	1.161	0.991
k_{em}	1.012	1.012	1.012	1	1
k_d	3.974	5.188	3.974	1.305	0.766
w_{em}	0.141	0.211	0.18	1.496	0.853
w_d	1.056	0.905	0.707	0.857	0.781
r_{em}	-0.461	-0.191	-0.31		1.623
r_d	0.031	-0.191	-0.31		1.623
$(\frac{nx}{y})_{em}$		0.042	0.044		1.048
$(\frac{nx}{y})_d$		-0.097	-0.113		1.165

Transitional dynamics. I solve for the equilibrium using Dynare. Figures 3 and 4 describe the transitional dynamics of the integrated equilibrium compared to the autarkic counterfactual.

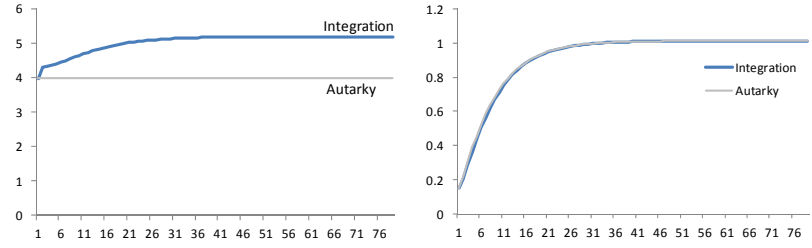
Upon financial integration, the developed economy starts accumulating capital, until it converges to its new steady state. The incentive to accumulate additional capital stems from the ability to create collateral-backed liquid claims. This trend is broadly consistent with the pre-crisis boom in the US, and especially with the view that the housing boom was driven by the incentive to create MBS (which had favorable liquidity properties).

On impact, financial integration leads to a 6% increase in consumption in the developed economy, reflecting a higher permanent income due to international liquidity rents. Faced with higher private returns to capital, households in the developed economy initially sacrifice some consumption growth in favor of investment. However, consumption growth quickly recovers as it converges to its new steady state.

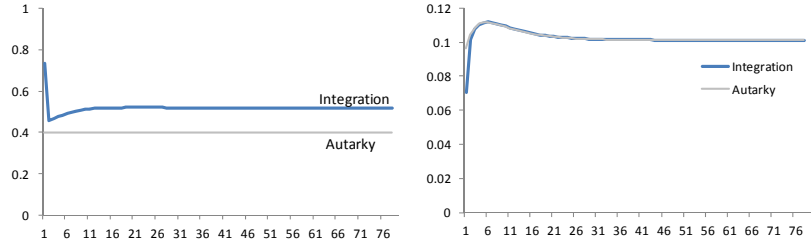
Interestingly, the wage rate in the developed economy falls, despite the fact that it is accumulating capital. Capital accumulation raises the “unconstrained” wage bill, as the marginal product of labor increases; however,



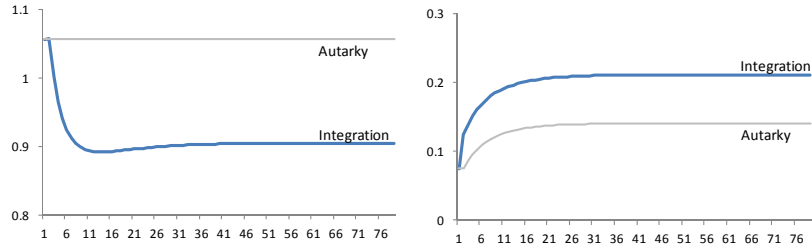
(a) Consumption: developed econ- (b) Consumption: emerging econ-
omy



(c) Capital: developed economy (d) Capital: emerging economy



(e) Investment: developed economy (f) Investment: emerging economy



(g) Wage: developed economy (h) Wage: emerging economy

Figure 3: A comparison of the integrated and autarkic equilibria: consumption, capital, investment and wages.

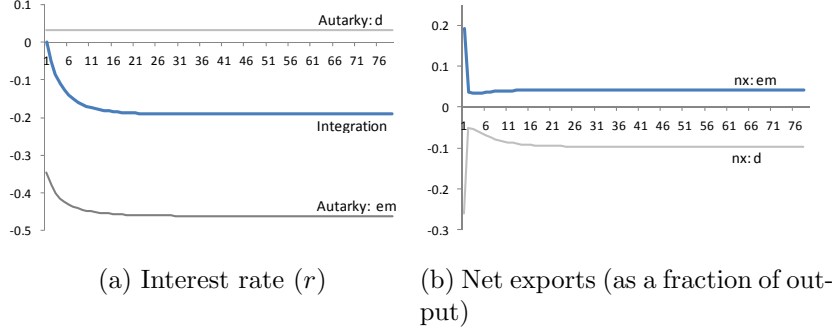


Figure 4: A comparison of the integrated and autarkic equilibria: the interest rate on publicly backed claims and net exports (in the closed economy, net exports are 0).

at the same time, the return to liquidity increases, and the option of selling liquid claims abroad becomes more attractive relative to paying for domestic labor. The widening gap between the marginal product of labor and the wage is consistent with recent trends in the US.¹²

The interest rate (r) is declining over time. From the perspective of developed economies, financial integration is associated with an initial drop in r from its autarkic steady state level of 3% to around 0. During the transition, the interest rate declines until reaching its steady state value of -19%. In principle, there are two competing forces affecting the interest rate trend: on the one hand, capital accumulation in both the emerging and the developed economies decreases the marginal return to capital, thus putting downward pressure on r . In addition, as the emerging economy grows, its excess demand for liquidity increases. This channel further contributes to the decline in r and to the increase in liquidity premiums. On the other hand,

¹²Calibrating the marginal product of labor as $MPL = \frac{(1-\alpha)Y}{l}$ with $\alpha = 0.33$, the “labor wedge” $\frac{MPL}{w}$ has been increasing steadily in the US, from around 1.2 in 1990 to 1.3 in 2010. The calculations are based on the following data from the OECD, 2013. For Y : B1 GA: Gross domestic product (output approach) National Currency, current prices. For l : Annual Labor Force Statistics, Total Employment. For w : Average annual wages, current prices in NCU.

capital accumulation in the developed economy increases the supply of both public and private liquid claims, somewhat countering the increased demand for liquidity; this channel puts some upward pressure on r . In equilibrium, the first channels dominate and the path of r is steadily decreasing.

Though not detectable in the figures, financial integration actually slows down capital accumulation in the emerging economy. For example, after one period, capital is 0.89 of what it would have been under autarky; by the fifth period, capital is 0.96 of its autarkic counterfactual level, and by the tenth period, it is 0.99 of its autarkic counterfactual level. This finding suggests that (contrary to popular beliefs in policy circles) high foreign savings does not accelerate growth, but rather slows down growth. In this model, growth is driven by standard convergence considerations, and, while a high saving rate emerges in equilibrium, equilibrium output growth is slower compared to the autarkic counterfactual.

Similarly, consumption in emerging economies initially drops by almost 13% (compared to the autarkic counterfactual). The gap gradually declines until it converges to its steady state level of 5.6%. Both consumption and investment are disproportionately affected in the first periods. In later periods, the increase in liquidity supply in the developed economy somewhat mitigates the strain on the budget constraint, as liquidity imports become relatively cheaper.

On impact, net exports in the emerging economy increase to roughly 20% of GDP, mirrored by net imports of around 25% of GDP in the developed economy. This initial surge is due to the fact that, in the first period, the emerging economy is buying foreign bonds but not redeeming foreign bonds; in subsequent periods, the trade balances are more modest, as the emerging economy is both buying and redeeming bonds.

7.2 A permanent enforceability shock

The second quantitative exercise illustrates the effects of a permanent and unexpected enforceability shock. In the benchmark economy, there are no enforceability problems and $x_t = 1$ for all t . At some \bar{t} , enforceability breaks down unexpectedly and $x_t = 0$ for every $t \geq \bar{t}$. Notice that this shock is equivalent to a shock to γ in the developed economy, that brings the value of γ^d permanently to $\gamma = 0$. This extreme scenario is meant to illustrate how, in a global environment characterized by liquidity shortages, a shock to enforceability - or, alternatively, a shock to the ability to use capital to create collateral-backed liquid claims - can lead to a surge in liquidity premiums and a reduction in investment.

Before presenting the results, it is useful to clarify how this type of “enforceability shock” is related to other models of the recent crisis. Broadly, theories attempting to explain the recent crisis fall into one of two categories: the “credit shock” view (e.g., Jermann and Quadrini [2012]) and the “demand shock” view (e.g., Mian and Sufi [2012]). The key difference between the two views is the implication for the investment wedge. According to the “credit shock” view, the tightening of a financial constraint creates an investment wedge that prevents agents from taking advantage of high-return investment opportunities. In contrast, according to the “demand shock” view, the contraction in investment is *voluntary*, as low demand lowers the expected return to capital.

This model falls somewhere in between. Mechanically, the shock is similar to a credit shock, or a fall in the underlying collateral value of physical capital. However, similar to the demand shock view, the contraction in investment is voluntary: the incentive to accumulate physical capital is lower, as it can no longer be used as collateral to back liquid claims.¹³

¹³This feature of the model is similar to Midrigan and Philippon [2011].

Steady state analysis. The steady state variables associated with the permanent enforceability shock are given by the third column of table 2. In both economies, steady state capital is equal to its autarkic steady state level. Compared to the no-shock trajectory, consumption is lower in both economies. In the emerging economy, this reflects higher liquidity rents. In the developed economy this reflects lower steady state capital and output. The steady state interest rate is substantially lower compared to the no-shock scenario, at -31%. With a higher liquidity premium, steady-state trade balances become slightly more extreme: the emerging economy exports an additional 0.2% of its GDP, and the ratio of imports to GDP in the developed economy increases by 0.6%.

Transitional dynamics. Figures 5 and 6 present the transitional dynamics associated with the enforceability shock, compared to the uninterrupted equilibrium path. The timing of the shock was chosen as $\bar{t} = 4$, to match an 8% growth rate in the emerging market at $t = 3$ (in 2006, the average growth rate of the BRIC economies was 8.55%¹⁴).

The dynamics of the model can qualitatively account for three interesting features of the recent crisis. First, in the model, the shock is associated with a sharp and permanent decline in interest rates and a surge in liquidity premiums. This reflects a shock to liquidity supply, as collateral-backed claims cease to be liquid. This is qualitatively consistent with the decline in the treasury rate following the 2007-2008 crisis.

Second, the model generates a decline in investment in the developed economy, and an increase in investment in the emerging economy. The decline in investment in the developed economy reflects the lower private return to capital. The increase in investment in the emerging economy is a result of the developed economy running down its capital stock: in part, this is achieved through saving in emerging economies, to smooth the declining consumption

¹⁴Source: World Development Indicators.

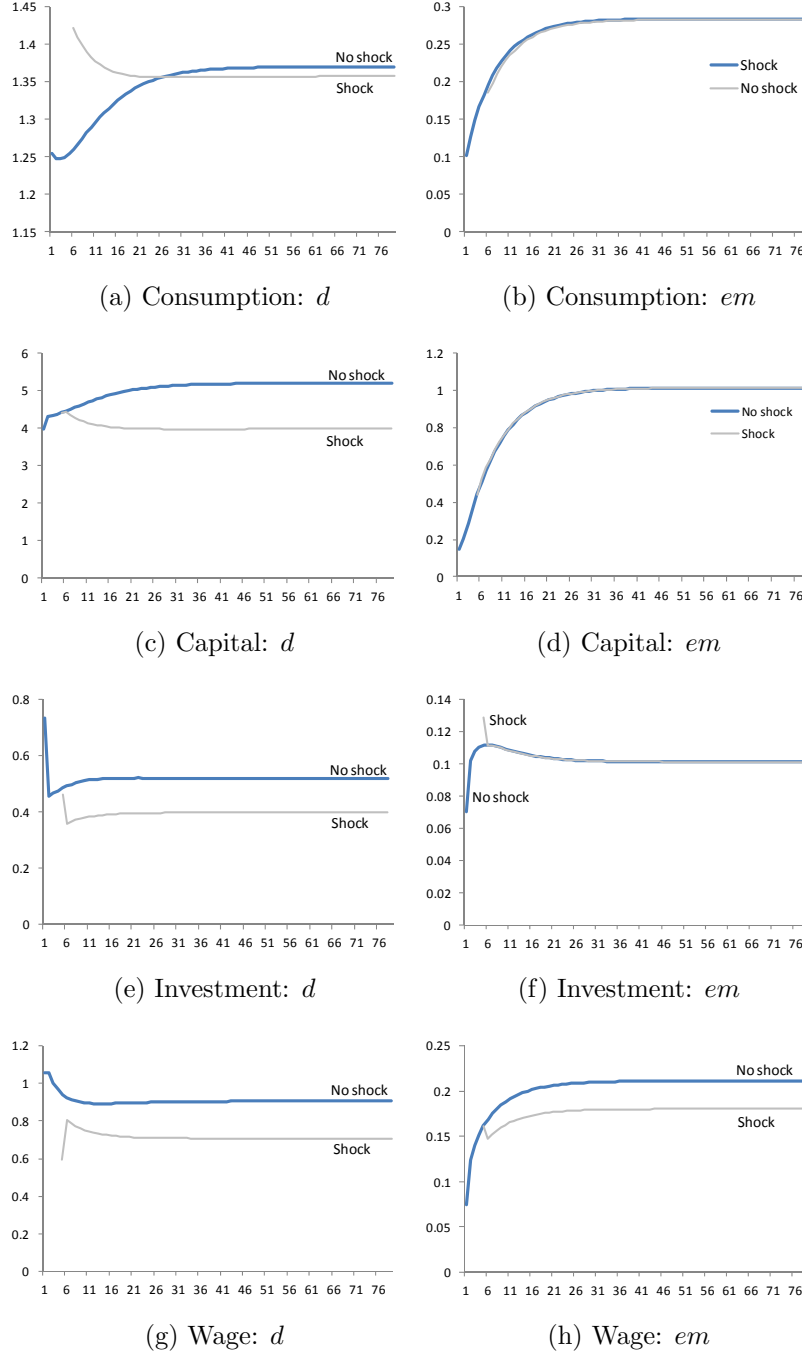


Figure 5: The equilibrium dynamics with and without the shock: consumption, capital, investment and wages.

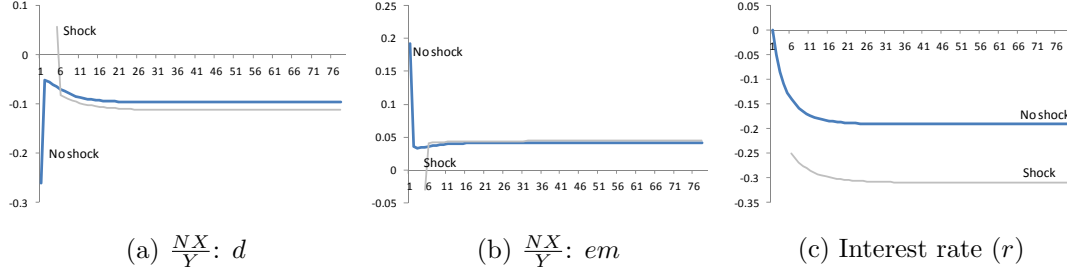


Figure 6: The equilibrium dynamics with and without the shock: net exports and the interest rate.

path. These predictions are roughly consistent with the observed changes in investment around the 2008-2009 crisis. The model predicts that the investment share of output in the developed economy should drop by 6.4% in the period following the shock. In the US, the investment share dropped by 5.1% between 2007-2009. The subsequent recovery is also of a similar magnitude: the model predicts that after two (additional) periods, the investment share in the developed economy should increase by 0.96%, which is roughly consistent with the 0.8% increase in the investment share in the US between 2009 and 2011. For the emerging economy, the model predicts an increase in the investment share of 3.7%, which is somewhat smaller than the increase in the investment share in China between 2007-2009 of 6.5%.¹⁵

Third, the model predicts a temporary current account reversal: in the period of the shock, the developed economy becomes a net exporter, and the emerging economy becomes a net importer. While the magnitudes in the model are large compared to the data, this result is qualitatively in line with current account movements during the crisis: the current account surplus in China dropped from 8.5% of GDP in 2006 to 4% of GDP in 2010, and the current account deficit in the US dropped from 6% of GDP in 2006 to 3.3% of GDP in 2010.¹⁶

¹⁵Source: World Development Indicators, Gross Capital Formation (% of GDP).

¹⁶Source: World Development Indicators, 2013: Current account balance (% of GDP).

In the model, this temporary reversal is driven by standard neoclassical channels: as the developed economy runs down its capital stock, it finds it optimal to smooth consumption by lending to emerging economies. It is worth emphasizing that, in this model, the current account reversal is temporary: the steady state current account balances are even larger than in the “no-shock” trajectory.

While the model qualitatively accounts for some aspects of the crisis, it misses the mark on others. Most notably, in the model, consumption in the developed economy increases following the shock. Part of this is due to mechanical aspects of the model: in a simple neoclassical framework, the only way to reduce global investment is to increase global consumption. Given that wages adjust instantaneously, the shock has no contemporaneous effect on output or employment. Standard “fixes” such as sticky wages would imply a contemporaneous effect on output, which would perhaps also translate into lower consumption.

Part of the increase in consumption reflects an increase in equilibrium welfare which is potentially worth noting. Since the developed economy remains a net exporter of liquid claims, the surge in liquidity premiums implies a permanent increase in liquidity rents. Welfare calculations reveal that the developed economy is made *better off* by the shock.¹⁷ The intuition for the welfare gain is one of standard “terms of trade” manipulation: as an exporter of liquid claims, developed economies are made better off by restricting the supply of liquid claims and enjoying higher liquidity premiums. This monopolistic argument reveals a coordination failure among agents in developed economies. Privately, each agent finds it profitable to create collateral-backed claims, not internalizing the effect that this will have on the equilibrium r . From an aggregate perspective, developed economies are made better off if they refrain from creating and using privately backed liquid claims, as limited

¹⁷The welfare improvement for the developed economy is equivalent to a permanent increase in consumption of 1.75%, compared to the “uninterrupted” integrated equilibrium.

supply hikes up the liquidity premium.

With the permanent enforceability shock, the steady state equilibrium is Pareto efficient, as the incentive to create privately-backed liquid claims is once again muted. However, the emerging market is made worse off by the shock: steady state consumption drops by about 0.38%, and, compared to the no-shock counterfactual, consumption is lower in every period. Emerging economies, who import liquid claims, are made worse off by the permanent increase in liquidity premiums. Their welfare loss is equivalent to a permanent 1.23% reduction in consumption.

8 Concluding remarks

The presence of binding liquidity constraints implies a transfer of surplus to liquidity suppliers. In the closed economy, liquidity is supplied domestically so the “liquidity rents” (if any) are consumed domestically. In the integrated equilibrium, “liquidity rents” are consumed disproportionately by those who have a comparative advantage in creating liquidity. Under the assumption that developed economies are better at creating liquidity than emerging economies, this implies a transfer of surplus from emerging to developed economies.

Even in the presence of neoclassical motives for intertemporal trade, financial integration may be welfare reducing for emerging economies when capital flows are primarily driven by liquidity motives. From the producer’s perspective, the liquidity constraint is binding, and there are strictly positive profits to be made from getting hold of additional liquidity. However, from a macro perspective, as the economy is in full employment, the binding constraint is not the liquidity constraint but rather the resource constraint. Importing liquidity is similar to importing money: in equilibrium, this does not change output but merely inflates domestic prices. Similarly, investing in capital for the purpose of creating privately backed liquid claims is similar

to investing in private money-printing machines, in that it merely inflates nominal prices but does not contribute to economic efficiency.

The monetary analogy is useful, also for pointing out potential avenues for further analysis. Naturally, this paper emphasizes some aspects of liquid claims, abstracting away from others. In this framework, a shortage in liquid claims does not create any inefficiency (as long as it does not increase the incentives to accumulate capital or import liquidity from abroad). Of course, there is a rich monetary literature suggesting various inefficiencies associated with the shortage of liquid claims (see, for example, Friedman [1969] with respect to transaction costs). The welfare analysis in this paper, by abstracting away from these channels, is of course incomplete. In particular, international trade in liquid claims may have some benefits if the shortage in liquid claims in emerging economies generates large inefficiencies. I hope that in light of the relevance of liquidity motives in international capital flows, the stark welfare conclusions suggested by this paper will refocus attention towards this important question.

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A Appendix

A.1 Proof of Lemma 1

Let λ_t be the Lagrange multiplier on the aggregate budget constraint of time t (equation 16). The FOC of the Lagrangian with respect to $k_{d,t+1}$ is:

$$\lambda_t - \lambda_{t+1} \left(\frac{\partial F(k_{d,t+1}, l)}{\partial k} + 1 - \delta \right) = 0 \quad (42)$$

Replacing $k_{d,t+1}$ with $k_{em,t+1}$ (and multiplying by ρ) yields the first order condition with respect to $k_{em,t+1}$. Thus,

$$\frac{\partial F(k_{d,t+1}, l)}{\partial k} = \frac{\partial F(k_{em,t+1}, l)}{\partial k} \Rightarrow k_{d,t+1} = k_{em,t+1} \quad (43)$$

The FOC with respect to $c_{d,t}$ and $c_{em,t}$ yields:

$$\beta^t u'(c_{d,t}) = \lambda_t \quad (44)$$

$$\Psi \beta^t u'(c_{d,t}) = \lambda_t \quad (45)$$

It follows that $\beta^t u'(c_{d,t}) = \Psi \beta^t u'(c_{d,t})$, and by equation 42 the Euler equation follows. By standard arguments, this system of equations converges to a steady state in which $\frac{1}{\beta} = \frac{\partial F(k^{ss}, l)}{\partial k} + 1 - \delta$, and the budget constraint is satisfied with equality.

A.2 Proof of Lemma 2

Denote the Lagrange multipliers on equations 9, 6, 4 and 5 by λ_t^1 , λ_t^2 , λ_t^3 and λ_t^4 respectively (it is easy to see that the constraint in equation 10 is never binding). Note that λ_t^3 and λ_t^4 are the constraints relevant at time t , when the firm is choosing $B_{i,t+1}$ and $\tilde{B}_{i,t+1}$.

The FOC of the Lagrangian are as follows:

- With respect to c_t :

$$u'(c_t) = \lambda_t^1 \quad (46)$$

- With respect to $l_{i,t}$:

$$\lambda_t^1 \left(\frac{\partial F(k_{i,t}, l_t)}{\partial l} - w_t \right) - \lambda_t^2 w_t = 0 \quad (47)$$

- With respect to $k_{i,t+1}$:

$$-\lambda_t^1 + \beta E(\lambda_{t+1}^1 (\frac{\partial F(k_{t+1}, l_{t+1})}{\partial k} + 1 - \delta)) + \gamma \lambda_t^4 = 0 \quad (48)$$

- With respect to $b_{i,t+1}$:

$$-\frac{\lambda_t^1}{1+r_t} + \beta E(\lambda_{t+1}^2 + \lambda_{t+1}^1) = 0 \quad (49)$$

- With respect to $B_{i,t+1}$:

$$\frac{\lambda_t^1}{1+r_t} - \beta E(\lambda_{t+1}^1) - \lambda_t^3 = 0 \quad (50)$$

- With respect to $\tilde{b}_{i,t+1}$:

$$-\frac{\lambda_t^1}{1+\tilde{r}_t} + \beta E(x_{t+1}(\lambda_{t+1}^2 + \lambda_{t+1}^1)) = 0 \quad (51)$$

- With respect to $\tilde{B}_{i,t+1}$:

$$\frac{\lambda_t^1}{1+\tilde{r}_t} - \beta E(x_{t+1}\lambda_{t+1}^1) - \lambda_t^4 = 0 \quad (52)$$

The autarkic equilibrium in the developed economy. To show that, for the developed economy, the equilibrium satisfies $\lambda_t^3 = \lambda_t^4 = \lambda_t^2 = 0$ for every S^{t+1} , I solve for the equilibrium under this assumption and verify that the constraints are satisfied. First, note that the assumption $\lambda_t^2 = 0$ (for every realization of x_t) implies that consumption is deterministic; to see this, note that x_t enters only in the budget constraint (equation 9) and the liquidity constraint (equation 6). Since the liquidity constraint is not binding, the problem is equivalent to one in which x_t appears only in the budget constraint; however, by symmetry and market clearing, it must be

the case that $\tilde{b}_{i,t} = \tilde{B}_{i,t}$; it follows that the term $x_t(\tilde{b}_{i,t} - \tilde{B}_{i,t}) = 0$, thus there is no consumption risk in equilibrium.

The equilibrium can be described by equation 46 and the following system of equations:

$$\frac{\partial F(k_t, l)}{\partial l} = w_t \quad (53)$$

$$\lambda_t^1 = \beta \lambda_{t+1}^1 \left(\frac{\partial F(k_{t+1}, l)}{\partial k} + 1 - \delta \right) \quad (54)$$

$$\lambda_t^1 = \beta \lambda_{t+1}^1 (1 + r_t) \quad (55)$$

$$\lambda_t^1 = \beta \lambda_{t+1}^1 (1 + \tilde{r}_t) E(x_t) \quad (56)$$

In equilibrium, the wage bill is given by $\frac{\partial F(k_{t+1}, l)}{\partial l} l = w_{t+1} l$; using the Cobb-Douglas specification, the equilibrium wage bill is $(1 - \alpha)F(k_{t+1}, l)$. Let $b_{i,t+1} = B_{i,t+1} \geq (1 - \alpha)F(k_{t+1}, l)$, such that $B_{i,t+1} \leq m_{t+1}$ (the set of such B 's is non-empty by the assumption $\theta^d \geq (1 - \alpha)$). Let $\tilde{b}_{i,t+1} = \tilde{B}_{i,t+1} \leq \gamma k_{i,t+1}$. Note that the solutions in this set satisfy the constraints in equations 6, 4 and 5.

The standard neoclassical growth model that we are left with converges to a steady state, that can be computed by replacing time t and $t + 1$ variables in the equilibrium equations with steady state values.

The autarkic equilibrium in the emerging economy. First, note that the emerging economy is deterministic, as it lacks any ability to issue collateral backed claims ($\gamma^{em} = 0$).

Note that the liquidity constraint is binding: recall that to finance the unconstrained wage bill, the liquidity supply must be at least a fraction $1 - \alpha$ of total output. In the emerging economy, there are only publicly backed claims, and publicly backed claims as a fraction of output are assumed to be less than $1 - \alpha$ ($\theta^{em} < 1 - \alpha$).

Thus, in equilibrium the liquidity constraint is binding for all firms, and

$\lambda_{t+1}^2 > 0$:

$$w_t l_{i,t} = b_{i,t} \quad (57)$$

Labor market clearing requires that $l_{i,t} = l$ for all t , and thus $w_t l = b_t$. Using the FOC with respect to $l_{i,t}$:

$$\lambda_t^1 \left(\frac{\frac{\partial F(k_t, l)}{\partial l}}{w_t} - 1 \right) = \lambda_t^2 \quad (58)$$

Substituting into the FOC with respect to $b_{i,t+1}$:

$$\lambda_{t+1}^1 \left(\frac{\frac{\partial F(k_{t+1}, l)}{\partial l}}{w_{t+1}} - 1 \right) = \frac{\lambda_t^1}{\beta(1+r_t)} - \lambda_{t+1}^1 \quad (59)$$

$$\Rightarrow \lambda_{t+1}^1 \frac{\frac{\partial F(k_{t+1}, l)}{\partial l}}{w_{t+1}} = \frac{\lambda_t^1}{\beta(1+r_t)} \quad (60)$$

$$\Rightarrow \lambda_{t+1}^1 \frac{\frac{\partial F(k_{t+1}, l)}{\partial l}}{w_{t+1}} \beta(1+r_t) = \lambda_t^1 \quad (61)$$

Using the FOC with respect to $B_{i,t+1}$, note that:

$$\lambda_t^3 = \frac{\lambda_t^1}{1+r_t} - \beta \lambda_{t+1}^1 = \beta \lambda_{t+1}^1 \frac{\frac{\partial F(k_{t+1}, l)}{\partial l}}{w_{t+1}} - \beta \lambda_{t+1}^1 = \beta \lambda_{t+1}^1 \left(\frac{\frac{\partial F(k_{t+1}, l)}{\partial l}}{w_{t+1}} - 1 \right) > 0 \quad (62)$$

It follows that $\lambda_t^3 > 0$ and thus $b_t = B_t = m_t = \theta^{em} F(k_t, l)$ for all t .

Since $\gamma^{em} = 0$, the FOC of the household with respect to $k_{i,t+1}$ can be rewritten as the standard Euler equation:

$$\lambda_t^1 = \beta \lambda_{t+1}^1 \left(\frac{\partial F(k_{t+1}, l)}{\partial k} + 1 - \delta \right) \quad (63)$$

Market clearing with respect to b_t and b_{t+1} implies the aggregate budget constraint. Furthermore, since there is no supply of collateral backed claims, $\tilde{r}_t = -1$ (an infinite price for collateral backed claims in terms of current goods) clears the market.

The rest of the proof follows trivially. The economy converges to a steady state, as the evolution of k_t and c_t can be described by a standard neoclassical growth model.

A.3 Proof of Proposition 1

Recall that by Lemma 1, any Pareto efficient allocation converges to a steady state in which $k_{em} = k_d = k^{ss}$, and $\frac{1}{\beta} = \frac{\partial F(k^{ss}, l)}{\partial k} + 1 - \delta$.

I show that the steady state is not an equilibrium outcome of the integrated economy. Using the household's FOC with respect to $k_{i,t+1}$ (equation 48), and equating $\lambda_{d,t+1}^1 = \lambda_{d,t}^1$, the autarkic steady state capital level implies that $\lambda_d^4 = 0$ at the steady state. In tern, using the developed economy household's FOC with respect to $\tilde{B}_{i,t+1}$, this implies that $1 + \tilde{r}_d^{ss} = \frac{1}{\beta E(x_t)}$. Inserting this into the developed economy's household's FOC with respect to $\tilde{b}_{i,t+1}$ yields $\lambda_d^2 = 0$. Using the FOC with respect to $b_{i,t+1}$, this yields $1 + r^{ss} = \frac{1}{\beta}$, and thus (using the same condition for the emerging economy), $\lambda_{em}^2 = 0$.

Thus, for the Pareto efficient steady state to be an equilibrium outcome it must be the case that $\lambda_{em}^2 = \lambda_d^2 = 0$; the liquidity constraint cannot bind in equilibrium, and wages must be equal to the marginal product of labor (using equation 47). Thus, the sum of wage bills are $(1-\alpha)F(k^{ss}, l)(1+\rho)$ (regardless of x_{t+1}). By assumption, this violates the aggregate liquidity constraint when $x_{t+1} = 1$, as aggregate liquidity is given by $F(k^{ss}, l)(\theta^d + \rho\theta^{em}) + \gamma k^{ss}$.

It follows that $\lambda_d^4 > 0$ at the steady state, and the steady state capital level in the developed economy is higher than in any Pareto efficient allocation.

A.4 Proof of Proposition 2

First, I solve for the integrated steady state in the riskless economy ($p = 0$). Using equations 49 and 47, and imposing steady state values for λ^1 , it follows that the wedge between the marginal product of labor and the wage

is equated across regions:

$$w_i = \beta(1+r) \frac{\partial F(k_i, l)}{\partial l} \quad (64)$$

If $\beta(1+r) = 1$, the marginal product of labor is equated with the wage in both countries. In this case, $\lambda^2 = 0$ in both countries. Using equations 51 and 52, it follows that $\lambda_d^4 = 0$. Using equation 48, it then follows that the steady state capital level in the developed economy is equal to its autarkic steady state level.

Note that, as $\gamma^{em} = 0$, by equation 48, the steady state capital level in the emerging economy is the same as in the autarkic steady state.

Thus, $(1+r)\beta = 1$ implies that both in emerging and in developed economies the steady state capital levels are the same as under autarky, and the liquidity constraint is not binding in either country. But this violates Assumption 1, according to which the aggregate liquidity issued in the autarkic steady state is insufficient to finance the unconstrained wage bill.

Thus, $w_i < \frac{\partial F(k_i, l)}{\partial l}$ in both countries, and $\beta(1+r) < 1$.

Since $w_d < \frac{\partial F(k_i, l)}{\partial l}$, it follows that the developed economy sells publicly backed liquid claims in equilibrium: otherwise, since $\theta^d > (1-\alpha)$, there would be enough domestically held publicly backed liquid claims to finance the unconstrained wage bill, and the liquidity constraint would not be binding.

It follows that in equilibrium, the emerging economy lends to the developed economy in every period ($b_{em}^{ss} - B_{em}^{ss} > 0$).

To show that when initial conditions are sufficiently similar, the emerging market is better off under autarky, I use the following reasoning: when initial conditions are the same, autarky is Pareto efficient. I show that (regardless of initial conditions) the developed economy is made strictly better off by financial integration; it follows that emerging economies are made worse off by financial integration. By continuity, this comparison holds true for initial conditions that are not identical but sufficiently close.

To show that the developed economy is made better off by financial inte-

gration, it is sufficient to show that, given equilibrium prices, the autarkic allocation is feasible. To see this, note that an agent in the developed economy can replicate his autarkic consumption sequence by excluding himself from financial markets, and financing his wage bill with self-issued publicly backed claims. Formally, consider the choice $b_{i,t+1} = B_{i,t+1} = (1 - \alpha)F(k_{d,t+1}, l)$ (for an agent i in country d). Note that this choice is feasible as $\theta^d > (1 - \alpha)$ (and m_t is the same for all firms, regardless of their individual capital levels).

Since $w_t l \leq (1 - \alpha)F(k_{d,t}, l)$, the agent always has sufficient liquidity to choose to hire l units of labor ($l_{i,t} = l$).

The agent receives the market wage, so his labor income is $w_{t+1}l$. The agent's budget constraint (under the assumptions $b_{i,t} = B_{i,t}$ and $l_{i,t} = l$) is therefore reduced to:

$$c_{i,t} + k_{i,t+1} = F(k_{i,t}, l) + (1 - \delta)k_{i,t} - w_t l + w_t l = F(k_{i,t}, l) + (1 - \delta)k_{i,t} \quad (65)$$

For $t > 0$. For $t = 0$, by assumption the wage is set (at time -1) such that all agents have enough liquidity to hire l units of labor; the only difference is some "initial wealth", $b_{i,0} - B_{i,0}$.

This sequence of budget constraints replicates the autarkic sequence of budget constraints. It follows that agents in developed economies can replicate the autarkic consumption sequence; the fact that they choose not to implies that they are made strictly better off by financial integration. As the autarkic equilibrium is efficient when initial conditions are identical, it follows that emerging economies are made strictly worse off.