Financial Distortions and the Distribution of Global Volatility

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Abstract

A generic feature of financial frictions, whatever their origins may be, is to distort the allocation of funds to projects, causing some less productive projects to be funded while more productive projects are not. I formalize this idea by introducing a log supermodularity condition which requires that, at the margin, the difference in productivity between funded and unfunded projects is smaller in more distorted economies. Using this condition, I then revisit the relationship between financial distortions and macroeconomic volatility. My first set of results establish that financial integration shifts the margin of adjustment to global liquidity shocks disproportionately to financially distorted regions, thereby providing a new and simple explanation for the divergent trends in the volatility of emerging and developed economies up to the recent crisis. My second set of results show that a global environment in which liquidity is cheap is conducive to a deterioration of the financial system in the developed world. While cheap liquidity increases and stabilizes output in that region, it amplifies large adverse shocks.

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1 Introduction

How does financial integration between emerging and developed economies affect the global distribution of output volatility? Why are shocks to external funding an important source of crises in emerging markets, but typically irrelevant in the developed world? What was the role (if any) of financial integration with emerging markets in setting the stage for the subprime crisis?

In this paper I develop a simple model of financial distortions to address these questions. I present two sets of results: first, I show that financial integration shifts the margin of adjustment to fluctuations in liquidity supply disproportionately from developed to emerging economies. In other words, shocks to external funding are an important source of crises in emerging markets *because* they are typically irrelevant in the developed world. Second, I show that a global environment in which liquidity is cheap is conducive to the deterioration of the financial system in developed economies. The deterioration of the financial system will amplify large contractions in liquidity supply; however, it will actually serve to increase and stabilize output during normal times. The model therefore generates volatility patterns that are consistent both with the amplification of the subprime crisis and with the euphoric pre-crisis environment, and suggests that financial integration with emerging economies may have led to endogenous structural changes in the financial system that set the stage for the subprime crisis.

The notion of financial distortions central to my simple model builds on the following idea. Regardless of whether distortions originate from collateral constraints, informational asymmetries or search frictions, financial distortions cause unproductive projects to be implemented before more productive projects. Because of this, the return to the marginal units of funding is relatively higher in more distorted economies. Stated formally, the marginal product of funds is log supermodular in funds and the level of distortion.

This simple condition has rich macroeconomic implications. An attractive feature of this approach is that it clearly disentangles the macroeconomic implications of financial distortions from their micro source, emphasizing the generality of the former. More importantly, this approach isolates a particular feature of financial distortions that is relevant for understanding macroeconomic volatility. For example, this feature is tightly linked to the amplification of liquidity supply shocks: in more distorted economies, the marginal units of funding are relatively more important, as they are used to implement relatively more productive projects.

I embed this notion of financial distortions in a general equilibrium framework. Working capital is the single input of production and is determined by a fluctuating liquidity supply. In reduced form, a more distorted economy can be represented simply as an economy with a less steeply declining marginal product of working capital. The first result is that, holding the levels of financial distortions fixed, financial integration shifts the margin of adjustment to fluctuations in liquidity supply disproportionately to emerging economies, mitigating the effect of shocks to the supply of funding on the developed world. This result is closely tied to the assumption that financial distortions are more prevalent in emerging markets: compared to developed economies, implemented projects are less productive and unimplemented projects are more productive. A contraction in global liquidity supply will therefore lead to a disproportionate contraction in the amount of implemented projects, as relatively fewer previously-implemented projects are able to meet more stringent borrowing requirements. Similarly, an expansion in global liquidity supply will lead to a disproportionate expansion in the amount of implemented projects, as relatively more previously-unimplemented projects generate returns high enough to justify implementation. The equilibrium counterpart of emerging markets' vulnerability to shocks to external funding is a decline in liquidity-driven output fluctuations in developed economies. Emerging economies essentially serve as a buffer zone insulating developed economies from shocks to their own domestic liquidity supply.

This result proposes a novel link between the vulnerability of emerging economies to shocks to external funding, and the moderation of liquidity-driven output fluctuations in the developed world prior to the recent crisis. There is a vast literature emphasizing the role of international capital flows as a source of heightened volatility in emerging markets[1]. Evidence suggests that emerging markets are more sensitive to shocks to the global supply of funds, and that, because of this, financial

[1] See Broner and Ventura (2010), Uribe and Yue (2006), Fostel and Geanakoplos (2008), Neumeyer and Perri (2005), Fernandez-Villaverde, Guerron-Quintana, Rubio-Ramirez, and Uribe (2009) and Chang and Fernandez (2010).

integration increases volatility in emerging market economies[2]. At the aggregate level, the last three decades, which have been characterized by rapid financial integration, have also been characterized by a divergence in the volatility levels of emerging and developed economies. Figures 4 and 5 plot the trends of the absolute value of the output gap (calculated based on a linear trend) in the developed and emerging market regions[3]. While the volatility of output has increased in the emerging market region, output volatility in the developed world has experienced a steep and steady decline, commonly referred to as the Great Moderation. As demonstrated by structural VAR analysis in Gali and Gambetti (2009), this decline seems to be attributed to the contribution of non-technology shocks, which, in the context of this model, can be interpreted as shocks to the supply of funding. The model in this paper suggests that these diverging trends can be explained as an equilibrium outcome of financial integration, holding the qualities of financial institutions fixed.

I extend the model to allow for the degree of financial distortions in the developed world to endogenously adjust to the financially integrated environment. Banks choose the level of financial distortions, where a more efficient allocation is associated with a higher cost. The second set of results relates to the idea that large flows of capital towards the developed world led to an endogenous deterioration of the financial system. In this model, the equilibrium level of financial distortions increases endogenously with financial integration. Intuitively, when liquidity is cheap most projects should be implemented anyway; the returns to sustaining institutions which enable differential implementation of projects based on their returns is low, so intermediaries as well as regulators may choose to refrain from doing so. In this model, these institutional changes have a mixed effect

[2]Examining a large panel of both emerging and developed markets that liberalized since the 1980s, Demirguc-Kunt and Detragiache (1999) document that the financial fragility induced by financial integration decreases with the quality of financial institutions. Stiglitz (2000) argues that financial liberalization in emerging markets is associated with more extreme shifts in capital flows, which make them more susceptible both to unsustainable boom and appreciation episodes, and to sudden stops. Further evidence of the fragility induced by financial integration in emerging markets is the drastic measures these economies take in order to insure against sudden stops and stabilize capital flows (for example, by accumulating large reserves, as documented by Caballero and Panageas (2005)).

[3]See Hakura (2007) for a more detailed discussion of volatility trends in emerging and developed economies.

on output volatility: while they amplify large adverse shocks, they actually serve to increase and stabilize output during normal times, a feature consistent with the tranquil and prosperous pre-crisis environment. Intuitively, increased reliance on the implementation of low-quality projects makes the implementation of these projects worthwhile even in the presence of small shocks[4]. However, a large enough shock that deems the implementation of low-quality projects unprofitable entails an inevitable domino effect, as the implementation of productive projects must contract as well.

These findings suggest a role for financial integration in setting the stage for the subprime crisis. It has been suggested that low interest rates and high demand for US assets have led to the loosening of lending standards and various structural changes in the financial system that increased the relative importance of low-quality loans, such as increased securitization and increased reliance on securitized products in banks' balance sheets[5]. Interestingly, while these structural changes may have evidently amplified the shock to housing prices (as suggested by Brunnermeier (2009) and Gorton (2008)), they did not immediately lead to a crisis. Rather, capital flows to the developed world remained high and increasing as the financial system underwent these structural changes. In the context of this model, these puzzling dynamics can be rationalized by the mixed implications of a deterioration in the financial system with respect to small and large shocks.

The rest of the paper is organized as follows. In section 2 I discuss the related literature. In section 3 I introduce a novel reduced-form formulation of financial distortions, and present examples of microfoundations consistent with this formulation. In section 4 I embed the notion of financial distortions in a simple general equilibrium model, and characterize the closed economy equilibrium. In section 5 I consider the effects of financial integration between a distorted emerging market region and an undistorted developed market region. In section 6 I extend the model in section 5 to allow for a deterioration of the quality of the financial system in the developed world. I show that a decline in the price of liquidity may cause a deterioration in the quality of the financial system, and discuss the implications

[4]This feature of the model is consistent with the findings of Keys, Mukherjee, Seru, and Vig (2008), according to which increased securitization led to the loosening of lending standards and increased implementation of low-quality projects.

[5]See Brunnermeier (2009) and Gorton (2008).

for output and output volatility. In section 7 I conclude.

2 Related literature

In this section, I discuss the related literature and clarify the contribution of this paper relative to others.

The results concerning the divergence in volatility between emerging and developed economies are related to several strands of literature. The idea that financial distortions exacerbate output volatility appears prominently in the context of collateral constraints. Kiyotaki and Moore (1997), Fostel and Geanakoplos (2008) and Caballero and Krishnamurthy (2001) are important examples, the latter two with specific applications to emerging market economies. The general formulation in this paper suggests that the link between financial distortions and volatility is not unique to collateral constraints, and is common to many forms of distortions. The mechanism in this paper is closest to Kiyotaki and Moore (1997), as the amplification of shocks through the financial system is a result of a domestic inefficient allocation of resources. However, the role of external funding in explaining emerging market volatility is closest to Fostel and Geanakoplos (2008). In Fostel and Geanakoplos (2008), a small group of constrained investors hold emerging market assets. Shocks to the liquidity in the hands of these investors evidently translate into movements in the liquidity supply for emerging market projects. The focus of this paper is complementary to the one in Fostel and Geanakoplos (2008): while their starting point is that emerging market projects are funded by a small group of "residual" investors, this paper uses financial distortions to endogenize the fact that emerging market projects are "residual".

Also related is the literature on volatility, development, and openness. The result that economies in earlier stages of development become more volatile with financial integration is in line with Obstfeld (1994), Greenwood and Jovanovic (1990), Acemoglu and Zilibotti (1997), and Koren and Tenreyro (2009). The focus in these papers is on the changes in the sectoral composition induced by better consumption diversification opportunities. If financial integration allows for better diversification, investors may be more inclined to take on high-risk projects, potentially increasing the aggregate riskiness of the economy. This mechanism is very different from the mechanism discussed in this paper, which does not rely on changes in sectoral composition. While sectoral composition seems like a plausible source for some shocks, particularly in lower stages of development, it seems like an unlikely explanation for the heightened volatility of emerging markets associated with movements in external funds (such as sudden stops). Moreover, it provides a poor explanation for the common movements in emerging market economies, which have very different sectoral compositions.

Conceptually related is the work of Caballero, Farhi, and Gourinchas (2008), who study global imbalances as an outcome of financial integration in a world with heterogenous financial development. While the questions motivating these papers are different, both share the view that integration with a financially underdeveloped region is an important factor behind recent trends in the US economy. The work of Fogli and Perri (2006) links the Great Moderation with global imbalances by arguing that global imbalances are a natural artifact of the decline in volatility. In their model, the decline in volatility (relative to the rest of the world) reduces households' relative incentives to accumulate precautionary savings. This paper proposes an alternative link between financial integration and the Great Moderation. In this model, financial integration decreases volatility in the developed world and increases volatility in emerging markets; it could be that as a result, through the mechanism in Fogli and Perri (2006), the external balance of the developed markets deteriorates. This combined mechanism demonstrates an additional channel through which financial underdevelopment in emerging markets translates into global imbalances.

The results concerning the endogenous deterioration of the financial system in the developed world are broadly related to two strands of literature. The idea that low interest rate environments are conducive to the deterioration of the financial system shares with the literature on bubbles. As shown in Tirole (1985), environments in which the interest rate is low are fertile grounds for the formation of bubbles. The formation of bubbles can be broadly viewed as a form of financial deterioration, as bubbles can be thought of as "low quality" investments with low fundamental value. Similar to the model presented here, the presence of bubbles may lead to an expansion in output (as in Farhi and Tirole (2010) and Martin and Ventura (2010)). However, the mechanisms through which a low interest rate leads to an expansion are different: in the bubble literature, bubbles serve as additional sources of liquidity, which enable more economic activity. In this paper, low interest rates are indicative of a situation in which the global supply of liquidity is already high; the expansion results from an endogenous decision of intermediaries to implement projects indiscriminately, increasing the total amount of projects implemented.

Similar to the literature on bubbles mentioned above, this paper takes the view that the root of the crisis is a sudden contraction in the supply of liquidity. The contraction in the supply of liquidity is not modeled here explicitly, and may be thought of as resulting from a burst of a bubble on an asset used for liquidity purposes (see Holmstrom (2008)). However, unlike the bubble-burst view of the crisis, in this model the burst of the bubble itself does not explain the full extent of the crisis. Rather, the crisis is amplified by the structural changes that the financial system underwent during the expansionary period. The emphasis on the role of financial frictions as an amplification mechanism of the crisis shares with Hall (2009), Gertler and Kiyotaki (2010), and others. The view closest to this paper is the one expressed in Brunnermeier (2009) and Gorton (2008). These papers discuss mechanisms through which a low interest rate environment led to a decline in lending standards and institutional changes which evidently amplified the subprime crisis. The model presented in this paper may be seen as a simple formalization grouping these phenomena.

Methodologically, this paper is related to the literature emphasizing the role of supermodularity and log supermodularity conditions in various economic fields. Prominent examples include, among others, Milgrom and Weber (1982) in auction theory; Bulow, Geanakoplos, and Klemperer (1985) in industrial organization; Jewitt (1987) and Athey (2002) in monotone comparative statics under uncertainty; Shimer and Smith (2000) in matching; and Costinot (2009) in international trade.

3 A simple model of financial distortions

In this section, I develop a notion of financial distortions, and show some microfoundations consistent with this formulation.

3.1 Basic environment

Consider an economy in which there is a single consumption good, and a single input of production called *working capital*, denoted N. Working capital is funds used to hire workers, rent capital and buy intermediate inputs. Many of the results that follow will focus on the volatility of output attributed to the volatility of working capital; thus, working capital should be thought of as a variable affecting output through a fluctuating supply of funds[6].

The fundamentals of the economy are given by an aggregate productivity level, A, and a set of *projects* indexed $x \in (0, 1)$. A project requires one unit of working capital to implement. If implemented, project x produces $Ag(x) > 0$ units of output, where, without loss of generality, g is decreasing.

3.2 The financial system

The role of the financial system is to allocate working capital to projects. I restrict attention to allocation schemes in which projects are implemented according to some *order*: the financial system organizes projects on a list. Given a supply of $N < 1$ units of working capital, the first N elements on the list are to be implemented. Each unit of working capital may implement fractions of different projects, as long as the fractions sum up to 1. Equivalently, the fraction of implemented projects of each type is assumed to be weakly increasing in the level of working capital.

Formally, a financial system is represented by a function $\sigma_\phi(N, x)$, that determines the density of projects of type x implemented with the Nth unit of working capital. At this point, the parameter ϕ is simply an index of the financial system; later I will assume that it corresponds to the level of distortion. The function σ must satisfy the following condition, which guarantees that the total volume of projects implemented with each unit of working capital is 1, and that each project is fully implemented when the economy is satiated with working capital:

$$\int_0^1 \sigma_\phi(N, x)dx = \int_0^1 \sigma_\phi(N, x)dN = 1 \tag{1}$$

[6]From an empirical standpoint, I prefer not to interpret N as physical capital, as physical capital does not fluctuate substantially at a business cycle frequency.

The marginal product of working capital is given by:

$$y(N,\phi) = \int_0^1 \sigma_\phi(N,x)Ag(x)dx \tag{2}$$

To see this, note that the above expression is a weighted average of productivities, where the weight on projects of type x is given by $\sigma_\phi(N,x)$, the density of projects of type x implemented with the N-th unit of working capital.

Aggregate output is given by the integral of the marginal product of working capital:

$$Y(N,\phi) = \int_0^N y(N',\phi)dN' \tag{3}$$

I restrict attention to allocation schemes that deliver a decreasing marginal product of working capital:

$$\frac{\partial y(N,\phi)}{\partial N} \leq 0 \tag{4}$$

I impose a partial ordering on the set of distortions. The notation $\phi > \phi'$ indicates that the allocation scheme governed by ϕ is more distorted than the allocation scheme governed by ϕ'.

Assumption 1 *For all $\phi > \phi'$ and $N > N'$:*

$$1 \geq \frac{y(N,\phi)}{y(N',\phi)} > \frac{y(N,\phi')}{y(N',\phi')} \tag{5}$$

The assumption above states that the marginal product of working capital, $y(N,\phi)$, is log supermodular in N and ϕ. If $\ln y$ is differentiable with respect to N, this condition is equivalent to the statement that $\frac{\partial \ln y(N,\phi)}{\partial N}$ is increasing in ϕ. This turns out to be an important aspect of Assumption 1. In particular, if N is the level of working capital, Assumption 1 implies that for any small $\epsilon > 0$,

$$1 \geq \frac{y(N+\epsilon,\phi)}{y(N-\epsilon,\phi)} > \frac{y(N+\epsilon,\phi')}{y(N-\epsilon,\phi')} \tag{6}$$

This inequality states that, around the marginal unit of working capital, the barely-implemented projects are more similar to the projects that just fall short from being implemented.

Intuitively, Assumption 1 means that better projects are implemented earlier on the list in less distorted economies; the decline in the relative quality of implemented projects is steeper the more efficient the allocation. The intuition is perhaps best understood when considering a simple economy in which there are only two projects: a good project which produces 3 if implemented, and a bad project which produces 1 if implemented:

$$g(\text{good}) = 3 \tag{7}$$

$$g(\text{bad}) = 1 \tag{8}$$

For whatever reason, the financial system errs with some probability $\phi \in [0, \frac{1}{2}]$ and implements the bad project before the good project. The parameter ϕ captures the level of distortion, as the probability of an error is higher in more distorted economies. The case $\phi = 0$ corresponds to the efficient case. The case $\phi = \frac{1}{2}$ corresponds to the case in which projects are implemented completely at random. In the general case, the marginal product of working capital is:

$$y(1, \phi) = (1 - \phi) \cdot g(\text{good}) + \phi \cdot g(\text{bad}) = 3 - 2\phi \tag{9}$$

$$y(2, \phi) = (1 - \phi) \cdot g(\text{bad}) + \phi \cdot g(\text{good}) = 2\phi + 1 \tag{10}$$

Assumption 1 is satisfied since the following ratio is increasing in ϕ:

$$\frac{y(2, \phi)}{y(1, \phi)} = \frac{2\phi + 1}{3 - 2\phi} \tag{11}$$

Assumption 1 is satisfied both because the return to the first unit of working capital is lower in more distorted economies, and because the return to the second unit of working capital is higher in more distorted economies.

More generally, Assumption 1 draws on the following principle. In efficient economies, only the most highly productive projects are implemented when funds are scarce. As funds become abundant, the economy runs out of highly productive projects, and less productive projects are implemented as well. In distorted economies, the order in which projects are implemented is inefficient. Scarce funds are used to implement an inferior set of projects; some unproductive projects are implemented, while some highly productive projects are not. This suggests that the quality of implemented projects is closer to the quality of unimplemented projects. At the margin, the expected ratio of the quality of just-implemented projects and just-not-implemented projects is lower in more distorted economies, reflecting the idea that the implementation outcome is more affected by factors unrelated to productivity.

Some notes are in order regarding the limitations of this approach. Assuming that projects are implemented according to some order is somewhat restrictive, as not all microfoundations of distortions take this form. This restriction rules out distortions in which some projects are implemented when resources are scarce, but not implemented when resources are abundant. However, in its reduced form, Assumption 1 will continue to hold as long as an increase in the amount of funding is associated with an increase in the efficiency of the allocation. This is in the spirit of Kiyotaki and Moore (1997), and consistent with other models of financial distortions, such as Rajan (1994). Intuitively, in these models the returns to the marginal units of funding have a relatively high return because they increase the productivity of the inframarginal units of funding.

Even under the restriction that projects are implemented according to some order, there are alternative ways to rank distortions that do not necessarily imply compliance with Assumption 1. A particularly appealing way to rank distortions is according to the productivity loss that they induce: a more distorted economy can be defined naturally as one in which output is lower for any given level of working capital. Assumption 1 is more restrictive than compliance with this property. However, there is some comfort in the fact that Assumption 1 guarantees that there is a productivity loss induced by higher financial distortions:

Lemma 1 *The level of output $Y(N, \phi)$, is decreasing in the distortion parameter ϕ.*

The proof is omitted from the text and, together with other omitted proofs, can be found in the appendix. The converse of Lemma 1 is not necessarily true: requiring that a higher distortion parameter induces a productivity loss need not imply compliance with Assumption 1. Intuitively, the added restriction in Assumption 1 is that in more distorted economies, the implementation outcome depends less on productivity at *any* level of working capital. It is possible to construct examples of distortions in which productivity matters less for the implementation outcome at some levels of working capital, but matters more at other levels of working capital[7].

While Assumption 1 does not include all possible models of distortions, it points at a property that is fairly general and common to many microfoundations, as will be demonstrated in the section that follows. The particular property emphasized by Assumption 1 turns out to have far-reaching implications for macroeconomic volatility, which may not be true under less restrictive conditions.

3.3 Microfoundations

In this section I present three microfoundations of distortions. The first microfoundation will be used to illustrate the results throughout the paper.

Asymmetric information (random allocation). Consider a stark model in which there are two types of economies: efficient and distorted. In efficient economies, the financial system employs a technology that allows projects to be screened according to their type. Projects are implemented in the efficient order. In distorted economies, the financial system lacks the technology to distinguish between projects. As project owners receive large private benefits from implementing their projects, the only equilibrium is a pooling equilibrium in which projects are implemented indiscriminately. As a result, projects are implemented completely at random: the order in which projects are implemented is completely unrelated to their productivity.

Formally, in the efficient economy, projects are implemented in an order decreasing in their returns; given any N units of working capital, the first N projects will be implemented. Output is given by the aggregation of the productivities of

[7]Consider the following simple example, in which an elite set of projects indexed $x \in (0, \bar{x})$ is implemented according to the efficient order, and the rest of the projects are implemented randomly. Of course, compared to the efficient allocation, there is a productivity loss induced by this distortion. However, Assumption 1 is violated, as at $N = \bar{x}$, there is a larger difference in the average productivities of projects implemented at the margin and projects just-not-implemented.

all implemented projects:

$$Y(N, \text{efficient}) = \int_0^N Ag(x)dx \tag{12}$$

The marginal product of working capital is therefore given by:

$$y(N, \text{efficient}) = Ag(N) \tag{13}$$

Note that, in the efficient allocation, the function σ is a Dirac measure, implementing the entire project indexed x with the x-th unit of working capital. The log of the marginal product of working capital is decreasing, as the productivity of implemented projects declines with working capital.

In contrast, in the distorted economy, a random set of projects is implemented. The function $\sigma(N, x)$ is equal to 1 for all x and N, capturing the fact that each unit of working capital implements a random set of projects. Output is given by:

$$Y(N, \text{distorted}) = N \int_0^1 1 \cdot Ag(x)dx \tag{14}$$

The marginal product of working capital is therefore given by:

$$y(N, \text{distorted}) = \int_0^1 1 \cdot Ag(x)dx \tag{15}$$

Since the log of the marginal product is decreasing in N in the efficient economy and constant in the random allocation, the random allocation is *more distorted* than the efficient economy in accordance with Assumption 1[8].

Collateral constraints. Consider a model in which projects are characterized by their type, x, and by their collateral type, b. Assume that collateral types (b) are distributed independently from the project type (x). Conditional on any project type, collateral is uniformly distributed on $[0, \phi]$. The collateral level of

[8]Alternatively, rather than assuming that the random allocation is a result of this form of asymmetric information, this allocation may result from institutional arrangements under which the incentives to implement projects are detached from their returns. This may be the case, for example, in the presence of corruption or government expropriation.

the project is given by the following decreasing function:

$$\kappa(b) = g(\min\{b, 1\}) \tag{16}$$

That is, collateral is decreasing in b, and is bounded from below by the productivity of the least productive project.

A project with features (x, b) is implemented if and only if both its return and its collateral level exceed the price of working capital:

$$g(x) \geq r \tag{17}$$

$$\kappa(b) \geq r \tag{18}$$

The mismatch between the quality of projects and their collateral changes the order in which projects are implemented. Note that a higher ϕ implies that the aggregate collateral is lower. It is easy to see that $\phi \to 0$ corresponds to the efficient allocation, as all projects have sufficient collateral to be implemented when their return is high enough. The case $\phi \to \infty$ corresponds to an extremely distorted economy, in which essentially all projects are collateral constrained and can be implemented only when the market return is equal to the productivity of the least productive project; in this case, the marginal product of working capital is close to constant, as projects are implemented essentially in a random order (as in the previous example).

Lemma 2 *Assume that $g(x) = \alpha x^{-(1-\alpha)}$. In this model of collateral constraints, Assumption 1 is satisfied.*

Search frictions. Consider a model in which economies differ in the search technology available to their financial systems. In each economy there are ϕ local banks indexed $i = 0, ..., \phi - 1$. Projects owners are unaware of their project's type until right before production decisions must be made. Local banks are modeled as risk sharing arrangements among project owners. Each local bank shares risk among $\frac{1}{\phi}$ project owners. The bank indexed i is a risk sharing arrangement between the owners of projects indexed $x \in (\frac{i}{\phi}, \frac{i+1}{\phi}]$ (for $i = \phi - 1$, the segment of projects is the open set $(\frac{\phi-1}{\phi}, 1)$). The process of distributing funds from households to projects is as follows:

1. Households supply funds to a large savings bank. The savings bank has direct access to projects (but is unaffiliated with the local banks, and is unaware of projects' types).

2. The savings bank distributes funds randomly among projects owners.

3. Project owners handover their funds to their local bank. When the productivity of projects is revealed, the local bank uses the funds in its hands to implement the best set of projects among those owned by the bank's members.

The parameter ϕ can be thought of as a measure inversely related to the integration of the domestic financial system. A high ϕ captures a situation in which there are some banks with access to highly productive projects that lack liquidity to implement them, and some banks with high liquidity without access to good projects. The case $\phi = 1$ corresponds to the efficient allocation: there is only one bank in charge of allocating the entire supply of funds, and the bank has access to the entire set of projects. The optimal set of projects is therefore implemented. The case $\phi \to \infty$ corresponds to the random allocation example: project owners are essentially in autarky, as they must use their own funds to implement their own project. The implementation of projects is therefore random, as it does not depend on the level of productivity.

Lemma 3 *Assume that $g(x) = e^{-x}$. In this model of search frictions, Assumption 1 is satisfied.*

4 Closed economy equilibrium

The characterization of the closed economy equilibrium is useful in two ways. First, it provides a benchmark for comparison with the open economy. Comparing the closed economy equilibrium with the open economy equilibrium will be useful for understanding the implications of financial integration. Second, the closed economy equilibrium isolates a particular mechanism through which financial distortions amplify output volatility, which will be important both in section 5 and in section 6.

Households inelastically supply Q units of *liquidity* to the financial system, in exchange for future returns. In this model, liquidity is defined simply as the supply side of working capital. The market clearing condition is:

$$N = Q \tag{19}$$

After production takes place, the financial system repays households at a rate of r units of output per unit of liquidity. I assume that r is equated with the marginal product of working capital. This can be thought of as a result of a competitive banking system in which banks compete for liquidity supply from households.

There are two sources of volatility: shocks to the domestic technology level A, and shocks to the supply of liquidity, Q. I assume that these shocks are independent. Appendix C presents a model of liquidity supply in which this assumption is satisfied. In that model, liquidity supply fluctuations are driven by shocks to the money supply and shocks to investor's risk aversion.

It is straightforward to show that, in the closed economy, the sensitivity of output to TFP shocks is unrelated to the degree of financial distortions. However, more distorted economies are more sensitive to shocks to liquidity supply:

Proposition 1 *For any given processes of A and Q,*

1. *Output is more volatile in more distorted economies:*

$$\frac{\partial \ln Y(Q,\phi)}{\partial \ln Q} \text{ is increasing in } \phi \tag{20}$$

2. *Average productivity is more sensitive to liquidity supply shocks in less distorted economies:*

$$\frac{\partial \frac{Y(Q,\phi)}{Q}}{\partial \ln Q} \text{ is increasing in } \phi \tag{21}$$

Proposition 1 follows from the property of financial distortions emphasized in Assumption 1. In relatively more efficient economies, the decline in the average productivity of projects mitigates the effect of an increase in working capital. In distorted economies, a suboptimal set of projects is implemented, so some low-yield projects are implemented before higher-yield projects. This implies two things. First, some projects that should have been implemented are not implemented; their implementation takes place only when the supply of working capital is higher, intensifying the returns to working capital. Second, some projects that should not have been implemented are implemented, lowering the average product of working capital in the economy. These two facts put together imply that the ratio of the marginal product of working capital and the average product of working capital is higher in distorted economies. In other words, liquidity abundance increases the efficiency of distorted economies relative to efficient economies both by alleviating the inefficiency caused by implementing a suboptimal set of projects and by allowing for the implementation of higher-yield projects. Using the random allocation example, figure 1 illustrates the properties of the closed economy equilibria in a distorted "emerging market" economy and an efficient "developed market" economy.

5 Volatility divergence

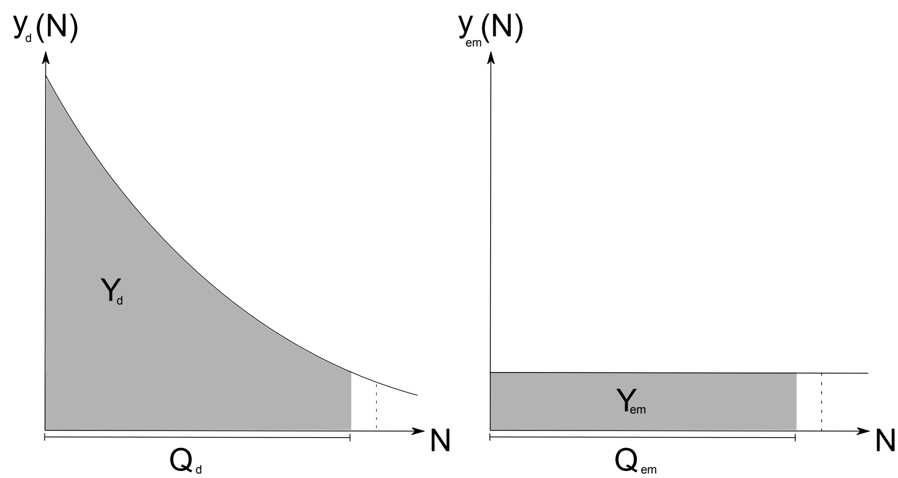
In this section I present a set of results concerning the divergence of volatility between emerging and developed economies following financial integration. I first present the globally integrated equilibrium, and then discuss equilibrium implications for small open economies.

The setup of the model is as follows. There are two regions of equal size: an emerging market region (em) and a developed market region (d). For the time being, I assume that the only difference between emerging and developed economies is that emerging economies are more distorted than developed economies:

$$\phi_{em} > \phi_d \tag{22}$$

I assume that $var(\ln(A_d)) = var(\ln(A_{em}))$[9] and that liquidity supply Q_i is independent from both foreign and domestic technology, A_i and A_j.

[9] The results trivially generalize to $var(\ln(A_d)) < var(\ln(A_{em}))$.



(a) Developed markets (b) Emerging markets

Figure 1: The figure on the left depicts the closed economy equilibrium in efficient "developed" economies, and the figure on the right depicts the closed economy equilibrium in distorted "emerging" economies. In both economies there is a positive shock to liquidity supply. The average productivity declines in efficient economies and remains constant in distorted economies. The output response is therefore larger in distorted economies.

In order to isolate the effects of financial heterogeneity on the global equilibrium environment, it is convenient to assume that Q_d and Q_{em} are perfectly correlated. Assuming that liquidity supplies are perfectly correlated isolates the effects of financial heterogeneity because, under this assumption, financial integration between two *identical* economies would have no effect on liquidity-supply driven output volatility. In contrast, independent liquidity supplies would imply that financial integration between two identical regions has a moderating effect on output in both regions, as shocks to liquidity supply are shared across regions. Replacing the assumption that Q_d and Q_{em} are perfectly correlated with the assumption that they are independent would therefore decrease volatility in both regions; however, the result that volatility induced by financial integration would be relatively higher for emerging economies would still hold.

5.1 Integrated equilibrium

Assume that liquidity can move freely across regions. The global equilibrium is characterized by two equations:

$$N_{em} + N_d = Q_{em} + Q_d = Q_w \tag{23}$$

$$y_{em}(N_{em}, \phi_{em}) = y_d(N_d, \phi_d) = r \tag{24}$$

The first equation is a market clearing condition, stating that the total amount of working capital, $N_{em} + N_d$, must be equal the global supply of liquidity, $Q_w = Q_{em} + Q_d$. The second condition is the optimality condition of the financial system, requiring that there is no gain from reallocating liquidity from one region to another.

I denote autarkic values with superscript a (N^a, Y^a, etc). Denote by Δ the absolute value of the *average* change in working capital levels induced by financial integration:

$$\Delta = |E(N_{em}) - E(N^a_{em})| = |E(N_d) - E(N^a_d)| \tag{25}$$

The value of Δ is determined in equilibrium as a function of the average supply of liquidity, the financial distortions, and the relative productivities $\frac{A_d}{A_{em}}$. In particular, there is always a value of $\frac{A_d}{A_{em}}$ for which $\Delta = 0$. For the purpose of this exercise, I assume that Δ is small. The importance of this assumption is in assuring that the sensitivity of output to working capital remains similar to its autarkic level. If this assumption is violated, the implications of financial integration on macroeconomic volatility depend more specifically on how the sensitivity of output with respect to working capital changes with the level of working capital.

The main result is stated in the proposition below:

Proposition 2 *For Δ sufficiently small, financial integration exacerbates the volatility differences between emerging and developed markets:*

$$var(\ln N_{em}) - var(\ln N_d) > var(\ln N_{em}^a) - var(\ln N_d^a) = 0 \tag{26}$$

$$var(\ln Y_{em}) - var(\ln Y_d) > var(\ln Y_{em}^a) - var(\ln Y_d^a) > 0 \tag{27}$$

Financial integration leads to a divergence in volatility levels for two reasons[10]. First, financial integration is associated with a new source of fluctuations in working capital, which is shocks to the relative productivity of emerging and developed economies ($\frac{A_{em}}{A_d}$). These shocks lead to a substitution of working capital across regions. Since, by proposition 1, financially-distorted emerging markets are more sensitive to fluctuations in working capital than developed markets, this works towards exacerbating the differences in output volatility across regions.

Second, it turns out that shocks to the global supply of liquidity adjust disproportionately through changes in the supply of working capital to emerging markets. This equilibrium property is closely related to the feature of financial distortions emphasized by Assumption 1, and particulary to its interpretation in equation 6. In developed markets, projects are implemented in an order decreasing in their returns: most implemented projects generate returns which well exceed r, and most of the unimplemented projects generate returns which are well below r. Fluctuations in the implementation threshold therefore have a relatively small impact on the amount of projects implemented in developed economies. In contrast, in

[10]Proposition 2 easily generalizes to an equilibrium with many countries with different levels of distortions. In an integrated equilibrium, the sensitivity of each economy to shocks to the global supply of liquidity or to TFP will be an increasing function of its level of financial distortions. Differences in volatility levels will magnify upon financial integration.

emerging markets, the order in which projects are implemented is more arbitrary; this implies that the return generated by the next unit of working capital is similar to the return generated by the previous unit. The same fluctuations in r therefore induce larger fluctuations in the amount of implemented projects. Figure 2 illustrates this equilibrium property in the random allocation example[11].

Generically, abstracting from productivity shocks, financial integration leads to less variation in r from the developed market's perspective, and more variation in r from the emerging market's perspective. Consequently, there is a divergence in liquidity-driven output volatility between emerging and developed economies.

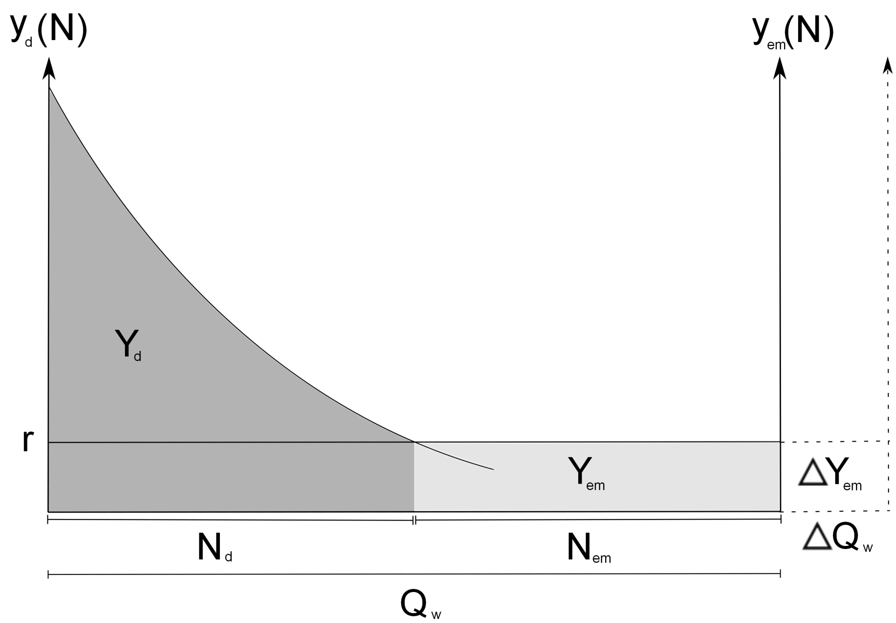


Figure 2: In this figure, the origin of the developed economy is on the left corner, and the origin of the emerging economy is on the right corner. The market clearing condition states that the distance between the two corners is equal to the global liquidity supply, Q_w. The intersection of the marginal products of working capital determines r, and hence the division of Q_w into N_d and N_{em}. Shocks to the global liquidity supply adjust entirely through changes in the working capital levels supplied to emerging markets, N_{em}. An increase in Q_w of size ΔQ_w is illustrated as a shift of the emerging economy's origin to the right.

The direction in which volatility levels change following financial integration is

[11] In the random allocation example, the equilibrium level of r does not change following a shock to global liquidity supply. Rather, the shock is adjusted entirely through changes in the quantity of working capital supplied to the emerging market region.

potentially different in emerging and developed economies. In emerging economies, the volatility of working capital necessarily increases upon integration. This is because working capital becomes vulnerable to two new shocks: shocks to foreign liquidity supply (Q_d) and shocks to relative technology levels ($\frac{A_{em}}{A_d}$). In developed economies, working capital also becomes vulnerable to shocks to relative technology, which works towards increasing volatility. However, working capital becomes less sensitive to shocks to domestic liquidity supply (Q_d), since shocks to liquidity supply adjust primarily through movements in the working capital supplied to emerging markets. The net effect on volatility depends on the relative importance of technology shocks and liquidity shocks. Specifically, if movements in the level of working capital result primarily from variation in the supply of liquidity, financial integration will decrease the volatility of output in developed economies.

Under stronger assumptions regarding the relative importance of liquidity and technology shocks, it is possible to obtain stronger results concerning the direction in which volatility levels change following financial integration:

Proposition 3 *For Δ sufficiently small,*

1. *Financial integration increases the volatility of working capital and the volatility of output in emerging markets:*

$$var(\ln N_{em}) > var(\ln N_{em}^a) \tag{28}$$

$$var(\ln Y_{em}) > var(\ln Y_{em}^a) \tag{29}$$

2. *If the variance of liquidity supply is sufficiently large compared to the variance of relative TFP, financial integration decreases the volatility of working capital and the volatility of output in developed markets:*

$$var(\ln N_d) < var(\ln N_d^a) \tag{30}$$

$$var(\ln Y_d) < var(\ln Y_d^a) \tag{31}$$

These results provide some insight into the distinct behavior of emerging and developed markets following globalization. The theory above suggests that the divergence in liquidity-driven output fluctuations may have been a result of developed markets effectively exporting their liquidity shocks to emerging markets.

5.2 Small open economies

Given that much of the literature on the excess volatility of emerging markets has focused on small open economies, it is useful to study small open economies in the context of this global equilibrium environment.

I assume that each region is composed of a continuum of small open economies, identical within regions. Small open economies are subject to idiosyncratic productivity shocks, as well as to exogenous shocks to r which result from changes in the global liquidity supply.

The first thing to note is that this model naturally implies comovements in emerging market economies. Compared to their developed counterparts, small open emerging markets are more severely affected by shocks to the global liquidity supply. The importance of global liquidity supply as a source of emerging market fluctuations naturally implies common movements in emerging market output levels. Similar to Fostel and Geanakoplos (2008), comovements in emerging market economies result from a common sensitivity to an external supply of funding.

Second, it is interesting to note that both in emerging and in developed markets, working capital responds similarly to idiosyncratic productivity shocks and to shocks to the price of liquidity. This suggests a link between the heightened sensitivity of emerging markets to interest rate shocks (as in Neumeyer and Perri (2005) and Uribe and Yue (2006)) and the amplification of shocks to productivity (as in Caballero, Cowan, and Kearns (2005)). To see this link, note that in a small open economy, the level of working capital is pinned down by a single indifference condition, equating the marginal product of working capital with the world rate of return:

$$y(N,\phi) = \int_0^1 \sigma_\phi(N,x)Ag(x)dx = r \Rightarrow \int_0^1 \sigma_\phi(N,x)g(x)dx = \frac{r}{A} \tag{32}$$

From the formulation above, it is easy to see that working capital is affected similarly by shocks to r and shocks to A. Essentially, in this model, the responsiveness of working capital to either type of shock captures the density of projects which are implemented at the margin and collectively yield a return equal exactly to r. A small shock to the returns of these projects will shift them above or below the implementation threshold; similarly, small shocks to r will determine whether or not the projects at the margin generate a return which justifies implementation. The result that small open emerging markets are relatively more sensitive to both shocks is closely tied to Assumption 1, as it guarantees that the density of projects implemented at the margin is higher.

The model presented in this section suggests the following conclusions regarding the role of financial institutions in determining the effects of financial integration on output volatility. Poor financial institutions in emerging markets exacerbate their sensitivity to working capital, as well as increase the volatility of working capital supplied to that region. At times in which financial institutions are intact in developed markets, their superior ability to implement projects differentially serves both to stabilize equilibrium working capital levels and to mitigate the effects of fluctuations in working capital on output.

6 The endogenous deterioration of the financial system

In section 5 it was assumed throughout that the quality of financial institutions remains fixed upon financial integration. While this may be a valid short-run assumption, the recent subprime crisis comes as a reminder that the quality of financial institutions may evolve with changing circumstances.

In section 6.1 I consider a model in which the financial system in the developed world deteriorates endogenously following financial integration. In section 6.2 I discuss the implications of the deterioration during "normal times". I show that in the absence of large shocks, the deterioration of the financial system actually increases and stabilizes output in the developed world. In section 6.3 I show that the deterioration in the financial system amplifies large adverse shocks.

6.1 Endogenous deterioration

I extend the setup to allow for an endogenous adjustment in the quality of the financial system in the developed world. Banks can choose the level of financial distortions out of some finite set. There is a cost $\lambda(\phi)$ associated with choosing the level of distortions ϕ, where $\lambda(\cdot)$ is decreasing. This cost should be thought of as the cost of sorting projects and overcoming other obstacles which stand in the way of an efficient allocation. For simplicity, I assume that banks consider only the mean price of liquidity when choosing the level of financial distortions, and do not take into account any uncertainty.

Given a price of liquidity r, the banks choose the level of working capital, N_d, and the level of distortion, ϕ_d, to maximize profits. The bank's profits are given by:

$$\pi(r) = \max_{\phi_d, N_d} \{\pi(r, N_d, \phi_d)\} = \tag{33}$$

$$\max_{\phi_d, N_d} \int_0^{N_d} y(N', \phi_d) dN' - rN_d - \lambda(\phi_d) \tag{34}$$

Note that for $\frac{A_d}{A_{em}}$ sufficiently large, financial integration will be associated with a decline in r from the developed market's perspective.

Proposition 4 *For Q sufficiently large, a decline in r will lead to an endogenous deterioration of the financial system.*

It is straightforward to show that the objective of banks in this model coincides with the objective of a social planner trying to maximize domestic output minus the costs of differentiation (under assumption that the cost of liquidity is given by r). The deterioration in the financial system can therefore be interpreted more broadly as an outcome of *endogenous* lax regulation.

In the context of the recent crisis, the above proposition formalizes the popular claim according to which financial integration increased the equilibrium level of financial distortions by lowering the price of liquidity from the developed market's perspective[12]. Intuitively, if liquidity is sufficiently cheap so that nearly all

[12] A note is in order regarding the applicability of these results to emerging market economies. The analysis in this section relies heavily on the assumption that financial integration is associated with a decline in the price of liquidity from the domestic perspective. The results are therefore

projects are implemented anyway, the benefits of differentiating between projects may not be worth the cost[13]. Broadly interpreted, the financial system will gravitate towards various institutional arrangements that tie the implementation of high quality projects with the implementation of low quality projects.

6.2 Normal fluctuations

What are the implications of the deterioration of the financial system on output and on output volatility? Under autarky, the implications would be fairly intuitive: a weakening of the financial system would decrease output and increase subsequent output volatility[14]. However, these intuitive results breakdown under financial integration. The following proposition states that the deterioration in the quality of the financial system in the developed world will increase working capital in that region, and may increase and stabilize output as well:

Proposition 5 *In a financially integrated equilibrium:*

1. *An endogenous weakening of the financial system in the developed market will* ***increase*** *working capital in that region.*

2. *For Q_w and $\frac{A_d}{A_{em}}$ sufficiently large, a weakening of the financial system in the developed world will increase and stabilize output.*

---

not applicable for emerging markets. For emerging markets, the mirror image is the relevant one: financial integration is associated with an increase in r, potentially leading to an endogenous increase the the quality of financial institutions. The characterization of the long run general equilibrium environment, in which financial institutions are allowed to adjust in both emerging and developed economies, is beyond the scope of this paper. I leave this interesting issue for future research.

[13]It is worth noting that, in general, the relationship between r and the equilibrium choice of financial distortions is non-monotonic. At sufficiently low levels of r, a decrease in r will decrease the benefits of investing in high-quality financial institutions. However, it is easy to show that, at high levels of r, a small drop in the price of liquidity will have the opposite effect. This is because there is a scale effect: the investment in the ability to differentiate is only worthwhile if production is sufficiently high.

[14]To see this, note that by Lemma 1, holding working capital fixed, output is higher when financial institutions are intact (because a superior set of projects are implemented). Thus, a weakening of the financial system constitutes an adverse shock to output. The fact that subsequent output volatility increases is immediate from the comparison between closed emerging and developed economies in section 4.

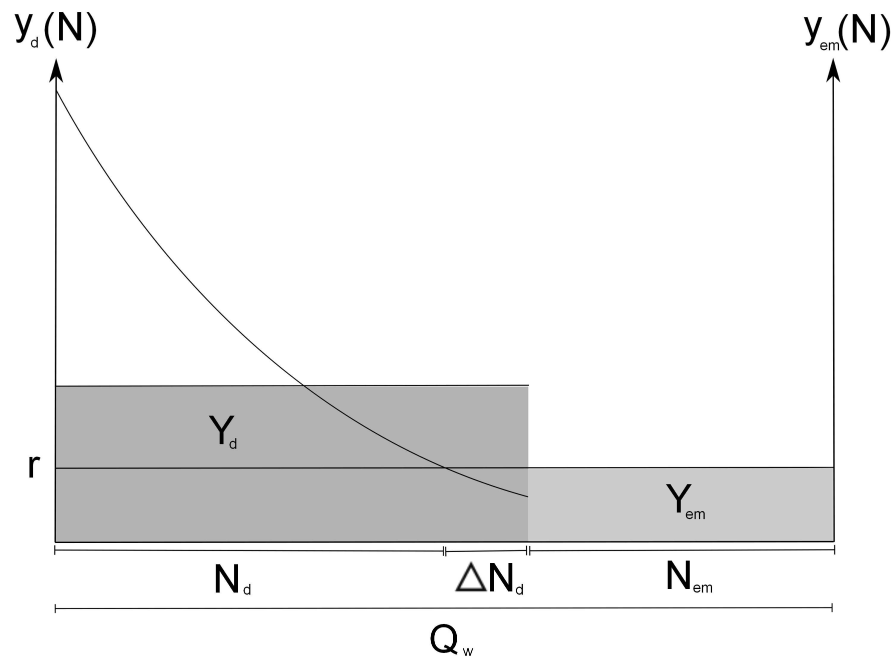


Figure 3: The origin of the developed economy is on the left corner, and the origin of the emerging economy is on the right corner. The market clearing condition states that the distance between the two corners is equal to the global liquidity supply, Q_w. The intersection of the marginal products of working capital determines r. A deterioration of the financial system in the developed world causes working capital to flow towards that region. In this figure, the deterioration of the financial system is illustrated by the “flattening” of the marginal product of working capital. The size of the increase in N_d is given by ΔN_d, the distance between the intersection of the autarkic (sloping) marginal product of working capital and r, and the point of satiation ($N_d = 1$).

Proposition 5 builds on a comparative static result that shows that an endogenous deterioration of the financial system is possible in equilibrium only if it increases the marginal product of working capital. The weakening of financial institutions is therefore associated with an additional flow of working capital towards developed economies. If this flow is sufficiently large, domestic output will rise. To understand why volatility declines, note that the distortion ties the implementation of high-quality projects to the implementation of low-quality projects. Thus, many "marginal" projects become inframarginal, as their discontinuation would necessitate the discontinuation of some high-quality projects.

Proposition 5 can shed light on the seemingly "irrational" behavior that led up to the subprime crisis, in which many bad loans were given to subprime borrowers, and, while the financial system behaved "irresponsibly", the demand for US assets seemed only to increase.

Finally, does the fact that output in the developed world increases with the deterioration of its financial system mean that such a deterioration is "good"? From a global perspective, no. The generic adverse effect of a deterioration in the financial system is that it decreases world output, both under autarky and under financial integration:

Lemma 4 *A weakening of the financial system in the developed world decreases world output.*

This lemma is immediate from the fact that intact financial institutions allow for a differential implementation of projects based on their returns; the set of projects implemented when differentiation is not possible is necessarily inferior to the set of projects implemented when some differentiation is possible.

6.3 Large adverse shocks

In the global environment described in this paper, the deterioration of the financial system in the developed world serves to increase and stabilize output in that region during normal times. However, while the response to small shocks is mitigated, the output response to large negative shocks is amplified:

Proposition 6 *In the developed world, the weakening of the financial system amplifies the output response to large adverse shocks to Q_w or $\frac{A_d}{A_{em}}$.*

Intuitively, cheap liquidity leads to structural changes in the financial system that disable the separation of high-quality projects from low-quality projects. During normal times, this increases the amount of low-quality projects being implemented, and output increases as a result. However, sufficiently large contractions in liquidity are amplified by the inability to separate the discontinuation of low-quality projects from the discontinuation of high-quality projects.

This result suggests that the deterioration in the quality of financial institutions preceding the sub-prime crisis may have indeed precipitated it by creating an amplification mechanism for large adverse shocks. This amplification mechanism is consistent with many inefficiencies that seem important for understanding the extent of the crisis. A straightforward interpretation is the mortgage market itself. The creation of mortgage backed securities enabled the pooling of idiosyncratic risk of subprime loans. Once housing prices declined, issuing new subprime loans became difficult, perhaps in part because the process of issuing subprime loans did not allow for differentiation between relatively promising borrowers and relatively unpromising borrowers. A more subtle interpretation is the balance sheet effect (as in Brunnermeier (2009)). The heavy reliance of banks' balance sheets on mortgage backed securities forced them to disengage from productive lending activities once the subprime crisis hit. This can be viewed as an additional mechanism that ties the implementation of productive projects to the implementation of unproductive projects.

Corollary 1 *Financial integration may lead to the amplification of large adverse shocks in the developed world.*

Corollary 1 is immediate from the analysis in this section: by Proposition 4, financial integration leads to the deterioration of the financial system. By Proposition 6, the deterioration in the financial system amplifies the output response to large adverse shocks.

Note that this analysis also suggests that the subprime crisis cannot be explained solely in terms of a breakdown in the financial system; rather, a complete explanation would require either an additional large shock to TFP or to liquidity supply.

The results in this section present a modification to the view presented in section 5 according to which financial integration mitigates output fluctuations in the developed world. If financial integration with a distorted emerging market region is coupled with a decline in the price of liquidity (as suggested by Caballero, Farhi, and Gourinchas (2008)), the quality of financial institutions may adjust downwards in accordance with Proposition 4. As a result, the sensitivity of output with respect to small shocks will decrease, but large adverse shocks will be amplified.

7 Conclusion

This paper studies the effects of financial distortions on the global equilibrium environment. I present a reduced form formulation of financial distortions according to which the marginal product of working capital is log supermodular in working capital and the level of distortion. This formulation is consistent with a class of microfoundations in which the distortion changes the order in which projects are implemented, in a way which results in an order of implementation which is less indicative of the relative quality of projects.

Upon financial integration, financial distortions affect global volatility patterns through two related channels: first, financial distortions determine the sensitivity of output to liquidity supply. Output in emerging markets is more sensitive to liquidity supply, because the projects implemented at the margin have high returns compared to the projects implemented infra-marginally. Second, in the integrated economy, the higher level of distortion in emerging markets causes them to absorb a larger fraction of the volatility of global liquidity supply. As a result, financial integration increases liquidity-driven output volatility in emerging markets, and decreases liquidity-driven output volatility in developed markets.

In the long run, a global environment in which liquidity is cheap is conducive to a deterioration in the financial system in the developed world. In the integrated economy, a deterioration in the quality of the financial system has a mixed effect on output in developed economies: in the absence of large liquidity or TFP shocks, it serves to increase output and to reduce output volatility. However, the response of output to large adverse liquidity shocks is amplified. This offers a modified view regarding the long run effect of financial integration on developed market output volatility. As the quality of financial institutions adjusts downward, the economy becomes less sensitive to normal fluctuations, but more adversely affected by large shocks.

References

Acemoglu, D., and F. Zilibotti (1997): "Was Prometheus Unbound by Chance? Risk, Diversification, and Growth," *Journal of Political Economy*, 105(4), 709–751.

Athey, S. (2002): "Monotone Comparative Statics Under Uncertainty," *The Quarterly Journal of Economics*, 117(1), 187–223.

Barro, R. J. (2006): "Rare Disasters and Asset Markets in the Twentieth Century," *The Quarterly Journal of Economics*, 121(3), 823–866.

Broner, F. A., G. Lorenzoni, and S. L. Shmukler (2008): "Why Do Emerging Economies Borrow Short Term?," unpublished manuscript.

Broner, F. A., and J. Ventura (2010): "Rethinking the Effects of Financial Liberalization," unpublished manuscript.

Brunnermeier, M. K. (2009): "Deciphering the Liquidity and Credit Crunch 2007-2008," *Journal of Economic Perspectives*, 23(1), 77–100.

Bulow, J. I., J. D. Geanakoplos, and P. D. Klemperer (1985): "Multimarket Oligopoly: Strategic Substitutes and Complements," *The Journal of Political Economy*, 93(3), 488–511.

Caballero, R. J., K. Cowan, and J. Kearns (2005): "Fear of Sudden Stops: Lessons from Australia and Chile," *The Journal of Policy Reform*, 8(4), 313–354.

Caballero, R. J., E. Farhi, and P.-O. Gourinchas (2008): "An Equilibrium Model of 'Global Imbalances' and Low Interest Rates," *American Economic Review*, 98(1), 358–393.

Caballero, R. J., and A. Krishnamurthy (2001): "International and Domestic Collateral Constraints in a Model of Emerging Market Crises," *Journal of Monetary Economics*, 48, 513–548.

Caballero, R. J., and S. Panageas (2005): "A Quantitative Model of Sudden Stops and External Liquidity Management," NBER Working Paper No. W11293.

Chang, R., and A. Fernandez (2010): "On the Sources of Aggregate Fluctuations in Emerging Economies," unpublished manuscript.

Costinot, A. (2009): "An Elementary Theory of Comparative Advantage," *Econometrica*, 77(4), 1165–1192.

Demirguc-Kunt, A., and E. Detragiache (1999): "Financial Liberalization and Financial Fragility," World Bank Policy Research Working Paper No. 1917.

Eden, B. (2009): "Does the Bailout of Banks Imply Higher Future Taxes: the Fiscal Implication of Replacing one Bubble Asset with Another," unpublished manuscript.

Farhi, E., and J. Tirole (2010): "Bubbly Liquidity," unpublished manuscript.

Fernandez-Villaverde, J., P. Guerron-Quintana, J. F. Rubio-Ramirez, and M. Uribe (2009): "Risk Matters: The Real Effects of Volatility Shocks," unpublished manuscript.

Fogli, A., and F. Perri (2006): "The 'Great Moderation' and the US External Imbalance," NBER Working Paper No. W12708.

Fostel, A., and J. Geanakoplos (2008): "Leverage Cycles and the Anxious Economy," *American Economic Review*, 98(4), 1211–1244.

Gali, J., and L. Gambetti (2009): "On the Sources of the Great Moderation," *American Economic Journal: Macroeconomics*, 1(1), 26–57.

GERTLER, M., AND N. KIYOTAKI (2010): "Financial Intermediation and Credit Policy in Business Cycle Analysis," in *Handbook of Monetary Economics*, ed. by B. Friedman, and M. Woodford. Elsevier, forthcoming.

GORTON, G. (2008): "The Panic of 2007," in *Maintaining Stability in a Changing Financial System*. Symposium sponsored by The Federal Reserve of Kansas City at Jackson Hole, Wyoming.

GREENWOOD, J., AND B. JOVANOVIC (1990): "Financial Development, Growth, and the Distribution of Income," *Journal of Political Economy*, 98(5), 1076–1107.

HAKURA, D. (2007): "Output Volatility and Large Output Drops in Emerging Market and Developing Countries," IMF Working Paper No. 07/114.

HALL, R. E. (2009): "The High Sensitivity of Economic Activity to Financial Frictions," unpublished manuscript.

HOLMSTROM, B. (2008): "Comment on: 'The Panic of 2007', by Gary Gorton," in *Maintaining Stability in a Changing Financial System*. Symposium sponsored by The Federal Reserve of Kansas City at Jackson Hole, Wyoming.

JEWITT, I. (1987): "Risk Aversion and the Choice Between Risky Prospects: The Preservation of Comparative Statics Results," *The Review of Economic Studies*, 54(1), 73–85.

KARLIN, S., AND Y. RINOTT (1980): "Classes of Orderings of Measures and Related Correlation Inequalities I. Multivariate Totally Positive Distributions," *Journal of Multivariate Analysis*, 10, 467–498.

KEYS, B. J., T. K. MUKHERJEE, A. SERU, AND V. VIG (2008): "Did Securitization Lead to Lax Screening? Evidence from Subprime Loans," EFA 2008 Athens Meetings Paper. Available at SSRN: http://ssrn.com/abstract=1093137.

KIYOTAKI, N., AND J. MOORE (1997): "Credit Cycles," *Journal of Political Economy*, 105(2), 211–248.

Koren, M., and S. Tenreyro (2009): "Technological Diversification," unpublished manuscript.

Martin, A., and J. Ventura (2010): "Theoretical Notes on Bubbles and the Current Crisis," unpublished manuscript.

Milgrom, P. R., and R. J. Weber (1982): "A Theory of Auctions and Competitive Bidding," *Econometrica*, 50(5), 1089–1122.

Neumeyer, P. A., and F. Perri (2005): "Business Cycles in Emerging Economies: the Role of Interest Rates," *Journal of Monetary Economics*, 52(2), 345–380.

Obstfeld, M. (1994): "Risk-Taking, Global Diversification, and Growth," *American Economic Review*, 84(5), 1310–1329.

Rajan, R. G. (1994): "Why Bank Credit Policies Fluctuate: A Theory and Some Evidence," *The Quarterly Journal of Economics*, 109(2), 399–441.

Shimer, R., and L. Smith (2000): "Assortative Matching and Search," *Econometrica*, 68(2), 343–369.

Stiglitz, J. E. (2000): "Capital Market Liberalization, Economic Growth, and Instability," *World Development*, 28(6), 1075–1086.

Tirole, J. (1985): "Asset Bubbles and Overlapping Generations," *Econometrica*, 53(6), 1499–1528.

Uribe, M., and V. Z. Yue (2006): "Country Spreads and Emerging Countries: Who Drives Whom?," *Journal of International Economics*, 69, 6–36.

A Figures

The diverging trends of output volatility in emerging and developed markets. The series are taken from the World Economic Outlook, April, 2009. The series labeled "Emerging markets" corresponds to the series "Emerging and developing economies", and the series labeled "Developed economies" corresponds to the series "Advanced economies".

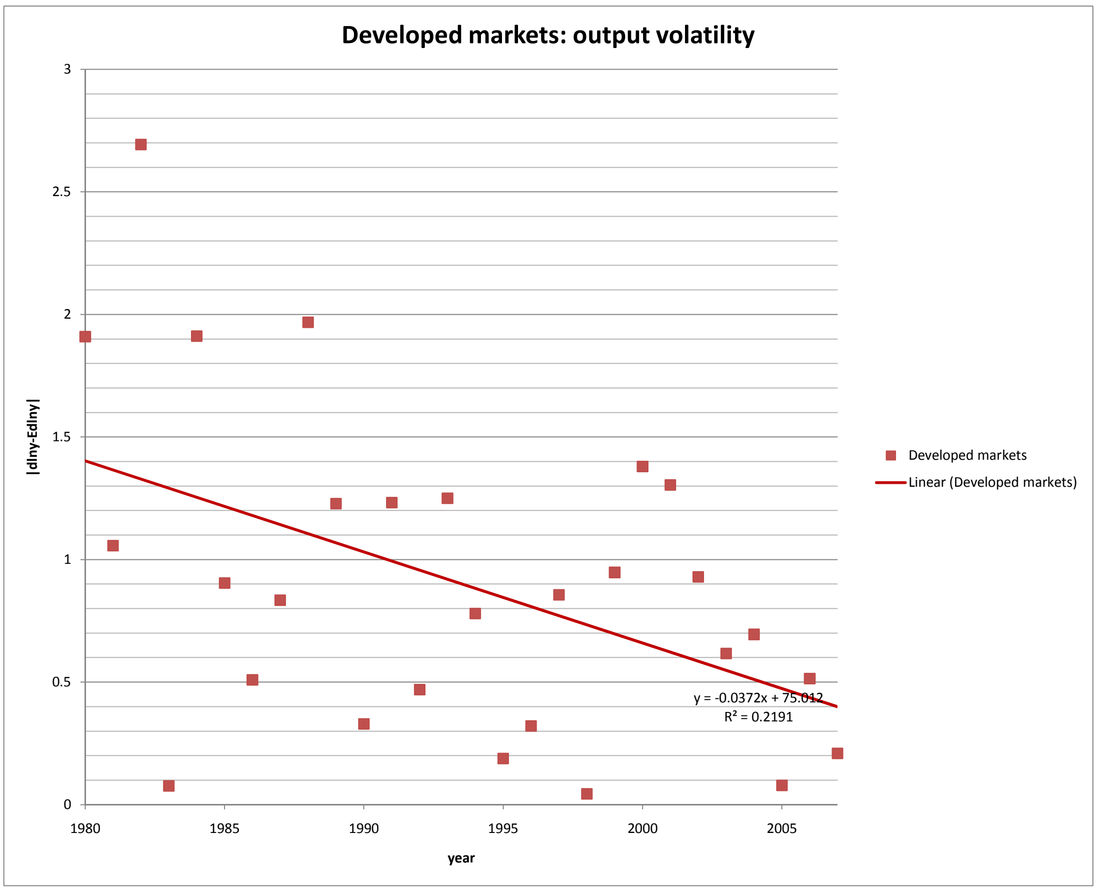


Figure 4

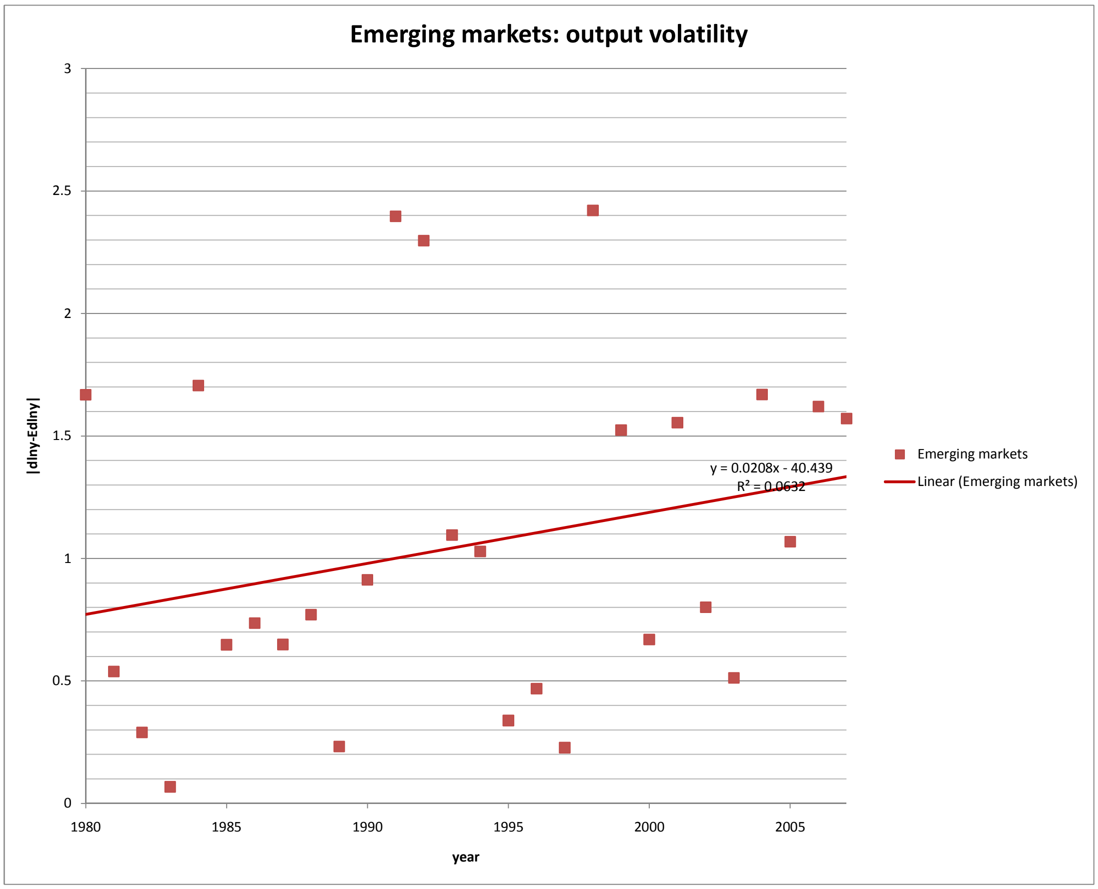

Emerging markets: output volatility
3
2.5
2
1.5
1
0.5
0
|dlny-Edlny|
1980
1985
1990
1995
2000
2005
year
y = 0.0208x - 40.439
R² = 0.0632
Emerging markets
Linear (Emerging markets)

Figure 5

B Proofs

B.1 Proof of Lemma 1

Let $\phi > \phi'$ and consider the function:

$$Y(N, \phi') - Y(N, \phi) \tag{35}$$

Recall that this function is 0 for $N = 0$ and for $N = 1$. Taking a first order condition yields:

$$y(N, \phi') - y(N, \phi) = 0 \tag{36}$$

This point is a local maximum, as the second derivative is negative by Assumption 1. To see this, using equation 36:

$$\frac{\frac{\partial y(N,\phi')}{\partial N} - \frac{\partial y(N,\phi)}{\partial N}}{y(N, \phi)} = \frac{\frac{\partial y(N,\phi')}{\partial N}}{y(N, \phi')} - \frac{\frac{\partial y(N,\phi)}{\partial N}}{y(N, \phi)} = \frac{\partial \ln y(N, \phi')}{\partial N} - \frac{\partial \ln y(N, \phi)}{\partial N} < 0 \tag{37}$$

The inequality stems from Assumption 1.

Thus, the function reaches a maximum at the point $y(N, \phi') = y(N, \phi)$. The minima or this function are therefore at $N = 0$ and $N = 1$, at which the function takes the value of 0. It follows that the function is always weakly greater than 0:

$$Y(N, \phi') - Y(N, \phi) \geq 0 \tag{38}$$

Which concludes the proof.

B.2 Proof of Lemma 2

Begin by considering the case $\phi \leq 1$. First, note that for every N, there is a threshold $\tilde{N}$ such that project (x, b) is implemented if and only if $x \leq \tilde{N}$ and $b \leq \tilde{N}$. For $\tilde{N} < \phi$,

$$N = Pr(x \leq \tilde{N}, b \leq \tilde{N}) = \tilde{N} \cdot \frac{1}{\phi}\tilde{N} = \frac{1}{\phi}\tilde{N}^2 \Rightarrow \tilde{N} = \sqrt{\phi}\sqrt{N} \tag{39}$$

Note that $\tilde{N} < \phi$ if and only if $N < \phi$. For $N > \phi$, it is easy to see that $\tilde{N} = N$.

For $N < \phi$, output is given by the following expression:

$$Y(\tilde{N}) = \int_0^{\tilde{N}} Pr(b \leq \tilde{N}) Ag(x)dx = \frac{1}{\phi}\tilde{N}\int_0^{\tilde{N}} Ag(x)dx = \frac{A}{\phi}\tilde{N}^{1+\alpha} \tag{40}$$

It follows that, for $N < \phi$:

$$Y(N,\phi) = A\phi^{\frac{\alpha-1}{2}} N^{\frac{1+\alpha}{2}} \tag{41}$$

The derivative of Y with respect to N is therefore given by:

$$y(N,\phi) = \frac{1+\alpha}{2} A\phi^{\frac{\alpha-1}{2}} N^{\frac{\alpha-1}{2}} \tag{42}$$

$$\Rightarrow \ln y(N,\phi) = \ln(\frac{1+\alpha}{2}A) - \frac{1-\alpha}{2}\ln\phi - \frac{1-\alpha}{2}\ln N \tag{43}$$

The derivative of above with respect to N is:

$$\frac{\partial \ln y(N,\phi)}{\partial N} = -\frac{1-\alpha}{2N} \tag{44}$$

The above does not depend on ϕ as long as $N < \phi$; the log supermodularity condition is trivially satisfied. However, Note that for a higher ϕ, there are more values of N such that $N < \phi$. Let there be ϕ and ϕ' such that $\phi' < N < \phi$. For ϕ', it is easy to see that the derivative of $\ln y(N,\phi')$ is given by the following expression:

$$y(N,\phi') = A\alpha N^{-(1-\alpha)} \Rightarrow \ln y(N,\phi') = \ln(A\alpha) - (1-\alpha)\ln N \tag{45}$$

$$\Rightarrow \frac{\partial \ln y(N,\phi')}{\partial N} = -\frac{1-\alpha}{N} < -\frac{1-\alpha}{2N} = \frac{\partial \ln y(N,\phi)}{\partial N} \tag{46}$$

Thus, the derivative of $\ln y$ with respect to N is higher in the more distorted economy ϕ, in accordance with Assumption 1.

Consider now the range $\phi \geq 1$. In this range, for $\tilde{N} < 1$, N is given by equation 39, output is given by equation 40 and $\frac{\partial \ln y}{\partial N}$ is given by equation 44. In this range, $\frac{\partial \ln y}{\partial N}$ is constant with respect to ϕ, so the log supermodular condition is trivially satisfied.

Note that $\tilde{N} < 1$ if and only if $\sqrt{\phi N} < 1$, or $N < \frac{1}{\phi}$. This condition is violated for more values of N if ϕ is larger. For $N > \frac{1}{\phi}$, the marginal product of working capital is constant; the collateral constraint is binding for all implemented projects, so the productivity of the projects implemented with each unit of working capital is the same. Thus, in the range $N > \frac{1}{\phi}$,

$$\frac{\partial \ln y(N,\phi)}{\partial N} = 0 > -\frac{1-\alpha}{2N} \tag{47}$$

The right hand side is equal to the derivative of $\ln y$ for the case $N < \frac{1}{\phi}$. It follows that the log supermodularity condition is satisfied for $\frac{1}{\phi} < N < \frac{1}{\phi'}$.

B.3 Proof of Lemma 3

Output is given by the following expression:

$$Y(N,\phi) = \sum_{i=0}^{\phi} \int_{\frac{i}{\phi}}^{\frac{i}{\phi}+\frac{N}{\phi}} Ag(x)dx \tag{48}$$

This is because each local bank has $\frac{N}{\phi}$ units of liquidity to allocate, and uses it to implement the first $\frac{N}{\phi}$ in the sample of projects available to it.

The marginal product of working capital is given by:

$$y(N,\phi) = \frac{1}{\phi}\sum_{i=0}^{\phi} Ag(\frac{i}{\phi}+\frac{N}{\phi}) = \frac{A}{\phi}\sum_{i=0}^{\phi} e^{-(\frac{i}{\phi}+\frac{N}{\phi})} \tag{49}$$

$$= \frac{Ae^{-\frac{N}{\phi}}}{\phi}\sum_{i=0}^{\phi} e^{-\frac{i}{\phi}} \tag{50}$$

It follows that:

$$\ln y(N,\phi) = \ln(\frac{A}{\phi}\sum_{i=0}^{\phi} e^{-\frac{i}{\phi}}) + \ln e^{-\frac{N}{\phi}} = c - \frac{N}{\phi} \tag{51}$$

The derivative of above with respect to N is $-\frac{1}{\phi}$, which is increasing in ϕ. The log supermodularity condition is satisfied, in accordance with Assumption 1.

B.4 Proof of Proposition 1

To show that $Y(N,\phi)$ is log supermodular, write $Y(N,\phi)$ as:

$$Y(N,\phi) = \int_0^\infty 1_{[0,N]}(n) y(n,\phi) dn \tag{52}$$

Where $1_{[0,N]}$ denotes the indicator function which takes a value 1 over the interval $[0,N]$ (and 0 elsewhere).

Recall the definition of log supermodularity as it appears in Costinot (2009), which allows for 0 values:

Definition 1 *For $X \subset \mathbb{R}^w$, a function $h : X \to \mathbb{R}^+$ is log supermodular if for all $z, z' \in X$,*

$$h(\max(z_1, z_1'), ... \max(z_m, z_m'))h(\min(z_1, z_1'), ... \min(z_m, z_m')) \geq h(z)h(z') \tag{53}$$

Claim 1 *The function $h(N,n,\phi) = 1_{[0,N]}(n)$ is log supermodular in N, n, and ϕ.*

To see this, note that both sides of the inequality in 53 can be either 0 or 1, and consider the case in which the left hand side of the inequality is 0:

$$h(\max(N,N'), \max(n,n'), \max(\phi,\phi'))h(\min(N,N'), \min(n,n'), \min(\phi,\phi')) = 0 \tag{54}$$

$$1_{[0,\max(N,N')]}(\max(n,n'))1_{[0,\min(N,N')]}(\min(n,n')) = 0 \tag{55}$$

Assume without loss of generality that $\max(n,n') = n$. From the above equality, $1_{[0,\max(N,N')]}(\max(n,n')) = 0$ or $1_{[0,\min(N,N')]}(\min(n,n')) = 0$. Assume $1_{[0,\max(N,N')]}(\max(n,n')) = 0$. Thus,

$$n > \max(N,N') \Rightarrow n > N \Rightarrow 1_{[0,N]}(n) = 0 \Rightarrow 1_{[0,N]}(n)1_{[0,N']}(n') = 0 \tag{56}$$

Assume instead that $1_{[0,\min(N,N')]}(\min(x,x')) = 0$. There are two cases: if $\min(N,N') = N'$,

$$n' > N' \Rightarrow 1_{[0,N']}(n') = 0 \Rightarrow 1_{[0,N]}(n)1_{[0,N']}(n') = 0 \tag{57}$$

if, instead, $\min(N, N') = N$, since $\max(n, n') = n$,

$$n' > N \Rightarrow n > N \Rightarrow 1_{[0,N]}(n) = 0 \Rightarrow 1_{[0,N]}(n)1_{[0,N']}(n') = 0 \tag{58}$$

Thus, log supermodularity is satisfied.

The assumption that $y(n, \phi)$ is log supermodular in (n, ϕ) implies trivially that it is log supermodular as a function of (N, n, ϕ).

Since the product of two log supermodular functions is log supermodular, and the integral of a log supermodular function is log supermodular[15], it follows that $Y(N, \phi)$ is log supermodular. Thus, by log supermodularity, $\frac{\partial \ln Y(N,\phi)}{\partial N}$ is increasing in ϕ.

The second part of the proposition builds on the first part:

$$\frac{Y(N, \phi)}{N} = Y(N, \phi)N^{-1} \tag{59}$$

Since $Y(N, \phi)$ is log supermodular, and N^{-1} is trivially log supermodular, it follows that average productivity is log supermodular as a product of two log supermodular functions. Thus, by log supermodularity, $\frac{\partial \ln(\frac{Y(N,\phi)}{N})}{\partial N}$ is increasing in ϕ. Since the derivative is negative, this implies that the sensitivity of average productivity to the level of working capital is higher in less distorted economies.

B.5 Proof of Propositions 2 and 3

1. To show that financial integration exacerbates volatility differences, I begin by showing that (at autarkic working capital levels) working capital is more sensitive to the price of liquidity in emerging markets. Since output is more sensitive to working capital (Proposition 1), and since, by assumption, mean levels of working capital remain unchanged following financial integration, the proposition follows. Since it is assumed that f is decreasing, the working capital level is such that the marginal product of working capital is equal to its market price r:

$$y(N, \phi) = r \tag{60}$$

[15]For proof see Karlin and Rinott (1980).

It follows that the derivative of N with respect to r is:

$$\frac{\partial N}{\partial r} = \frac{1}{\frac{\partial r}{\partial N}} = \frac{1}{\frac{\partial y(N,\phi)}{\partial N}} \tag{61}$$

Denote:

$$f(N,\phi) = \int_0^1 \sigma_\phi(N,x)g(x)dx \tag{62}$$

Note that $y(N,\phi;A) = Af(N,\phi)$. The assumption that y is log supermodular implies trivially that f is log supermodular.

Log supermodularity implies that:

$$\frac{A_{em}f_1(N,\phi_{em})}{A_{em}f(N,\phi_{em})} = \frac{f_1(N,\phi_{em})}{f(N,\phi_{em})} > \frac{f_1(N,\phi_d)}{f(N,\phi_d)} = \frac{A_d f_1(N,\phi_d)}{A_d f(N,\phi_d)} \tag{63}$$

Since, by assumption, $A_{em}f(N,\phi_{em}) = A_d f(N,\phi_d)$, it follows that

$$A_{em}f_1(N,\phi_{em}) > A_d f_1(N,\phi_d) \tag{64}$$

It follows that:

$$\frac{\partial N_d}{\partial r} = \frac{1}{A_d f_1(N,\phi_d)} > \frac{1}{A_{em}f_1(N,\phi_{em})} = \frac{\partial N_{em}}{\partial r} \tag{65}$$

Since the response of N to r is negative, it follows that N_{em} is more sensitive to changes in r. By construction, N_{em} and N_d are similarly affected by shocks to relative productivity (which cause a substitution between N_d and N_{em}). Thus, since these are the only two sources of variation in N, under the assumption that $Q_i = N_i^a$ are identically distributed,

$$var(\ln N_{em}) - var(\ln N_d) > var(\ln N_{em}^a) - var(\ln N_d^a) = 0 \tag{66}$$

To see that financial integration exacerbates the difference in output volatility, note that:

$$var(\ln Y) = \frac{\partial \ln Y}{\partial \ln N} var(\ln N) + var(\ln A) \tag{67}$$

Decompose volatility in N into volatility conditional on Q shocks and volatility conditional on relative TFP shocks:

$$var(\ln N) = var(\ln N|Q) + var(\ln N|A) \tag{68}$$

$$var(\ln Y_{em}) - var(\ln Y_d) - (var(\ln A_{em}) - var(\ln A_d)) = \tag{69}$$

$$\frac{\partial \ln Y_{em}}{\partial \ln N}(var(\ln N_{em}|Q)+var(\ln N_{em}|A)) - \frac{\partial \ln Y_d}{\partial \ln N}(var(\ln N_d|Q)+var(\ln N_d|A)) \tag{70}$$

$$= \frac{\partial \ln Y_{em}}{\partial \ln N} var(\ln N_{em}|A) - \frac{\partial \ln Y_d}{\partial \ln N} var(\ln N_d|A) + \tag{71}$$

$$var(\ln N|Q)(\frac{\partial \ln Y_{em}}{\partial \ln N} - \frac{\partial \ln Y_d}{\partial \ln N}) \tag{72}$$

Since the last term is positive, the above is greater than the first term in the above expression:

$$> \frac{\partial \ln Y_{em}}{\partial \ln N} var(\ln N_{em}|A) - \frac{\partial \ln Y_d}{\partial \ln N} var(\ln N_d|A) \tag{73}$$

The following lemma will be useful to conclude the proof:

Lemma 5 *(a)* $var(\ln N_{em}|A) > var(\ln N^a_{em})$

(b) $var(\ln N_d|A) < var(\ln N^a_d)$

Proof: To see this, consider a benchmark in which economy i integrates with an economy with an **identical** sensitivity to r shocks. In this hypothetical case, shocks to domestic and foreign liquidity supply adjust equally between the two countries. Using the assumption that Q_i are perfectly correlated, it follows that:

$$var(N_i) = var(\frac{1}{2}(Q_i + Q_j)) = \frac{1}{4}(var(2Q_i)) = var(Q_i) = var(N^a_i) \tag{74}$$

The lemma above is proved using comparative statics with this benchmark. Since shocks to liquidity supply have a greater effect on emerging markets, the volatility of $var(N_{em})$ is greater than this benchmark, and since shocks to liquidity supply have a smaller effect on developed markets, the volatility of $var(N_d)$ is lower than this benchmark. As mean liquidity levels stay the same, the lemma (as stated in logs) immediately follows.

Using the above lemma, the expression in equation 73 is greater than the expression below, in which $var(\ln N_i|A)$ are replaced with autarkic values:

$$(73) > \frac{\partial \ln Y_{em}}{\partial \ln N} var(\ln N^a_{em}) - \frac{\partial \ln Y_d}{\partial \ln N} var(\ln N^a_d) \tag{75}$$

$$= var(\ln Y^a_{em}) - var(\ln Y^a_d) - (var(\ln A_{em}) - var(\ln A_d)) \tag{76}$$

$$\Rightarrow var(\ln Y_{em}) - var(\ln Y_d) > var(\ln Y^a_{em}) - var(\ln Y^a_d) \tag{77}$$

Which concludes the proof.

2. (a) To see that financial integration increases volatility of working capital in the emerging market region, note that both $var(N_{em}|A) > var(N^a_{em}|A) = 0$, and $var(N_{em}|Q) > var(N^a_{em}|Q)$. To see that financial integration increases the volatility of output in the emerging market region, note that since $var(A)$ remains the same, and since the level N is unchanged, from equation 67 output volatility increases as well.

   (b) The effect of financial integration on $var(N_d)$ is ambiguous: the volatility of N_d conditional on holding technology levels constant is smaller, so $var(N_d|A) < var(N^a_d|A)$. However, through the standard RBC channel, $var(N_d|Q) > var(N^a_d|Q) = 0$. If shocks to relative TFP are sufficiently small, the first effect dominates so $var(N_d) < var(N^a_d)$. In this case, from equation 67 (and the assumption that the mean level of N is unchanged), it follows that output volatility decreases as well.

B.6 Proof of Proposition 4

Lemma 6 *Consider the problem:*

$$\max_{\phi} \int_0^N y(N', \phi)dN' - \lambda(\phi) \tag{78}$$

The solution ϕ^* is increasing in N for some range $N \in (\tilde{N}, 1]$.

Using the proof of Lemma 1, for each pair $\phi_i > \phi_j$ there is a point $0 < N_{i,j} < 1$ such that $Y(N, \phi)$ has increasing differences for $N > N_{i,j}$ and $\phi \in \{\phi_i, \phi_j\}$. Let $\tilde{N}$ denote the maximum of these $N_{i,j}$. In the region $(\tilde{N}, 1]$, there are increasing differences for all ϕ within the set of possible values. By Sundaram (1996), ϕ^* is increasing in N on that region.

Note that, for any r, ϕ^* is the solution to:

$$\max_{\phi} \int_0^N y(N', \phi)dN' - \lambda(\phi) - rN \tag{79}$$

This is because rN is a constant in this problem.

Now, assume that $Q \in (\tilde{N}, 1]$. In this range, a drop in r is associated with an increase in N^*. It follows that ϕ^* increases.

B.7 Proof of Proposition 5

For what follows, denote by ϕ_d^w the level of distortions in the deteriorated "weak" financial system, and by ϕ_d^i the autarkic "intact" level of financial distortions. Normalize $\lambda(\phi_d^w) = 0$ and $\lambda(\phi_d^i) = \lambda$.

I begin with the first part of the proposition. By equations 36 and 37, there is a unique point $N_0 \in (0, 1)$ such that:

$$y_d(N_0, \phi_d^i) = y_d(N_0, \phi_d^w) \tag{80}$$

For every $N < N_0$, $y(N, \phi_d^i) > y(N, \phi_d^w)$ and for every $N > N_0$, $y(N, \phi_d^i) < y(N, \phi_d^w)$.

Recall that in this setup, prior to financial integration the financial system in the developed world was endogenously intact, and it endogenously deteriorated following a drop in r. It turns out that these dynamics are possible only if r is such that working capital levels exceed N_0 (when the financial system is intact and the economy is integrated):

Lemma 7 *There is an endogenous weakening of the financial system (in the developed world) only if* $r \leq y(N_0, \phi_d^i) = y(N_0, \phi_d^w)$.

Here, r denotes the rate of return on working capital when the financial system in the developed world is intact.

Proof: Assume $r > y(N_0, \phi_d^i)$, and it will be shown that in this case there is no endogenous financial deterioration. Denote by r^a the return to working capital under autarky in the developed world. We know that given r^a, the optimal choice of financial quality is $\phi_d = \phi_d^i$:

$$\pi(r^a, \phi_d^i) > \pi(r^a, \phi_d^w) \tag{81}$$

$$\Rightarrow \max_N \int_0^N y(N', \phi_d^i)dN' - r^a N - \lambda > \max_N \int_0^N y(N', \phi_d^w)dN' - r^a N \tag{82}$$

The standard optimality condition is $y(N, \phi_d) = r^a$. Denote this N by $N^*(r, \phi_d)$.

Thus, the inequality in equation 82 can be rewritten as:

$$\int_{r^a}^{\infty} (y(N^*(r', \phi_d^i), \phi_d^i) - y(N^*(r', \phi_d^w), \phi_d^w))dr' > \lambda \tag{83}$$

From the assumption that $r > y(N_0, \phi_d^i)$, it follows that $r^a > y(N_0, \phi_d)$, because $r^a > r$ (there is a drop in r upon financial integration). For $r > y(N_0, \phi_d^i)$, it is also the case that:

$$N^*(r, \phi_d^i) > N^*(r, \phi_d^w) \tag{84}$$

This is because, since $N^*(r, \phi_d^i) < N_0$,

$$y(N^*(r, \phi_d^i), \phi_d^w) < y(N^*(r, \phi_d^i), \phi_d^i) \tag{85}$$

Thus, since y is decreasing in N, the inequality in equation 84 holds true.

Note that equation 85 holds for any $y(N_0, \phi_d) < r < r^a$. Thus,

$$\int_0^{N^*(r,\phi_d^i)} y(N', \phi_d^i)dN' - rN^*(r, \phi_d^i) - \int_0^{N^*(r,\phi_d^w)} y(N', \phi_d^w)dN' - rN^*(r, \phi_d^w) = \tag{86}$$

$$\int_r^{\infty} y(N^*(r', \phi_d^i), \phi_d^i)dr' - \int_r^{\infty} y(N^*(r', \phi_d^w), \phi^w)dr' = \tag{87}$$

$$\int_{r^a}^{\infty} (y(N^*(r', \phi_d^i), \phi_d^i) - y(N^*(r', \phi_d^w), \phi_d^w))dr' + \tag{88}$$

$$\int_r^{r^a} (y(N^*(r', \phi_d^i), \phi_d^i) - y(N^*(r', \phi_d^w), \phi_d^w))dr' \tag{89}$$

By equation 83, the first term is greater than λ. The second term is positive by equation 85. Thus, the sum above is greater than λ. It follows that choosing $\phi_d = \phi_d^i$ is still preferable to choosing $\phi_d = \phi_d^w$. I conclude that an endogenous financial deterioration is not possible if $r > y(N_0, \phi_d^i)$.

To conclude the proof, note that for $r < y(N_0, \phi_d^i)$,

$$N^*(r, \phi_d^i) < N^*(r, \phi_d^w) \tag{90}$$

Thus, the deterioration in the quality of the financial system is associated with an increase in N.

To see the second part of the proposition, note that for $\frac{A_d}{A_{em}}$ sufficiently large,

$$y_d(1, \phi_d^w) > y_{em}(1, \phi_{em}) \tag{91}$$

From continuity, there exists $\epsilon > 0$ such that for every $1 - \epsilon < N < 1$,

$$y_d(1, \phi_d^w) > y_{em}(N, \phi_{em}) \tag{92}$$

It follows that for $Q_w > 2 - \epsilon$, the developed market will be satiated with working capital. Output is weakly higher than in the intact case (note that the conditions under which the weakened financial system is satiated with working capital are weaker than the conditions under which the intact economy is satiated with working capital, because, since $N_0 < 1$, $y_d(1, \phi_d^w) > y_d(1, \phi_d^i)$). Under satiation, the developed economy is stable with respect to small shocks to the global supply of working capital, as the economy remains satiated as long as Q_w satisfies:

$$y_d(1, \phi_d^w) > y_{em}(Q_w - 1, \phi_{em}) \tag{93}$$

Similarly, the level of working capital is unaffected by shocks to relative TFP. The volatility of output is therefore smaller both with respect to liquidity supply shocks and with respect to shocks to relative TFP.

B.8 Proof of Lemma 4

Recall the notation from the proof of Proposition 5: ϕ_d^w denotes the level of distortions in the deteriorated "weak" financial system, and ϕ_d^i denotes the autarkic "intact" level of financial distortions.

Given ϕ_d, world output maximization solves:

$$Y_w(\phi_d) = \max_{N_d, N_{em}} Y_w(\phi_d, N_d, N_{em}) = \tag{94}$$

$$\max_{N_d, N_{em}} A_d \int_0^{N_d} y(N', \phi_d) dN' + A_{em} \int_0^{N_{em}} y(N', \phi_{em}) dN' \tag{95}$$

s.t.

$$N_d + N_{em} = Q_w \tag{96}$$

$$N_i \leq 1 \tag{97}$$

Under autarky there is an additional constraint which is:

$$N_i = Q_i \tag{98}$$

It is easy to see that for any *given* couple (N_d, N_{em}) which satisfy constraints 96-97 or 96-98, the output produced is higher when the financial system in the developed market is intact:

$$Y_w(\phi_d^i, N_d, N_{em}) \geq Y_w(\phi_d^w, N_d, N_{em}) \tag{99}$$

Denote by $(N_d^*(\phi_d), N_{em}^*(\phi_d))$ the optimal allocation of working capital given ϕ_d.

From the optimality of $N_i^*(\phi_d^i)$:

$$Y_w(\phi_d^i) = Y_w(\phi_d^i, N_d^*(\phi_d^i), N_{em}^*(\phi_d^i)) \geq Y_w(\phi_d^i, N_d^*(\phi_d^w), N_{em}^*(\phi_d^w)) \tag{100}$$

And, from equation 99:

$$Y_w(\phi_d^i, N_d^*(\phi_d^w), N_{em}^*(\phi_d^w)) \geq Y_w(\phi_d^w, N_d^*(\phi_d^w), N_{em}^*(\phi_d^w)) = Y_w(\phi_d^w) \tag{101}$$

It follows that world output is higher when the financial system in the developed market is intact:

$$\Rightarrow Y_w(\phi_d^i) \geq Y_w(\phi_d^w) \tag{102}$$

B.9 Proof of Proposition 6

Recall the notation from the proof of Proposition 5: ϕ_d^w denotes the level of distortions in the deteriorated "weak" financial system, and ϕ_d^i denotes the autarkic "intact" level of financial distortions.

Let N_0 be given by the condition in equation 36:

$$y(N_0, \phi_d^i) = y(N_0, \phi_d^w) \tag{103}$$

Consider a shock to the global supply of liquidity such that $Q_w < N_0$. In this range, the marginal product of working capital in the developed world is higher under intact financial institutions. It follows that working capital is higher:

$$N_d^*(Q_w, \phi_d^i) > N_d^*(Q_w, \phi_d^w) \tag{104}$$

Since output decreases with the level of distortion by Lemma 1,

$$Y_d(N_d^*(Q_w, \phi_d^i), \phi_d^i) > Y_d(N_d^*(Q_w, \phi_d^i), \phi_d^w) \tag{105}$$

Since output is increasing in the level of working capital,

$$Y_d(N_d^*(Q_w, \phi_d^i), \phi_d^w) > Y_d(N_d^*(Q_w, \phi_d^w), \phi_d^w) \tag{106}$$

It follows that output is higher under intact financial institutions:

$$Y_d(N_d^*(Q_w, \phi_d^i), \phi_d^i) > Y_d(N_d^*(Q_w, \phi_d^w), \phi_d^w) \tag{107}$$

Similarly, a shock to relative TFP such that $N_d^*(Q_w, \phi_d^i) < N_0$ is amplified by lack of high quality financial institutions.

C A monetary model of liquidity supply

In this section, I develop a model of liquidity supply, in which liquidity supply fluctuations are caused by two primitive shocks: shocks to the money supply and shocks to consumers' risk aversion[16]. Recall that the model makes three assumptions about the distribution of liquidity supply:

1. The distribution of liquidity supply is unchanged by financial integration.
2. Liquidity supply is independent from both domestic and foreign productivity, A_i.
3. Liquidity supply is perfectly correlated across regions.

Consider a model in which labor (denoted L) is the only productive input. Given L_i hired units of labor, output in country i is given by:

$$Y_i = A_i F_i(L_i) \tag{108}$$

In this model, liquidity is money used to hire labor; thus, in this formulation, F_i already captures the efficiency of the financial system in allocating liquidity (in other words, F is log supermodular in L and ϕ).

Assumption 2 *1. The price of a unit of labor in terms of money, w, is determined at the beginning of the period, before all shocks are realized. Agents agree to supply any amount of labor for the wage w.*

[16] The analysis of Broner, Lorenzoni, and Shmukler (2008) suggests that shocks to the risk aversion of international investors is indeed an important driving source of supply driven volatility in emerging markets.

2. The price of output is fixed within a period, and is normalized to one.

Agents live for one period and consume at the end of their lives. The preferences of agents in region i are given by:

$$E(u_i(c_i) - v_i(L_i)) \tag{109}$$

I assume that $u_i(c_i)$ takes the following stark form:

$$u_i(c_i) = \begin{cases} c_i & \text{if } c \geq c_{0,i}; \\ -\infty & \text{otherwise.} \end{cases} \tag{110}$$

In this formulation, $c_{0,i}$ captures the level of risk aversion of households in region i. To see this, consider the comparison between two agents, one denoted h with $c_{0,h} = c_{0,h}$ and one denoted l with $c_{0,l} < c_{0,h}$.

Definition 2 *Agent h is more risk averse than agent l if the following condition holds: for any certain consumption payment c, and any lottery q, if agent h prefers q over c then so does agent l.*

To see that, according to this standard definition, the condition $c_{0,h} > c_{0,l}$ implies that agent h is more risk averse than agent l, note the following claim:

Claim 2 *Agent i prefers a lottery q over a certainty payment of c if and only if the lottery q never delivers a payment of less than $c_{0,i}$, and $E(q) > c$.*

Proof: Trivially, if the above condition holds, the agent will prefer the lottery: if $c > c_{0,i}$ he is risk neutral between the two lotteries, and if $c \leq c_{0,i}$ his utility from consuming c is $-\infty$ whereas it is positive given the lottery. If the above condition is violated, it means that one of the following holds: either $E(q)$ delivers a payment of less than $c_{0,i}$ with positive probability, or $E(q) < c$. If $E(q)$ delivers a payment of less than $c_{0,i}$ with positive probability, then the agent's expected utility from the lottery is $-\infty$, so it is not preferred over anything. If $E(q) < c$, but q always delivers a payment of more than $c_{0,i}$, then it follows that $c > c_{0,i}$, so the agent is risk neutral with respect to q and c and would prefer c.

Using this claim, it is easy to see that h is more risk averse than l, as the fact that q never delivers a payment of less than $c_{0,h}$ implies that it never delivers a payment of less than $c_{0,l} < c_{0,h}$, so the set of lotteries and certainty payments in which h prefers the lottery is included in the set of lotteries and certainty payments in which l prefers the lottery.

Thus, we will think of c_0 as the level of risk aversion of the agents.

Corollary 2 *A higher level of $c_{0,i}$ implies a higher level of risk aversion.*

C.1 Liquidity supply in the closed economy

After wages are agreed upon and prices are set, the money supply, M_i, and the level of risk aversion, $c_{0,i}$, are realized. Agents can choose to hold their money in a safe ($M_{h,i}$) or buy stocks in the productive sector (Q_i):

$$M_i = Q_i + M_{h,i} \tag{111}$$

The level of Q_i is also the level of liquidity supply which can be used to hire workers. After the productivity shock A_i is realized, the financial system allocates the liquidity Q_i to domestic projects who use it to hire workers:

$$Q_i = w_i L_i \tag{112}$$

After production takes place but before workers are paid, there is a shock to the ability of the productive sector to make monetary transfers. With probability $(1-\theta)$, this ability is *intact*; in this case, wages are paid and two rounds of consumption follow. In the first round, households use their money holdings (which include wage payments, $w_i L_i$, and money from the safe, $M_{h,i}$) to buy output and consume. In the second round, monetary revenues from sales are redistributed to households as dividends (denoted d per share), and are used for consumption. The end of the period consumption is given by:

$$c_i = M_{h,i} + w_i L_i + dQ_i \tag{113}$$

With a small probability θ, the ability of the productive sector to make monetary transfers *collapses*. This implies two things: first, wages are not paid to workers. Second, revenues from sales cannot be redistributed back to households, so no dividends are paid. There is only one round of consumption, in which households use the money which they had kept in the safe ($M_{h,i}$) to buy consumption goods. It follows that the end of the period consumption is given by:

$$c_i = M_{h,i} \tag{114}$$

Simplistically, the shock to the ability of the productive sector to make monetary transfers can be thought of as a strike in the postal services: households who receive wage payments and dividend payments by mail (and are subject to a cash in advance constraint) do not receive these payments in time to consume before they die. Realistically, this shock is meant to capture a shock to the money supply, in which certain substitutes for money used by the productive sector are no longer valued[17]. For example, prior to the sub-prime crisis, mortgage backed securities were accepted by all as means of payment. In the sub-prime crisis, these securities turned into illiquid assets, and people were no longer willing to hold these assets without understanding the value of their components. Thus, it became harder to trade these assets for consumption goods, which made bonds and cash more desired[18]. In this model, agents hold bonds ("money in the safe") precisely to insure against events of this kind[19].

To summarize, the timing within a period is as follows:

1. The wage w_i and the price of output (normalized to 1) is set.
2. The initial money supply, $M_{0,i}$, and the level of risk aversion, $c_{0,i}$, are realized.
3. Agents use some of their money to buy stocks and effectively supply liquidity to the productive sector (and keep the rest in a safe).
4. The productivity shock, A_i, is realized.

[17] See Eden (2009) for a complete development of this idea.

[18] See Holmstrom (2008) for a complete development of this idea.

[19] Results similar to those derived in this section can be derived in a more standard framework, in which agents hold money to insure against unemployment risk; however, this motive for hoarding liquidity seems less compelling as the mechanism through which shocks to risk aversion affect liquidity supply. Rather, in this formulation portfolio decisions are motivated by fear of large aggregate disasters, consistent with the view expressed in Barro (2006).

5. The financial system allocates liquidity to projects, and production takes place.

6.
   - With prob. $(1-\theta)$ (*intact*): wages are paid, followed by a first round of consumption in which agents trade their wage earnings ($w_i L_i$) and their money holdings ($M_{h,i}$) for consumption. The productive sector redistributes revenues from sales back to households in the form of dividends. A second round of consumption takes place in which the dividends are traded for consumption.
   - With prob. θ (*collapse*): the productive sector loses its ability to make monetary transfers. Wages are not paid and revenues from sales cannot be redistributed back to households. There is therefore only one round of consumption, in which households use their money holdings ($M_{h,i}$) to buy consumption goods.

C.1.1 Equilibrium

The portfolio decision. Clearly, the agent will reserve at least enough money to finance $c_{0,i}$ units of consumption in case of a collapse (as otherwise his expected utility is $-\infty$):

$$M_{h,i} \geq c_{0,i} \tag{115}$$

Denote by d the realized dividend per share of the productive sector, and let Q_i^0 be the equilibrium level of liquidity supply, which the individual agent takes as given. Agents solve:

$$\max_{Q_i, M_{h,i}} c_i - v_i(L_i) \tag{116}$$

s.t.:

$$M_i = Q_i + M_{h,i} \tag{117}$$

$$c_i = \begin{cases} M_{h,i} + Q_i d + w_i L_i & \text{with prob. } (1-\theta); \\ M_{h,i} & \text{with prob. } \theta. \end{cases} \tag{118}$$

$$M_{h,i} \geq c_{0,i} \tag{119}$$

Substituting in the first constraint, this problem can be rewritten as:

$$\max_{Q_i}(1-\theta)(M_i - Q_i + Q_i d + w_i L_i) + \theta(M_i - Q_i) - v_i(L_i) \tag{120}$$

s.t.

$$M_i - Q_i \geq c_{0,i} \tag{121}$$

The derivative of the above with respect to Q_i is:

$$(1-\theta)d - 1 \tag{122}$$

Note that, in equilibrium, the dividends per share are given by:

$$d = \frac{M_i}{Q_i^0} \tag{123}$$

Assumption 3 *The value of θ is sufficiently small so that, for any realization of M_i and $c_{0,i}$, the derivative of equation 120 with respect to Q_i is positive at $Q_i^0 = M_i - c_{0,i}$:*

$$(1-\theta)\frac{M_i}{M_i - c_{0,i}} - 1 > 0 \tag{124}$$

Result 1 *Under Assumption 3, the optimal portfolio decision is $M_{h,i} = c_{0,i}$, $Q_i = M_i - c_{0,i}$.*

Proof: Under Assumption 3, the constraint in equation 121 is binding. Thus, $M_i - Q_i = c_{0,i}$.

C.2 Liquidity supply in the integrated economy

I assume that there is a single currency, so both labor and consumption can be paid for in either domestic or foreign money. For simplicity, I assume that agents consume foreign and domestic goods proportional to their shares in output (so that, regardless of the realizations of money supplies, a unit of domestic output has the same probability of being consumed as a unit of foreign output).

As in the closed economy, agents choose between keeping money in the safe ($M_{h,i}$) and buying stocks (Q_i). In the integrated economy, a stock is a claim on the sales revenues of the global economy. After portfolio decisions are made, the global financial system distributes liquidity between foreign and domestic projects in an output maximizing way[20].

Assumption 4 *Shocks to the ability of the productive sector to make monetary transfers are i.i.d. across regions.*

C.2.1 Equilibrium

The portfolio decision. Because there is a positive probability that both economies suffer a simultaneous collapse (an event that happens with probability θ^2), similarly to the closed economy case the agent will reserve at least enough money to finance $c_{0,i}$ units of consumption:

$$M_{h,i} \geq c_{0,i} \tag{125}$$

Denote by d the realized dividend per share of the global productive sector, and let Q_i^0 be the equilibrium level of liquidity supplied by country i which the individual agent takes as given. Similarly to the closed economy, agents solve:

$$\max_{Q_i, M_{h,i}} c_i - v_i(L_i) \tag{126}$$

s.t.:

$$M_i = Q_i + M_{h,i} \tag{127}$$

$$c_i = \begin{cases} M_{h,i} + Q_i d + w_i L_i & \text{with prob. } (1-\theta); \\ M_{h,i} + Q_i d & \text{with prob. } (1-\theta)\theta; \\ M_{h,i} & \text{with prob. } \theta^2. \end{cases} \tag{128}$$

$$M_{h,i} \geq c_{0,i} \tag{129}$$

[20] In this model, it is implicitly assumed that consumption is always less than output, and that there are some units of output which are ex-post "wasted". A natural question is therefore why the global financial system allocates liquidity between foreign and domestic projects in an output maximizing way. If we think of the global financial system as a monopoly, this indeed need not be the case; however, a more competitive structure (for example, one in which the financial system is composed of many small banks competing for liquidity) would deliver this result, as the expected real value of a unit of produced output is positive.

Substituting in the first constraint, this problem can be rewritten as:

$$\max_{Q_i} E(Q_i d) + (1-\theta)w_i L_i + (M_i - Q_i) - v_i(L_i) \tag{130}$$

s.t.

$$M_i - Q_i \geq c_{0,i} \tag{131}$$

The derivative of the above with respect to Q_i is:

$$E(d) - 1 \tag{132}$$

To calculate $E(d)$, note that positive dividends are paid unless both economies suffer a collapse. If neither suffers a collapse (an event which occurs with probability $(1-\theta)^2$), dividends per share are $d = \frac{M_d + M_{em}}{Q_d^0 + Q_{em}^0}$. If economy i suffers a collapse but economy j doesn't suffer a collapse (events which occur with probability $(1-\theta)\theta$ each), the dividend per share is positive, as consumers in region i receive some dividends from their stock holdings in region j. Expected dividends per share are therefore bounded from below by:

$$E(d) > (1-\theta)^2 \frac{M_d + M_{em}}{Q_d^0 + Q_{em}^0} \tag{133}$$

Assumption 5 *The value of θ is sufficiently small so that for any realization of M_i and $c_{0,i}$, the following inequality holds:*

$$(1-\theta)^2 \frac{M_d + M_{em}}{(M_d - c_{0,d}) + (M_{em} - c_{0,em})} - 1 > 0 \tag{134}$$

Result 2 *Under Assumption 5, the optimal portfolio decision is $M_{h,i} = c_{0,i}$, $Q_i = M_i - c_{0,i}$.*

Proof: Under Assumption 5, the derivative of equation 130 with respect to Q_i is positive at $Q_i^0 = M_i - c_{0,i}$:

$$E(d) - 1 > (1-\theta)^2 \frac{M_d + M_{em}}{Q_d^0 + Q_{em}^0} - 1 = (1-\theta)^2 \frac{M_d + M_{em}}{(M_d - c_{0,d}) + (M_{em} - c_{0,em})} - 1 > 0 \tag{135}$$

Thus, the constraint in equation 131 is binding, so $M_i - Q_i = c_{0,i}$.

Corollary 3 *Both under autarky and under financial integration, the liquidity supply of country i is given by $Q_i = M_i - c_{0,i}$.*

Assumption 6 *The money supply, M_i, and the risk aversion parameter, $c_{0,i}$, are perfectly correlated across regions and follow time invariant distributions.*

Since equilibrium liquidity supply is $Q_i = M_i - c_{0,i}$ both in the integrated economy and under autarky, it follows trivially that the assumptions I make on the distribution of liquidity supply are satisfied.