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

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Abstract

Corporate sectors in emerging market economies have increased noticeably their reliance on foreign financing, presumably reflecting low global interest rates. This trend has largely reflected increased bond issuance by emerging economies' firms, in contrast to the bank loans that dominated capital flows in the past. To shed light on these developments, we develop a stochastic dynamic model of an open economy in which the levels of direct versus intermediated finance are determined *endogenously*. The model embeds the static, partial equilibrium model of Holmström and Tirole (1997, henceforth HT) into a dynamic general equilibrium setting. A calibrated version generates an increase in both direct and indirect finance following an exogenous drop in world interest rates, in line with the empirical observations mentioned above, and reflecting the role of equity in the adjustment process. We also argue that aggregate responses to exogenous shocks are smoother when the split between direct versus indirect finance is determined endogenously rather than exogenously.

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1 Introduction

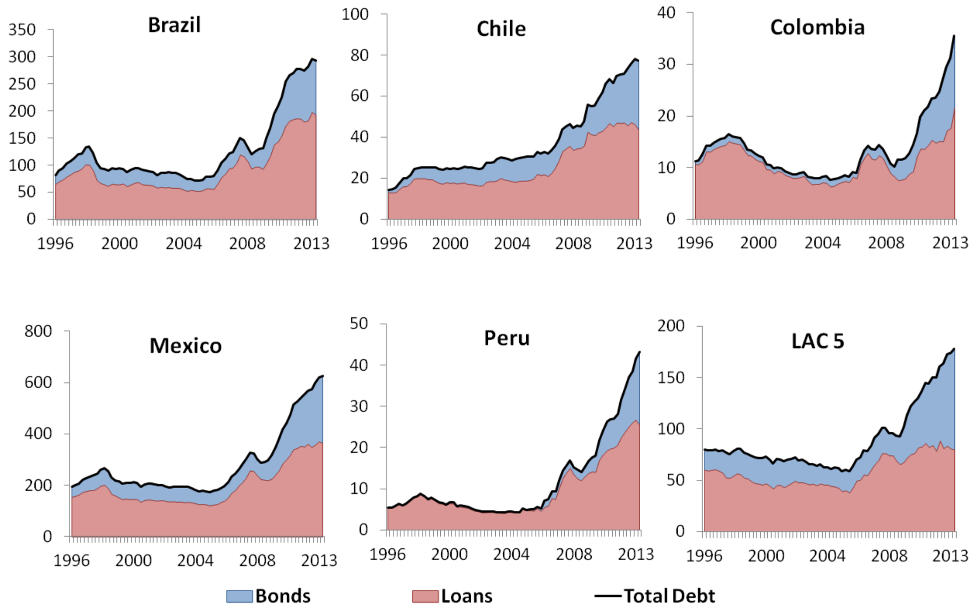
In recent years, the corporate sector in emerging market economies has increased its reliance on foreign financing considerably. This trend became more marked during the period of low global interest rates following the global financial crisis, and has generated a lively debate regarding its interpretation 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 in Brazil, Chile, Colombia, Mexico, and Peru, as well as an average (LAC-5). The figure shows a clear acceleration in the 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 in the stock of international corporate debt increased from 22% in 2000 to 43% in 2013. This process has taken place while, simultaneously, debt-to-output ratios have increased in emerging economies. In 2005 debt-to-GDP for LAC-5 was about 30%, while by the end of 2013 it had almost doubled, just below 60%.[1]

Figure 2 shows that the surge of external borrowing has been accompanied by the drop in interest rates faced by emerging economies. This drop was partly related to the low global interest rates since the onset of the crisis, here measured by the U.S. T-bill rates. However, since the early 2000s it was also accompanied by the low spreads that these countries are charged on top of the riskless rate. These favorable borrowing conditions have been enjoyed not only by

[1] The Online Appendix reproduces Figure 1 by scaling the amount of debt by GDP

Figure 1: Stock of foreign non-financial debt in LAC-5

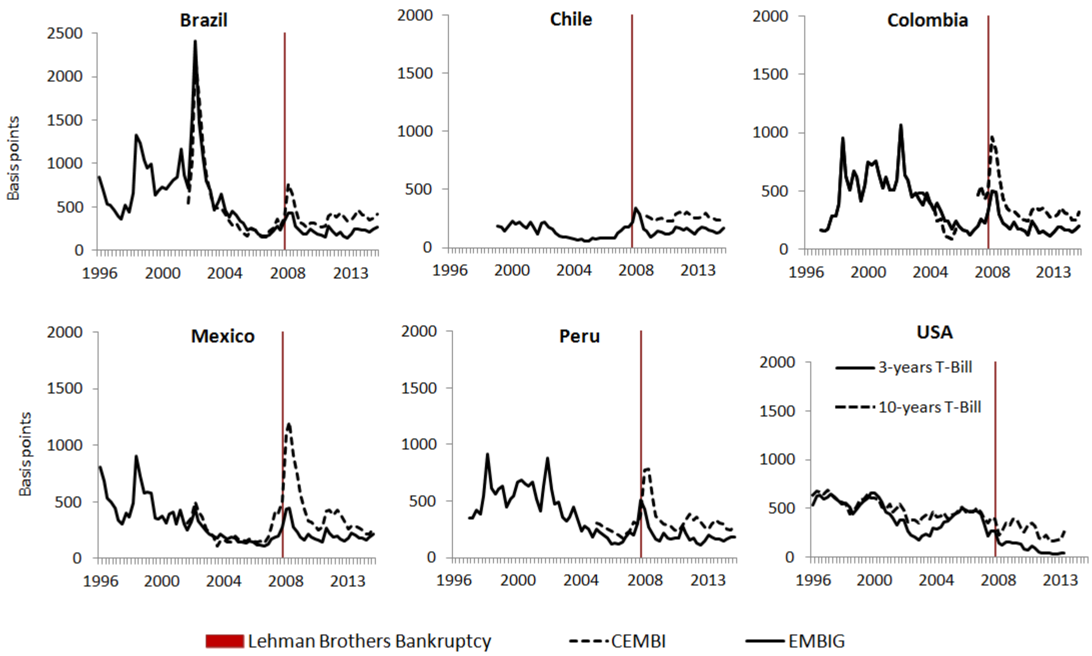


Notes: Units are bln USD. For LAC-5, the internal lending and borrowing between the 5 economies is netted out. Source: IADB (2014).

sovereign borrowers (EMBIG spread) but also by non-financial corporations (CEMBI spread). They continued despite the short-lasting jump following the panic of 2008.

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 Holmström and Tirole (1997, henceforth HT) into an otherwise standard dynamic setting. As in HT, the production of capital goods requires finance from outside investors. Due to moral hazard problems, a fraction of this production can be financed directly from the outsiders, while another portion can be financed only with the participation of monitors or "banks". In each period, therefore, the amounts of bank loans and direct finance are endogenous and depend 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 to HT. Hence our model allows for a study of the interaction between modes of finance and the macroeconomy.

Figure 2: Interest rate spreads in LAC-5 over the U.S. T-bills.



Source: Bloomberg.

We calibrate the model and analyze dynamic responses to exogenous shocks. We find, in particular, that the model generates an increase in both direct and indirect finance following an exogenous drop in world interest rates. This is in line with the empirical observations mentioned above, and reflects 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 also increases 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.

We also explore the role of the endogenous determination of direct versus indirect finance in aggregate fluctuations. To this end, we compare our model against two alternatives in which the mode of finance is fixed: an economy with only direct finance and another with only bank-intermediated finance. Our results indicate that the response of our baseline model to exogenous shocks is smoother than the corresponding response of the two alternatives. This is intuitive, reflecting that the mode of finance provides our baseline economy with an additional margin of adjustment to deal with exogenous shocks. This may be a significant observation in practice, suggesting that the recent increase in corporate liabilities is a natural response to favorable interest rates and relatively favorable investment prospects in emerging countries. This contrasts with the less sanguine view of Shin (2013) and others, which argues that larger foreign liabilities are dangerous and place emerging economies in a precarious position.[2]

Our work is related to several strands of literature. One is a set of empirical studies that have documented recent international trends in corporate debt issuance and analyzed the determinants of corporate debt choice. Shin (2013) and Turner (2014) report the considerable increase in foreign currency borrowing in international bond markets by emerging market corporations, part of which has been done by their offshore affiliates and most of it in dollars. IADB (2014) carefully document this phenomenon for Latin American economies while Caballero et.al. (2015) show evidence for emerging economies in Asia and Eastern Europe. Our model can be seen as a theoretical explanation of these empirical findings.

In developing our model, we build upon HT and other basic contributions that have provided microfoundations for the choice between bank and market finance under moral hazard.[3] Our work extends this line of research by endogenizing the choice between bank finance and market finance embedding HT's dual moral hazard problem within a dynamic, general equilibrium context of a small open economy.

Our approach emphasizes the role of corporate equity and bank equity as determinants of the demand for credit, like HT. We go beyond HT, however, in exploring dynamics as well as macroeconomic implications. Chen (2001), Aikman and Paustian (2006), and Meh and Moran (2010) have also embedded HT into dynamic equilibrium settings. A crucial difference with our paper, however, is that none of these forerunners modeled the endogenous determination of direct finance versus intermediated finance, which is the central concern of our paper.

[2]It should be mentioned that Shin (2013) and others conjecture that increased reliance on direct finance may exacerbate the role of currency mismatches. Whether switching from bank intermediated finance to bond finance will worsen currency mismatches, however, is not obvious (at least to us).

[3]Repullo and Suarez (2000) also endogenize the choice between bank finance and market finance within an environment where firms are heterogeneous in the amount of available net worth. See also Diamond, 1991; Rajan, 1992; Besanko and Kanatas, 1993; and Bolton and Scharfstein, 1996

Perhaps the closest antecedent of our study is the recent work by De Fiore and Uhlig (2011, 2015). These papers develop an asymmetric information model of bond and bank borrowing which can account for the behavior of standard macroeconomic variables as well as the long-run differences between the Euro Area and the US. They also provide a model-based assessment of the changes in corporate debt composition in the US during the Great Recession, relying on a combination of different shocks, including an increase in firm-level uncertainty and in the intermediation costs of banks. While our paper coincides with those by De Fiore-Uhlig in modeling the endogenous determination of direct finance versus bank finance in dynamic macro models, it differs in several respects. As mentioned, our setting is based on a dual moral hazard problem and gives prominence to the role of corporate equity and bank equity; in contrast, De Fiore and Uhlig's model focuses on the special ability of banks in resolving informational problems (i.e. through screening and monitoring), and assigns no special role to equity. In addition, De Fiore and Uhlig's model is a closed economy one, while we model an open economy in order to understand the international phenomena described above.

The plan of the paper is as follows. Section 2 starts the description of the model, laying out parts that are standard relative to the literature. Section 3 discusses the finance and production of new capital goods, which incorporates HT's problem into investment supply. Sections 4 and 5 complete the model description by specifying temporary equilibrium and dynamics. The steady state and our calibration strategy are explained in Section 6. Section 7 examines dynamic implications of the calibrated model. Final remarks are given in Section 8. Some technical issues are delayed to an Appendix.

2 The Model

This section describes the production of final goods and the household sector. Production requires capital, which is owned by domestic households. The behavior of households, therefore, implies a dynamic demand for new capital goods which depends on capital's relative price. This part of the model is standard, except that the price of capital will vary.

2.1 Final Goods Production

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

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

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

$$\alpha Y_t = r_t^K K_t \tag{2}$$

$$(1-\alpha) Y_t = w_t H_t \tag{3}$$

where r_t^K 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 $\Psi_{t+1} R_{t+1}^*$, where R_{t+1}^* is the safe world interest rate between periods and Ψ_{t+1} is a country specific spread.

The household's budget constraint in period t is, then,

$$C_t + Q_t X_t + \Psi_t R_t^* D_t = w_t H_t + r_t^K K_t + D_{t+1} + \left(1 - \phi^f\right) \Pi_t \tag{4}$$

where C_t denotes consumption of the final good, X_t purchases of new capital, Q_t the price of new capital, $\left(1 - \phi^f\right) \Pi_t$ dividends from firms transferred to the household, and D_{t+1} the amount borrowed abroad.

Capital accumulation is subject to adjustment costs

$$K_{t+1} = (1-\delta)K_t + X_t - \frac{\varphi}{2}K_t\left(\frac{K_{t+1}}{K_t} - 1\right)^2 \tag{5}$$

where $0 < \delta < 1$ is the depreciation rate and $\varphi > 0$ is a parameter giving the degree of adjustment costs.

The spread Ψ_t is exogenous to the household but, as discussed by Schmitt-Grohé and Uribe (2003), it depends on $\bar{D}_t$, the aggregate value of D_t:

$$\Psi_t = \bar{\Psi} + \tilde{\Psi}(e^{\bar{D}_t - \bar{D}} - 1) \tag{6}$$

The representative household maximizes the expected present discounted utility of consumption and labor effort. We assume GHH preferences (Greenwood, Hercowitz, and Huffman 1988) for which the marginal utility of consumption is

$$\lambda_t^c = \left(C_t - \kappa\frac{H^\tau}{\tau}\right)^{-\sigma} \tag{7}$$

where κ, τ, and σ are parameters.

Optimal labor supply is then given by:

$$w_t = \kappa H_t^{\tau-1} \tag{8}$$

The optimal foreign borrowing-lending policy is given by

$$1 = \beta^h E_t \frac{\lambda_{t+1}^c}{\lambda_t^c}\Psi_{t+1}R_{t+1}^* \tag{9}$$

where $\beta^h \in (0,1)$ is the household's discount factor and $E_t(.)$ is the conditional expectation operator.

Finally, capital accumulation is given by the dynamic equation:

$$
\begin{aligned}
& Q_t\left[1+\varphi\left(\frac{K_{t+1}}{K_t}-1\right)\right] \qquad (10)\\
= \;& \beta^h E_t \frac{\lambda_{t+1}^c}{\lambda_t^c}[r_{t+1}^K+Q_{t+1}(1-\delta)+\varphi\left(\frac{K_{t+2}}{K_{t+1}}-1\right)\frac{K_{t+2}}{K_{t+1}}-\frac{\varphi}{2}\left(\frac{K_{t+2}}{K_{t+1}}-1\right)^2]
\end{aligned}
$$

where β^h is the household's discount factor. This equation, as well as the previous ones, have standard interpretations.

For a given process for the price of capital Q_t, the preceding equation and the capital accumulation equation (5) determine the demand for investment. It is often assumed 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 determine 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 reflect the dynamic supply of investment as well as demand.

3 Finance and Production of New Capital Goods

New capital goods are produced by "holding companies" or "holdings", each of which manages a continuum of productive units ("branches" for short) indexed by $i \in [0,1]$. The representative holding arrives to period t with some amount of equity K_t^f , inherited from the previous period. At the beginning of the period, the holding's equity is split between its branches (this may reflect some idiosyncracies in startup costs, for example). A branch i is given equity A_t^i, according to some distribution $G_t()$, so that $K_t^f = \int_0^\infty A_t^i \mathrm{d}G_t(A_t^i)$. 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 branch is given the same initial amount of equity money, but idiosyncratic shocks to equity imply that branches effectively start projects with an equity distribution given by G.

3.1 Individual Projects

Consider the problem of a branch which starts period t with equity A_t^i. Assuming that $I_t > A_t^i$, 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 Holmström and Tirole (1997).

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 successful 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 $R_t^{f,i}$ the payoff to the branch manager in case of project success, the necessary incentive compatibility constraint can be written as

$$p_H R_t^{f,i} \geq p_L R_t^{f,i} + BI_t$$

or

$$R_t^{f,i} \geq \frac{BI_t}{\Delta}$$

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,

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

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

$$\bar{A}_t = I_t \left[1 - p_H(RQ_t - \frac{B}{\Delta})\right] \tag{11}$$

Given I_t, $\bar{A}_t$ depends naturally on investment parameters such as R, as noted by HT. In our setting, $\bar{A}_t$ also depends on the price of capital: it falls if Q_t increases. This will imply that the supply of capital will increase with Q_t , which is intuitive.

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 cI_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 $R_t^{m,j}$, has to provide enough incentives for the bank to monitor:

$$p_H R_t^{m,j} - cI_t \geq p_L R_t^{m,j}$$

or

$$R_t^{m,j} \geq \frac{cI_t}{\Delta} \equiv R_t^m$$

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 β_t, and the bank's contribution to the project by $I_t^{m,j}$, the condition is that $p_H R_t^{m,j} \geq \beta_t I_t^{m,j}$.

Note that, although the contract is within a period, β_t will be, in general, greater than one, in order to compensate banks for monitoring costs. 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, the participation of outside investors implies the incentive compatibility constraint $p_H R_t^{f,j} \geq p_L R_t^{f,j} + bI_t$, that is,

$$R_t^{f,j} \geq \frac{bI_t}{\Delta}$$

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:

$$p_H(Q_t R I_t - R_t^{f,j} - R_t^{m,j}) \geq I_t - I_t^{m,j} - A_t^i$$

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: $A_t^j \geq \underline{A}_t$, where

$$\underline{A}_t = I_t \left[1 - \frac{cp_H}{\beta_t \Delta} - p_H \left(RQ_t - \frac{b+c}{\Delta} \right) \right] \tag{12}$$

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 μ_t to be specified shortly, so that $G_t(A) = G(A;\mu_t)$.

With that convention, the profits of the holding company/consoritum in period t can be written as:

$$\begin{aligned}\Pi_t^f &= p_H Q_t R I_t(1-G(\underline{A}_t;\mu_t)) + \int_0^{\underline{A}_t} A_t^i \mathrm{d}G\left(A_t^i;\mu_t\right) \\ &\quad - \int_{\bar{A}_t}^{\infty}\left(I_t - A_t^i\right)\mathrm{d}G\left(A_t^i;\mu_t\right) - \int_{\underline{A}_t}^{\bar{A}_t}\left(I_t - \frac{p_H}{\beta_t}\frac{cI_t}{\Delta} - A_t^i\right)\mathrm{d}G\left(A_t^i;\mu_t\right) \\ &\quad - p_H\frac{cI_t}{\Delta}\left(G(\bar{A}_t;\mu_t) - G(\underline{A}_t;\mu_t)\right)\end{aligned}$$

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 β_t as given. The first order condition is

$$\begin{aligned}&(p_H R Q_t - 1)(1-G(\underline{A}_t;\mu_t)) - \frac{p_H c}{\Delta}(1-\frac{1}{\beta_t})[G(\bar{A}_t;\mu_t) - G(\underline{A}_t;\mu_t)] \\ =\ &\lambda_t^1\left[1 - p_H(RQ_t - \frac{B}{\Delta})\right] + \lambda_t^2\left[1 - \frac{cp_H}{\beta_t\Delta} - p_H\left(RQ_t - \frac{b+c}{\Delta}\right)\right]\end{aligned}$$

where λ_t^1 and λ_t^2 are the Lagrange multipliers associated with 11 and 12:

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

$$\lambda_t^2 = I_t g(\underline{A}_t;\mu_t)\left[p_H R Q_t - 1 - \frac{c p_H}{\Delta}(1-\frac{1}{\beta_t})\right]$$

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

Given Q_t and β_t, the five equations above determine $I_t, \lambda_t^1, \lambda_t^2, \underline{A}_t$, and $\bar{A}_t$. To simplify, note that the RHS of the first order condition can be written simply as $\lambda_t^1(\bar{A}_t/I_t)+$ $\lambda_t^2(\underline{A}_t/I_t)$. In turn, λ_t^1/I_t and λ_t^2/I_t are given by the last two equations. This means that we can eliminate the Lagrange multipliers and write the optimality condition as:

$$\begin{aligned} & (p_H R Q_t - 1)(1 - G(\underline{A}_t;\mu_t)) - \left[\frac{c p_H}{\Delta}(1-\frac{1}{\beta_t})\right]\big(G(\bar{A}_t;\mu_t) - G(\underline{A}_t;\mu_t)\big) \\ = \; & \bar{A}_t g(\bar{A}_t;\mu_t)\frac{p_H c}{\Delta}(1-\frac{1}{\beta_t}) + \underline{A}_t g(\underline{A}_t;\mu_t)\left[p_H R Q_t - 1 - \frac{c p_H}{\Delta}(1-\frac{1}{\beta_t})\right] \qquad (13) \end{aligned}$$

The preceding equation together with 11 and 12 now determine $I_t, \underline{A}_t$, and $\bar{A}_t$. The interpretation of this condition is interesting. The LHS can be seen as the expected increase in the surplus to the holding from a marginal increase in project size I_t. Each additional unit of initial investment has expected return $p_H R Q_t - 1$, and is undertaken by $1 - G(\underline{A}_t;\mu_t)$ firms. Part of that gain, however, is appropriated by the banks if the return on bank equity exceeds the market return (that is, if $\beta_t > 1$): this is the second term in the LHS. The RHS collects terms associated with the impact of an increase in I_t on the distribution of firms. A larger I_t implies an increase in $\underline{A}_t$ and, hence, a reduction of approximately $\underline{A}_t g(\underline{A}_t;\mu_t)$ producing units; the loss of each of these units represents a corresponding reduction in the holding's profit of $p_H R Q_t - 1 - \frac{c p_H}{\Delta}(1-\frac{1}{\beta_t})$. Finally, $\bar{A}_t$ also increases, which means that approximately $\bar{A}_t g(\bar{A}_t;\mu_t)$ move from direct finance to bank finance, with a cost of $\frac{p_H c}{\Delta}(1-\frac{1}{\beta_t})$.

4 Market Clearing

The return on the bankers' equity, β_t, adjusts so that the bankers' participation in investment projects adds up to bank equity, denoted by K_t^m. Recalling $I_t^m = p_H R_t^m/\beta_t$ and $R_t^m = c I_t/\Delta$, this requires

$$K_t^m = \frac{p_H c I_t}{\beta_t \Delta}\left[G(\bar{A}_t;\mu_t) - G(\underline{A}_t;\mu_t)\right] \tag{14}$$

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

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

The characterization of a period's equilibrium is completed with the specification of μ_t as a function of K_t^f. We will assume that

$$A_t^i = K_t^f z_t^i$$

where z_t^i is iid across agents and time, with cdf $F(z)$, mean one, and variance $-\sigma^2/2$. In this case,

$$G_t(A) = \Pr\left\{A_t^i \leq A\right\} = \Pr\left\{K_t^f z_t^i \leq A\right\} = F\left(\frac{A}{K_t^f}\right) \equiv G(A;\mu_t)$$

In particular, for $G_t(.)$ to be log normal with mean μ_t and standard deviation σ_G,

$$\mu_t = \log K_t^f - \frac{\sigma_G^2}{2} \tag{16}$$

5 Dynamics

To describe the dynamics, we need to describe the laws of motion of the equity variables K_t^m and K_t^f. We assume that banks and holding company branches have fixed dividend rates $1-\theta^m$ and $1-\theta^f$ respectively.

Hence the law of motion of K_t^m is

$$K_{t+1}^m = \theta^m p_H \frac{cI_t}{\Delta}\left[G(\bar{A}_t;\mu_t) - G(\underline{A}_t;\mu_t)\right] \tag{17}$$

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

$$\begin{aligned} K_{t+1}^f &= \theta^f \Pi_t^f = \theta^f \{(p_H R Q_t - 1) I_t \left[1 - G(\underline{A}_t; \mu_t)\right] \\ &\quad + K_t^f - p_H \frac{c I_t}{\Delta}(1 - \frac{1}{\beta_t}) \left[G(\bar{A}_t; \mu_t) - G(\underline{A}_t; \mu_t)\right] \} \end{aligned} \tag{18}$$

Now the eight equations (11)-(18) give $I_t, \underline{A}_t, \bar{A}_t, \beta_t Q_t, \mu_t$ 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

We now move to the calibration part of the model. A period is a quarter. As we have noted, the model is fairly standard except for the block of equations characterizing the production of new capital goods and their financing. Consequently, we can set at conventional values many of the model parameters, especially those shared with real business cycle models for a small open economy.

We start by calibrating the values for H, σ, τ and α, $\frac{C}{Y}$, R^* as well as $\tilde{\Psi}$ and φ following Fernández and Gulan (2015), and normalizing the price of capital goods Q as well as A to 1. We then choose β^h and δ to qualitatively match the empirical ratios $\frac{X}{Y} = 0.2$ and $\frac{K}{Y} = 8$. The last value translates into capital stock being worth two years of output and is consistent with the data for Mexico collected by Kehoe and Meza (2012) . The volatility and persistence parameters of the exogenous shocks are set to standard values as well. We make the R^* shock rather persistent, reflecting the low level of world interest rates over the last decade. All calibrated parameters, normalizations and matched ratios are summarized in Table 1.

The second step of the calibration is more novel and involved. It concerns the parameters of the investing supply side, i.e. the holding companies. We assume that the distribution of equity within the holding $G_t(.) = G(.; \mu_t)$ is log-normal, a commonly used specification in macroeconomics (e.g. Bernanke, Gertler, and Gilchrist 1999) and in line with the literature

Table 1: Calibrated parameters.

Parameter	**Description**	**Value**	**Source**
φ	cost of capital adjustment	4.602	[15]
$\tilde{\Psi}$	risk premium elasticity	0.001	[25]
β	rate of return to bank equity	1.036	[10]
p_H	high probability of project success	0.99	[20]
p_L	low probability of project success	0.96	min. satisfying $\beta > \frac{p_H}{p_L}$
α	Cobb-Douglas capital share	0.32	[2]
K/Y	capital-to-output ratio	8	[19]
β^h	Households' discount factor	0.9852	found endogenously
δ	Depreciation rate	0.025	found endogenously
A	TFP	1	normalization
H	labor time	0.33	[2]
Q	price of capital	1	normalization
$\frac{X}{Y}$	investment to output ratio	0.2	Data
C/Y	consumption-to-output ratio	0.746	[15]
R^*	foreign interest rate on HH debt	1.002	[15]
τ	GHH labor parameter	1.6	[21]
σ	relative risk aversion	2	[2]
R^*	foreign interest rate on HH debt	1.002	[15]
ρ_{R^*}	persistence of R^* shock	0.99	
ρ_A	persistence of A shock	0.95	
ρ_R	persistence of R shock	0.95	
σ_{R^*}	std dev. of R^* shock	0.01	
σ_A	std dev. of A shock	0.01	
σ_R	std dev. of R shock	0.01	

on the size of firms (e.g. , Axell 2001, Quandt 1966). The mass of firms within the holding company and the number of holdings are both normalized to 1, which implies that μ adjusts endogenously as in (16). We set the quarterly rate of return to bank equity $\beta = 1.0357$, based on the World Bank's Global Financial Development Database (see Cihak et al. 2013) for a sample of 13 emerging economies analyzed in Fernández and Gulan (2015) (referred to as EME-13). This automatically gives the value of banks' dividend parameter $\phi^m = \frac{1}{\beta}$. We then set $p_H = 0.99$ following Meh and Moran (2010) , which reflects a quartely bankruptcy rate of 1%. We then manually set $p_L = 0.96$, the minimum value satisfying $\beta > \frac{p_H}{p_L}$.

At this stage one is is left with equation (13), describing the first-order condition of the holding. Using formulas for $\bar{A}$, $\underline{A}$, λ^1, λ^2, 16, as well as normalizing all terms by K^f allows us to reduce it to an expression in only 6 unknowns: c, b, B, σ_G, $\frac{I}{K^f}$ and R. To pin down their values, we use five more independent restrictions:

- The ratio of bank operating costs-to-bank assets, which we set to 3% guided by recent observations for EME-13 in the World Bank's WFDD.
- The ratio of bank assets to bank equity (i.e. bank leverage) where we target the value 8, in line with the evidence reported in Fernández and Gulan (2015).
- The typical holding's leverage: Fernández and Gulan (2015) report an average value of 1.71 for publicly-traded firms in EME-13. We set the target lower, at 1.5, to reflect the fact that non-publicly traded firms may have harder access to credit or perhaps no sources of external financing.
- The ratio of gross external bank credit to GDP, reported in IADB (2014) for selected Latin American countries, approximately equal to 15%.
- Using the same source as guidance, we set the fifth and final ratio, gross foreign corporate bond issuance to GDP, to 10%.

In principle, the above list of conditions constitutes a system of 6 independent equations in 6 unknowns so should be uniquely solvable. Nevertheless, an exact solution is in practice impossible for three main reasons. Firstly, the system is highly non-linear. Secondly, the 6 unknown parameters and variables have restricted support and limited plausible ranges (e.g. monitoring costs cannot be negative and the rate of return R should be greater than 1). Thirdly, there is also a set of additional inequalities which the parameters c, b, B and R have to satisfy. These inequalities stem directly from the discussion in HT and section 3, and guarantee that the model is well-behaved. These conditions can be translated into the following ordering: $0 < \underline{A} < I - I^m < \bar{A} < I$, as well as conditions $\lambda^1 > 0$, $\lambda^2 > 0$ and $b + c > B$. For these reasons we proceed in the spirit of GMM estimation and minimize an objective function which captures the relative difference between the model-generated and empirical ratios.[4] Details are given in the Appendix.

Table 2 presents the empirical targets of the ratios alongside those in the calibrated model. The match is very good and we get very close to the chosen targets. The one dimension in which the match is not as close is the leverage of banks: the target is 8 whereas the best we can generate with the model parameters is 2.654.

Table 2: Matched empirical financial ratios.

Condition	**Target**	**Model**
Bank operating costs to bank assets	0.030	0.031
Bank assets to bank equity	8.000	2.654
Holding assets to holding equity	1.500	1.511
Gross foreign bank loans to GDP	0.150	0.146
Gross foreign corporate debt to GDP	0.1	0.1
FOC of the holding	0	0

Finally, Table 3 summarizes the chosen parameter values for the financial part of the model.

Table 3: Calibrated financial parameter values.

Parameter	c	b	B	σ_G	$\frac{I}{K^f}$	R
Calibrated value	0.027	0.005	0.006	2.590	155.592	1.062

7 Dynamic Implications

7.1 A Drop in R*

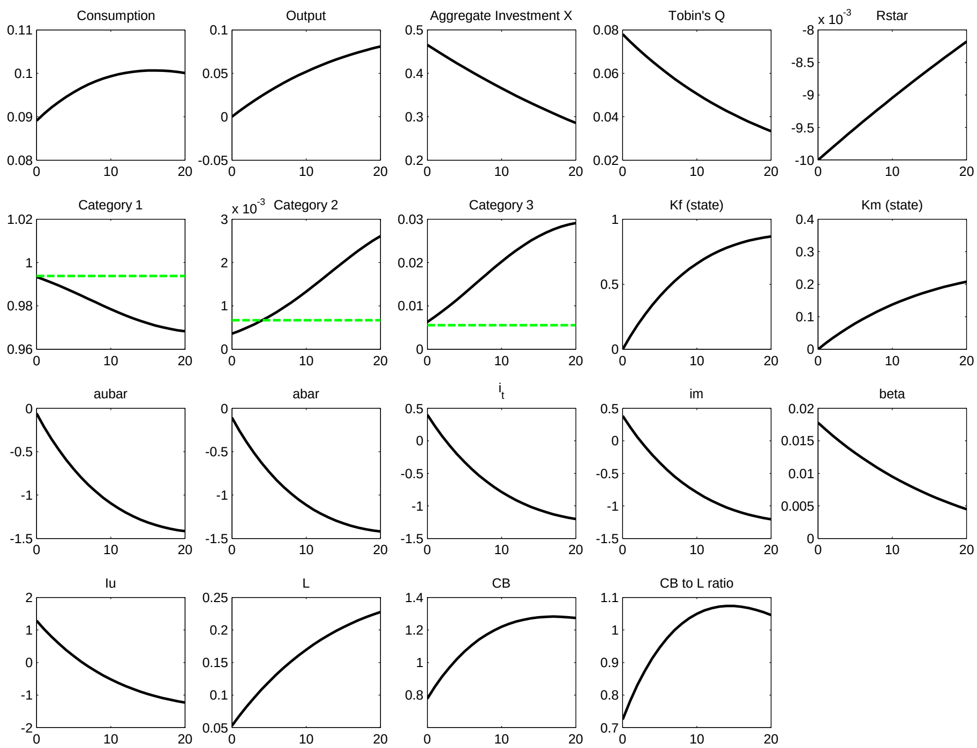
Figure 3 describes the impulse responses to a one percentage point drop in the world interest rate R^*. This exercise is intended to explore the response of the model to the fall in real interest rates observed since the start of the millenium.

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,

[4]For the FOC equation, we minimize the difference between LHS and RHS and give it exceptionally large weight so as to guarantee that this equation holds for any parameterization.

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.

Figure 3: Impulse responses to one percentage point drop in R^{*}.



Notes: All variables plotted are percentage deviations from the non-stochastic steady state. The exceptions are the IRFs for the three categories where the levels (i.e. percentage shares of branches) are plotted. Green dotted lines denote steady state shares of firms in a given category.

The dynamic responses of investment and the mix of direct vs. indirect finance accord 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, $i_t = I_t/K_t^f$, increases. Also, some firms that were not producing before the shock (because of the lack of finance) become profitable and hence start producing: this is reflected in the fall in the measure of inactive firms ("Category 1" in the figures), and in the fall of $\underline{A}$ (aubar in the figure). Finally, some firms that were obtaining finance from banks ("Category 2") become profitable enough to switch to direct finance ("Category 3"). Initially, more firms move from

Category 2 to Category 3 than from Category 1 into Category 2, so that the size of Category 3 firms increases but Category 2 shrinks.

Both bank loans (L) and commercial bond issue (CB) increase, reflecting both the increase in project size and in the number of producing firms. Also, as some producing firms switch to direct finance, the ratio of commercial bonds to loans increases.

Enhanced participation of banks is reflected in the increase of the rate of return on bank equity, β_t. Profits increase both for investment holdings and for banks. This leads to a gradual accumulation of equity, K_f and K_m which, over time, reinforces the gradual increase in the measure of firms getting credit, both direct (Category 3) and indirect (Category 2). The impact on the former is still greater than on the latter, so that the ratio of commercial bonds to loans increases for about fifteen quarters.

In equilibrium, aggregate investment increases over time, and so does output, because of capital accumulation.

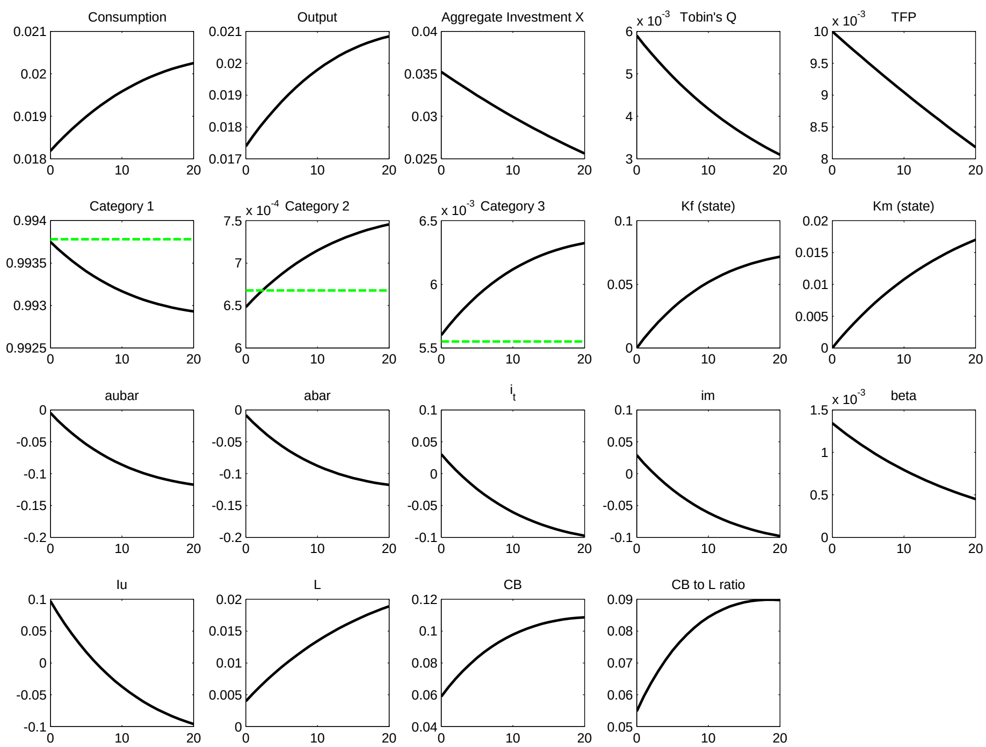
Over time, the impact of the shock wanes, and all variables return to their steady state values. In particular, the rate of return on bank equity, β_t, falls over time. For a long period, this is not only because of mean reversion but also because of the accumulation of equity in banks.

This experiment indicates, therefore, that our model can replicate the recent observed increases in both direct and indirect finance, as the economy reacts to a fall in the world interest rate. In this sense, the model rationalizes the evidence in the introduction and suggests that it is consistent with an intuitive mechanism by which an economy arranges for the financing of investment projects.

7.2 A Productivity Shock

In order to examine the model's behavior under a conventional productivity shock, Figure 4 displays 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 on impact is greater, however, because it reflects both capital accumulation and higher productivity. Correspondingly, consumption increases.

Figure 4: Impulse responses to one percentage point increase in A.



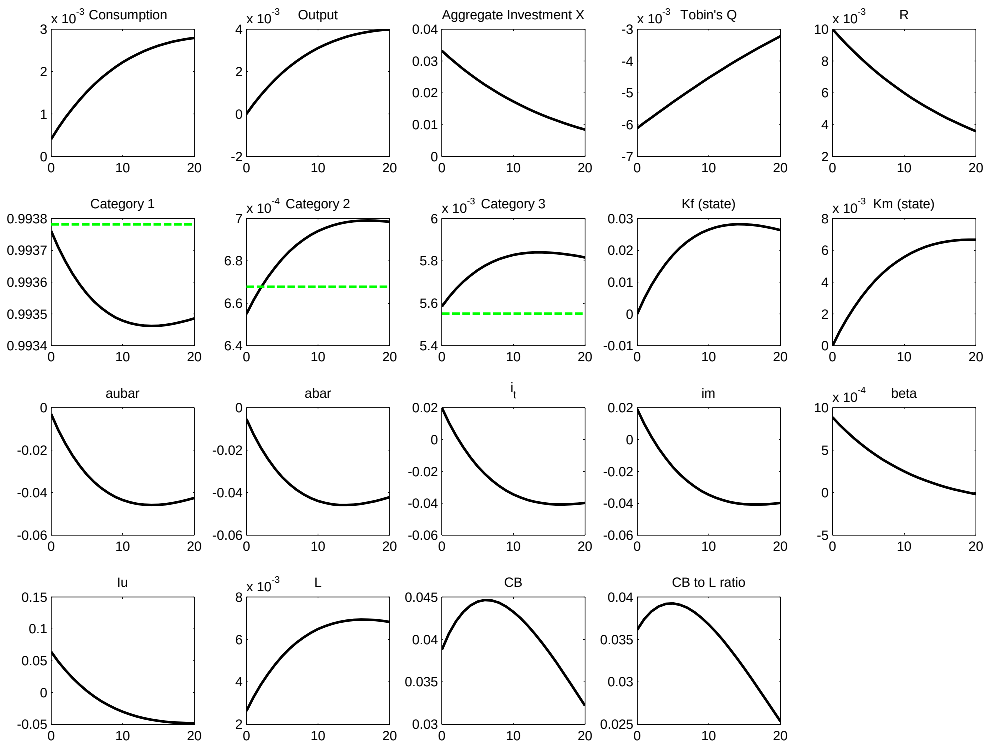
Notes: All variables plotted are percentage deviations from the non-stochastic steady state. The exceptions are the IRFs for the three categories where the levels (i.e. percentage shares of branches) are plotted. Green dashed lines denote steady state shares of firms in a given category.

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.

7.3 Shock to Investment Technology

Figure 5 shows the impulse response to a one percent increase in R, the within period return to investment projects. Intuitively, this should lead to a fall in the cost of producing capital goods and, therefore, an increase in their supply.

Figure 5: Impulse responses to one percentage point increase in R.



Notes: All variables plotted are percentage deviations from the non-stochastic steady state. The exceptions are the IRFs for the three categories where the levels (i.e. percentage shares of branches) are plotted. Green dashed lines denote steady state shares of firms in a given category.

In equilibrium, this is reflected in a drop in Q and an increase in aggregate investment. On impact, the increased profitability of investment results in an increase of the number of producing firms and also in some firms switch from bank finance to investment finance. The net result, again, is that the number of firms with access to direct finance increases, while the other categories shrink in measure. The size of the typical project increases, however, so that both bank loans and bond issues increase. The bonds to loans ratio increases for about six quarters.

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.

7.4 The Role of Endogenous Mode of Finance

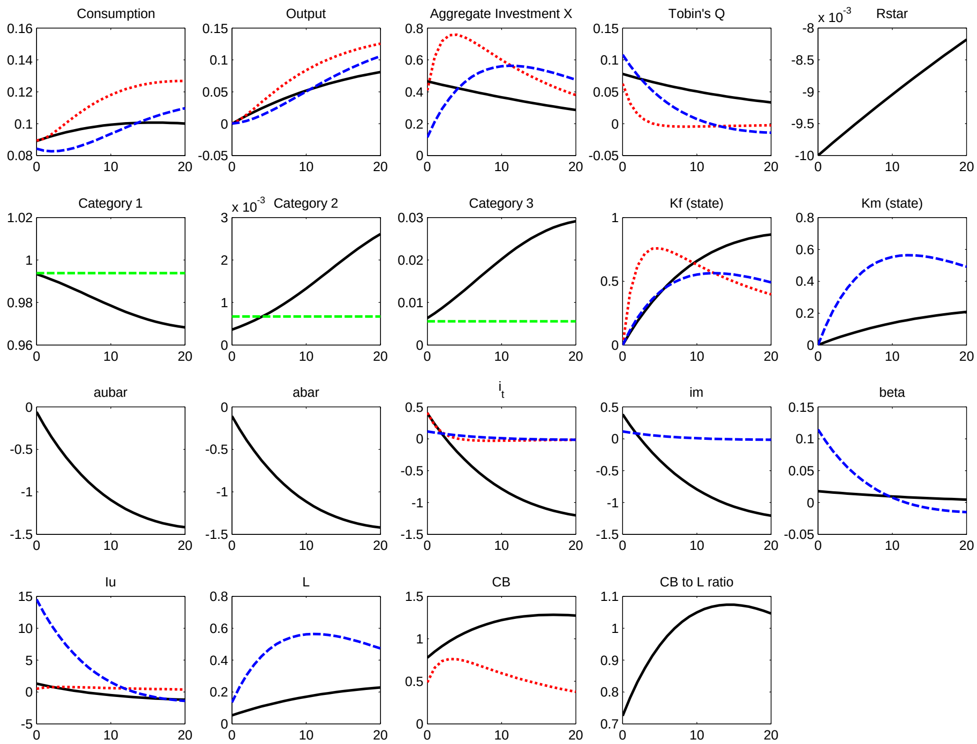
Perhaps the most novel aspect of our model is that, in response to a shock, the adjustment mechanism includes the endogenous response of the number of firms borrowing directly from the world market as well as the number of firms borrowing through banks. It may be asked, what exactly does the endogenous response add to the behavior of the model? To answer, we compare the baseline model against two alternatives that assume away that endogenous response. The first alternative assumes that all firms borrow directly from the world market; the second one, that all firms borrow through intermediaries.

The calibration of both counterfactuals is the same as in the counterfactual model. For tractability, the counterfactuals assume that every firm gets the same amount of equity from the holding manager, that is, K_f. Otherwise, the holding's problem is quite similar to the one in the baseline model, so the technical details are delayed to the Appendix.

Figure 6 presents impulse responses to a one percent fall in the world interest rate R^*. For reference, responses to the baseline model are given in black. Responses in the case of only direct finance are given in red. Finally, blue impulse responses correspond to the case of only intermediated finance.

The most noticeable difference between the baseline model and the two alternatives is the response of aggregate investment X, which is monotonic in the baseline but hump-shaped in the two alternatives. This is reflected in the response of the price of capital goods, which is slower than in the baseline model. Intuitively, these differences correspond to the dynamics of equity accumulation and financial frictions. A fall in R^* stimulates investment demand, raising the price of capital goods. In the case of only direct finance, the reaction of investment supply is initially limited by the equity of investing firms, K_f. The peak response is delayed by the fact that accumulating K_f takes time. In contrast, in the baseline model, the response of investment can be faster because financial frictions are alleviated by the participation of banks, which bring

Figure 6: Counterfactual economies following a one percentage point drop in R^*.



Notes: All variables plotted are percentage deviations from the non-stochastic steady state. The exceptions are the IRFs for the three categories where the levels (i.e. percentage shares of branches) are plotted. Green dashed lines denote steady state shares of firms in a given category. Red dotted lines denote IRFs of an economy with direct borrowing only. Blue dashed lines denote IRFs of an economy with intermediated borrowing only.

their own equity into the process.

In the case of only bank finance, the logic is somewhat different. Bank intermediation is costly, so that on impact the response of investment to a lower R^* is less than in the baseline. The counterpart is that the return to bank equity, β, increases sharply with the shock, reflecting windfall profits for banks. These profits lead to a faster accumulation of bank equity, K_m, than in the baseline. This, and the accumulation of firms' equity, lead to smaller financing costs over time, a fall in β, and an increase in investment supply.

The endogeneity of finance mode, therefore, results in a *smoother* response of investment and aggregate demand to exogenous shocks than under the alternatives. This should not be too surprising, because in our baseline model investment holdings do take advantage of an additional margin of adjustment when facing shocks.

This finding suggests that recent changes in the size of commercial bond issue relative to bank loans in Latin America and elsewhere may reflect stabilizing rather than destabilizing forces. In this sense, our analysis provides an interpretation of the data reviewed in the introduction that is more optimistic than that of Shin (2013) and others. (Of course, Shin has emphasized that the increase in commercial debt can be problematic because of the possibility of exacerbating currency mismatch problems. But there is no obvious reason why currency mismatches should be worse for firms than for banks, and hence the increase of bond issue relative to bank loans has no clear implications from this perspective.)

8 Final Remarks

To be written

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