Emerging Market Lending: Is Moral Hazard Endogenous?*

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Abstract

This paper looks at the effect of moral hazard, resulting from information asymmetries in financial markets, on growth in financially open developing countries. We show that if domestic entrepreneurs can gamble with foreign creditors' money, borrowing under standard debt contracts is constrained by a No-Gambling Condition similar to that of Hellmann, Murdock, and Stiglitz (2000). However, this incentive constraint is endogenous in the development process: growth increases entrepreneurs' own capital at risk, thus reducing gambling incentives, but it decreases profitability of capital investment, which has the opposite effect.

General equilibrium under moral hazard shows a unique and stable steady state, but involves at least temporary rationing of profitable projects and possibly capital flight from developing countries.

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Introduction

The literature on international finance has frequently highlighted the incentive problems associated with cross-border capital flows. Often, implicit guarantees to foreign creditors, by domestic governments or via the prospect of IMF bailouts, are seen to cause a moral hazard situation, where creditors have no incentives to make sure that their money is prudently invested.[1] One standard policy conclusion is thus to eliminate guarantees in order to make foreign creditors bear the risk of their investment.

However, removing guarantees does certainly not eliminate the problem of asymmetric information at the origin of moral hazard. As studies on domestic lender-borrower relations (such as Holmström and Tirole 1997, or Hellmann, Murdock and Stiglitz 2000) show, moral hazard-type conflicts of interest arise under standard-debt contracts whenever limited liability borrowers have insufficient own capital at risk, or insufficient prospective profits. In the absence of guarantees, international lenders will thus take into account incentive constraints for their lending policy if information asymmetries rule out contracts contingent on borrower behaviour. Creditors effectively impose a "No-Gambling Condition" (Hellmann, Murdock and Stiglitz 2000), which constrains borrowing by minimum capital requirements for borrowers, conditional on the profitability of their projects. For poor countries, which lack sufficient own capital but offer numerous investment opportunities, this may well be a severe constraint, with important consequences for the supposedly beneficial impact of international capital mobility.

Furthermore, economic growth seems to play an important role for incentives. It gives countries more own capital to signal incentives for prudent investment, but presumably also reduces marginal returns to capital and thus profits. As opposed to purely financial models of moral hazard in financial markets, which usually take the profit structure as given, this double role of capital accumulation for incentives – a beneficial "capital at risk effect" and a negative "profit effect" – requires an analysis that endogenises both capital and profits. Thus, only a dynamic general equilibrium growth model can show the reciprocal relation between incentives, which constrain capital accumulation, and growth, which determines incentives via capital and profits. This in fact is the endeavour of the present paper.

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[1] Thus, Paul Krugman (1998) argues that the main story behind the 1997 Asian crisis is that of moral hazard leading to "pangloss" overinvestment: without control by implicitly insured lenders, limited liability borrowers will invest international funds in excessively risky and unprofitable activities.

We analyse the consequences of moral hazard in financial markets for growth in open developing economies when international creditors impose a No-Gambling Condition à la Hellmann, Murdock and Stiglitz (2000). We choose a simple overlapping generations growth model of the Diamond (1965)-type to endogenise entrepreneurs' own capital as well as profits in the growth process. Adding this simple incentive constraint to an otherwise entirely neo-classical model yields results quite different from those of standard growth theory: despite international capital mobility, poor economies with low own capital will converge slowly to a steady state where output may well be lower than it would have been without moral hazard. Moreover, not only the degree but also the existence of moral hazard is shown to be endogenous in the growth process: decreasing marginal returns to capital are crucial in that for high marginal productivity there is no moral hazard problem, which only arises at some point in the development process. The net effect of further capital accumulation on incentives, combining the impact of rising capital at risk and falling marginal returns, is shown to be positive. We thus show a causal link from capital accumulation to moral hazard, as opposed to the reverse "pangloss" investment mechanism, where moral hazard leads to overaccumulation of capital.

Our paper draws on two main sources in the literature: we take our incentive structure from the Hellmann, Murdock and Stiglitz (2000) paper on the danger of banks gambling after the liberalisation of domestic financial markets, but we endogenise profits as a function of aggregate capital in the economy and take the opportunity costs of funds as exogenously determined in international capital markets. This yields a situation of capital constrained borrowing not very different from that in Holmström and Tirole (1997) for example. On the other hand, our overlapping generations framework is most similar to those in Boyd and Smith (1997), or Ma and Smith (1996) that are part of a small but growing literature on growth under asymmetric information in financial markets (see also Boyd and Smith 1992, Huybens and Smith 1998, Gertler and Rogoff 1990 or Sakuragawa and Hamada 2001). However, this literature relies usually either on the assumption of pure credit constraints prevailing under costly state verification[2] (notably the work of Smith et al.) or on exogenous profitability of capital. Both assumptions are in our view quite restrictive, which is why we choose a simple moral hazard framework, where however both profits and moral hazard are endogenous in the growth process.

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[2] The seminal paper on pure credit constraints in a domestic costly state verification framework is Gale and Hellwig (1985).

The paper proceeds as follows: After presenting a simple small open economy growth model with moral hazard in financial relations (I.), we analyse partial equilibrium in financial markets (II.), as well as dynamic general equilibrium (III.) and give some comparative static results (IV). Our conclusion includes suggestions on policy responses and further research.

I. The Model

In the following overlapping generations growth model, a small open economy faces moral hazard in an intermediary capital-investment sector. Entrepreneurs have the possibility to “gamble” with borrowed money by investing in a risky but inefficient asset. Their incentives to do so are governed by two factors: expected profits from successful investment projects increase incentives to avoid failure and thus to invest prudently. And entrepreneurs’ own finance in their project discourages gambling due to a “capital at risk” effect. When international creditors are aware of this incentive structure but cannot observe gambling unless a project fails, borrowing can be capital-constrained by a simple No-Gambling condition - a one-period version of that in Hellmann, Murdock and Stiglitz (2000) with endogenised profits. In fact, both incentive effects, the capital at risk and the “profit” effect depend on aggregate capital in the economy and are thus endogenous in the development process.

Agents

The population of the economy consists of overlapping generations of two-period lived agents. Each generation is assumed to be of constant size N for simplicity. Agents are endowed with one unit of labour when young, which they supply inelastically to earn the going wage rate in the economy w_t, and retire at the beginning of period two. They are risk-neutral and care only about period 2 consumption. Thus

$$U(c)=c_{old} \qquad A1$$

This utility function is maximised by agents subject to a limited liability constraint. Thus, agents’ wealth cannot be negative.

International lenders are numerous, risk-neutral and ready to lend any amount at the expected rate of return i. Since our economy is small, it has no influence on this going rate of interest.

Saving and Investment

Agents are assumed to have two saving opportunities to transfer consumption from period t to period t+1. They can invest either in financial assets that yield the international gross rate of return i, or in their idiosyncratic investment project in an intermediary sector. These projects need an indivisible financial investment of size q in order to yield production capital at the beginning of t+1, which is then used to produce consumption goods and paid the going rental rate R_{t+1}. In other words, agents are born with a capital investment "idea", a technology or a business, that they cannot sell but only realise themselves.

These investment projects play a crucial role in the analysis. Their size differs between some lower bound $\underline{q}$, and an upper bound Q. Agents are randomly assigned a project before they are born, where the probability of an agent obtaining a project of size q is given by the probability density function g(q), which is assumed to be differentiable and of mass 1 (i.e. $G(\underline{q})=0$ and $G(Q)=1$ with G(q) the associated cumulative distribution function). Also we assume

$$Q>w_t \text{ for all } t \qquad A2$$

Thus, at least some agents have to obtain outside finance to run their project.

The projects' output depends on which of two investment technologies is employed: agents can opt for a prudent investment technology that yields q units of capital with probability one, or for a "gambling" technology that yields $\beta q>q$ units of capital with probability π, and zero otherwise. We make the following assumptions about β and π.

$$\pi\beta<1 \qquad A3$$

and as stated above

$$\beta>1 \qquad A4$$

A3 states that the gambling technology is less efficient since its expected return is lower than that of the safe technology. However, according to A4, returns from gambling are higher if the project is successful.

The reason for this particular set-up of gambling in an intermediary investment sector is to show the effects of falling marginal productivity of capital on entrepreneurs' incentives to gamble.

In fact one important difference between our No-Gambling Condition and that of Hellmann, Murdock and Stiglitz (2000) is that in our model, profits are endogenous and thus affected by decreasing marginal returns.

"Gambling" can intuitively be interpreted in different ways: for example entrepreneurs might economise on security installations in the investment stage, or invest in projects that only pay off in certain states of the world, such as with a continuing boom in property prices, etc. The set-up may also be viewed as a crude way of allowing for idiosyncratic risks of foreign financing, such as exchange rate risks where the project can only pay back its dollar-loan if there is no rise in the exchange rate. In fact, one interpretation of our model is of projects to be financial companies that provide capital services to final sector firms. These financial companies would then have the possibility to gamble by engaging in risk-shifting, as in Hellmann, Murdock and Stiglitz (2000) or in Krugman (1998), or by borrowing in foreign currency against domestic assets without hedging the involved risk.[3]

Production of a Single Consumption Good

There is a single final consumption good in the economy that is produced by the production technology F=F(K, N) that uses labour (N) and capital (K), the output from investment projects. The production technology satisfies $F_K(K)>0$, $F_{KK}(K)<0$ and Inada conditions, where capital-letter subscripts denote derivatives. Capital is assumed to depreciate fully in production.

We thus have two production technologies, a binary investment technology that yields capital, and a well-behaved neo-classical technology that combines this capital with labour to produce consumption goods, a framework similar to those of Boyd and Smith (1997), or Ma and Smith (1996). Note that we do not include technological progress. Since also our population is constant, there will be no steady state growth in the model. However, it would be straightforward to account for this, albeit making the algebra in the following somewhat cumbersome. We choose this simplifying framework since we are primarily interested in the convergence process to the steady

[3] At least in the case of financial services companies, one would probably want to limit the possible number of these companies to some fraction of the population, which however only adds one parameter to our model without substantially affecting results.

state, and the steady state level of capital and output per capita under asymmetric information with respect to the full information case.

Markets for Labour and Capital

Markets for labour and capital are competitive, such that both are paid their marginal product, therefore

$$F_N = N^{-1}[F(K_t)-K_tR_t]=w_t$$

and

$$F_{K,t}=R_t.$$

We also assume

$$F_K(K_{max})<i \qquad A5$$

where K_{max} is the capital output when all investment projects get realised. According to A5, it is not efficient to run all projects, since in that case the marginal productivity of capital would be lower than the international rate of return i.

Financing Contracts

At the end of their young period, i.e. after obtaining their wage income, entrepreneurs offer standard debt contracts to raise the financing they need to run their projects, $b_t=q-w_t$. Standard debt contracts are characterised by a fixed payment by the borrower to the lender as agreed in the contract unless the former declares bankruptcy. In the case of bankruptcy the lender audits the project and seizes all assets up to a value equal to the contractual repayment plus the auditing costs. Note that in our framework expected auditing costs are zero when an agent chooses the prudent investment technology, since it cannot fail. So the per-unit cost of financing a loan to a prudent investment project is i, the riskless rate. All interest rates or rates of return are gross, i.e. include repayment of the borrowed capital plus net interest.

Standard debt contracts are information-poor in that the lender operates at arm's length with the borrower, according to the information structure described below. They may be viewed as international bond issues, loans from offshore banking institutions, or ordinary loans as long as the international bank is convinced that the project will be run prudently without close monitoring.[4]

Information Structure

Lenders are assumed to have ex ante information about agents' preferences, their wealth (or, which is equivalent in this framework, the past period's wage) and their investment technology options. However, ex post they have no information about de facto payoffs or the chosen production technology unless they see the project fail. Failure reveals the zero payoff and thus the investment technology employed (since the prudent technology could not have failed). But limited liability means that there cannot be any financial penalties in the failure case, since borrower wealth is zero (assuming full equity participation, a subject which we will treat below).

Note that moral hazard arises from the information asymmetry between borrowers and lenders that makes it impossible to write incentive contracts contingent on the production technology chosen by borrowers. To ensure prudent investment of their funds, lenders respond to this moral hazard problem by imposing a No-Gambling incentive constraint in their lending policy.

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[4] While the restriction to standard debt contracts is certainly important, it may be viewed merely as an easy way of showing the effects of asymmetric information in financial markets. In a related piece we add the possibility of monitoring, which does not substantially alter the results (Broer 2001).

II. Equilibrium in Financial Markets

We start by analysing the partial equilibrium in financial markets. The analysis is partial in that it takes the period t capital stock per head, and thus wages, as given to derive equilibrium investment as a function of the international interest rate and incentive constraints. In a general equilibrium analysis we will afterwards endogenise profits and wages to derive the impact of economic development on incentive constraints and vice versa.

In equilibrium, individual rationality constraints require investors and entrepreneurs to get at least the opportunity cost of funding investment projects, i. Therefore, lenders need to get at least an expected interest rate of i

$$E[\Gamma] = prb \geq ib \qquad (IR1)$$

where Γ are returns to the lender in different states of nature, b is the size of the loan, r denotes a contractual loan rate, p denotes the probability that the project is successful and we drop time subscripts for convenience.

For borrowers, expected profits from investment must equally correspond to a net unit return on own finance (wage investment) of i

$$E[\Pi] = p[\tau R_{t+1}(w_t' + b_t) - rb_t] \geq w_t' i \qquad (IR2)$$

where Π indicates profits in different states of nature, R_{t+1} is the rental rate on capital in the next period, w_t' is the amount of period t borrower wealth invested in the project and τ equals payoff in units of capital when the project goes through, in other words 1 or β. Since international markets are assumed to be competitive, IR1 will always hold with equality in equilibrium since lenders never earn pure profits (a zero profit condition).

Note that in our model there are always potentially more projects than actually get realised (from A5). Also projects cannot be sold by entrepreneurs who are the only ones that have the knowledge to run them. It is thus the number of projects that adjusts to yield equilibrium in financial markets and not their prices.[5]

2.1 Benchmark Equilibrium under Full Information

Assume as a benchmark case full and free information. The resulting equilibrium is very simple and emerges from the two individual rationality constraints together with decreasing marginal returns to capital: Entrepreneurs will invest as long as expected returns to their projects are greater than their opportunity costs, provided they can meet IR1. Since under full information lenders can observe the investment technology employed ex post, they can make contract terms contingent on it. IR1 thus requires the contractual loan rate i if the prudent investment is made, and i/π for gambling investment, since this is just sufficient to yield an expected unit return of i for the lender.

However, expected profits Π from gambling are with $r=i/\pi$

$$E[\Pi_{gambling}] = p[\tau E[R_{t+1}]\ (w'+b)-rb]$$

$$= \pi[\beta E[R_{t+1}](w'+b)-i/\pi b]$$

$$= \pi\beta E[R_{t+1}](w'+b)-ib$$

$$\leq \Pi_{prudent}=E[R_{t+1}](w'+b)-ib \qquad (1)$$

where for the remainder of this section we drop time subscripts for period t variables for convenience.

Under full information it is thus never optimal for agents to gamble. Agents will decide to invest prudently in their project until capital is accumulated to the point where its expected marginal productivity R is such that returns from prudent investment projects equal returns from safe assets, thus

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[5] Allen and Gale (2000) present a model where moral hazard and risk shifting under standard debt contracts lead to a bubble in asset prices. Krugman (1998) also presents a simple model of the same spirit.

$$\Pi_{prudent} = E[R_{t+1}](w'+b)-ib = w'i$$

$$\Leftrightarrow R_{t+1} = i = F_{K,t+1}(K') \qquad (2)$$

where the last line like the remainder of this section assumes perfect foresight of R_{t+1}. (2) implicitly defines a unique level of full information capital K', since F_K is a monotonically decreasing function by assumption. Note that under full information entrepreneurs do not earn rents in equilibrium.

2.2 Introducing Asymmetric Information

Under asymmetric information lenders cannot make their contractual loan rate depend on the investment technology chosen, since it is non-observable. For a given contractual loan rate, they strictly lose from entrepreneurs gambling as opposed to prudent investment, since they only get their money back with probability π. Thus, they will not be ready to lend at the rate i unless they know that agents have incentives to invest prudently. For this, agents' pure profits from investing prudently must be higher than expected pure profits from the gambling.[6] Imposing the condition yields

$$\Pi_{prudent} > E(\Pi_{gambling})$$

$$\Leftrightarrow (R_{t+1}-i)(w+b) > \pi[(\beta R_{t+1}-i)(w+b)]+(1-\pi)(-iw) \qquad (3)$$

Solving this for b yields a condition for maximal borrowing, the No-Gambling Condition

$$b < w\frac{(1-\pi\beta)R_{t+1}}{(\pi\beta-1)R_{t+1}+i(1-\pi\ )} \text{ for } (\pi\beta-1)R_{t+1}+i(1-\pi)>0 \qquad (NGC)$$

[6] In the following, it turns out to be convenient to phrase the dicussaion in terms of pure profits, i.e. there is always an opportunity cost of w'i to own funds invested in projects.

From NGC we get the maximum project size q* as the sum of period 1 wage income and the maximum loan size.

$$q^* = w + b_{MAX} = w\frac{i(1-\pi)}{(\pi\beta - 1)R_{t+1} + i(1-\pi)} \qquad \text{for } (\pi\beta\text{-}1)R_{t+1}+i(1\text{-}\pi)>0 \qquad (NGC')$$

NGC makes borrowing of entrepreneurs constrained by own capital in projects w. Intuitively, own capital mitigates the moral hazard problem because the entrepreneur faces the whole down-side risk on this invested capital: His opportunity cost in the bad state is wi, the gains from the alternative investment in the safe asset yielding safe return i. That means that his net expected loss from gambling with his own capital equals the difference in expected payoffs between the two technologies, -wR(1-πβ)<0. These losses are opposed to expected gains from gambling with borrowed money of b[π(βR-i)-(R-i)]. NGC then says that for prudent investment to be optimal, the expected gains from gambling with borrowed capital compared to prudent investment have to be smaller than the expected losses from gambling with the amount of own capital employed in the project. It is immediate that entrepreneurs with great ideas but no capital will never be able to borrow and realise their project.

Figure 1a shows how for fixed w and R entrepreneurs' expected profits are higher from gambling than from investing prudently above the threshold size q* given by NGC'. Figure 1b shows how higher wages, or wealth at the end of period 1, increases q* by more than the change in w. This is the capital at risk effect of rising entrepreneur own capital on borrowing limits, that can also be shown by differentiating NGC' with respect to w

$$\frac{\delta q^*}{\delta w} = \frac{i(1-\pi)}{(\pi\beta - 1)R_{t+1} + i(1-\pi)} > 1 \text{ for } (\pi\beta\text{-}1)R_{t+1}+i(1\text{-}\pi)>0 \qquad (4)$$

Figure 1c shows how the maximum project size for debt finance q* rises with the rental rate of capital R, since the effect of a marginal rise in R on profits from prudent investment, equal to 1, is bigger than its impact on profits from gambling, πβ<1, thus reducing incentives to gamble as R rises.

Intuitively, as entrepreneurs only make profits in good states, they like high probabilities of success the more, the higher the possible gains in success states. Creditors who know this, will thus be willing to lend more money when profits are high, leading to a positive relation between q* and R. This is the profit effect, equivalent to the franchise value effect in a dynamic setting, such as Hellmann, Murdock and Stiglitz (2000). It can be obtained algebraically by differentiating NGC' with respect to R_{t+1}:[7]

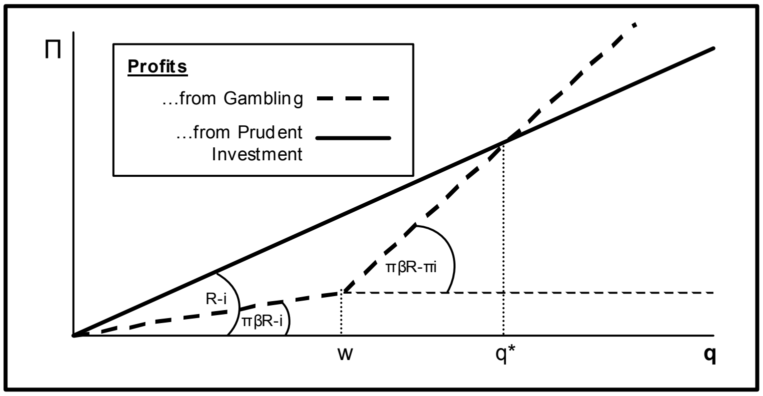

Figure 1a **Total Profits (Π) from Gambling and Prudent Investment for Given Wealth (w)**
Above q* gambling yields higher profits for entrepreneurs.

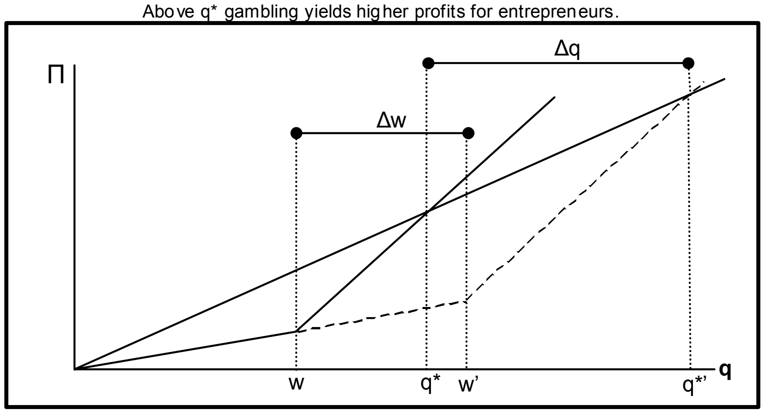

Figure 1b **Increasing Wealth by Δw from w to w' Increases the Maximum Project Size q* by Δq>Δw**

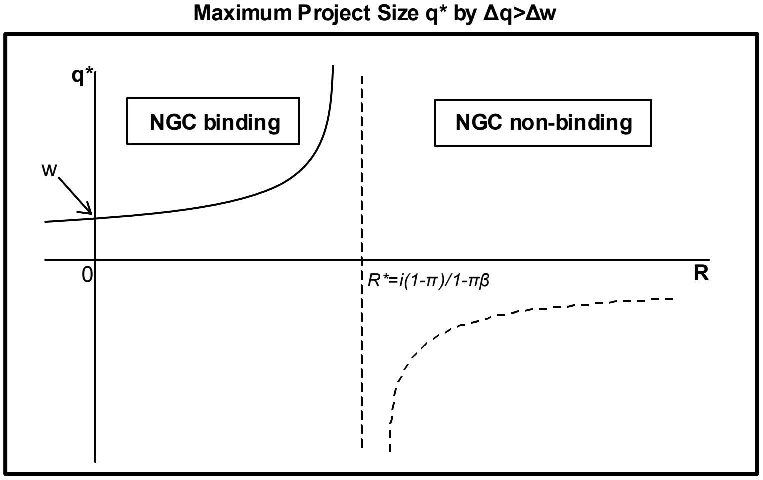

Figure 1c **q* as a Function of the Rental Rate R (NGC')**
Note that NGC is non-binding for R > *R*=i(1-π)/1-πβ.*

[7] To derive this illustrative result and figure 1c, we obviously need to take R as exogenous.

$$\frac{\delta q_t*}{\delta R_{t+1}} = w \ \frac{i(1-\pi)}{\left[(\pi\beta-1)R_{t+1}+i(1-\pi)\right]^2}(1-\pi\beta) > 0 \text{ for } (\pi\beta-1)R_{t+1}+i(1-\pi)>0 \quad (5)$$

Profits thus relax gambling incentives, and can even eliminate them altogether as we show now. Note that all our results so far have been conditional on

$$(\pi\beta-1)R_{t+1}+i(1-\pi)>0$$

$$\Leftrightarrow R_{t+1}<R^*=i(1-\pi)/1-\pi\beta \qquad (MHC)$$

Figure 3c shows why this is the case: NGC' is not binding for values higher than R*, since in this case the denominator in NGC becomes negative and the inequality is inversed, such that NGC holds for all positive values of borrowing – agents' borrowing is not incentive-constrained for high values of R. Intuitively, the reason for this is as follows: entrepreneurs gain from gambling since under limited liability the borrower need not (and cannot) pay the contractual interest in the bad state, thus leading to an expected gain from lower interest payments of $bi(1-\pi)>0$. However, the borrower loses from the lower expected payoffs on the borrowed capital, equal to $-bR(1-\beta\pi)<0$. NGC only applies when the sum of the two is positive, i.e. when there are gains from gambling with borrowed money. In other words, above a certain rental rate, agents will never gamble, since they lose more from a lower success probability than they gain from not paying interest in bad states. This yields the "Moral-Hazard-Condition" (MHC) that NGC only binds for a rental rate of capital below R*. In our general equilibrium analysis this is the reason why incentives to gamble arise endogenously in the development process as the rental rate and thus profits fall.

The denominator in NGC, $i(1-\pi)-R(1-\pi\beta)$, can thus be interpreted as the "degree of moral hazard": the higher i, the higher incentives to gamble (since gambling reduces interest payments in bad states), the higher R, the lower these are since entrepreneurs expected gains from high profitability are less under gambling.

Note in passing that the impact of the international interest rate on the maximal project size under debt finance is given by

$$\frac{\delta q^*}{\delta i} = -w\frac{(1-\pi)(1-\pi\beta)R_{t+1}}{\left[(\pi\beta-1)R_{t+1}+i(1-\pi)\right]^2} < 0 \qquad (5).$$

This also shows that the effect of increasing interest rates on q* are decreasing the higher the interest rate.

Maximal Equity Participation

In our model, entrepreneurs need some equity participation to meet NGC. Also, since they are risk-neutral and never get less but sometimes more than the average rate of return i on capital invested in their projects they always weakly prefer to invest in their own entreprise than in the safe international asset (provided they get sufficient outside finance). In the following we will thus assume maximal equity participation for all projects unless stated otherwise.[8]

[8] In a more general costly state verification framework, Gale and Hellwig (1985) show more formally that standard debt contracts with maximal equity participation (i.e. where a risk-neutral borrower puts up all his own wealth to cofinance a loan) are indeed optimal.

III. Dynamic General Equilibrium

Above we have derived equilibrium in financial markets and showed how a moral hazard problem can lead to a No-Gambling constraint that limits borrowing by a function of entrepreneurs' own capital and expected profits of their projects. However, both these variables depend crucially on the per capita capital stock in the economy, which makes it natural to proceed to a dynamic general equilibrium analysis. More specifically, the number of realised projects is affected in two ways in the development process: first of all labour's surplus and wages rise when capital is accumulated, thus leading to more own finance and a less constraining No-Gambling Condition, the capital at risk effect. In other words, with higher wages, more projects get international finance. On the other hand, capital accumulation leads to a falling marginal productivity of capital, thus a falling rental rate and less profits to entrepreneurs. The danger of moral hazard arises when profitability falls below the level where gambling with borrowed money suddenly becomes optimal, indicated by MHC above. Further capital accumulation alleviates the No-Gambling Condition by higher capital at risk, but aggravates it by falling marginal returns.

In the following part of our study, we thus show how capital accumulation affects incentives and can first of all bring about and subsequently alleviate a moral hazard problem in investment. That is, moral hazard arises as a by-product of development. We will inquire into existence, stability and uniqueness of a steady state in the economy, as well as the process of convergence.

It turns out to be straightforward to derive general equilibrium properties for our model, characterised by the competitive market clearing rates for wages and the rental rate on capital, the individual rationality conditions IR1 and IR2, as well as the No-Gambling Condition.[9]

3.1 Benchmark Equilibrium with full information

The benchmark equilibrium for an open economy with zero monitoring costs, i.e. under full information, is simply given by the two conditions on expected returns: no matter their period t capital, agents will borrow such that from period t+1 the full information capital stock K' is realised,

[9] A word might be in order about rationed entrepreneurs that do not get international finance. In equilibrium these have no incentive to invest domestically since they obtain no more than the international rate of return i.

i.e. that marginal profits from investment are i. Again, gambling is not profitable, since under full information it would lead to a higher contractual interest rate. Also, there is no convergence process: in line with other simple neoclassical growth models, under full information the economy would jump to its steady state capital level K' between period t and t+1. Under asymmetric information this result changes substantially.

3.2 General Equilibrium under Asymmetric Information

Under asymmetric information and thus moral hazard, the period t+1 capital stock is simply the output of investment projects that get financing according to the No-Gambling Condition. Capital output per invested unit of finance is simply one, since when NGC holds no agents gamble.

Assume for a moment that NGC' is binding, i.e. $R_t<i(1-\pi)/(1-\pi\beta)$, and also that K_t is less than the full information capital stock. Since the assignment of projects to agents is done by independent drawings from the distribution g(q), the number of realised projects N* is simply N times the probability of a project being smaller than the maximum incentive compatible project size q^*_t, which is

$$N^* = N \int_{\underline{q}}^{q^*_t} g(q)dq = NG(q)\Big|_{\underline{q}}^{q_t^*} \qquad (7)$$

The amount of capital in period t+1 is then simply N* times the expectation of the project size conditional on the project being realised, which according to Bayes' Law is

$$K_{t+1} = N^* \int_{\underline{q}}^{q_t^*} q \frac{g(q)}{G(q^*_t)} dq = \frac{NG(q^*_t)}{G(q^*_t)} \int_{\underline{q}}^{q_t^*} qg(q)dq = N \int_{\underline{q}}^{q_t^*} qg(q)dq \qquad (8)$$

where q^*_t is a function of K_t, via period t wages, and of K_{t+1}, via expected returns on capital $E[R_{t+1}]$.

However, this depends crucially on the assumption that they can obtain the riskless rate by investing in international markets without any informational costs.

Intuitively, the importance of the distribution g(q) is evident: the more concentrated projects are in the lower region of possible qs, the less severe is the rationing of investment under standard debt finance. On the other hand the more large potential projects there are in the economy, the higher the benefits from measures that relax the rationing.

It seems plausible that the number of projects in an economy decreases with size, i.e. that there are less large-scale projects than small-scale projects, which is equivalent to g(q) being a decreasing function. However, the distribution of capital as a function of project size, qg(q), may still be increasing or decreasing. For analytical tractability, we choose here the intermediate case: a distribution of projects over different sizes that leads to a neither decreasing nor increasing distribution function of capital, i.e. a uniform distribution of capital with respect to project size, which requires

$$g(q)=1/q \qquad A6$$

and thus

$$qg(q)=1.$$

A6 yields

$$K_{t+1} = N\int_{\underline{q}}^{q_t^*} q\frac{1}{q}dq = Nq\Big|_{\underline{q}}^{q^*_t} = N[q^*_t - \underline{q}]$$
$$= N\left[w_t\frac{i(1-\pi)}{(\pi\beta-1)E(R_{t+1})+i(1-\pi)} - \underline{q}\right] \qquad LM$$

or in per capita terms

$$k_{t+1} = w_t\frac{i(1-\pi)}{(\pi\beta-1)E(R_{t+1})+i(1-\pi)} - \underline{q} \qquad LM'$$

LM implicitly defines t+1 capital as a function of capital in period t – implicitly since the right hand side depends on expected t+1 profitability. That is LM is the law of motion for the economy when only standard debt contracts are available.

If we assume rational expectations of next period's rental rate, that is

$$E[R_{t+1}]=R_{t+1}=F_{K,t+1} \qquad (9)$$

we get the slope of LM by differentiating it implicitly.[10]

$$\frac{\delta K_{t+1}}{\delta K_t}=\frac{-K_tF_{KK,t}\dfrac{i(1-\pi)}{(\pi\beta-1)F_{K,t+1}+i(1-\pi)}}{1-[F_t-K_tF_{K,t}]\dfrac{i(1-\pi)(1-\pi\beta)F_{KK,t+1}}{\left[(\pi\beta-1)F_{K,t+1}+i(1-\pi)\right]^2}}>0 \text{ for } K_t>0 \qquad (10)^{11}$$

where F=F(K,N) for convenience.

Under standard debt finance, the law of motion is thus an increasing function for all K>0.[12] This is equivalent to saying that under debt finance the positive capital at risk effect on borrowing

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[10] This is admissible since LM is an identity.

[11] Note in passing that for a general distribution function g(q) we get from integrating (8) by parts

$$K_{t+1}=N\int_{\underline{q}}^{q_t^*}qg(q)dq=N\left[qG(q)\Big|_{\underline{q}}^{q^*_t}-\int_{\underline{q}}^{q_t^*}G(q)dq\right] \qquad (F5)$$

and thus

$$\frac{\delta K_{t+1}}{\delta K_t}=\frac{q^*_t\,g(q^*_t)N\dfrac{\delta q^*_t}{\delta K_t}}{1-q^*_t\,g(q^*_t)N\dfrac{\delta q^*_t}{\delta K_{t+1}}} \qquad (F6)$$

where $N\delta q^*/\delta K_t$ is equal to the numerator and $N\delta q^*/\delta K_{t+1}$ to the second term in the denominator of (10). This expression is equally positive for positive K_t, but its magnitude depends on the distribution function g(q).

[12] However, this result depends crucially on the way expectations are made about future productivity. If expectations are rational, i.e. K_{t+1} is derived by agents using the true model of the economy (LM), the above result holds. If however, expectations are completely naive, a simplifying assumption with respect to the more general case of adaptive expectations, i.e. $E(R_{t+1})=F_{K,t}$, then we get

constraints from rising wages is always larger than the negative profit effect from falling profitability of investment as the economy accumulates capital.

For a general production function, we can only derive the slope of LM, not its curvature, which depends on the third derivative of the production function, which we have made no assumptions about. Thus it is difficult to derive uniqueness and stability properties for possible equilibria from the derivatives of LM.

However, if we assume Cobb-Douglas technology

$$F=F(K,N)=K^{\alpha}N^{1-\alpha} \qquad A7$$

and also set $\underline{q}=0$[13] for simplicity, we get the steady state capital stock, where $K_{t+1} = K_t = K^*$, as

$$K^* = N\left[\frac{\alpha(1-\pi\beta)}{i(1-\pi)} + (1-\alpha)\right]^{\frac{1}{1-\alpha}} \qquad (11)$$

or in per capita terms

$$k^* = \frac{K^*}{N} = \left[\frac{\alpha(1-\pi\beta)}{i(1-\pi)} + (1-\alpha)\right]^{\frac{1}{1-\alpha}} \qquad (12)$$

Note in passing that for Cobb-Douglas production technology we get

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$$\frac{\delta K_{t+1}}{\delta K_t} = \frac{-KF_{KK,t}i(1-\pi)[(\pi\beta-1)F_{K,t}+i(1-\pi)]+[F_t-K_tF_{K,t}]i(1-\pi)(1-\pi\beta)F_{KK,t}}{\left[(\pi\beta-1)F_{K,t}+i(1-\pi)\right]^2} \qquad (F7)$$

which can be negative or positive. The intuition for this is that with rational expectations an increase in period t capital affects period t+1 capital directly only by the wealth effect i.e. via period t wages that mitigates borrowing constraints, whereas the effect of diminishing returns in t+1 due to increased capital is second order and only shows up in the denominator. However, with naive expectations the diminishing return effect shows up directly as a downward effect on gains from higher capital as of period t, which is first order. Its magnitude depends on the bowedness of the production function (F_{KK} being large or small) and of the stage of development (the amount of capital and therefore the magnitude of F_K).

$$\frac{\delta^2 K_{t+1}}{\delta^2 K_t} < 0 \qquad (13)$$

i.e. the law of motion is concave in K_t and thus the equilibrium is unique and stable.

However, to characterise the law of motion for capital completely we have to bear in mind our two restrictions made at the beginning of this section: First of all we assumed NGC to bind, i.e. $R_t = F_{K,t} < i(1-\pi)/(1-\pi\beta)$ for all t. However, due to Inada conditions, this is certainly not the case for low values of K, where marginal productivity is high. But wherever NGC is not binding, no agents in the economy have incentives to gamble, and entrepreneurs will always obtain the amount of investment that brings the expected marginal productivity of capital down to the level where NGC is just not binding, i.e. where

$$[(\pi\beta - 1)R_{t+1} + i(1-\pi)]q = wi(1-\pi) \qquad (NGC''')$$

holds with equality. Intuitively, no matter how low the initial capital stock, entrepreneurs can always borrow until they are indifferent between gambling and investing prudently, bearing in mind the effect of period t investment on period t+1 profits. Thus even when $K_t = w_t = 0$, they obtain outside finance until the left-hand side of NGC''' is zero, or $E[R_{t+1}] = F_{K,t+1} = i(1-\pi)/(1-\pi\beta) > i$. With Cobb-Douglas technology the according lower bound on the capital stock of our open economy is thus

$$K_{t+1}|_{kt=0} = K_{NGC} = N[i(1-\pi)/\alpha(1-\pi\beta)]^{1/\alpha-1} \qquad (14)$$

i.e. there is a jump in the law of motion at $K_t=0$ to K_{NGC}, and for all $K_t>0$ the borrowing constraint NGC will be binding since K_{t+1} will be greater than K_{NGC}, since LM is increasing in K_t for all $K_t>0$.

[13] Note that g(q) is not defined for q=0. However, since the probability of any particular value of q occurring is 0 for any continuous probability density function we implicitly exclude q=0 without affecting the results.

However, when we derived LM, we also assumed K_t<K', i.e. that capital never attains the full information level. This was necessary since the full information capital stock is a binding upper limit for K: otherwise the capital output of investment projects would not be sufficient to meet IR1 and IR2, i.e. entrepreneurs and outside investors would not get their required rate of return. The period t+1 capital stock thus stays at K' for all periods when LM attains this upper limit.

Under Cobb-Douglas technology the full information capital stock is simply

$$K' = N\left[\frac{i}{\alpha}\right]^{\frac{1}{\alpha-1}} \qquad (15).$$

This yields proposition 1.

Proposition 1: Steady state convergence under Standard debt finance

Under standard debt finance and asymmetric information, the economy never jumps to its full information capital stock at K_t=0. I.e. there is always some process of convergence if the initial capital of the economy is low.

Proof

From (14) and (15) it is evident that K_{NGC}<K', i.e. the lower bound of the capital stock is smaller than the full information capital stock for all parameter values and interest rates, since (1-π)/(1-βπ)<1. *QED*

Incorporating incentive constraints under international debt finance thus eliminates the usual instantaneous convergence of standard neoclassical growth models under international mobility of capital.

Also, by setting K'>K* we get a condition for the steady state capital stock under asymmetric information to be smaller than that under full information. This is stated in proposition 2:

Proposition 2: Non-Convergence to the Full Information Steady State

There is non-convergence in our economy if the international interest rate is sufficiently low. In other words, under standard debt finance the asymmetric information capital stock and output are lower than those under full information even when the economy has converged to a steady state if

$$i < \frac{\pi(\beta - 1)}{1 - \pi} \frac{\alpha}{1 - \alpha} \qquad (16)$$

Proof

The proposition is easily derived from setting k<k' and solving for i from (12) and (15). Note that since LM is an increasing function for all parameter values, it never crosses K' as long as the steady state capital stock K* is lower than K'.* *QED*

Corollary to Proposition 2: Rents in Equilibrium

From proposition 2 it is immediate that agents that obtain funding to finance their project can earn rents in equilibrium, since whenever (16) holds, steady state per capita capital under asymmetric information is lower than K', such that marginal producitivity is strictly higher than i. Since IR1 holds with equality the higher rental rate on capital leads to pure profits by entrepreneurs.

Note that Proposition 2 states that under asymmetric information poor countries take less advantages from low interest rates. Intuitively this is since for high values of interest the opportunity loss from gambling with own finance (w) become relatively more important than the gains from gambling with borrowed money, due to not paying the interest rate in bad states. Thus for high values of i the agency costs from moral hazard are alleviated.

Since total investment in the economy in period t is equal to period t+1 capital, and savings are equal to N times the wage, we get the possibility of South-North Capital flows, whenever savings are greater than domestic investment, a result known from Gertler and Rogoff (1990), or Boyd and Smith (1997). This is stated in proposition 3.

Proposition 3: South-North Capital Flight

The economy will experience net capital outflows, whenever

$$\underline{q} > \frac{w_t E[R_{t+1}](1 - \pi\beta)}{(1 - \pi\beta)E[R_{t+1}] + i(1 - \pi)} \qquad (17)$$

Proof

The proposition follows from setting $Nw_t > K_{t+1}$ by solving for $\underline{q}$. *QED*

There is thus the possibility of transitory capital flight in the economy, if (18) holds in the initial stages of development, where wages are low, but not in steady state. Figure 2a summarises our results for the law of motion under standard debt finance graphically for a Cobb-Douglas production technology when (16) holds.

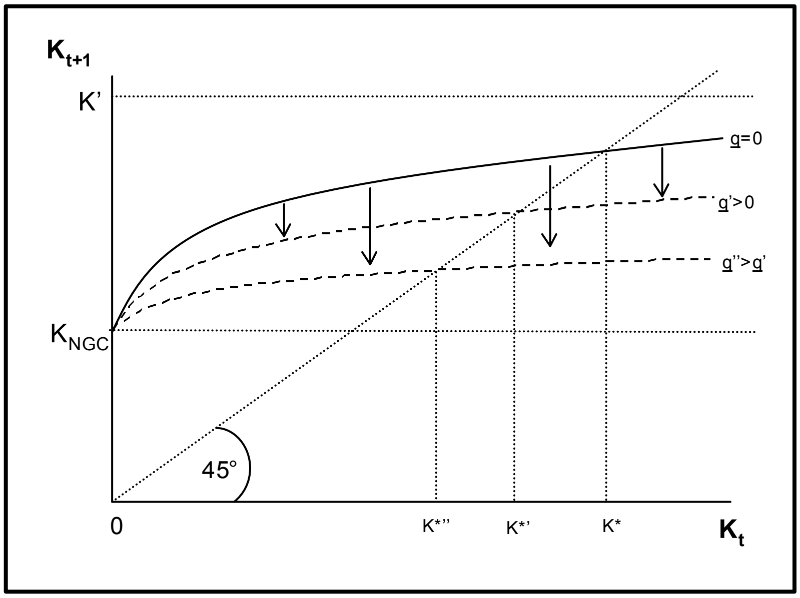

Figure 2a **The Law of Motion for Capital with Steady State Rationing**
For different values of minimum project size $\underline{q}$ under the assumption that there is steady state rationing, i.e. $i < \alpha\pi(\beta-1)/(1-\alpha)(1-\pi)$

Note that K_{t+1} is bounded below by K_{NGC} and above by K'. The dotted curves indicate laws of motion for different values of minimum project size $\underline{q}$ in LM.[14]

In figure 2b, we draw the same for high values of i, i.e. for

[14] Note that even for $\underline{q}$ very large, the t+1 capital stock at $K_t=0$ stays K_{NGC},. Intuitively this is because at $K_{t+1}=K_{NGC}$ the maximum project size is in fact infinite according to NGC' (since the denominator is zero). The behaviour of K_{t+1} for rising $\underline{q}$ with K_t held constant can be seen by differentiating LM with respect to $\underline{q}$, which yields

$$\frac{\delta K_{t+1}}{\delta \underline{q}} = \frac{-1}{1-[F_t - K_t F_{K,t}]\frac{i(1-\pi)(1-\pi\beta)F_{KK,t+1}}{\left[(\pi\beta-1)F_{K,t+1}+i(1-\pi)\right]^2}} < 0 \text{ for } F_{K,t+1}<i(1-\pi)/(\pi\beta-1) \qquad \text{(F8)}$$

This derivative is always negative when NGC is binding, but it goes to zero as K_{t+1} approaches K_{NGC} (since the denominator goes to plus infinity). Thus rising $\underline{q}$ moves the law of motion downwards but the effect dampens out near K_{NGC}, i.e. the laws of motion start at the same point (0, K_{NGC}) but are flatter than that for $\underline{q}$=0, as drawn.

$$i > \frac{\pi(\beta - 1)}{1 - \pi} \frac{\alpha}{1 - \alpha} \quad (18)$$

where we can get convergence to the full information capital stock if the minimum capital stock $\underline{q}$ is not too large.

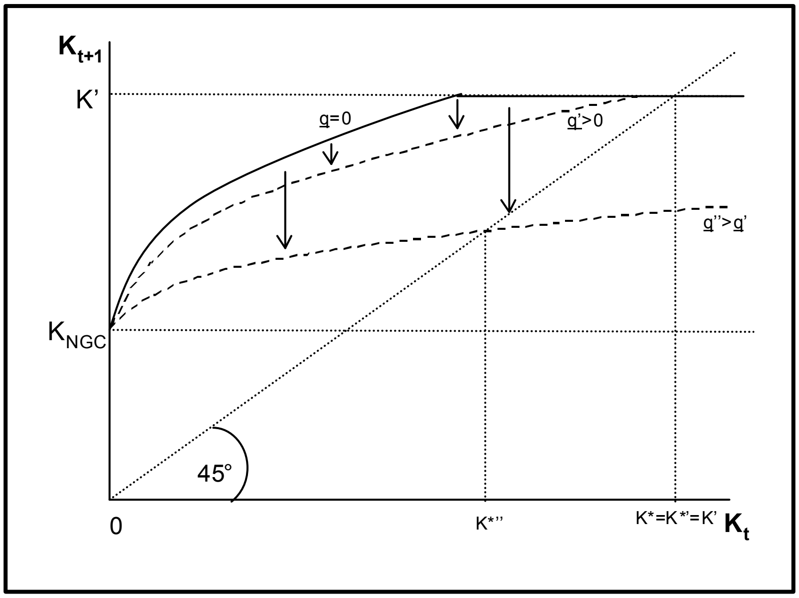

Figure 2b **The Law of Motion for Capital without Steady State Rationing for low $\underline{q}$**
I.e. under the assumption that $i > \alpha\pi(\beta\text{-}1)/(1\text{-}\alpha)(1\text{-}\pi)$

This section thus yields the main results of the paper: despite incentive constraints there exists a single and unique steady state for our financially open model economy. Equivalently, the positive capital at risk effect strictly dominates the negative effect on borrowing constraints from falling profitability of capital. However, contrary to the full information case, incentive compatibility constraints always lead to a time-consuming process of convergence and possibly to capital flight from developing countries. Steady state output and capital are for low values of the international interest rate or sufficient minimum project size strictly lower than the full-information level. That is, some entrepreneurs are rationed in equilibrium: they have projects that could generate the required rate of return, but they do not obtain funds to finance the investment due to incentive constraints.

IV. Comparative Statics: Response to Shocks

4.1 Steady State Capital and the International Interest Rate

As in most models capital markets with limited information, the response of the economy to changes in the interest rate is different from that under full information. Differentiating the steady state capital stock with respect to i yields, under a binding No-Gambling Condition,

$$\frac{\delta k^*}{\delta i}=\frac{1}{\alpha-1}\frac{(1-\pi)\alpha(1-\pi\beta)}{[\alpha(1-\pi\beta)+i(1-\pi)(1-\alpha)]^2}\left[\frac{i(1-\pi)}{\alpha(1-\pi\beta)+i(1-\pi)(1-\alpha)}\right]^{\frac{2-\alpha}{\alpha-1}}<0 \quad (19)$$

This is clearly different from the marginal effect of a change in i under full information

$$\frac{\delta k'}{\delta i}=\frac{1}{\alpha(\alpha-1)}\left[\frac{i}{\alpha}\right]^{\frac{2-\alpha}{\alpha-1}}<0 \quad (20).$$

4.2 Productivity Shocks and the Law of Motion

In order to get the response of K_{t+1} capital to productivity shocks, we add a stochastic shock term θ_t to the production function

$$G(K_t)=\theta_t F(K_t) \quad (21)$$

We thus get the following responses of t+1 capital to shocks in productivity in t and t+1 by implicitly differentiating LM:

$$\frac{\delta K_{t+1}}{\delta\theta_t}=\frac{[F_t-KF_{K,t}]\dfrac{i(1-\pi)}{(\pi\beta-1)E(R_{t+1})+i(1-\pi)}}{1-\theta_t[F_t-K_tF_{K,t}]\dfrac{i(1-\pi)(1-\pi\beta)F_{KK,t+1}}{[(\pi\beta-1)E(R_{t+1})+i(1-\pi)]^2}}>0 \quad (22)$$

A negative shock to period t productivity and thus to the wage rate at time t inevitably reduces period t+1 capital and wealth by tightening the NGC and thus the borrowing limit.

This gives rise to the following proposition:

Proposition 4

If an economy is borrowing constrained due to limited wealth, one-time negative shocks to productivity are propagated to future periods by a credit crunch.

Proof

From (10) and (22) we get

$$\frac{\delta K_{t+n}}{\delta\theta_t} = \prod_{i=1}^{n-1} \frac{\delta K_{t+i+1}}{\delta K_{t+i}} \frac{\delta K_{t+1}}{\delta\theta_t} > o \qquad (23)$$

The effect thus dampens out in future periods whenever

$$\frac{\delta K_{t+i+1}}{\delta K_{t+i}} < 1$$

for all i>0. *QED*

Thus, our model predicts financial conditions (here entrepreneur wealth) to have real effects, as in the "financial accelerator" models of for example Bernanke and Gertler (1989).

Concerning the response to the expected profits of projects we can state the following.

Proposition 5

An expected negative shock to the economy is anticipated by a credit crunch in the preceding period.

Proof

To prove proposition 5 it is sufficient to show that the derivative of K_{t+1} with respect to $E[\theta_{t+1}]$ is positive, leading to a credit crunch as a result of lower expected profits when agents expect a negative shock.

$$\frac{\delta K_{t+1}}{E[\delta\theta_{t+1}]} = N \frac{\left[w_t \frac{i(1-\pi)(1-\pi\beta)E[F_{K,t+1})]}{[(\pi\beta-1)E(R_{t+1}) + i(1-\pi)]^2} + \frac{\gamma^\circ E[F_{K,t+1)}]}{(E(R_{t+1)} - i - \gamma')^2} \right]}{1-\theta_t[F_t - K_t F_{K,t}] \frac{i(1-\pi)(1-\pi\beta)F_{KK,t+1}}{[(\pi\beta-1)E(R_{t+1}) + i(1-\pi)]^2}} > 0 \qquad (24)$$

where

$$E(R_{t+1})=E[G_{K,t+1})]=E[\theta_{t+1}F_{K,t+1}]. \qquad (25) \qquad QED$$

Expected negative shocks to period t+1 productivity thus have an impact on lending in period t by decreasing the maximum size of No-Gambling projects, via the known profit effect.

Conclusion

This study has shown that moral hazard, resulting from information asymmetries in financial markets, may have severe consequences for growth in financially open developing countries. Some important results can be identified. Firstly, we showed that if domestic entrepreneurs can gamble with creditors' money, standard debt finance is constrained by their own capital at risk in their project, as indicated by a No-Gambling Condition similar to that of Hellmann, Murdock, and Stiglitz (2000). This can be an important constraint for capital-poor developing economies.

The constraint was shown to be endogenous in the development process via the effect of growth on capital at risk and profits to capital investment: first of all, there is a threshold for returns to capital above which entrepreneurs never have incentives to gamble. Capital accumulation, by reducing marginal returns to capital and investment, was thus shown to give rise to moral hazard at some point of the development process. However, we also showed that once one takes into account the positive effect of capital accumulation on wealth and thus entrepreneurs' capital at risk, further development alleviates the No-Gambling constraint. The steady state was shown to be unique and stable under Cobb-Douglas production technology, and involves rationing of potentially profitable projects at low international interest rates. Depending on the minimum project size, there can be capital flight from developing countries. Also, one period shocks to our economy have lasting effects in the future, and anticipated shocks effect entrepreneurs' borrowing lines even before they occur.

What could be the appropriate policy responses to the described consequences of moral hazard in emerging market lending?[15] One cause of the problem is clearly the lack of entrepreneurs' own capital. A domestic equity market, built on sound corporate governance, might be able to increase firms' own capital and thus to alleviate incentive constraints for further borrowing from international investors. This obviously introduces another incentive compatibility problem between shareholders and entrepreneurs, which might however lead to less important constraints if information asymmetries within countries are less severe than internationally. Another way of improving on the above situation of moral hazard constrained growth could go via regulatory policy, using the idea of

[15] In our companion paper (Broer 2001) we spell out the policy implications in more detail.

"non-pecuniary penalties" first put forward by Diamond (1984). Given that some of the non-financial inconveniences associated to bankruptcy are certainly under the discretion of governments (preclusion from starting a new business, imprisonment for financial fraud, etc.), government regulation could in fact ease the effect of limited financial liability. If entrepreneurs face punishment above the loss of their capital, this alleviates incentive constraints. In fact, our companion paper shows how this mechanism might actually give government reasons to introduce the kind of guarantees to foreign investors that were so much criticised after the 1997 Asian crisis, as a signal for sound bankruptcy regulations, or because of cost-advantages in domestic, centralised monitoring.

Inevitably, our simple analytical framework gives rise to several possible extensions. First of all, the limitation to standard debt contracts is certainly constraining. In a companion paper (Broer 2001) we look at the role of costly monitoring in this context, where outside investors have the possibility to observe entrepreneurs' investment decisions at a certain cost. This is similar to the domestic framework of Holmström and Tirole (1997) albeit with the difference that we adopt a more general cost structure for monitoring. We call monitoring finance FDI since there are inevitably economies of scale in lending to projects of a given size if increasing the loan does not increase monitoring costs. This then leads to large, "FDI-like", participation by outside investors in projects. We show that with fixed and variable costs for monitoring projects of different size, there is a minimum efficient scale for FDI-projects and thus the possibility of a "gap in the credit supply", where intermediate projects are too small to be monitored and too large to get standard debt finance due to their limited own finance. The role of FDI is most important when borrowing under standard debt contracts is most constrained, since FDI finance is independent of entrepreneur wealth. But monitoring finance always crowds out some standard debt finance due to the profit effect.

Another natural extension of this simple framework would be to adopt a more general probability distribution of projects over size, to show the conditions under which development dynamics can present unstable or multiple equilibria. Furthermore, a more general production function with human capital might be able to show the trade-off between capital-at-risk-increasing accumulation of production capital and productivity-increasing human capital accumulation.

The bottom line of our study seems to be the following: that the benefits that often go unquestioned when talking about the effect of international capital mobility on growth in poor countries might have to be revisited. Even our limited amendment of an otherwise very neo-classical framework, to include limited information about investment choices, has led to a much more pragmatic picture of the effects of international financial liberalisation on development, mainly due to slower convergence to a steady state where some profitable projects might be rationed by international markets.

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