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Credit Constraints and the North-South Transmission of Crises

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Abstract

Adverse shocks to rich countries often have a large and persistent negative impact on investment and output in developing countries. This paper examines a transmission mechanism that can account for this stylized fact. The mechanism is based on the existence of international financial frictions. Specifically, if a small, developing country has to collateralize its assets to borrow funds to invest, falling asset prices caused by a negative shock in an advanced economy worsen the developing country's collateral value and reduce its ability to borrow and reinvest. Hence, investment in the developing country declines, and international investors repatriate capital to the advanced country. As less capital now can be pledged as collateral, the developing country's credit constraint is further tightened, which leads to another round of decline in investment. This generates a downward spiral that may cause large output losses to the developing country. The mechanism finds empirical support in the 2008–2009 crisis data.

This paper—a product of the Macroeconomics and Growth Team, Development Research Group—is part of a larger effort in the department to understand crisis transmissions. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at hanguyen@worldbank.org.

Credit Constraints and the North-South Transmission of Crises

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1 Introduction

The 2008-2009 financial crisis without doubt is the most severe crisis since the Great Depression. Initially thought to be limited within the U.S.'s subprime housing market, the crisis quickly spread across sectors and countries after the collapse of Lehman Brothers in September 2008. Many developing countries also saw large declines in investment and output, in many countries much larger declines than the U.S.'s (see Figure 1). These developments call for explanations about how a crisis can spread from advanced countries to developing ones.

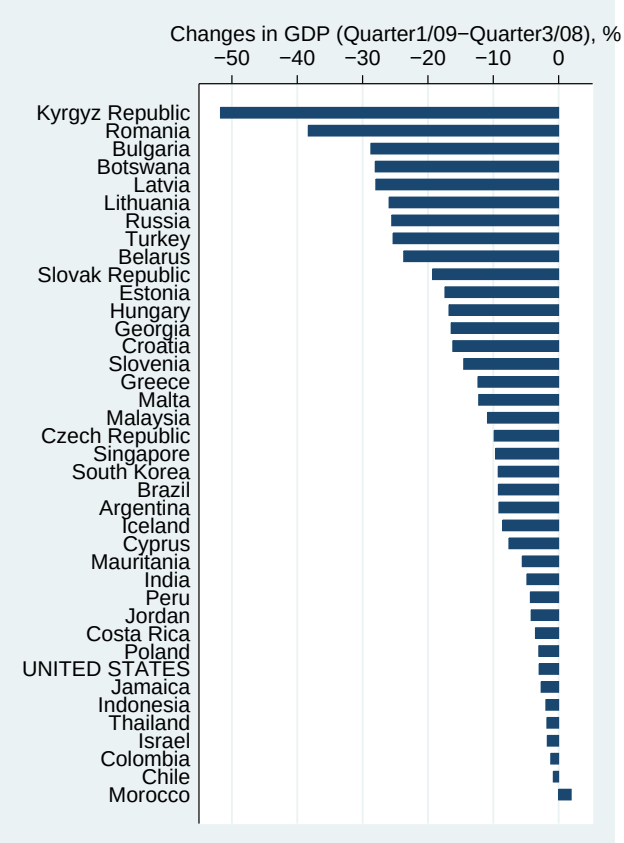

Figure 1: GDP growth rates- Source: International Financial Statistics

The question of interest is why a negative shock in an advanced economy can have large (sometimes larger) and persistent impacts in terms of investment and output on a developing country. In this paper I study the following mechanism: a negative productivity shock in a large, advanced economy drives down international asset prices. If a small, developing country has to collateralize its assets to borrow funds to invest, falling asset prices worsen its ability to borrow and hence to reinvest. Investment in the developing country declines, and capital repatriates to the advanced country. As less capital now can be pledged as collateral,

the developing country's asset value further drops, which further tightens its credit constraint and leads to another round of decline in investment. This constitutes a downward spiral that causes large damage to output of the developing country. Its recovery is also sluggish, since the credit constraint prevents the country from quickly borrowing and accumulating capital.

The mechanism finds empirical support in the 2008-2009 crisis data. There are statistically significant and positive relationships between pre-crisis external debt and capital outflows; and between pre-crisis external debt and the declines in GDP. The relationship between the declines in stock prices and capital outflows is less clear: although there is a positive correlation between the two variables, it is not significant.

To the extent that relaxing credit constraints helps developing countries raise capital and boost investment, the analysis in this paper implies that some amount of assistance from advanced economies or international financial institutions in bad times can help developing countries cope with negative external shocks.

The mechanism described in the paper complements a common view about the transmission of crises, in which banks in advanced countries simply pull out of emerging markets in response to crises in their home countries. While this mechanism no doubt is in play, it does not explain why foreign banks withdraw from one set of emerging countries and not others. I argue that countries that have high levels of external debt and face credit constraints are more likely to see larger capital outflows, and larger declines in investment and GDP.

I use a modified version of Kiyotaki and Moore (1997) (henceforth KM) to study the mechanism. The model features a small, developing country that borrows funds and faces a collateral-based credit constraint, and a large, advanced country that lends to the developing country. The model shows that when the developing country is credit constrained, a negative productivity shock in the advanced country can cause large adverse impacts on the developing country. This is particularly true when the developing country borrows lots of debt abroad to invest domestically, or put differently, the country is highly leveraged. In those instances, adverse external shocks can be particularly damaging to developing countries (even more than domestic shocks).

My analysis assumes a perfectly integrated asset market: international asset prices move in lock steps. As in KM, I simply assume the two countries use the same type of capital and there is a competitive spot market where agents in both countries can buy and sell capital at the market price. While the assumption is not the most realistic, it is for the paper to focus on the link between the fall of asset prices and the declines of economic activities in developing countries, via credit constraints. Empirical evidence, as shown in

Didier, Love, and Martinez-Peria (2010), indicates clear comovements between the U.S.'s and international stock prices in the 2008-2009 crisis (see Figure 10 in the Appendix for changes in stock indices during the crisis).

This paper contributes to a large literature on crisis transmission across countries, of which Kaminsky, Reinhart, and Vegh (2003) is a good starting survey. A large number of papers focus on trade linkages as a key mechanism for crisis transmission. Recent literature has begun to argue that financial linkages play a more important role, especially for countries that are more financially integrated[1]. Among recent papers, Paasche (2001) uses a version of the KM model to investigate a transmission mechanism between two developing countries, via adverse terms of trade shocks which are amplified by credit constraints. Pavlova and Rigobon (2008) also look at crisis transmission between two "periphery" developing countries via the portfolio constraints in the "center" country. More recently, Devereux and Yetman (2009) and Dedola and Lombardo (2009) focus on crisis transmission among major economies. Korinek, Roitman, and Vegh (2010) examine how different financially constrained sectors transmit negative shocks via a common set of lenders.

However, there is an important difference between my paper and the literature. In KM, Paasche (2001), Pavlova and Rigobon (2008) and many other papers along the same theme, the focuses are put on the direct shocks to credit demanders/producers. Instead, I focus on the shocks to credit suppliers. Furthermore, I show that the impact of these credit supplier shocks on credit demanders/producers can be much more severe.

Devereux and Yetman (2009) and Dedola and Lombardo (2009) are probably the closest to my paper. Theirs focus on a credit-constraint based crisis transmission mechanism among major economies. With the presence of credit constraints in the form of KM, Devereux and Yetman (2009) show that through inter-connected portfolios, financial deleveraging in one large country can spread to other major countries, causing a sell-off in assets and a forced reduction in borrowing among foreign investors. This, in turn, drives a further sell-off in the first country, creating a feedback loop. Dedola and Lombardo (2009) also look at a similar transmission mechanism, but use a Bernanke, Gertler, and Gilchrist (1999) version of financial frictions, rather than KM. Clearly, Devereux and Yetman (2009) and Dedola and Lombardo (2009) have the U.S. and other major economies in mind when they study the mechanism.

Although in the same spirit as those two papers, mine uses a simpler version of the

[1]Among other papers, see Kaminsky and Reinhart (2000), Calvo and Mendoza (2000), Paasche (2001), Chari and Kehoe (2004), Pavlova and Rigobon (2008), Devereux and Yetman (2009), Dedola and Lombardo (2009)...

KM model to make a different point, that developing countries can be particularly vulnerable to shocks in advanced economies. Investors in the advanced economies need not be leveraged for the transmission to take place. Unlike Devereux and Yetman (2009) and Dedola and Lombardo (2009), who study symmetric models, my paper stresses on asymmetric impacts. The damage to the developing countries' output can be more disproportionate and more persistent, even after the advanced economies have recovered.

My analysis is also related to a large class of models that use credit frictions to explain financial crises and "sudden stops" in emerging markets[2]. The contribution of this paper is that it focuses on the North-South crisis transmission, a new phenomenon prominently featured in the current crisis. By adopting an asymmetric two-country setup, the paper can discuss explicitly a potentially important transmission mechanism and hence provide a clear framework for international coordination in crises.

This paper also relates to a small but growing literature on the 2008-2009 financial crisis, most of which has focused on the U.S. However a few papers have studied the global transmission of the crisis, and they seem to point to financial channels as the key transmitter, at least in the short run. Dooley and Hutchison (2009) find that emerging markets responded very strongly to the deteriorating situation in the U.S. financial system and real economy after September 2009. Didier, Love, and Martinez-Peria (2010) also find that the stock markets in many countries fell even more than the U.S.'s stock market, and the main channel that drives the comovement between the US return and other countries' stock returns is financial. Blanchard, Faruqee, and Das (2010) look at GDP growth of 33 countries before and after the collapse of Lehman Brother in September 2008, and show that a higher level of external debt pre-crisis is instrumental to the decline of a country's GDP growth. Similarly, Lane and Milesi-Ferretti (2010) find that among others, countries' external vulnerabilities-including a large external debt position- are helpful in understanding the intensity of the crisis. Looking at the medium run, Comin, Loayza, Pasha, and Serven (2009) explore a different channel of transmission in which crises disrupt the technology transfer process between advanced economies and developing ones, hurting developing countries in the medium run.

The paper is organized as follows. Some motivating facts are presented in section 2. Section 3 describes the model. The solution of the model and the dynamics are analyzed in Section 4. A bailout scenario is discussed in Section 5. Finally, section 6 concludes.

[2]See for example Calvo (1998), Caballero and Krishnamurthy (2001), Gopinath (2004), Cook and Devereux (2006), Gertler, Gilchrist, and Natalucci (2007), and Mendoza (2010)...

2 Motivating facts

In this section I look at some motivating empirical evidence for the connections between external debt before the 2008-2009 crisis, the declines in stock prices, capital outflows, and the declines of GDP during the crisis. The set of countries is emerging markets with quarterly data. External debt data are from the Joint External Debt Hub-JEDS. The proxy for capital outflows is the decline in countries' external debt position. Data for stock indices are from Thomson Reuters Datastream, and data for GDP are from the International Financial Statistics.

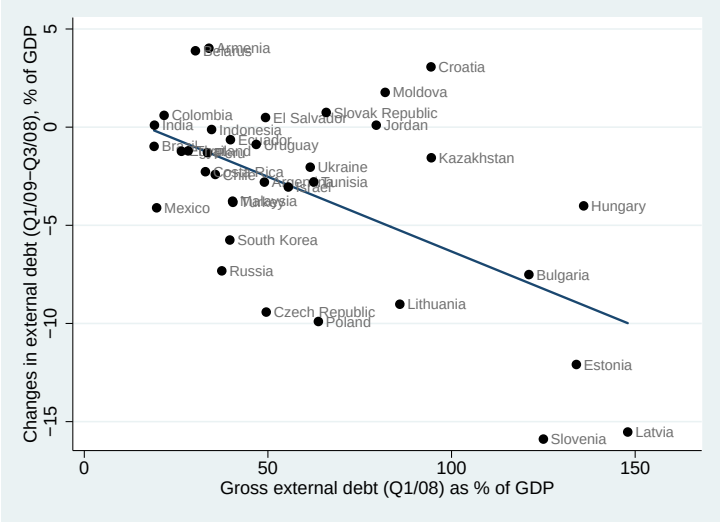

Figure 2: External debt pre-crisis and capital outflows

Crisis data indicate significant negative impacts of external debt pre-crisis on capital outflows and output during the crisis. However, the relationship between capital outflows and declines in stock prices is less significant. Figure 2 shows a positive relationship between external debt in quarter I, 2008 and the decline in external debt position between quarter III of 2008- the time Lehman Brothers collapsed- and quarter I of 2009, for a set of 36 emerging countries. External debt and changes in external debt are measured as percentages of 2007 GDP. Negative numbers indicate shrinkages of external debt (i.e. capital repatriation). It is statistically significant that countries with higher levels of external debt pre-crisis (i.e. high ϕ) see larger declines in external debt level (the t-statistic is -4.03).

When it comes to changes in stock indices, Figure 3 indicates a positive relationship between financial outflows and the declines in stock indices for 30 emerging countries. However, it is not statistically significant (the t-statistic is 1.44).

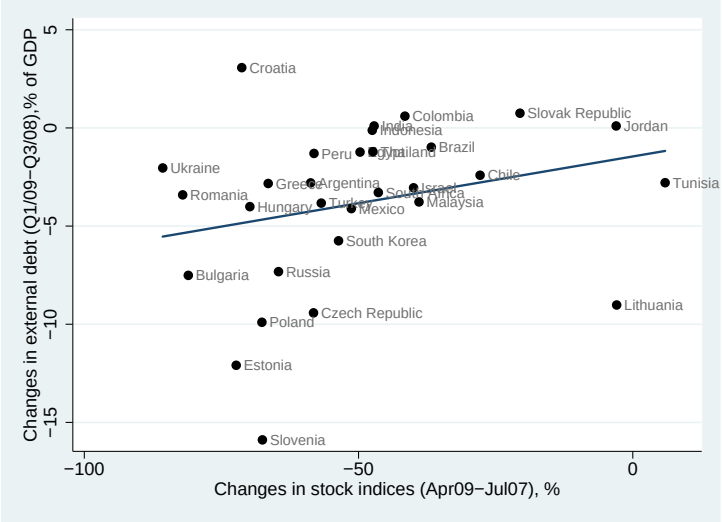

Figure 3: Change in stock indices and capital outflows

Finally I look at changes in GDP and the levels of external debt pre-crisis. Figure 4 presents a scatter plot of GDP growth and external debt for 27 emerging countries. The values on the Y-axis represent percentage changes in GDP between quarter III, 2008 and quarter I, 2009. It is statistically significant (t-stat is -2.75) that countries with higher levels of external debt pre-crisis witness larger declines in GDP[3].

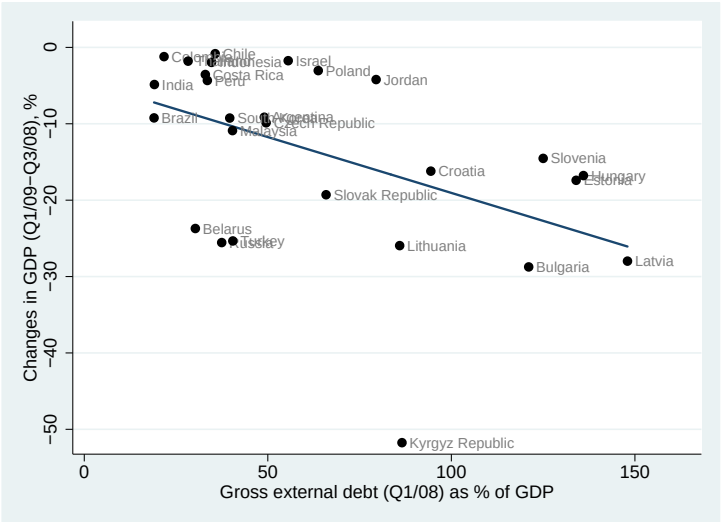

Figure 4: External debt pre-crisis and GDP growth

[3]If Kyrgyz Republic is removed from the sample, the relationship is more significant: the t-stat rises to -3.07.

Similar empirical evidence regarding the adverse impact of large external debt position on output is also found elsewhere in the literature (for example Blanchard, Faruqee, and Das (2010) and Lane and Milesi-Ferretti (2010) discussed above).

3 The model

3.1 Model setup

Consider a two-country world that consists of a large, advanced economy (called country A) and a small, developing country (called country D). Country D faces a collateral-based credit constraint, and country A does not. The two countries have the same decreasing returns to scale production technology, but the advanced country has accumulated more capital (per capita). This implies that the marginal product of capital in country A is lower than that of country D. If the credit constraint were not present, country D would borrow from country A and accumulate more capital until the two countries have the same level of capital. As in KM, the collateralized credit constraint captures imperfect financial markets: lenders can not force borrowers to repay their debt unless the debt is secured.

There are two kinds of goods: a durable asset (capital) and a non-durable good. It is assumed, as in KM, that the total stock of capital is fixed[4]. Capital does not depreciate and there is a competitive spot market where agents in both countries can buy and sell capital at the market price.

Consider country D. The country maximizes its life-time discounted utility:

$$\max E_0 \sum_{t=0}^{\infty} \beta^{*t} \frac{c_t^{*1-\sigma}}{1-\sigma}$$

subject to the budget constraint:

$$c_t^* + R_t b_t^* + q_t k_{t+1}^* = z_t^* k_t^{*\alpha} + b_{t+1}^* + q_t k_t^* \tag{1}$$

where z_t^* follows an AR(1) process:

$$z_t^* = \rho z_{t-1}^* + \varepsilon_t^*$$

and b_{t+1}^* is the borrowing of a representative household/firm of country D, R_t is the interest

[4]This assumption is for simplicity; relaxing this assumption would not change the intuition of the model.

rate, q_t is the market price for capital (in units of consumption). The country uses its output, its borrowing and the value of its asset/capital to finance consumption, debt repayments and the purchase of capital for production next period. Capital has two functions: it is used as an input in the production process and also as collateral. Country D can only borrow up to a fraction of their asset value:

$$b^*_{t+1} \leq \phi q_t k^*_{t+1}$$

In a standard macroeconomic model without credit constraints, the developing country borrows more for investment, increases production and grows through the accumulation of capital. The marginal productivity of the two countries are equalized in the equilibrium. When the credit constraint is present however, the developing country's borrowing capacity is limited: it has a lower level of capital stock than the advanced country. As a result, it has a higher marginal productivity and it is optimal for them to invest as much in capital as the borrowing constraint allows.

Consider the advanced economy (country A). The country has an identical production function as country D, but has accumulated more capital and hence their marginal productivity of capital is lower.

The country maximizes its life-time discounted utility:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma}}{1-\sigma}$$

subject to:

$$c_t + b_{t+1} + q_t k_{t+1} = z_t k_t^{\alpha} + R_t b_t + q_t k_t \tag{2}$$

where z_t also follows an AR(1) process

$$z_t = \rho z_{t-1} + \varepsilon_t$$

and b_{t+1} is the lending from a representative household/firm of country A. Here I assume $\beta > \beta^*$. This assumption ensures that country D is more impatient and borrows from country A.

I also assume the two countries are different in their sizes. I normalized the size of country D to one, and denote N as the size of country A. The market clearing conditions for the

debt market, the capital market, and the good market respectively:

$$
\begin{aligned}
Nb_{t+1} &= b^*_{t+1} && (3)\\
Nk_{t+1} + k^*_{t+1} &= \overline{K} && (4)\\
Nc_t + c^*_t &= Nz_t k_t^{\alpha} + z^*_t k_t^{*\alpha} && (5)
\end{aligned}
$$

3.2 The equilibrium

The first order conditions for the developing country are:

$$
\begin{aligned}
c_t^{*-\sigma} &= \beta^* E_t c_{t+1}^{*-\sigma} R_{t+1} + \lambda_t && (6)\\
q_t c_t^{*-\sigma} &= \beta^* E_t c_{t+1}^{*-\sigma} (\alpha z^*_{t+1} k_{t+1}^{*\alpha-1} + q_{t+1}) + \lambda_t \phi q_t && (7)
\end{aligned}
$$

λ_t is the shadow value of relaxing the credit constraint. A positive λ_t implies that the constraint binds: the developing country would like to borrow more for production and consumption but cannot.

The first order conditions for the advanced country are:

$$
\begin{aligned}
c_t^{-\sigma} &= \beta E_t c_{t+1}^{-\sigma} R_{t+1} && (8)\\
q_t c_t^{-\sigma} &= \beta E_t c_{t+1}^{-\sigma} (\alpha z_{t+1} k_{t+1}^{\alpha-1} + q_{t+1}) && (9)
\end{aligned}
$$

Equation (9) states that the marginal utility loss of investing one additional unit of capital equals the expected marginal utility gain from investing that unit. The gain consists of the marginal product from that unit, and the potential increase in asset/capital prices. (9) indicates that at the margin, capital is priced by the advanced country.

Substituting (8) to (9):

$$
E_t c_{t+1}^{-\sigma} \left(q_t - \frac{1}{R_{t+1}} q_{t+1} - \frac{1}{R_{t+1}} \alpha z_{t+1} k_{t+1}^{\alpha-1} \right) = 0 \qquad (10)
$$

Denoting $u_t \equiv q_t - \frac{1}{R_{t+1}} q_{t+1}$, following KM, u_t is defined as the user cost of capital. In the case of $\sigma = 0$ (risk neutral agents) and no uncertainty, we would obtain the same result as in KM: the marginal productivity of the advanced country equals the user cost of capital.

The equilibrium is defined as a sequence of capital holdings, debt outstanding, prices of capital, consumption and interest rate $\{k_t, k^*_t, b_t, b^*_t, q_t, c_t, c^*_t, R_t\}$ that satisfies the first order conditions and the market clearing conditions.

3.3 The transmission mechanism

Before proceeding to solve the model, it is useful to examine the transmission mechanism in which a shock can spread across countries (section 4.2 explains this in more detail).

Consider a negative shock to country A. After the shock, asset price falls. A falling asset price worsens country D's ability to borrow and reinvest. Its borrowing and capital stock decline as a consequence. This leads to a further decline in the value of its total assets, further tightening the borrowing constraint and reducing its capital stock. This constitutes a downward spiral that could cause severe damage to the developing country's output. The mechanism is summarized in the diagram below:

$$z_t \Downarrow \Longrightarrow q_t \Downarrow \Longrightarrow \phi q_t k^*_{t+1} \Downarrow \Longrightarrow b^*_{t+1} \Downarrow \Longrightarrow \phi q_t k^*_{t+1} \Downarrow ...$$

Why does the asset price fall? It falls via the following channels: the first one is the expected decrease in future productivity in country A due to the persistence of the shock. The second channel which is more important, is the change in the marginal rate of substitution. Note that after the shock, consumption falls. Since agents are risk averse, falling consumption reduces their marginal rate of substitution: the marginal utility of current consumption increases, that is, agents value current consumption more. This pushes the interest rate up, and the asset price goes down as a consequence:

$$z_t \Downarrow \Longrightarrow c_t \Downarrow \Longrightarrow MRS \Downarrow \Longrightarrow R_t \Uparrow, q_t \Downarrow$$

Note that in this model, capital repatriation is not the main factor that drives the asset price down. This is an important difference to KM. In the KM model, the asset price declines because capital moves from more efficient producers (i.e. farmers) to less efficient producers (i.e. gatherers). This is not the case here: although capital does move from the developing country to the advanced country, where it has a lower return, it does not significantly change the advanced country's capital stock, and hence has only a marginal impact on the asset price. The decline in consumption, combined with risk aversion is the main factor that generates the decline of the asset price[5]. The role of risk aversion is crucial here, because if agents are risk neutral, as in KM, a decrease in consumption has no impact on marginal utility.

[5]Jeanne and Korinek (2010) describe a similar mechanism in which a reduction in asset prices operates through a decline in consumption.

4 Solution of the model

I solve for the first order approximation of the model. All the benchmark parameters are chosen as standards. Following Korinek (2010), I choose $\phi = 0.5$. Regarding the size of the two countries, I choose $N = 10$, i.e. the population of country A is 10 times larger than country D.

σ	Risk aversion	2
β	Discount factor country A	0.98
β^*	Discount factor country D	0.97
α	Share of capital in production	0.33
ϕ	Borrowing constraint coefficient	0.5
ρ_z	Persistence of AR(1) shocks	0.5
$\overline{K}$	Total Capital	10
N	Relative size of country A	10

Table 1: Benchmark parameter values

4.1 The deterministic steady state

In the steady state, the first order conditions of the two countries are as follows:

$$qc^{-\sigma} = \beta c^{-\sigma}(\alpha z k^{\alpha-1} + q) \tag{11}$$

$$c^{-\sigma} = \beta c^{-\sigma} R \tag{12}$$

$$qc^{*-\sigma} = \beta^* c^{*-\sigma}(\alpha z k^{*\alpha-1} + q) + \lambda\phi q \tag{13}$$

$$c^{*-\sigma} = \beta^* c^{*-\sigma} R + \lambda \tag{14}$$

From (11), we can derive the price of capital in the steady state:

$$q = \frac{\beta}{1-\beta}\alpha z k^{\alpha-1} \tag{15}$$

Equation (15) states that the price of capital equals the discounted stream of the marginal product of capital in the advanced country. The more capital the advanced country holds, the lower the price of capital.

From (12) and (14):

$$\lambda c^{*\sigma} = 1 - \frac{\beta^*}{\beta} \tag{16}$$

From (16) and $\beta^* < \beta$, we can see that $\lambda > 0$. This implies that the credit constraint

binds in the steady state equilibrium. The developing country borrows as much as it can from the advanced country and its marginal productivity is higher than that of the advanced country. In the neighborhood of the steady state, the credit constraint always binds, as in KM.

The values of the variables in the steady state are given in the table below:

K	K^*	Y	Y^*	C	C^*	B	B^*	Q	R	λ
0.93	0.66	0.97	0.87	0.99	0.76	0.56	5.65	17.09	1.02	0.0179

Table 2: Steady State Values

4.2 Dynamics

4.2.1 No credit constraints

This section considers a benchmark case with no credit constraint. This is for us to contrast the different responses in terms of capital movements and output with the case when the constraint is in place.

Without the credit constraint, the two countries have the same level of capital (per capita) in the long run and no borrowing takes place. Suppose there is a 1% negative productivity shock in the advanced country. Figure 5 below shows the impulse responses of relevant variables:

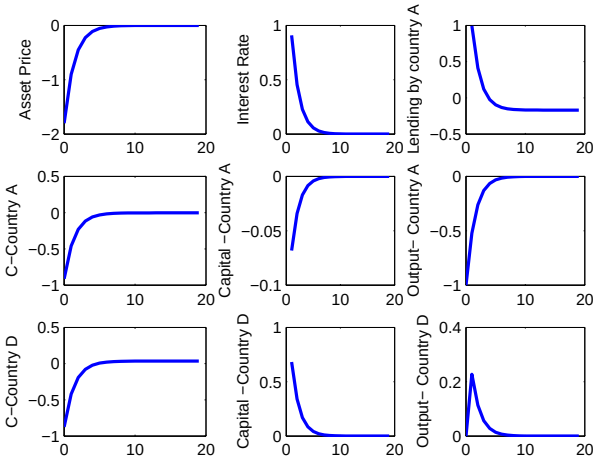

Figure 5: Impulse Responses to a -1% negative productivity shock to the Advanced economy- No credit constraints

After the shock, the asset price falls via the following channels: first is the expected decrease in future productivity due to the persistence of the shock. Second is the change in the marginal rate of substitution. As section 3.3 explains, the second channel is the main mechanism in which the asset price falls. Persistence of the shocks seems to play a smaller role, because the asset price also falls by about the same amount if the shocks are *iid*, as seen in Figure 11 in the Appendix.

Notice that decoupling occurs: capital flows from country A to country D. This is a standard result: country D borrows from country A to finance the purchase of capital, and gradually returns the debt. If the credit constraint is in place, capital movements will be different. A falling asset price will have negative implications on the borrowing capacity of country D: country D will not be able to borrow due to a decline in their collateral's value. We will witness capital outflows from country D, as the subsequent section will analyze.

4.2.2 With credit constraints

This section first considers the dynamics of the world economy after an unexpected negative productivity shock to the advanced economy (country A). It shows the impact of the shock on the developing country is more severe and persistent than that on the advanced economy.

I also examine the dynamics of the world economy after a negative productivity shock of the same size to the developing country (country D). I show that a negative shock to the developing country can actually cause less damage to the developing country than a negative external shock does.

Finally I consider the dynamics of the system when the developing country is more leveraged. I will show that a more leveraged developing country suffers more.

Let us start with a -1% technology shock on country A (Figure 6). The values on the Y-axis represent percentage deviations from the steady state values. After the negative shock, output in country A returns to the normal level. Output in country D does not change on impact, but declines afterward due to the decline in its capital stock. Why does its capital stock decline? Here the negative productivity shock in the advanced economy depresses the asset price. As should be clear by now, the falling asset price worsens the developing country's ability to borrow and reinvest. The falling asset price, the collapse of investment and a tightened budget constraint form a self-enforcing mechanism that causes severe damage to the developing country's output. The downward spiral happens in period 1 after the shock.

As in the case with no credit constraints, the asset price decreases mostly because of the

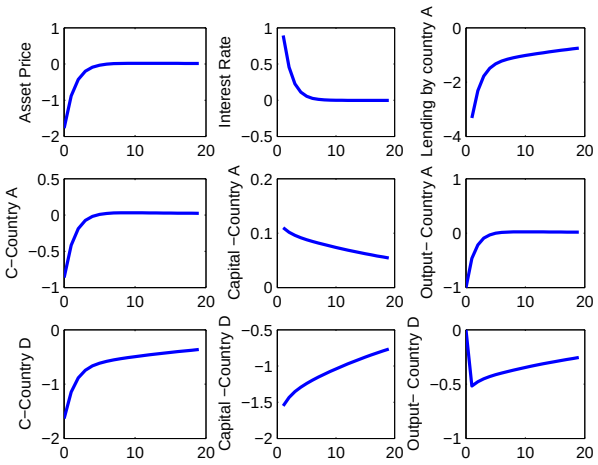

Figure 6: Impulse Responses to a -1% negative productivity shock to the Advanced economy

change in the marginal rate of substitution. The decrease in the asset price, in combination with the presence of credit constraints, generates a fundamentally different direction of capital flows to the benchmark case: in response to negative shocks in advanced countries, capital actually repatriates from developing countries to developed ones. This is an interesting result that is in line with what has happened in the current crisis. It is fair, however, to note that in the model, I assume the total stock of world capital is fixed, so if a country is credit constrained, capital has to go to the other country. Having said that, if one thinks of $\bar{K}$ as the total world saving, which does not change rapidly over a short period of time, the model describes an interesting phenomenon in the current crisis.

Going back to the impulse responses, output in the developing country gradually returns to the normal level because the country's capital slowly accumulates, which limits their ability to borrow. The sluggish return of country D's output to the normal level explains why in the long run, output of country D can be more volatile than that of country A, even in the case that the technology shocks only occur in country A. I show in the simulation that this is the case. With the benchmark parameters, even when the productivity shocks in country D are completely shut off, country D's output is more volatile than country A's in the long run.

A fall in country D's capital stock implies that country A accumulates more capital, which drives the marginal product and the asset price down. However due to a much larger size of country A, a reallocation of capital out of country D would have very little impact on

the capital stock of country A. This has implications when we consider a -1% productivity shock in country D.

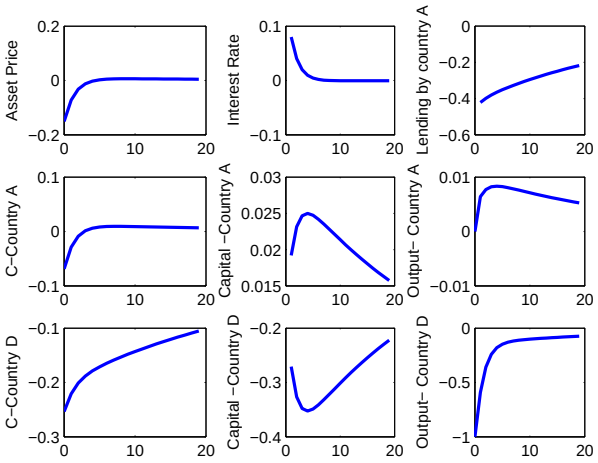

Figure 7: Impulse Responses to a -1% negative productivity shock to the Developing economy

Figure 7 shows the responses to a -1% technology shock on country D. The dynamic is similar to what we see above, and so is the intuition. A negative productivity shock lowers the asset price and tightens country D's credit constraint, generating capital outflows. But now since country A is much larger, the shock in country D has little impact on country A's capital stock, output and consumption. The international asset price drops much more moderately (compared to a shock of the same size in country A). Consequently, country D's borrowing capacity is less affected, and capital flows to country A are more modest. Country D's output hence recovers more quickly from the initial decline.

It is interesting to note that a negative productivity shock in country D causes less damage to country D's output than an external shock of the same size does. This illustrates the power of financial integration and financial frictions in transmitting and amplifying shocks across countries. In this case, a small but leveraged economy is vulnerable to dangerous "sudden stops"- sudden withdrawals of foreign capital when the value of the country's assets plummets.

Obviously, if the developing country relies more on outside funds (i.e. it is more leveraged), the impact of the external shock is more severe. Figure 8 shows the impulse responses in the case of $\phi = 0.7$. With a higher leverage level, the developing country witnesses larger declines in borrowing, investment and output in responses to negative shocks in the advanced

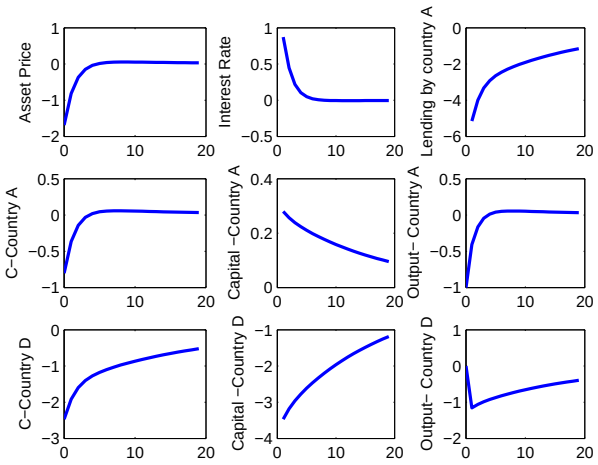

Figure 8: Impulse Responses to a -1% negative productivity shock to the Advanced economy, the Developing country is more leveraged

country. The larger decline in borrowing is not due to the interest rate however, as the interest rate rises to a similar level as before. Instead, it is due to a sharper deterioration of their borrowing capacity. As a result, the developing country's capital outflows, its investment and output declines are larger.

In the simulation I run 200 simulations each of 100 periods. I shut down the z^* shocks (productivity shocks of country D) and only leave the z shocks (productivity shocks of country A) with the standard deviation of 0.01 (1% deviation on average). Then I repeat the exercise with different values of the leverage ratio (ϕ). The long run standard deviations of output are reported in the table below. As can be seen from the table, at the benchmark value $\phi = 0.5$, country D's output is even more volatile than country A's. The relative volatility is larger when country D is more leveraged.

	Stdev of country A's output	Stdev of country D's output
$\phi = 0.1$	0.0054	0.0004
$\phi = 0.5$	0.0050	0.0079
$\phi = 0.9$	0.0049	0.0355

Table 3: Output Volatility with Different Leverage Ratios

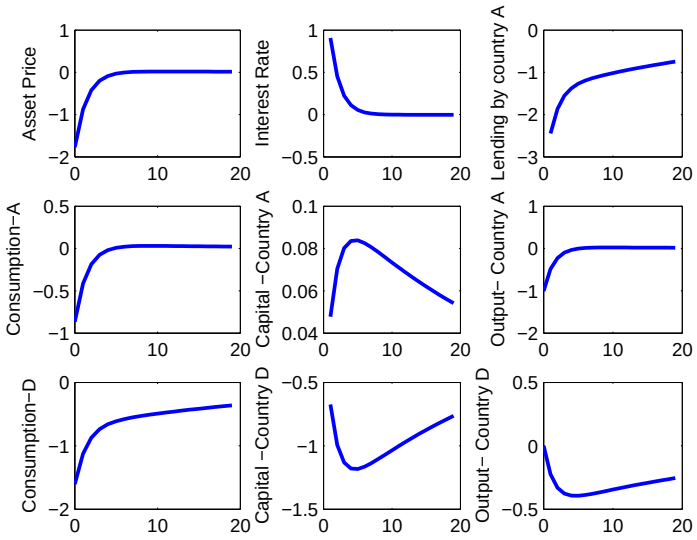

Figure 9: Impulse Responses to a -1% productivity shock to the Advanced economy, and a loan of 0.05% of the Advanced country's output

5 A bailout scenario

This section illustrates a situation in which a bailout loan from the advanced country can help the developing country relieve the credit constraint to some extent. The bailout is Pareto-improving: both countries are better off with the bailout.

Figure 9 shows the impulse responses to a -1% productivity shock to the advanced country. In the period after the shock, the government of the advance country decides to lend 0.5% of its output to the developing country at the prevailing market interest rate. The loan is to be repaid the following period, when another loan is made. For every subsequent period, the new loan is reduced by 50%. Note that the amount and the terms of the loan are arbitrary and by no means optimal. The point of this section therefore is just to illustrate that a bailout can be Pareto-improving.

The developing country benefits from the bailout loan. Due to the credit constraint, it can not even borrow as much as it would like at the market rate. As a result, this bailout loan provides the developing country credits that they can use to patch up their collateral and maintain some of their borrowing capacity. In the period after the shock, capital in the developing country falls much less than otherwise, thanks to the loan. Ultimately, the declines in investment and output in the country are more modest.

The advanced country at least is not worsen off because it makes a loan at the rate equal

to its marginal return on investment.

Note that the bailout hinges on the assumption that the advanced country's government has a better enforcement mechanism to ensure repayment than the private sector. This allows the advanced country's government to make loans to the developing country, when the private sector is no longer willing to lend even at a higher interest rate.

6 Conclusion

This paper presents a simple model to examine a transmission mechanism in which a productivity shock originating from an advanced economy can have potentially large and persistent impacts on a developing country's investment and output. The transmission works through the global integration of asset markets and the credit constraint of the developing country. The impact can be particularly devastating if the developing country is highly leveraged. The results find some empirical support with the 2008-2009 crisis data.

To the extent that relaxing credit constraints in bad times will help developing countries raise capital and boost investment significantly, some amount of assistance, in the form of grants or long term debt, from advanced economies or international financial institutions can help developing countries recover from a recession caused by a negative external shock.

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A Appendix

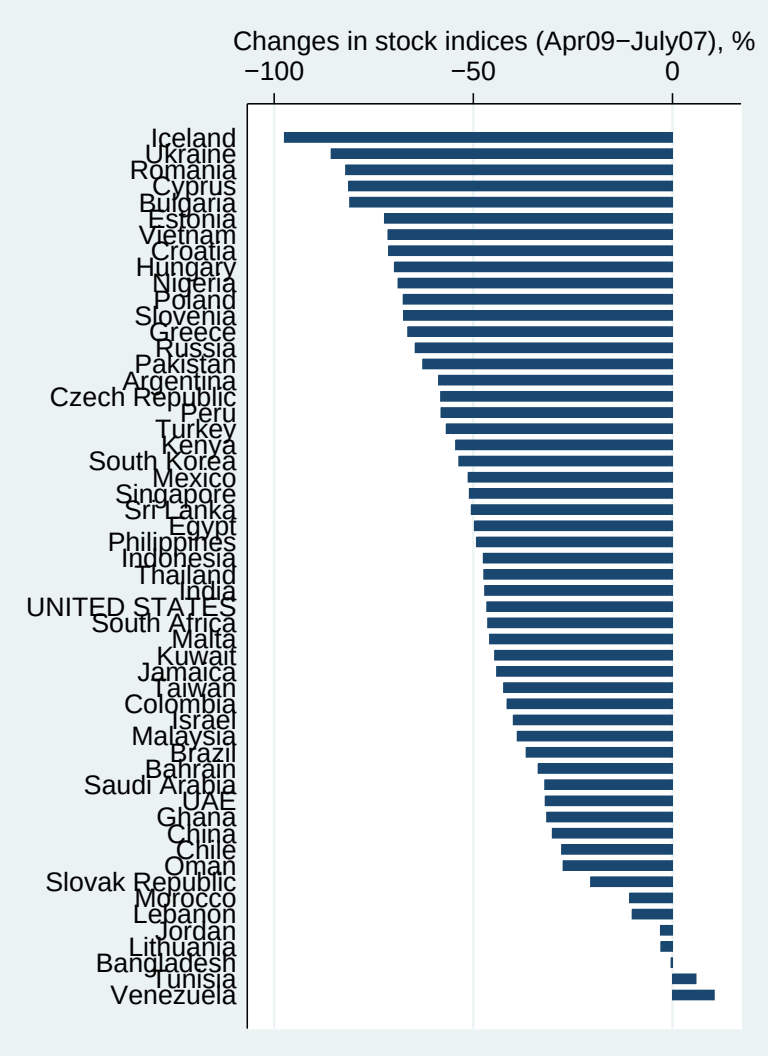

Figure 10: Changes in stock indices, April-09 vs July-07- Source: Thomson Reuters Datastream

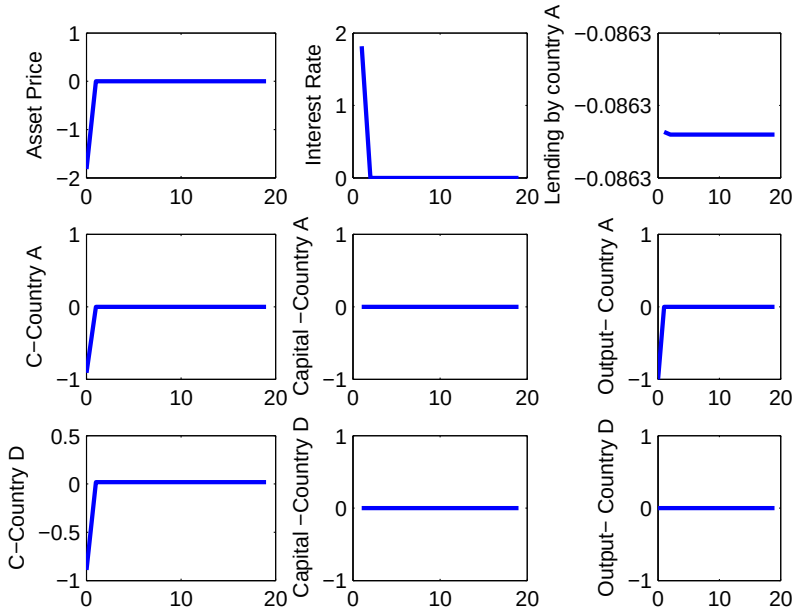

Figure 11: Impulse Responses to a -1% negative productivity shock to the Advanced economy- No credit constraint- iid shocks