Bond Finance, Bank Credit, and Aggregate Fluctuations in an Open Economy*

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1 Introduction

In recent years, the corporate sector in emerging market economies has increased its reliance on foreign financing considerably. This trend became more marked during the period of low global interest rates following the global financial crisis, and has generated a lively debate regarding its interpretation and policy implications. An optimistic view is that the increase in corporate liabilities is a natural response to favorable interest rates and relatively favorable investment prospects in emerging countries. A less sanguine view is that larger foreign liabilities are dangerous and place emerging economies in a precarious position.

Understanding this phenomenon has been complicated by the observation that it has largely reflected increased bond issuance by emerging economies’ firms, in contrast to the bank loans which dominated capital flows in the past. To illustrate, Figure 1 reproduces a chart from IADB (2014), describing the evolution of foreign corporate liabilities Brazil, Chile, Colombia, Mexico, and Peru, as well as an average (LAC-5). The figure shows a clear acceleration in the

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Figure 1: Private International Debt (US $ Billions)

Source: IADB (2014)
amount of both bonds and loans owed by Latin American firms. It also shows that the relative importance of bonds has increased since the start of the century and, more emphatically, since the global crisis. As pointed out by IADB (2014), for the typical country in the figure, the share of bonds increased from 22% in 2000 to 43% in 2013.

This paper attempts to shed light on the interpretation and implications of these events by developing a stochastic dynamic equilibrium model of an open economy in which the quantities of direct versus intermediated finance are determined endogenously. Our model embeds the static, partial equilibrium model of Holmstrom and Tirole (1997, henceforth HT) into an otherwise standard dynamic setting. As in HT, the production of capital goods requires finance from outsiders. Due to moral hazard problems, a fraction of this production can be financed directly from the outsides, while another portion can be financed only with the participation of monitors or "banks". In each period, therefore, the amount of bank loans and direct finance is endogenous and depends on variables such as the price of capital goods and the equity capital of investment producing firms and banks. The latter are determined in a dynamic general equilibrium, in contrast with HT. Hence our model allows for a study of the interaction between modes of finance and the macroeconomy.

We use the model to study the dynamic responses to exogenous shocks. In particular, we show how the model generates an increase in both direct and indirect finance following a drop in world interest rates. The analysis highlights the role of equity in the adjustment process. As corporate equity builds up, firms are able to access more and cheaper direct finance. Access to more costly indirect finance because some firms, that were previously absent from the market due to their low net worth, now have enough equity to participate in credit markets, and also because bank equity increases over time.
2 The Model

2.1 Final Goods Production

Time is discrete and indexed by $t = 0, 1, \ldots$. We focus on a small open economy. There a freely traded final good that will serve as numeraire. The small economy has a competitive sector of firms that can produce final goods with capital and labor via a Cobb Douglas function:

$$Y_t = A_t K_t^\alpha H_t^{1-\alpha}$$

with $Y_t$ denoting output of final goods, $K_t$ capital input, $H_t$ labor input, $A_t$ total factor productivity (assumed to be exogenous), and $0 < \alpha < 1$

Competitive factor markets yield the usual marginal conditions

$$\alpha Y_t = r^K_t K_t$$

$$ (1 - \alpha) Y_t = w_t H_t$$

where $r^K_t$ and $w_t$ denote the rental rate of capital and the wage rate.

2.2 Households

Households are the owners of productive factors, including capital. They can also borrow or lend in world markets at a gross interest rate $\Psi_t R^*_t$, where $R^*_t$ is the safe world interest rate between periods and $\Psi_t$ is a country specific spread.

The household budget constraint in period $t$ is, then,

$$C_t + Q_t X_t + B_{t+1} = w_t H_t + r^K_t K_t + \Psi_t R^*_t B_t$$

where $C_t$ denotes consumption of the final good, $X_t$ purchases of new capital, $Q_t$ the price of new capital, and $B_{t+1}$ the amount lent abroad.
Capital accumulation is subject to adjustment costs

\[ K_{t+1} = (1 - \delta)K_t + X_t - \frac{\varphi}{2} K_t \left( \frac{K_{t+1}}{K_t} - 1 \right)^2 \]  

(5)

where \( 0 < \delta < 1 \) and \( \varphi > 0 \).

The spread \( \Psi_t \) is exogenous to the household but, as discussed by Schmitt Grohe and Uribe (200x), it depends on \( \bar{B}_t \), the aggregate value of \( B_t \):

\[ \Psi_t = \Psi - \phi(e^{B-B} - 1) \]  

(6)

The representative household maximizes the expected present discounted utility of consumption and labor effort. We assume GHH preferences (Greenwood, Hercowitz, and Huffman 19xx) for which the marginal utility of consumption is

\[ \chi^c_t = \left( C_t - \kappa \frac{H^\tau}{\tau} \right)^{-\sigma} \]  

(7)

where \( \kappa, \tau, \) and \( \sigma \) are parameters.

Optimal labor supply is then given by:

\[ w_t = \kappa H_t^{\tau-1} \]  

(8)

The optimal foreign borrowing-lending policy is given by

\[ 1 = \beta^h E_t \frac{\chi^c_{t+1}}{\chi^c_t} \Psi_{t+1} R_{t+1}^* \]  

(9)

Finally, capital accumulation is given by the Euler equation
\[
Q_t \left[ 1 + \varphi \left( \frac{K_{t+1}}{K_t} - 1 \right) \right] = \beta^h E_t \frac{\lambda^c_{t+1}}{\lambda^c_t} [r^c_{t+1} + Q_{t+1} (1 - \delta) + \varphi \left( \frac{K_{t+2}}{K_{t+1}} - 1 \right) \frac{K_{t+2}}{K_{t+1}} - \frac{\varphi}{2} \left( \frac{K_{t+2}}{K_{t+1}} - 1 \right)^2 ]
\]

where \( \beta^h \) is the household’s discount factor.

For a given process for the price of capital \( Q_t \), the preceding Euler equation, together with the capital accumulation equation (5), express the demand for investment. The usual assumption is to assume that domestic output can be split between consumption goods and new capital goods at no cost, so that \( Q_t = 1 \) always. In that case, (1)-(10) is a system of ten equations that suffices to solve for the rest of the variables so far.

To depart from the usual approach, we assume that the production of new capital goods \( X_t \) is subject to financial frictions. This will imply that \( Q_t \) will be variable, and that investment will be an increasing function of \( Q_t \).

### 3 Finance and Production of New Capital Goods

New capital goods are produced by "holding companies", each of which manages a continuum of productive units ("branches" for short) indexed by \( i \in [0, 1] \). The representative consortium arrives to period \( t \) with some amount of "equity" \( K^f_t \), inherited from the previous period. At the beginning of the period, the consortium’s equity is split between its branches. A branch \( i \) is given equity \( A^i_t \), according to some distribution \( G_t (\cdot) \), so that \( K^f_t = \int_0^\infty A^i_t dG_t (A^i_t) \). Each branch \( i \) is charged with financing and executing a project, which takes \( I_t \) units of tradables as input, and returns a random amount of new capital goods at the end of the period, as we will describe. The size of the investment project, \( I_t \), is chosen by the manager of the holding to maximize end of period profits.

This setting might correspond to a situation in which there are nationwide corporations
(holdings) that own units (branches) in different locations. The holding chooses a project
design that has to be implemented by all branches. Each branches is given the same initial
amount of equity money, but idiosyncratic shocks to equity imply that they effectively start
projects with the distribution given by $G$.

### 3.1 Individual Projects

Consider the problem of a branch which starts period $t$ with equity $A^i_t$. Assuming that $I_t > A^i_t$, the branch manager will need to seek external finance in order to implement the investment project. In order to allow for both direct and intermediated finance, we borrow the assumptions of Holmstrom and Tirole (199x).

Specifically, investment projects are subject to moral hazard. The manager of a branch can
invest $I_t$ funds at the beginning of the period into a "good" project that yields $RI_t$ units of new
capital with probability $p_H$ and zero with probability $1 - p_H$. The manager can, alternatively,
invest $I_t$ in a "bad" project, which reduces the probability of the $RI_t$ outcome to $p_L < p_H$ but
gives the manager a private benefit of size $BI_t$.

Branch managers can seek funds from outside investors. Because contracts are settled within
a period, and the rest of the world is included in the set of outside investors, it is appropriate
to assume that outside investors are risk neutral and have a zero opportunity cost for funds.
However, assuming that the good project has positive expected value but the bad project does
not, outside investors will agree to lend only under a contract that provides enough incentives
to the branch manager not to undertake the bad project. Denoting by $R^d_{t,i}$ the payoff to the
branch manager in case of project success, the necessary incentive compatibility constraint can
be written as

$$p_H R^f_{t,i} \geq p_L R^f_{t,i} + BI_t$$

or

$$R^f_{t,i} \geq \frac{BI_t}{\Delta}$$
with $\Delta = p_H - p_L$

Also, for the branch manager to be able to finance the project entirely by borrowing from the outside lenders, the amount borrowed must be $I_t - A_t^i$. Then, the expected payoff to the lenders must be at least as large, that is,

$$p_H(Q_t R I_t - R_{i,t}^{f,i}) \geq I_t - A_t^i$$

Combining the last two inequalities, it follows that the branch manager will be able to finance its project directly from outside lenders only if it has enough equity: $A_t^i \geq \bar{A}_t$, where

$$\bar{A}_t = I_t \left[ 1 - p_H(R Q_t - \frac{B}{\Delta}) \right]$$

(11)

What if $A_t^i < \bar{A}_t$? As in HT, we assume the existence of financial intermediaries or "banks". Banks start each period with some equity of their own that can be used for funding projects. More importantly, they also own a monitoring technology that allows them to reduce the branch manager’s private benefit of the bad project from $B$ to $b < B$. However, using the monitoring technology entails a private cost $c I_t$ to a bank.

This implies that, for a branch $j$ to secure external funding with the participation of a bank, the bank’s payoff if the project is successful, denoted by $R_{m,j}$, has to provide enough incentives for the bank to monitor:

$$p_H R_{m,j} - c I_t \geq p_L R_{m,j}$$

or

$$R_{m,j} \geq \frac{c I_t}{\Delta} \equiv R_t^m$$

Also, for a branch $j$ to convince a bank to participate in the project, it must offer the bank a return on its funds at least as large as what the banker would obtain elsewhere. Denoting the latter by $\beta_t$, and the bank’s contribution to the project by $I_{t}^{m,j}$, the condition is that $p_H R_{t}^{m,j} \geq \beta_t I_{t}^{m,j}$. In equilibrium, banks will not be paid more than strictly necessary, so that
the condition must hold with equality, which combined with the previous relation gives

\[ I_t^{m,j} = \frac{p_H R_t^m}{\beta_t} \equiv I_t^m \]

In this case, outside investors participation necessitates the incentive compatibility constraint

\[ p_H R_t^{f,j} \geq p_L R_t^{f,j} + b I_t, \]

that is,

\[ R_t^{f,j} \geq \frac{b I_t}{\Delta} \]

where \( R_t^{f,j} \) denotes the payoff to the branch manager in case of project success. Finally, for outside investors to recover the opportunity cost of their funds, their expected payoff must be at least as large as the amount they lend to the project. This can be written as:

\[ p_H (Q_t R_I - R_t^{f,j} - R_t^{m,j}) \geq I_t - I_t^{m,j} - A_t^j \]

As in the case of direct finance, one can show now that a branch \( j \) will be able to finance its project via monitored finance if it has enough equity: \( A_t^j \geq \Delta_t \), where

\[ \Delta_t = I_t \left[ 1 - \frac{c p_H}{\beta_t \Delta} - p_H \left( RQ_t - \frac{b + c}{\Delta} \right) \right] \quad (12) \]

### 3.2 The Choice of Project Size

To proceed, it will be convenient to write the distribution of equity in each period as a function of a parameter \( \mu_t \) to be specified shortly, so that \( G_t(A) = G(A; \mu_t) \).

With that convention, the profits of the holding company in period \( t \) can be written as:

\[ \Pi_t^f = p_H Q_t R_I (1 - G(\Delta_t; \mu_t)) + \int_0^{\Delta_t} A_t^i dG(A_t^i; \mu_t) \]

\[ - \int_{\Delta_t}^{\infty} (I_t - A_t^i) dG(A_t^i; \mu_t) - \int_{\Delta_t}^{\tilde{\Delta}_t} \left( I_t - \frac{p_H c I_t}{\beta_t \Delta} - A_t^i \right) dG(A_t^i; \mu_t) \]

\[ -p_H \frac{c I_t}{\Delta} (G(\tilde{\Delta}_t; \mu_t) - G(\Delta_t; \mu_t)) \]
The first line expresses the holding’s end of period revenue, the sum of expected payoff from investment projects plus the (zero) return from funds from branches that will not be able to finance project. The second line summarizes payments for outside investors. The last line is the cost of bank finance.

The holding chooses investment size $I_t$ to maximize profits subject to 11 and 12, taking $Q_t$ and $\beta_t$ as given. The first order condition is

$$(p_H RQ_t - 1)(1 - G(A_t; \mu_t)) - \frac{p_H c}{\Delta} (1 - \frac{1}{\beta_t})[G(\bar{A}_t; \mu_t) - G(A_t; \mu_t)]$$

$$= \lambda_1^t \left[ 1 - p_H (RQ_t - B) \right] + \lambda_2^t \left[ 1 - \frac{c p_H}{\beta_t \Delta} - p_H \left( RQ_t - \frac{b + c}{\Delta} \right) \right]$$

where $\lambda_1^t$ and $\lambda_2^t$ are the Lagrange multipliers associated with 11 and 12:

$$\lambda_1^t = I_t g(\bar{A}_t; \mu_t) \frac{p_H c}{\Delta} \left( 1 - \frac{1}{\beta_t} \right)$$

$$\lambda_2^t = I_t g(\bar{A}_t; \mu_t) \left[ p_H RQ_t - 1 - \frac{c p_H}{\Delta} \left( 1 - \frac{1}{\beta_t} \right) \right]$$

and $g(A; \mu_t)$ is the density function of $G(A, \mu_t)$.

Given $Q_t$ and $\beta_t$, the five equations above determine $I_t$, $\lambda_1^t$, $\lambda_2^t$, $A_t$, and $\bar{A}_t$. To simplify, note that the RHS of the first order condition can be written simply as $\lambda_1^t (\bar{A}_t/I_t) + \lambda_2^t (A_t/I_t)$. In turn, $\lambda_1^t/I_t$ and $\lambda_2^t/I_t$ are given by the last two equations. This means that we can eliminate the Lagrange multipliers and write the optimality condition as:

$$(p_H RQ_t - 1)(1 - G(A_t; \mu_t)) + \left[ \frac{p_H c}{\Delta} \left( \frac{1}{\beta_t} - 1 \right) - 1 \right] (G(\bar{A}_t; \mu_t) - G(A_t; \mu_t))$$

$$= \bar{A}_t g(\bar{A}_t; \mu_t) \frac{p_H c}{\Delta} \left( 1 - \frac{1}{\beta_t} \right) + A_t g(A_t; \mu_t) \left[ p_H RQ_t - 1 - \frac{c p_H}{\Delta} \left( 1 - \frac{1}{\beta_t} \right) \right]$$

(13)

The preceding equation together with 11 and 12 now determine $I_t$, $A_t$, and $\bar{A}_t$. 9
4 Temporary Equilibrium

The return on the bankers’ equity, $\beta_t$, adjusts so that the bankers’ participation in investment projects adds up to bank equity, $K^m_t$. Recalling $I^m_t = p_H R^m_t/\beta_t$ and $R^m_t = c_0 t / \Delta$, this requires

$$K^m_t = \frac{p_H c I_t}{\beta_t \Delta} [G(\bar{A}_t; \mu_t) - G(A_t; \mu_t)] \tag{14}$$

In turn, the equilibrium price of new capital goods, $Q_t$, must adjust to equate the demand for new capital goods to their supply:

$$X_t = p_H R I_t \left[1 - G(\bar{A}_t; \mu_t)\right] \tag{15}$$

The characterization of a period’s equilibrium is completed with the specification of $\mu_t$ as a function of $K^f_t$. We will assume that

$$A^i_t = K^f_t z^i_t$$

where $z^i_t$ is iid across agents and time, with cdf $F(z)$, mean one, and some variance. In this case,

$$G_t(A) = \Pr \{ A^i_t \leq A \} = \Pr \{ K^f_t z^i_t \leq A \} = F\left(\frac{A}{K^f_t}\right) = G(A; \mu_t)$$

In particular, for $G_t(.)$ to be log normal with mean $\mu_t$ and standard deviation $\sigma^2_G$,

$$\mu_t = \log K^f_t - \frac{\sigma^2_G}{2} \tag{16}$$

5 Dynamics

To describe the dynamics, we need to describe the laws of motion of the equity variables $K^m_t$ and $K^f_t$. This is easiest if we assume that banks and holding company branches have death rates $1 - \theta^m$ and $1 - \theta^f$ respectively.
Hence the law of motion of $K_t^m$ is

$$K_{t+1}^m = \theta^m p_H \frac{cI_t}{\Delta} \left[ G(\bar{A}_t; \mu_t) - G(A_t; \mu_t) \right]$$

and the law of motion of $K_t^f$ is $K_{t+1}^f = \theta^f \Pi_t^f$, which can be simplified to:

$$K_{t+1}^f = \theta^f \Pi_t^f = \theta^f \left\{ (p_H RQ_t - 1) I_t \left[ 1 - G(A_t; \mu_t) \right] + K_t^f - p_H \frac{cI_t}{\Delta} \left( 1 - \frac{1}{\beta_t} \right) \left[ G(\bar{A}_t; \mu_t) - G(A_t; \mu_t) \right] \right\}$$

Now the eight equations (11)-(18) give $I_t, A_t, \bar{A}_t, \beta_t, Q_t, \mu_t$ and the motion of $K_t^m$ and $K_t^f$. Together with (1)-(10) and an assumption about the process for exogenous shocks, they complete the specification of the model.

6 Steady State and Calibration

Table 1 summarizes the benchmark calibration. As we have emphasized, the model is standard except for the block of equations characterizing the production of new capital goods and their financing. Consequently, for purposes of calibration, we can set many of the model parameters at conventional values.

The novel part of the calibration concerns the parameters of the investing supply side. We assume that $G_t(.) = G(.) ; \mu_t$ is log normal so that (16) holds. Then we assume that the steady state is such that the fraction of branches which do not receive credit in the steady state is forty percent. Of the remaining branches, we assume that one third can obtain direct finance; the rest obtain finance with the help of banks. These two steady state conditions plus the first order condition of the holding company’s manager are three restrictions on the values of $b, B, c, \sigma_G, \frac{1}{K_T}, QR$. These parameters need to satisfy some natural inequalities (e.g. they must be positive) but otherwise there is some room for choice. For each such choice, the remaining parameters are easy to determine. (Appendix xx, to be written).
Finally, exogenous shocks are assumed to be AR(1) processes.

Table 1: Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
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<tbody>
<tr>
<td>$\varphi$</td>
<td>Cost of capital adjustment</td>
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<tr>
<td>$\tilde{\Psi}$</td>
<td>Risk premium elasticity</td>
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<tr>
<td>$\beta$</td>
<td>Rate of return to Bank Equity</td>
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<tr>
<td>$p_H$</td>
<td>High prob. of project success</td>
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</tr>
<tr>
<td>$p_L$</td>
<td>Low prob. of success</td>
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<tr>
<td>$G(A; \mu)$</td>
<td>Fraction of Cat 1 firms</td>
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</tr>
<tr>
<td>$G(\bar{A}; \mu)$</td>
<td>Fraction of Cat 1-2 firms</td>
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<tr>
<td>$\alpha$</td>
<td>CD production parameter</td>
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<td>$\beta^h$</td>
<td>Household’s discount</td>
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<td>$\delta$</td>
<td>Depreciation Rate</td>
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<tr>
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<td>$C/Y$</td>
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<tr>
<td>$\sigma$</td>
<td>Coef of RRA</td>
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</table>
7 Dynamic Implications

7.1 A Drop in $R^*$

Figure 2 describes the impulse responses to a ten basis point drop in the world interest rate $R^*$. A direct implication is that the household has an incentive to increase borrowing and consumption in the short term. Hence consumption increases for about fifteen quarters. Also, households increase their demand for capital goods. This is met, in equilibrium, with both an increase in the production of new capital goods ($X$) and the price of capital $Q$.

The dynamic response of investment and the mix of direct vs. indirect finance is non-monotonic although, overall, it accords with intuition. Since the price of new capital increases, holding companies have an incentive to increase production. To do this, the size of the typical project relative to the holding’s capital, $i_t = I_t/K^f_t$, increases. The only way to accomplish this, however, is to increase the participation of the banks: notice that the rate of return on bank capital increases on impact. This is coupled with an increase in the number of branches that get bank finance (Category 2 branches), with a corresponding fall in the number of branches that obtain finance directly (Category 3 branches). In other words, the equity threshold separating firms that have access to direct finance from those that get intermediated finance, $\bar{a}_t = \bar{A}_t/K^f_t$, increases on impact.
Beyond the impact period, however, holding companies accumulate equity. The total number of branches that succeed in financing projects increases and, remarkably, there are more branches in both Categories 2 and 3. As holding companies accumulate equity, bank equity becomes less necessary for finance, and the rate of return $\beta_t$ falls.

Over time, all of these variables return to their steady state levels, as $R^*$ does. Notably, however, the price of new capital goods $Q$ adjust faster than $R^*$. This reflects that the supply of new capital goods shifts the the right for a while, as holding companies accumulate equity and manage to reduce the finance cost of investment.

### 7.2 A Productivity Shock

Figure 3 displays impulse responses to a one percent increase in $A_t$. Naturally, the increase in the marginal productivity of capital in future periods induces households to increase their demand for new capital goods. As in the case of a lower $R^*$, this is met with an increase in $Q$ and of production of new capital goods. The response of output is steeper, however, because it reflects both capital accumulation and higher productivity. Correspondingly, consumption increases.

The responses of the investment supply side and the finance mix are very similar to those
of the drop in $R^*$ and have a similar intuition. Both lower $R^*$ and higher $A$ affect the supply of new capital goods only through the equilibrium response of the price of capital, $Q_t$.

![Figure 3](image)

### 7.3 Shock to Investment Technology

Finally (for now), Figure 4 shows the impulse response to a one percent increase in $R$, the return to investment projects. Intuitively, this should lead to an increase in the cost of producing capital goods and, therefore, of their supply. In equilibrium, this is reflected in a drop in $Q$. Households accumulate productive capital which, over time, leads to higher output. Consumption increases, and its path reflects both higher household wealth and, effectively, increasing interest rates.

The dynamics of direct and indirect finance, the accumulation of equity by capital good producers, and the behavior of the return to bank equity, all follow the previous patterns.
Figure 4