Bank Capital Regulation and Efficiency of Corporate Foreign Investment

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In this paper we develop a banking model to study interdependencies between corporate foreign investment and the capital structure of lending banks. We argue that MNCs have incentives to allocate resources inefficiently in order to save on financing costs. The reason is that the more a bank is refinanced by deposits, the lower are financing costs, but it requires an MNC to commit itself to favor investments in highly tangible assets. We find that bank capital regulation can eliminate this incentive by putting a lower bound on financing costs. However, the new Basel framework is shown to miss this potential.

Keywords: financial contracting; multinational corporations; internal capital markets.

JEL-Codes: G21, F23, G28

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Abstract

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1 Introduction

Minimum requirements for bank capital is one of the most important elements of banking regulation. By influencing lending decisions of internationally active banks, the Basel framework for the international convergence of capital measurement and capital standards (Basel II) mainly strives for further strengthening the stability and efficiency of the international financial system. But regulating bank capital may not only affect the international allocation of funds channeled through the banking system. Instead it may also influence the transnational capital budgeting process within the borrowing companies and thereby affect the allocative efficiency of corporate foreign investments. This aspect has received relatively little attention in the academic discussion.

Our paper aims at filling this gap by addressing the following questions. First, what role do bank loan contracts have for allocating resources across the subsidiaries of multinational corporations (henceforth MNCs)? Second, what are the effects of bank capital regulation on bank loan contracts? And finally, does Basel II account for potential interrelations between the efficiency of firm-internal capital budgeting, loan contracting and capital regulation?

We analyze these questions within a simple model of financial intermediation that captures the two necessary basic features. First, the model takes into account the particular challenges faced by financiers who grant loans to MNCs. Second, banks and the need to regulate them both arise endogenously in the model.[1] Our starting point is the Diamond and Rajan (2000, 2001) framework for analyzing financial intermediation. There, banks emerge as liquidity providers because they are able to pledge their specific loan collection skills. In the model presented below, a banker's ability to extract more from borrowing firms stems from her informational advantage she obtains by monitoring the company-internal resource allocation process. MNCs often operate in countries differing with respect to jurisdiction, regulations and other institutional factors that affect the financiers' valuation of invested resources. Lacking property rights, unpredictable legal decisions, or restrictive labor market regulations, for example, typically reduce this value. Hence, financiers' opportunities to collect much in the event of a default may be limited for institutional reasons in some countries, while they are not in other countries. This potentially generates incentives for MNCs to allocate resources strategically in order to hold up financiers. The role of a bank then is to limit such strategic behavior by monitoring the investment policy of MNCs (Dietrich 2006).

[1] That banks play an important role in financing FDI projects of multinational corporations is documented by, e. g., *Klein, Peek and Rosengren* (2002) and *Marin, Lorentowicz and Raubold* (2003). See also *Desai, Foley and Hines* (2004), who have further examined the financing structure of MNC subsidiaries, particularly in the light of differences in national tax systems.

A major concern for financiers of MNCs here is not that resources could be inefficiently used. Financiers are rather inclined to be more interested in whether resources will be channeled to countries where they are of high value to them in the case of default.[2] In a nutshell, the more resources are put to where they are of their highest value to the bank, the less risky the loan will be for the banker. This lowers the banker's need to issue bank capital in order to protect herself against loan risks, or, to put it differently, increases her ability to refinance loans with deposits. As from the MNC's perspective bank capital is more expensive than deposits, investment in highly tangible assets lowers the firm's financing costs. The flip side of such a bias, however, is that the MNC forgoes investment returns because marginal returns will not be balanced across countries. We show that, while deciding on the firm-internal allocation of resources across national boundaries, MNCs have an incentive to deviate from an efficient resource allocation in order to save on financing costs and thus on bank capital.

The conclusion we draw is twofold. First, there is good news insofar as imposing minimum bank capital requirements can, in principle, improve the efficiency of corporate foreign investment. Since financing costs depend on the capital structure of the lending bank, regulating bank capital can be seen as an incentive device for the borrowing firm as it effectively limits the scope for reducing financing costs at the expense of investment efficiency. Second, there is also bad news as it will be shown that the Internal-ratings based (IRB) approach of the Basel II framework is not appropriately designed to exploit this potential. The reason for this is that, while bank capital regulation is needed to encounter the firms' incentive for inefficient resource allocations, in many cases this incentive is aggravated when the probability of default decreases. Hence, when capital standards are eased because of a decreasing probability of default, the regulator makes bank finance too inexpensive and therefore incites an inefficient resource allocation.

The insight that firm-internal allocation processes do not always work efficiently in the sense that scarce resources are directed to where they are of highest productivity, has already been pointed out. Rajan, Servaes and Zingales (2000), e. g., argue that such inefficiencies arise because of power struggles among division managers. Stein (2002) and Brusco and Panunzi (2005) point to the managers' disincentives with respect to information processing or to exert effort. Scharfstein and Stein (2000) and Inderst and Müller (2003) identify disincentives on the part of headquarters for allocating resources inefficiently. This literature basically does not take the interrelation between bank financing and firms' allocation incentives into account.

[2] Evidence that asset tangibility affects the willingness of lenders to provide funds and, therefore, serves as an important determinant of firms' financial constraints is provided by *Almeida and Campello* (2006).

A second strand of the literature closely related to our analysis is that on the interrelation between bank capital and lending risks. For example, Holmström and Tirole (1997) argued that financial intermediaries, pledging their monitoring services to ultimate financiers, need a sufficient stake in the success of borrowers' projects in order to have an incentive to reduce the probability of default. In a competitive banking sector this has been shown to translate into market-based capital requirements for banks. Unlike their paper, we focus on the borrowers demand for monitoring services. This perspective relates our paper to Allen, Carletti and Marquez (2006). These authors argue that borrowers demand these services in order to commit themselves to behave decently. The main difference to Allen, Carletti and Marquez (2006), however, is that in their model a borrower tends to not fully internalize the cost of bank capital and thus demands a too large a capital-to-asset ratio when these costs are high. In our approach, the borrower indeed ascribes too much weight to financing costs from the perspective of allocative efficiency.

Another related literature is on the assessment of the new Basel rules and how to improve them. For example, Repullo and Suarez (2004) have proposed a net interest income correction for capital requirements on the basis of the Internal ratings-based approach as its charges are too high, especially for high risk loans. Pennacchi (2005) further suggests that procyclicality of bank lending under the new Basel rules can be mitigated when risk-based deposit insurance systems were introduced. Rime (2005) argues that the effective choice between the Standardized and the IRB approach may induce banks to specialize on specific loan risks, with those banks using the Standardized approach taking too much risk and thus jeopardizing the stability of the banking system (see also Repullo 2004).

The paper is organized as follows. In section 2 we present the basic setup of a model of financial intermediation and foreign corporate investment. In section 3 we analyze the interrelation between bank loan contracts and bank capital structure. In section 4 we derive the loan contract that will be chosen in equilibrium by MNCs in absence of bank capital regulation. Section 5 shows that these contracts will lead to allocative inefficiencies and how a regulator can improve on it. In section 6 we critically assess the Basel II framework in the light of our results. The final section gives a brief summary.

2 The basic model

The model captures the general idea of corporate foreign investment. Foreign direct investment projects are long-term decisions of firms. Although those projects may generate some returns in the medium run, interim returns generally do not suffice to repay the initial outlay. Instead, they have to be used for financing follow-up investments, which are necessary for realizing the projects' potential long-term returns on investment. As will be shown, it is this reinvestment that is of special interest because it puts the relationship with external financiers at risk.

2.1 Technology

We consider an internationally operating entrepreneur who owns two plants. The first is located in the entrepreneur's home country while the second is a foreign plant. He (the entrepreneur) can invest 1 EUR into a long-term production technology that comprises two stages. In the first stage (between dates $t = 0$ and $t = 1$), he has to transform the financial investment into one unit of an intermediate (physical investment) good. This good is specific to the entrepreneur's technology. It has thus no value except for company-internal reinvestment at $t = 1$ in the production of a final good, which takes place in the second stage (between dates $t = 1$ and $t = 2$).

Reinvestment of the intermediate good at $t = 1$ may take place at home as well as abroad. Let I denote the quantity of the intermediate good that goes to the foreign plant. When everything is doing well during the second stage of production, the cashflows of projects, due at $t = 2$, are given by $R(1 - I)$ at home and by $R(I)$ abroad, where R is a strictly increasing and concave function with $R'(0) = \infty$.

In order to be a success, producing the final good not only requires the intermediate good, but also the entrepreneur's specific skills. This is because he is the only agent who knows how to appropriately adjust, e. g., the production process or even the characteristics of the final good when market conditions change. Although those changes are, given the overall length of the production, not fully unexpected, it is not possible to identify a proper adjustment policy ex ante. Consequently, the projects cannot generate their potential returns without the entrepreneur's skills in the second stage of production.

2.2 Specificity of human capital

Without employing the entrepreneur's specific knowledge the only way to finalize production is to withdraw the entrepreneur and to replace him by someone else. Such a substitute will necessarily possess less specific skills because this agent has not accompanied the project right from the beginning and is thus less familiar with the markets or with the technology or both. Replacement has thus two implications for what can be squeezed out of the projects.

First, owing to the substitute's lack of knowledge of local peculiarities he cannot run a global enterprise as effectively as the initial entrepreneur could (Dietrich 2004). More precisely, while the substitute possibly runs the home business quite well, he faces some difficulties in finishing the project in the other country, where those difficulties are mainly related to country-specific institutions. For example, the substitute may have to incur additional expenses abroad to learn where and how to get an official license needed for restructuring the production appropriately. In short, project returns tend to be lower abroad than at home when the substitute finishes the second stage of production.

Second, a substitute is less skilled in appropriately fine-tuning the production process in accordance with changing market conditions. The reason here lies, e. g., in the lacking intimacy with consumer needs or with possibilities to refine the technology. As regards market conditions, there are two possible states of nature. With probability p, the state s is good, $s = g$, in the sense that market conditions are relatively easy to handle. Then, the substitute can generate moderate project returns so that the degree of specificity of the original entrepreneur's human capital is low. With probability $1 - p$, the state is bad, $s = b$, and the substitute faces severe problems in adjusting production to market conditions. Returns from the projects are therefore considerably low in the bad state without the help of the initial entrepreneur implying that his human capital is highly specific. As in Diamond and Rajan (2000), the returns achievable by a substitute are thus risky and depend on the state of nature.[3]

We formalize this general idea of specificity of human capital in the following way. Shortly before date $t = 1$, at which the intermediate good is actually reinvested, nature reveals its state s and the degree of specificity of human capital materializes. In state $s = g$, specificity turns out to be low and the substitute can generate relatively high returns of $\beta_g(1 - I_g)$ at home and $\mu\beta_g I_g$ abroad, where $\mu < 1$ is a measure of country-related specificity of the entrepreneur's human capital. In state $s = b$ specificity is high and returns will be only $\beta_b(1 - I_b)$ and $\mu\beta_b I_b$ respectively where $2\beta_b < \beta_g$, i. e. the specificity of human capital exhibits significant risk. Abusing terminology slightly, we will henceforth refer to these returns realizable by a substitute as liquidation value.

Our framework thus reflects two dimensions of human capital specificity. The first, which is captured by μ, relates to the multinational nature of the firm. As regards this country-related specificity of human capital, there is no aggregate risk. The second dimension of specificity, however, is risky and stems from differences in agent's skills to cope with changing market conditions. This dimension is captured by β_s.

2.3 Contracting

If the entrepreneur does not possess sufficient funds W on his own, he needs external financing in order to start production. Since all variables and the state of nature are

[3] The view that the value of a firm's assets to outsiders fluctuates and is therefore risky to them can also be found in *Kiyotaki and Moore* (1997).

assumed to be observable but not verifiable, financial contracting with external financiers not only cannot be made contingent on states but suffers from additional frictions.

Inspired by Hart and Moore (1994), we assume that the entrepreneur cannot commit himself to contribute his specific skills in the second stage, which are needed to convert the intermediate good into the final product. After the intermediate good has been reinvested, the entrepreneur may thus threaten to quit and to withdraw his human capital. As in Diamond and Rajan (2000) and in Hart and Moore (1994), we consider a situation where the entrepreneur has full bargaining power vis-a-vis an external financier at any date. Therefore, the entrepreneur can make a take-it-or-leave-it offer regarding an alternative repayment so that, for a given allocation I_s, repayments actually made at $t = 2$ are bounded by the total value of assets $\Psi_s(I_s) := \beta_s(1 - I_s) + \mu\beta_s I_s$ to financiers. His repayment is thus given by $\min\{H, \Psi_s(I_s)\}$, where H denotes the entrepreneur's repayment obligation.

The problem of external financiers' dependency on the borrowing firm's overall liquidation value is aggravated by another imperfection. If financiers provided funds directly, they would hardly be able to control actual allocation of the intermediate good across the company's subsidiaries at $t = 1$, which however affects the overall liquidation value of assets $\Psi_s(I_s)$. Differences in the respective liquidation values then would generate incentives on the part of the entrepreneur to invest relatively more abroad where financiers would collect only little by liquidating assets. The reason is that, from the entrepreneur's perspective, this strategy improves his bargaining position for renegotiations at $t = 2$ by restraining financiers to some extent from liquidating assets in case he defaults (Dietrich 2006).

The entrepreneur can avoid this additional adverse incentive problem when he opts for a bank loan. The banker possesses a monitoring technology that allows to gather verifiable information about the allocation of the intermediate good. Hence, if parties agree at $t = 0$ on some foreign investment I^* with $I^* \leq 1$, she (the banker) can ensure that the entrepreneur indeed does exactly transfer I^* across borders.

The terms of the loan contract, i. e. foreign investments I^* and the repayment obligation H^*, can be renegotiated already at $t = 1$ when parties have learned the state of nature. The entrepreneur then can make a take-it-or-leave-it-offer to repay $\tilde{H}$ instead of H^* to the banker and to invest according to some profile $\tilde{I}$. As the entrepreneur has all the bargaining power, the banker can either agree to replace the initial contract by the new offer, so that the entrepreneur invests according to $\tilde{I}$, or she can reject the offer, in which case the initial contract remains in place and the entrepreneur invests I^* abroad.[4]

[4] As we shall see, this bargaining structure neither excludes offers to direct more resources to the foreign plant than originally agreed upon, i. e. $\tilde{I} > I^*$, nor that such offers will necessarily be rejected in equilibrium.

Finally, since all agents are risk-neutral, financiers are willing to bridge the entrepreneur's financial gap only if payments they expect to receive cover the opportunity costs of funding. The net return on alternative investments is assumed to be zero, financiers thus simply require to get their money back.

3 Bank finance

In this section, we discuss the basic principles of bank finance in two steps. First, we investigate the allocation decision of the entrepreneur at $t = 1$ resulting from renegotiations with the banker. Second, we discuss the banker's refinancing opportunities.

3.1 Renegotiations and resource allocation

As outlined above, the allocation of the intermediate good across domestic and foreign plants is determined by renegotiations between the entrepreneur and the banker at $t = 1$, when the entrepreneur offers to repay $\tilde{H}$ and to invest $\tilde{I}$ abroad after he and the banker have learned the state of nature. The initial loan contract then merely serves to define the scene on which renegotiations take place. If the banker accepts the new offer, the entrepreneur will repay $\min\{\tilde{H}, \Psi_s(\tilde{I})\}$ to the banker at $t = 2$. If, however, the banker rejects the offer, the initial contract remains in place, foreign investment is I^*, and the entrepreneur will repay $\min\{H^*, \Psi_s(I^*)\}$ at $t = 2$. Consequently, the banker accepts an offer of the entrepreneur if and only if

$$\min\{\tilde{H}, \Psi_s(\tilde{I})\} \geq \min\{H^*, \Psi_s(I^*)\} \tag{1}$$

holds true. As the banker can insist on the initial contract, (1) implies that there is both, a lower bound for acceptable new repayment offers $\tilde{H}$ and an upper bound for acceptable new foreign investment offers $\tilde{I}$.

In renegotiations, the entrepreneur makes an offer that maximizes his profits, i. e.

$$\max_{\tilde{H},\tilde{I}} R(1-\tilde{I}) + R(\tilde{I}) - \min\left\{\tilde{H}, \Psi_s(\tilde{I})\right\} - W, \tag{2}$$
$$s.t.\,(1).$$

The resulting investment pattern at $t = 1$ and the actual repayment of the entrepreneur at $t = 2$ are thus given by

Lemma 1 *A loan contract with I^* and H^* implies that the entrepreneur allocates resources at $t = 1$ according to*

$$I_s = \min\left\{\tfrac{1}{2}, \max\left\{\tfrac{\beta_s - H^*}{(1-\mu)\beta_s}, I^*\right\}\right\} \tag{3}$$

and offers a repayment such that the banker will get $\min\{H^*, \Psi_s(I^*)\}$ *at $t = 2$.*

Proof. See Appendix. ■

Lemma 1 reflects the principle that the banker always gets the same amount from the entrepreneur as under the initial loan contract. This principle translates to the entrepreneur being forced either to fully meet his initial repayment obligation H^*, or to invest no more than I^* abroad. When the initially agreed upon foreign investment I^* and the repayment obligation H^* are small enough to ensure that the entrepreneur does not default, $\Psi_s(I^*) \geq H^*$, the banker will insist on full repayment of H^*. As regards investment, she is willing to make concessions, i. e. she allows the entrepreneur to invest more than I^* abroad as long as this does not reduce his repayment. When $\Psi_s(I^*) < H^*$ holds true, default of the entrepreneur cannot be avoided even by enforcing the initial contract. In this case, the banker will not accept any foreign investment beyond I^* as this would further decrease what she can collect at $t = 2$.

Total project returns at $t = 2$ are higher, the more symmetric the entrepreneur's reinvestment is at $t = 1$, i. e. the closer is I_s to $\frac{1}{2}$.[5] Therefore, he will allocate exactly half of the intermediate good abroad, $I_s = \frac{1}{2}$, as long as the banker accepts this. Otherwise, the entrepreneur will invest the maximum quantity of the intermediate good abroad that is acceptable for the banker. The degree of investment symmetry is thus higher, the lower the repayment obligation H^* is and the higher is I^*, since the banker then is willing to make more concessions concerning investment. The same is true when the state of the world is good. Then, the liquidation value of projects is relatively high so that default of the entrepreneur is less likely, implying more leeway to renegotiate the investment pattern. Consequently, the good state tends to be associated with both, higher repayments of the entrepreneur and more symmetric investments than the bad state.[6]

[5] Note that, because of the same production technology R applying to both plants, the more symmetrically resources are invested, the more efficient is the allocation.

[6] Desai (2007) provides anecdotal evidence for MNCs renegotiating the terms of a loan, in particular amendments such as new capital expenditures and other asset acquisitions, in times when credit markets have gained strength.

3.2 Bank capital structure and financing costs

Thus far, we have only been concerned with the asset side of the bank's balance sheet. We next analyze its capital structure, which is important for the entrepreneur's financing costs.

The banker is the only agent who can monitor the entrepreneur. Hence, she might hold her financiers up by threatening to withdraw her monitoring skills once the initial investment is sunk. Diamond and Rajan (2000, 2001) have shown that demandable deposits allow a banker to commit herself to refrain from doing so. Deposits are payable on demand according to a first-come-first-served principle. This creates a collective action problem among depositors such that any attempt of the banker to renegotiate the face value D of deposits will result in a bank run. The threat of a run effectively deters the banker from ever renegotiating with depositors, as a run would ultimately exclude the banker from access to her assets and thus drive her rents to zero.

The downside of deposits is, however, that they cannot be renegotiated even in bad times, when the banker collects less from the entrepreneur than what she owes to depositors. Then, a bank run is inevitable. Given that a run definitely excludes a banker for all times from carrying on banking, the banker is unwilling to agree on any contractual arrangement that is associated with a positive probability of a bank run.[7] Since avoiding runs for all states can only be achieved when deposits are limited to what the banker can repay in the worst state, their face value D is restricted to $D_{\max} := \min\{H^*, \Psi_b(I^*)\}$, which according to lemma 1 is the minimum repayment of the entrepreneur to the banker.

The banker can also issue capital to refinance herself. Capital is not subject to a first-come-first-served principle, but assigns some specific rights to shareholders. They give bank shareholders some bargaining power vis-a-vis the banker. We will not explicitly model bargaining between shareholders and the banker, but assume, consistently with Diamond and Rajan (2000), that shareholders get only half of the banker's loan earnings net of deposits and that the banker diverts the other half as her personal rents. At $t = 2$, the entrepreneur will thus pay $\min\{H^*, \Psi_s(I^*)\}$ to the banker, of which depositors will receive D while the remainder will be equally split between shareholders and the banker.

The setting for the analysis of the banker's refinancing opportunities is herewith established. As the banker is assumed to possess no funds on her own, she has to borrow a total of $1-W$ from her financiers. Given a zero net return on the alternative investment,

[7] See *Diamond and Rajan* (2000) for an in depth analysis of a banker's choice between safe and risky deposit contracts.

borrowing is possible only if depositors and shareholders can expect to get a repayment of at least $1 - W$. The participation constraint of the banker's financiers thus reads as

$$p\left[D + \tfrac{1}{2}\left(\min\{H^*, \Psi_g(I^*)\} - D\right)\right] + (1-p)\left[D + \tfrac{1}{2}\left(\min\{H^*, \Psi_b(I^*)\} - D\right)\right] \geq 1 - W. \tag{4}$$

Since expected repayments of the entrepreneur, that is his financing costs, are $P(H^*, I^*) := p\min\{H^*, \Psi_g(I^*)\} + (1-p)\min\{H^*, \Psi_b(I^*)\}$, condition (4) can be rearranged to

$$P(H^*, I^*) - 2(1 - W) + D \geq 0. \tag{5}$$

The volume D of deposits thus establishes a lower bound on financing costs. Intuitively, the more the bank is financed by deposits, the cheaper it becomes for the entrepreneur to obtain financing. Every additional Euro of deposits makes one Euro of capital plus one Euro of banker's rents redundant so that minimum financing costs decrease by one Euro.

4 Disincentives for financial contracting

We next investigate the terms of the loan contract as agreed upon between the entrepreneur and the banker at $t = 0$. With foreign investment I^* and the repayment obligation H^*, the contract has two dimensions. A reasonable way is thus to proceed in two steps. First, we identify the optimum H^* for some given contractual allocation I^*, and discuss the resulting financing costs and actual resource allocation. Second, we determine that I^*, which finally maximizes the entrepreneur's expected profits, and analyze the implied investment efficiency.

4.1 Contractual repayment obligations

For a given I^*, the entrepreneur seeks to minimize the repayment obligation H^* as this maximizes his expected profits for two reasons, both following from lemma 1. The first is that, in each state, a lower H^* gives him more leeway to invest resources efficiently irrespective of I^*, and more efficient investment increases returns. The second reason is that his financing costs $P(H^*, I^*)$ decrease in H^*. Consequently, if there are repayment obligations H^* satisfying the participation constraint (5), the entrepreneur always offers the smallest possible one that meets this constraint. Intuitively, suppose that the entrepreneur offered $H^* = 0$. Then both, expected repayments to financiers and deposits issued by the banker, would be zero, and condition (5) would be violated. Therefore, the entrepreneur must raise his offer H^*. One the one hand, this increases expected repayments $P(H^*, I^*)$ and thus eases constraint (5). On the other hand, a higher H^*

also allows the banker to issue more deposits, and, to save on financing costs, the entrepreneur will force the banker to indeed maximally increase the volume of deposits up to $D_{\max}$. After all, he thus raises H^* until financiers are marginally willing to accept. For a given I^*, the profit maximizing H^*, henceforth denoted by $h(I^*)$, is implicitly defined by

$$\min\left\{h(I^*), \Psi_b\left(I^*\right)\right\} + \tfrac{p}{2}\left(\min\left\{h(I^*), \Psi_g\left(I^*\right)\right\} - \min\left\{h(I^*), \Psi_b\left(I^*\right)\right\}\right) = 1 - W. \quad (6)$$

From the so defined profit maximizing repayment obligation and the associated optimal volume of deposits $d(I^*) = \min\left\{h(I^*), \Psi_b\left(I^*\right)\right\}$, we can derive the resulting entrepreneur's financing costs and resource allocation:

Lemma 2 *For a given $I^* \leq 1$, the profit maximizing repayment obligation $h(I^*)$, the associated volume of deposits $d(I^*)$, as well as the implied entrepreneur's financing costs $P\left(h(I^*), I^*\right)$ and actual resource allocation $\iota_s(I^*)$ in state s have the following properties:*

1. *if*

$$W \geq 1 - \Psi_b\left(I^*\right), \quad (7)$$

then

$$\begin{aligned} h(I^*) &= d(I^*) = P\left(h(I^*), I^*\right) = 1 - W, & (8)\\ \iota_g(I^*) &= \tfrac{1}{2}, & (9)\\ \iota_b(I^*) &= \min\left\{\tfrac{1}{2}, \tfrac{\beta_b - (1-W)}{(1-\mu)\beta_b}\right\}, & (10)\end{aligned}$$

2. *if*

$$1 - \Psi_b\left(I^*\right) > W \geq W_{\min}\left(I^*\right), \quad (11)$$

then

$$\begin{aligned} h(I^*) &= \Psi_b\left(I^*\right) + \tfrac{2}{p}\left[(1-W) - \Psi_b\left(I^*\right)\right], & (12)\\ d(I^*) &= \Psi_b\left(I^*\right), & (13)\\ P\left(h(I^*), I^*\right) &= (1-W) + \left[(1-W) - \Psi_b\left(I^*\right)\right], & (14)\\ \iota_g(I^*) &= \min\left\{\tfrac{1}{2}, \tfrac{\beta_g - h(I^*)}{(1-\mu)\beta_g}\right\}, & (15)\\ \iota_b(I^*) &= \min\left\{\tfrac{1}{2}, I^*\right\}, & (16)\end{aligned}$$

where

$$W_{\min}\left(I^*\right) := 1 - \Psi_b\left(I^*\right) - \tfrac{p}{2}\left[\Psi_g\left(I^*\right) - \Psi_b\left(I^*\right)\right], \quad (17)$$

3. *if $W_{\min}\left(I^*\right) > W$, then the entrepreneur cannot obtain a loan with I^*.*

Proof. See Appendix. ■

The lemma states that in order to economize on financing costs, the entrepreneur forces the banker to refinance the loan primarily with deposits and to issue bank capital to the least possible extent. There is, however, an upper bound for both deposits and capital. Intuitively, the agreement I^* on foreign investment defines the entrepreneur's threat point for renegotiations at $t = 1$, which pinpoints his maximum possible repayment for each state. The maximum repayment in the bad state, $\Psi_b(I^*)$, specifies the maximum volume of deposits, while the maximum repayment in the good state, $\Psi_g(I^*)$, limits the maximum volume of additional bank capital to $\frac{p}{2}[\Psi_g(I^*) - \Psi_b(I^*)]$.

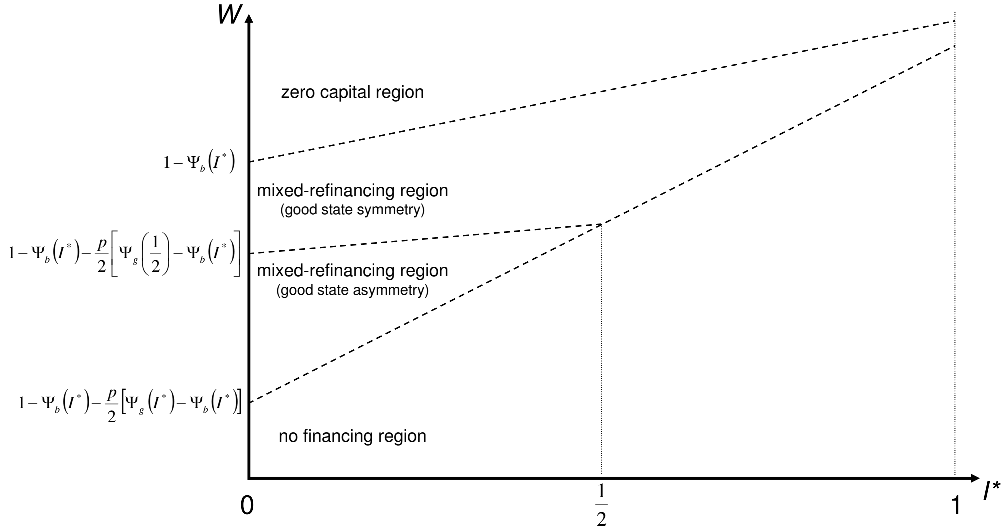

Figure 1: Contracting options.

Based on these upper bounds, lemma 2 distinguishes three basic regions with combinations of contractual allocations I^* and financial endowments W of the entrepreneur establishing the borders between them. They are depicted in figure 1. In the first region, defined by (7), the maximum volume of deposits $\Psi_b(I^*)$ suffices to cover the entrepreneur's financing needs $1 - W$ completely. Consequently, he forces the banker to refinance herself by deposits only, so that she issues no bank capital. In this *zero capital* region, the entrepreneur promises to repay $h(I^*) = 1 - W$ and will always meet this obligation. Put differently, the contractual allocation I^* is sufficiently small (compared to W) to deter him from defaulting in any state. This, however, also means that the entrepreneur can renegotiate I^* in both states, so that his actual investment pattern is never restricted by I^*. With $\beta_g \geq 2\beta_b$, this leads to symmetric investments in the good state. Note that internal funds required for deposit-only refinanced debt are increasing in I^*. This is because a higher agreed upon foreign investment worsens the banker's bargaining position vis-a-vis the entrepreneur and thus reduces her capability to issue deposits by $(1-\mu)\,\beta_b$.

In the second region, defined by (11), the maximum volume of deposits falls short of the entrepreneur's external financing needs. The bank loan must therefore be refinanced in part with bank capital, giving the banker some leeway to extract rents. The repayment obligation $h(I^*)$ then is the sum of deposits, $\Psi_b\,(I^*)$, the payment to bank shareholders in the good state such that they agree to fill the financial gap, $\frac{1}{p}\left[(1-W)-\Psi_b\,(I^*)\right]$, and the banker's rent, which is equal to what shareholders get. Hence, for this *mixed-refinancing* region, the contractual foreign investment I^* is too large (relative to W) to allow for a loan in which the entrepreneur credibly promises a state-independent repayment. Instead, the entrepreneur will default in the bad state. Then, however, he cannot renegotiate I^* since the banker never permits to deviate from I^* in the case of default. Consequently, the entrepreneur is forced to invest at most I^* abroad in the bad state, and he will fully exploit this opportunity as long as it does not allow for symmetric investment.

In the good state, the entrepreneur can, in principle, renegotiate foreign investment because he is capable of complying with the promised repayment. As regards the outcome of renegotiations, lemma 2 suggests to further divide mixed-refinancing into two subregions. The first subregion is where the initial endowment W of the entrepreneur is relatively high compared to I^*, such that (11) and

$$W \geq 1-\Psi_b\,(I^*)-\tfrac{p}{2}\left[\Psi_g\left(\tfrac{1}{2}\right)-\Psi_b\,(I^*)\right], \tag{18}$$

are both met. Here, the entrepreneur's need for external financing and thus his repayment obligation is sufficiently small to let the banker accept symmetric investment in the good state. This subregion will henceforth be labeled as the *good state symmetry* subregion. The second subregion is where the initial endowment of the entrepreneur is relatively small, i. e. (11) holds but (18) is not met. Then, his repayment obligation $h(I^*)$ is too high to allow for symmetric investment in the good state. Consequently, in this *good state asymmetry* subregion, the entrepreneur invests the maximum amount abroad which marginally allows him to repay $h(I^*)$. Note that an entrepreneur with the smallest possible $W_{\min}\,(I^*)$, as defined in (17), can no longer renegotiate I^* in the good state, but must invest according to I^* in any state. As deposits are restricted to $\Psi_b\,(I^*)$ and additional bank capital is limited to $\frac{p}{2}\left[\Psi_g\,(I^*)-\Psi_b\,(I^*)\right]$, the entrepreneur can start production only if he is able to bridge the resulting financial gap $W_{\min}\,(I^*)$ with internal funds, which is increasing in I^* by $(1-\mu)\left[\beta_b+\frac{p}{2}\,(\beta_g-\beta_b)\right]$ since a higher I^* widens the scope for renegotiating repayments, as shown above, thereby lowering the entrepreneur's credit worthiness.

In the third region, the entrepreneurs' endowment falls short of $W_{\min}(I^*)$. Consequently, their credible repayments are to small to raise a loan with I^* in this *no financing* region.

4.2 Contractual allocation rules

The last step in characterizing the loan contract is to determine the contractual foreign investment I^*. The preceding section has shown that in the the zero capital region financing costs and the efficiency of reinvestment patterns do not depend on I^*. Consequently, the entrepreneur is indifferent between all I^* as long as they allow for deposit-only refinancing. In the mixed-refinancing region, however, the entrepreneur faces a tradeoff when deciding upon I^*. On the one hand, lowering I^* serves as an additional commitment device to repay loans so that the banker can issue more deposits. This allows to reduce the financing costs, because the entrepreneur can save on the banker's rent by lowering the share of the loan refinanced by bank capital. Therefore, the repayment obligation of the entrepreneur can decrease, giving him more leeway to allocate resources efficiently in the good state. On the other hand, an increase in I^* allows for more efficient investment in the bad state.

Given this tradeoff between lowering financing costs and enhancing allocative efficiency, it never pays for the entrepreneur to conclude a contract with $I^* > \frac{1}{2}$ allowing him to invest more resources abroad than at home. While an increase of I^* beyond $\frac{1}{2}$ does not affect investment as it will then be already symmetric in either state, it worsens the banker's ability to issue deposits and thus tends to raise the financing costs of the entrepreneur. Consequently, a contract containing $I^* > \frac{1}{2}$ never makes him better off than a contract with $I^* = \frac{1}{2}$. We can therefore restrict attention to contracts with $I^* \leq \frac{1}{2}$.

The above tradeoff leads to our first main conclusion.

Proposition 1 *The equilibrium contractual allocation rule I^*_{eq} is given by*

1. *if $W \geq 1 - \Psi_b\left(\frac{1}{2}\right)$, then*

$$I^*_{eq} = \tfrac{1}{2}, \tag{19}$$

2. *if $1 - \Psi_b\left(\frac{1}{2}\right) > W \geq 1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right]$, then*

$$I^*_{eq} = \max\left\{I^*_2, I^*_3\right\} < \tfrac{1}{2}, \tag{20}$$

3. *if $1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right] > W \geq 1 - \Psi_b(0) - \frac{p}{2}\left[\Psi_g(0) - \Psi_b(0)\right]$, then*

$$I^*_{eq} = \min\left\{I^*_1, \max\left\{I^*_2, I^*_3\right\}\right\} < \tfrac{1}{2}, \tag{21}$$

4. if $1 - \Psi_b(0) - \frac{p}{2}[\Psi_g(0) - \Psi_b(0)] > W$*, then the entrepreneur cannot raise a loan at all,*

where I_1^**,* I_2^* *and* I_3^* *are implicitly defined by*

$$\begin{aligned} W &= 1 - \Psi_b(I_1^*) - \tfrac{p}{2}[\Psi_g(I_1^*) - \Psi_b(I_1^*)], & (22)\\ W &= 1 - \Psi_b(I_2^*), & (23)\\ 0 &= (1-p)[R'(I_3^*) - R'(1-I_3^*)] & (24)\\ &\quad - (2-p)\tfrac{\beta_b}{\beta_g}[R'(\iota_g(I_3^*)) - R'(1-\iota_g(I_3^*))] - (1-\mu)\beta_b. \end{aligned}$$

Proof. See Appendix. ∎

Proposition 1 distinguishes four groups of entrepreneurs differing in their respective initial financial endowment W. The first group comprises entrepreneurs with $W \geq 1 - \Psi_b\left(\frac{1}{2}\right)$, who are effectively too wealthy to face the above tradeoff. For them, any combination of W and $I^* \leq \frac{1}{2}$ belongs to the zero capital region. Therefore, they commit to repay $1 - W$ for any circumstance and thus minimize financing costs by demanding a loan that is completely refinanced by deposits. Besides, they choose a contractual foreign investment $I^* = \frac{1}{2}$, which allows them to invest symmetrically and thus efficiently in each state (see figure 2).

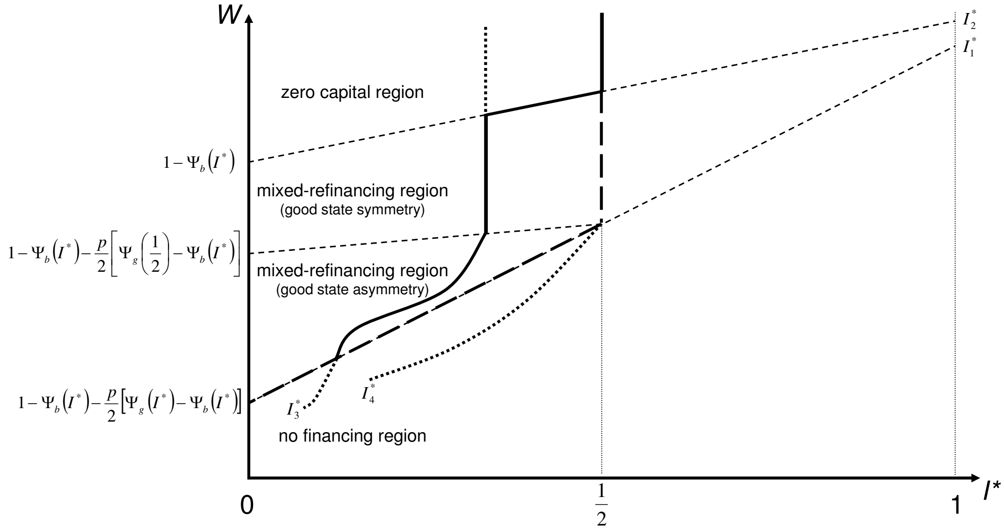

Figure 2: Equilibrium (solid) versus socially efficient (dashed) contractual foreign investment.

Entrepreneurs with $1 - \Psi_b\left(\frac{1}{2}\right) > W \geq 1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right]$ form the second group. They face the aforementioned tradeoff between investing efficiently and minimizing financing costs. An entrepreneur in this group can, in principle, ensure symmetric investment by setting $I^* = \frac{1}{2}$. He will not do so, however, since this would require refinancing the loan by both, deposits and capital. Instead, the entrepreneur lowers I^* either until he reaches I_2^*, where the zero capital region begins, so that a further decrease of financing costs is no longer feasible, or until he reaches I_3^*, where marginal benefits from reducing financing costs equal the marginal costs from inefficient investments. As regards the latter, only bad state investments are relevant for him since in this group entrepreneurs are sufficiently wealthy to invest symmetrically in the good state anyway.

The third group of entrepreneur has an initial wealth in the range $1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right] > W \geq 1 - \Psi_b(0) - \frac{p}{2}\left[\Psi_g(0) - \Psi_b(0)\right]$. In principle, entrepreneurs in this group are confronted with the same tradeoff as the second group. As their endowment is even smaller, however, they cannot conclude a loan with $I^* = \frac{1}{2}$. Instead, the highest possible contractual foreign investment for them is $I_1^* < \frac{1}{2}$, where I_1^* is defined by (22). Hence, when I_1^* is stipulated, the loan is refinanced partly by bank capital, and implies that foreign investment is I_1^* regardless of the state. By further lowering I^* below I_1^*, entrepreneurs in this third group cannot only lower their financing costs as it was the case for the second group. Instead, they can also use the additional leeway they obtain for more symmetric investment in the good state until either the marginal benefits and costs of reduction are equal, or the zero capital region is reached. But for the poorest entrepreneurs in this group, it can be even the case that the benefits from reducing I^* never outweigh the loss of investment symmetry in the bad state so that they stipulate I_1^* in the loan contract.

Entrepreneurs with an initial endowment smaller than $1 - \Psi_b(0) - \frac{p}{2}\left[\Psi_g(0) - \Psi_b(0)\right]$ are in the forth group. They are too poor to obtain a loan. Even if they committed to make no foreign investment at all, $I^* = 0$, they would be unable to credibly promise a repayment that would convince the banker's financiers to provide the funds needed for investment.

5 Investment efficiency and minimum capital requirements

In this section, we derive the next two main results of the paper. We shall demonstrate that from the perspective of a social planner, at least some entrepreneurs choose a loan contract that leads to an inefficient investment pattern. We will also show that imposing minimum capital requirements for banks is, in contrast to direct financing, appropriate to always fully eliminate investment inefficiencies arising from the tradeoff between lowering financing costs and balancing marginal returns.

5.1 Inefficiency of bank loan contracts

When writing financial contracts, entrepreneurs tend to care not only about the returns that can be realized but also on their respective financing costs. These costs comprise both, the initial outlay of 1 EUR for the physical investment at $t = 0$ and the rents paid to the banker, which depend on the bank's capital structure. From a social planner's point of view, the latter should be irrelevant as they are only a matter of a redistribution of returns. Accordingly, a social planner would like to force the entrepreneur to choose the loan such that the expected net returns of investment are maximized. This leads to our second main conclusion. Given the existing difficulties in financial contracting, the socially efficient contractual foreign investment is characterized as follows.

Proposition 2 *Let I^*_{eff} denote the socially efficient contractual foreign investment.*

1. *If $W \geq 1 - \Psi_b\left(\frac{1}{2}\right)$, then*

$$I^*_{eff} = \tfrac{1}{2} = I^*_{eq}, \tag{25}$$

2. *If $1 - \Psi_b\left(\frac{1}{2}\right) > W \geq 1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right]$, then*

$$I^*_{eff} = \tfrac{1}{2} > I^*_{eq}, \tag{26}$$

3. *if $1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right] > W \geq 1 - \Psi_b(0) - \frac{p}{2}\left[\Psi_g(0) - \Psi_b(0)\right]$, then*

$$I^*_{eff} = I^*_1 \geq I^*_{eq}, \tag{27}$$

when the probability of default $1-p$ is not too small, i. e. when $1 - p > \frac{\beta_b}{\beta_g - \beta_b}$, and

$$I^*_{eff} = I^*_4 \geq I^*_{eq} \tag{28}$$

otherwise, where I^*_4 is implicitly defined by

$$0 = (1-p)\left[R'\left(I^*_4\right) - R'\left(1 - I^*_4\right)\right] - (2-p)\frac{\beta_b}{\beta_g}\left[R'\left(\iota_g\left(I^*_4\right)\right) - R'\left(1 - \iota_g\left(I^*_4\right)\right)\right]. \tag{29}$$

Proof. See Appendix. ■

The proposition shows that at least for some entrepreneurs, the socially efficient allocation I^*_{eff} is above the actually chosen I^*_{opt} as given in proposition 1 (see figure 2). That is, the socially efficient loan contract tends to allow for higher investments abroad. This is because entrepreneurs, as opposed to a social planner, tend to favor reinvestments at home in the bad state in order to save on bank capital and thus on banker's rents.

An exception of this principle is the first group of entrepreneurs with $W \geq 1 - \Psi_b\left(\frac{1}{2}\right)$. They possess plenty of internal funds so that bank capital is irrelevant to them.

Therefore, they already choose a loan with $I^* = \frac{1}{2}$ which allows them to always invest symmetrically as a social planner would like them to do.

For the second group of entrepreneurs with $1 - \Psi_b\left(\frac{1}{2}\right) > W \geq 1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right]$, the social optimum is also characterized by investment symmetry in either state. Entrepreneurs in this group will, however, not implement this as long as their choice of the bank loan is unrestricted. Instead, they commit themselves to invest less than half of the intermediate good abroad in the bad state, since this allows them to obtain a loan with a higher share of deposits, thereby making a smaller expected repayment to the banker.

The third group of entrepreneurs with $1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right] > W \geq 1 - \Psi_b(0) - \frac{p}{2}\left[\Psi_g(0) - \Psi_b(0)\right]$ is too poor to obtain a loan with $I^* = \frac{1}{2}$ so that they cannot always invest symmetrically. Consequently, in the social optimum, project returns in the good and in the bad state are traded off. For this group, we can distinguish two cases. The first is when the probability of default (PD) is relatively high, $1 - p > \frac{\beta_b}{\beta_g - \beta_b}$, so that a social planner is mainly interested in investment efficiency in the bad state. He would then find it optimal to incite entrepreneurs in this group to make more symmetric investments in the bad state than in the good state. This, however, is impossible under a bank loan contract since the contractual foreign investment cannot be made state contingent. That is, a relatively symmetric investment in the bad state requires a high I^* on which the entrepreneur would insist in the good state as well. The best that a social planner can do in this case is to enforce the maximum feasible contractual foreign investment I_1^*, as depicted in figure 2, so that the investment pattern is the same in each state. This, however, implies that marginal expected returns from investments in both states are not balanced. The second case is when PD is relatively small with $1 - p \leq \frac{\beta_b}{\beta_g - \beta_b}$. A balancing of marginal returns then is feasible and can be implemented by choosing I_4^*.

5.2 Direct financing

We have seen that for entrepreneurs with initial endowments below $1 - \Psi_b\left(\frac{1}{2}\right)$, a bank loan necessarily implies inefficient investments. A remedy for this problem could be direct financing. In contrast to a banker, financiers who lend directly cannot control the resource allocation at $t = 1$. From the viewpoint of the entrepreneur (and a social planner), this has two advantages. The first is that the entrepreneur can always invest symmetrically, because he is not effectively restricted in his reinvestment decision. The second is that no bank capital is needed, because there is no banker potentially withholding her skills. The downside of direct financing is, however, that unskilled financiers have a very weak bargaining position vis-a-vis the entrepreneur when he decides upon resource allocation at $t = 1$. Therefore, only a limited number of entrepreneurs has access to direct financing.

In principle, a loan provided by unskilled financiers is identical to a bank loan with $I^* = 1$, since the entrepreneur can, at worst, threaten to allocate all resources to the foreign plant at $t = 1$. It therefore follows from lemma 1 that the entrepreneur can at most promise to repay $\Psi_s(1)$ in state s to his unskilled financiers. Consequently, the maximum size of a loan granted by means of direct financing is $p\Psi_g(1) + (1-p)\Psi_b(1)$, so that his financial endowment must be at least

$$W \geq 1 - p\Psi_g(1) - (1-p)\Psi_b(1).$$

With the help of this minimum financial endowment for obtaining a loan from unskilled financiers, we can investigate whether or not direct financing helps to improve overall investment efficiency. Recall from proposition 1 that the first group of entrepreneurs with $W \geq 1 - \Psi_b\left(\frac{1}{2}\right)$ concludes a bank loan contract with $I^* = \frac{1}{2}$ that implies symmetric investments in either state. As long as only this group has access to direct financing, i. e. as long as

$$\mu \leq \frac{\frac{1}{2}\beta_b}{p(\beta_g - \beta_b) + \frac{1}{2}\beta_b} \tag{30}$$

holds true, direct financing will not lead to more efficient investment patterns. If (30), however, is not met, direct financing is also available to at least some entrepreneurs who would, according to proposition 1, agree on a bank loan with $I^* < \frac{1}{2}$. Consequently, direct financing then improves investment efficiency by allowing these entrepreneurs to make symmetric investments and they will indeed demand direct finance because this makes them better off than a bank loan.

To conclude, direct financing cannot generally eliminate the problem of inefficient investment, because it is not necessarily available to every entrepreneur. The extent to which it mitigates the problem depends, inter alia, on μ and β_b, as can be seen from (30). First, it is less suitable, the smaller is μ since this makes the threat to invest everything abroad more painful for financiers, so that fewer entrepreneurs can obtain direct financing. Second, it is also less suitable, the higher is β_b since this allows more entrepreneurs to refinance a bank loan with symmetric investments by deposits only.

5.3 Optimal bank capital regulation

Proposition 2 has shown that the arising inefficiencies in financial contracting are basically associated with a too low level of bank capital. Imposing capital standards for banks might therefore be a remedy for this problem. Indeed, we will show that with minimum capital requirements a regulator can eliminate the above disincentives in financial contracting provided the rules are properly designed.

In order to define a bank's capital-to-asset ratio, we need a closer look at a bank's balance sheet at $t = 0$. In accordance with accounting standards, the loan is booked on the asset side with its face value $1 - W$ (which is the amount borrowed by the entrepreneur), while liabilities consist of deposits with face value D and capital. The book value of capital is, owing to the adding-up constraint, equal to $1 - W - D$. Hence, the capital-to-asset ratio k at $t = 0$ is defined as

$$k := \tfrac{1-W-D}{1-W}. \tag{31}$$

At $t = 1$, after the banker and the entrepreneur have reached an agreement in renegotiations, the banker is redundant. Then, capital standards no longer restrict the banker for two reasons. First, she could simply sell the loan at a price equal to what she would get from the entrepreneur at $t = 2$. Second, she could unlimitedly issue further bank capital without extracting further rents because her monitoring skills are no longer required from date $t = 1$ onwards.

In essence, a regulatory minimum requirement k^{reg} on bank capital effectively places an upper bound $D^{reg} := (1 - k^{reg})(1 - W)$ on the volume of deposits issued by the bank at $t = 0$. With this instrument at hand, the regulator can restrict the set of loan contracts available. Using this tool wisely, the regulator can even enforce the socially optimal contract for each entrepreneur, which is our third main conclusion.

Proposition 3 *For every entrepreneur with $W < 1 - \Psi_b\left(\frac{1}{2}\right)$ there is an optimal minimum capital-to-asset ratio k^{reg} satisfying*

$$k^{reg} = \tilde{k} := \tfrac{1-W-\Psi_b(I^*_{eff})}{1-W} \tag{32}$$

which completely eliminates the incentive to stipulate inefficient contractual maximum foreign investment.

Proof. omitted. ■

The intuition for proposition 3 is the following. According to (32) and lemma 2, the efficient contractual foreign investment I^*_{eff} is associated with a specific capital-to-asset ratio $\tilde{k}$ and with effective financing costs of $(1 - W)(1 + \tilde{k})$. When the regulator imposes $\tilde{k}$ as a minimum requirement, the entrepreneur could in principle still put an I^*, which is either above or below I^*_{eff}, into the contract. He will, however, choose none of these two options.

For any $I^* > I^*_{\text{eff}}$, the optimal contract for the entrepreneur as specified in lemma 2 is associated with a bank's capital-to-asset ratio above $\tilde{k}$. Therefore, he would be in no way restricted by a requirement $\tilde{k}$ when agreeing on $I^* > I^*_{\text{eff}}$. But stipulating such an I^* is not worthwhile for the entrepreneur because proposition 1 suggests that his expected profits decrease when he increases the contractual foreign investment beyond I^*_{eff}. For all $I^* < I^*_{\text{eff}}$, the entrepreneur cannot conclude a contract according to lemma 2. This is because the bank's capital then would fall short of the minimum requirement. Instead, the capital requirement $\tilde{k}$ must be observed for all I^* below I^*_{eff} so that the entrepreneur has no scope to further decrease financing costs below $(1-W)(1+\tilde{k})$. Therefore, he would prefer such contracts only if they yielded higher expected returns on investment than the contract with I^*_{eff}. This, however, is not true since, by definition, I^*_{eff} already maximizes expected returns on investment. The entrepreneur will therefore find it optimal to write I^*_{eff} into the contract when $k^{reg} = \tilde{k}$ is imposed.

6 A critical assessment of the Basel II framework

An important property of the optimum capital-to-asset ratio is that it does not imply a one-size-fits-all policy. Instead, as laid down in proposition 3, it depends on the respective characteristics of the borrower. From this general perspective the move from the first Basel accord to Basel II has to be appreciated. Yet, the new Basel rules have some unpleasant features that actually limit their potential to enhance efficiency regarding corporate investment.

The progress made by Basel II has often been seen in its economic approach to evaluating credit risk. With its Standardized Approach, risk is measured on basis of external credit assessments. With its Internal Ratings-based approach (IRB), banks are allowed to use their internal rating systems in order to evaluate their risk. Under the foundation IRB approach, banks basically provide their own estimates of the loans' probabilities of default (PD), while under the advanced IRB approach banks also provide their estimates of the other risk components (loss given default, exposure at default, maturity). The risk-weight functions, set by the Basel Committee, then map these risk measures onto capital requirements. A main property of these functions is that they imply higher capital requirements when PD increases.

It has been argued that these functions have come into effect in order to improve the stability and efficiency of the international banking system. While they may indeed be helpful in this regard, they unfortunately limit the efficiency enhancing potential of minimum capital-to-asset ratios regarding corporate foreign investment as they are not in line with the borrowers' incentives needed for allocating resources efficiently. This is our final main conclusion.

Proposition 4 *When the probability of default (PD) decreases, the optimal minimum capital-to-asset ratio* $\tilde{k}$*:*

1. *remains constant for entrepreneurs with* $W \geq 1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right]$,
2. *increases for every entrepreneur with* $1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right] > W \geq 1 - \Psi_b(0) - \frac{p}{2}\left[\Psi_g(0) - \Psi_b(0)\right]$ *if the probability of default is not too small, i. e. if* $1 - p > \frac{\beta_b}{\beta_g - \beta_b}$*, and otherwise increases for at least some entrepreneurs.*

Proof. See Appendix. ■

The proposition shows that for entrepreneurs possessing sufficient funds on their own for writing a contract that stipulates $I^* = \frac{1}{2}$, efficiency cannot be further improved. Consequently, the optimal minimum capital-to-asset ratio $\tilde{k}$ for them does not change after a decrease of PD.

As argued above, for all other entrepreneurs symmetric investment in both states is not achievable. For them, a fall in PD has two countervailing effects on the respective optimal capital requirement, which a social planner has to account for. First, when PD decreases, achieving symmetric investment in the good state gains in importance for a social planner, while missing symmetric investment in the bad state becomes less important. Hence, one might conjecture that a planner, striving for maximizing expected returns, could be tempted to let the entrepreneur agree on a lower I^*. According to lemma 2, this would allow for more symmetric investment in the good state but comes at the expense of lost efficiency in the bad state. According to proposition 3, the planner can achieve such a lower I^* by reducing the imposed capital-to-asset ratio.

Second, a decrease in PD also implies that the entrepreneur's repayment obligation can be decreased as a full repayment of the loan becomes more likely. A lower repayment obligation in turn gives the entrepreneur more leeway to invest resources efficiently in the good state even when I^* remains unchanged. This makes higher contractual I^* possible, for which allocative efficiency in the bad state can be improved without completely deteriorating the scope for efficiency gains in the good state. As a higher I^* further restricts the banker's ability to issue deposits, it coincides with an increase in the regulatory capital-to-asset ratio.

Which of the two effects dominates, strongly depends on the relative importance of achieving efficiency in the bad state. When PD is already high, such that $1 - p > \frac{\beta_b}{\beta_g - \beta_b}$ holds true, the second effect dominates, that is, the optimal capital-to-asset ratio will increase when PD decreases. As we have argued in proposition 2, a high PD implies that a social planner cannot balance marginal returns from investments in both states since he cannot implement more symmetric investments in the bad state than in the good state under a bank loan. Therefore, he enforces the maximum feasible contractual foreign investment I_1^* so that the entrepreneur makes the same investment in both states. When the PD decreases in this situation, higher contractual foreign investments I^* become feasible, and in order to narrow the gap between expected marginal returns, a regulator should fully exploit this additional scope by tightening capital requirements.

But even if PD is relatively small, such that $1 - p \leq \frac{\beta_b}{\beta_g - \beta_b}$, there will always be at least some entrepreneurs whose optimal capital-to-asset ratio $\tilde{k}$ increases when PD falls. Consider, for example, entrepreneurs with an efficient I^* close to $\frac{1}{2}$. They can invest almost symmetrically in both states. For them, a decrease in PD lowers their repayment obligation to such an extent that they are no longer kept off from investing resources symmetrically in the good state even when I^* remains unchanged. Hence, the planner is given additional leeway to improve investment efficiency in the bad state as well. In order to exploit it, the planner will further tighten capital requirements such that the entrepreneur is incited to write a loan contract with higher corporate foreign investment I^*.

To sum up, there never is a positive relation between PD and $\tilde{k}$ when PD is already large. When it is small, a positive relation holds true at best for a subset of entrepreneurs. In the light of these results, the Basel II framework obviously is not a proper instrument to cope with MNC's incentives to invest inefficiently. Instead, it gives them more leeway to save on financing costs when PD decreases. This may even imply that the capital requirement becomes non-binding for them so that the effective capital-to-asset ratio of the bank is above the regulatory requirement.[8]

7 Summary

In this paper we have investigated the effects of bank capital regulation on the firm-internal allocation of resources within MNCs. Based on Diamond and Rajan (2000), we have developed a model of financial intermediation that allows to study the interrelation between the firms' decisions on corporate foreign investment, the capital structure of their lending banks, and regulatory bank capital requirements. The basic insight is that MNCs face a tradeoff between allocative efficiency and financing costs. We have argued that the more a bank is refinanced by deposits, the lower are the MNC's financing costs because it then saves on costly bank capital. At the same time, more deposits require the MNC to commit itself to allocate resources mainly to those locations where tangibility (but not productivity) of assets is highest. This is because more deposits can be issued only when repayments to the banker in the case of default will be sufficiently large.

[8] Our framework thus provides a further explanation for banks holding capital in excess of regulatory requirements.

Given this tradeoff, MNCs are inclined to write loan contracts that deter them from allocating resources efficiently as they can save on financing costs in doing so. As the latter are, however, solely a matter of redistribution, a social planner prefers to force MNCs to choose loan contracts that allow for efficient investment. For those MNCs that have no access to direct finance, we have shown that imposing a properly designed minimum capital-to-asset ratio for their lending banks can eliminate this inefficiency completely. The argument is that with minimum capital requirements the regulator effectively puts a lower bound on MNCs' financing costs, thereby restricting the set of feasible contracts to those that prevent MNCs from investing inefficiently.

Against this background, the existing Basel II framework does not allow for this efficiency enhancing potential of bank capital standards. The model implies that loose capital requirements for loans to firms with lower probabilities of default are not advisable. Instead, as a decrease in PD incites MNCs even more to not take allocative efficiency into account, the regulator should further tighten capital standards for those firms. Hence, even when the existing Basel rules effectively contribute to further strengthening the stability and efficiency of the international banking sector, their overall effect on efficiency of international capital flows needs to be reappraised.

Appendix

Proof of Lemma 1

To begin with, note that the entrepreneur is indifferent between making an inacceptable offer to the bank and offering to repay H^* and to invest I^* abroad. Consequently, we can restrict attention to acceptable offers which meet $\tilde{H} \geq H_s^B := \min\{H^*, \Psi_s(I^*)\}$ and $\tilde{I} \leq I_s^B := \max\left\{\frac{\beta_s - H^*}{(1-\mu)\beta_s}, I^*\right\}$. Furthermore, as the repayment $\min\{\tilde{H}, \Psi_s(\tilde{I})\}$ of the entrepreneur is weakly decreasing in $\tilde{H}$ for a given $\tilde{I}$, the optimal repayment offer is $\tilde{H} = H_s^B = \min\{H^*, \Psi_s(I^*)\}$ so that the entrepreneur's profit is:

$$R(1-\tilde{I}) + R(\tilde{I}) - \min\left\{\min\{H^*, \Psi_s(I^*)\}, \Psi_s(\tilde{I})\right\} - W. \tag{33}$$

Now, note that the restriction (1) directly implies $\Psi_s(\tilde{I}) \geq \min\{H^*, \Psi_s(I^*)\}$ so that his profit simplifies to:

$$R(1-\tilde{I}) + R(\tilde{I}) - \min\{H^*, \Psi_s(I^*)\} - W. \tag{34}$$

The entrepreneur thus repays $\min\{H^*, \Psi_s(I^*)\}$ to the banker and, as (34) is weakly increasing (decreasing) in $\tilde{I}$ for $\tilde{I} \leq \frac{1}{2}$ ($\tilde{I} \geq \frac{1}{2}$), he offers $\tilde{I} = \frac{1}{2}$ when $I_s^B = \max\left\{\frac{\beta_s - H^*}{(1-\mu)\beta_s}, I^*\right\} \geq \frac{1}{2}$ holds true and $\tilde{I} = I_s^B = \max\left\{\frac{\beta_s - H^*}{(1-\mu)\beta_s}, I^*\right\}$ otherwise, i. e.

$$I_s = \min\left\{\tfrac{1}{2}, I_s^B\right\} = \min\left\{\tfrac{1}{2}, \max\left\{\tfrac{\beta_s - H^*}{(1-\mu)\beta_s}, I^*\right\}\right\}.$$

Proof of Lemma 2

If $W \geq 1 - \Psi_b(I^*)$, then (6) implies that

$$h(I^*) = 1 - W \leq \Psi_b(I^*) < \Psi_g(I^*) \tag{35}$$

and therefore $H_b^B = H_g^B = 1 - W$. Consequently, the optimal volume of deposits is $d(I^*) = H_b^B = 1 - W$ and the expected repayment of the entrepreneur is $P(h(I^*), I^*) = pH_g^B + (1-p)H_b^B = 1 - W$. Besides, (35) implies $I_s^B = \frac{\beta_s - (1-W)}{(1-\mu)\beta_s}$ so that it follows from lemma 1 and $\beta_g \geq 2\beta_b$ that the entrepreneur's investment abroad is $\iota_g(I^*) = \frac{1}{2}$ in the good state and $\iota_b(I^*) = \min\left\{\frac{1}{2}, \frac{\beta_b - (1-W)}{(1-\mu)\beta_b}\right\}$ in the bad state.

If $1 - \Psi_b(I^*) > W \geq W_{\min}(I^*)$, then (6) implies that

$$h(I^*) = \Psi_b(I^*) + \tfrac{2}{p}\left[(1-W) - \Psi_b(I^*)\right] \in \left(\Psi_b(I^*), \Psi_g(I^*)\right]. \tag{36}$$

Consequently, we have $H_b^B = \Psi_b(I^*)$ and $H_g^B = h(I^*)$, the volume of deposits is $d(I^*) = H_b^B = \Psi_b(I^*)$, and the expected repayment of the entrepreneur is $P(h(I^*), I^*) = (1-W) + [(1-W) - \Psi_b(I^*)]$. Besides, (36) implies $I_g^B = \frac{\beta_g - h(I^*)}{(1-\mu)\beta_g}$ and $I_b^B = I^*$. Therefore, the entrepreneur invests according to $\iota_g(I^*) = \min\left\{\frac{1}{2}, \frac{\beta_g - h(I^*)}{(1-\mu)\beta_g}\right\}$ in the good state and $\iota_b(I^*) = \min\left\{\frac{1}{2}, I^*\right\}$ in the bad state.

If $W_{\min}(I^*) > W$, we know from (6) that no financing is available for the entrepreneur.

Proof of Proposition 1

Taking his initial endowment W as given, the entrepreneur chooses I^* (and the associated variables as specified in lemma 2) such that his expected profit

$$\begin{aligned}\Pi \;=\; & p\left[R(1-\iota_g(I^*)) + R(\iota_g(I^*))\right] + (1-p)\left[R(1-\iota_b(I^*)) + R(\iota_b(I^*))\right] \\ & - P(h(I^*), I^*) - W\end{aligned} \tag{37}$$

is maximized. As we have argued in lemma 2 and in the main text, we can restrict attention to $I^* \leq \min\left\{\frac{1}{2}, I_1^*\right\}$, where I_1^* is the maximum feasible contractual allocation as defined in (22). We now determine the equilibrium I^* by investigating the first derivative of Π with respect to I^*. We do so for two cases, depending on how much internal funds the entrepreneur owns.

First, consider the case $W \geq 1 - \Psi_b\left(\frac{1}{2}\right)$. When this holds true, (23) implies that $I_2^* \geq \min\left\{\frac{1}{2}, I_1^*\right\}$. Accordingly, it follows from (8), (9) and (10) that the expected profit of the entrepreneur is independent of I^* for all $I^* \leq \min\left\{\frac{1}{2}, I_1^*\right\} \leq I_2^*$. Consequently, the contract with $I^* = \frac{1}{2}$ is among the set of equilibrium contracts, i. e.

$$I_{\text{eq}}^* = \tfrac{1}{2}.$$

Second, consider the case $1 - \Psi_b\left(\frac{1}{2}\right) > W \geq 1 - \Psi_b(0) - \frac{p}{2}\left(\Psi_g(0) - \Psi_b(0)\right)$. In this case, (23) implies that $I_2^* < \min\left\{\frac{1}{2}, I_1^*\right\}$, and the first derivative of the entrepreneur's expected profit (37) with respect to I^* is therefore

$$\begin{aligned}\frac{\partial \Pi}{\partial I^*} \;=\;& p\left[R'\left(\iota_g(I^*)\right) - R'\left(1 - \iota_g(I^*)\right)\right]\frac{\partial \iota_g}{\partial I^*} \\ &+ (1-p)\left[R'\left(\iota_b(I^*)\right) - R'\left(1 - \iota_b(I^*)\right)\right]\frac{\partial \iota_b}{\partial I^*} - \frac{\partial P(h(I^*), I^*)}{\partial I^*},\end{aligned} \tag{38}$$

where it follows from (9) and (15) that

$$\frac{\partial \iota_g(I^*)}{\partial I^*} = \begin{cases} 0 & if \quad I^* \leq I_2^* \vee \iota_g(I^*) = \frac{1}{2} \\ -\frac{2-p}{p}\frac{\beta_b}{\beta_g} & if \quad I_2^* < I^* \leq \min\left\{\frac{1}{2}, I_1^*\right\} \wedge \iota_g(I^*) < \frac{1}{2}Q_g \end{cases}, \tag{39}$$

because $\frac{\partial \iota_g(I^*)}{\partial I^*} = \frac{\partial \iota_g(I^*)}{\partial h(I^*)}\frac{\partial h(I^*)}{\partial I^*}$ and

$$\frac{\partial h(I^*)}{\partial I^*} = \begin{cases} 0 & if \quad I^* \leq I_2^* \\ \frac{2-p}{p}(1-\mu)\beta_b & if \quad I_2^* < I^* \leq \min\left\{\frac{1}{2}, I_1^*\right\} \end{cases}. \tag{40}$$

Moreover, from (10) and (16) we obtain that

$$\frac{\partial \iota_b(I^*)}{\partial I^*} = \begin{cases} 0 & if \quad I^* \leq I_2^* \\ 1 & if \quad I_2^* < I^* \leq \min\left\{\frac{1}{2}, I_1^*\right\} \end{cases}, \tag{41}$$

and from (8) and (14) that

$$\frac{\partial P(h(I^*), I^*)}{\partial I^*} = \begin{cases} 0 & if \quad I^* \leq I_2^* \\ (1-\mu)\beta_b & if \quad I_2^* < I^* \leq \min\left\{\frac{1}{2}, I_1^*\right\} \end{cases}. \tag{42}$$

Substitution of (39), (41) and (42) in (38) thus implies $\frac{\partial \Pi}{\partial I^*} = 0$ if $I^* \leq I_2^*$ and, since $R'\left(\frac{1}{2}\right) - R'\left(\frac{1}{2}\right) = 0$,

$$\begin{aligned}\frac{\partial \Pi}{\partial I^*} \quad = \quad & -\left(2-p\right)\frac{\beta_b}{\beta_g}\left[R'\left(\iota_g\left(I^*\right)\right) - R'\left(1-\iota_g\left(I^*\right)\right)\right] + \left(1-p\right)\left[R'\left(I^*\right) - R'\left(1-I^*\right)\right] \\ & -\left(1-\mu\right)\beta_b, \qquad (43)\end{aligned}$$

if $I_2^* < I^* \leq \min\left\{\frac{1}{2}, I_1^*\right\}$. Note that (43) is weakly decreasing in I^* and non-negative for $I^* = 0$.

Therefore, we can conclude that in the subcase $1 - \Psi_b\left(\frac{1}{2}\right) > W \geq 1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right]$ in which $I_1^* \geq \frac{1}{2}$ holds true, the equilibrium contract is

$$I_{\text{eq}}^* = \max\left\{I_2^*, I_3^*\right\} < \tfrac{1}{2},$$

where $I_3^* < \frac{1}{2}$ is implicitly defined by (24).

In the subcase $1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right] > W \geq 1 - \Psi_b\left(0\right) - \frac{p}{2}\left(\Psi_g\left(0\right) - \Psi_b\left(0\right)\right)$, however, in which $I_1^* < \frac{1}{2}$ holds true, the equilibrium contract is

$$I_{\text{eq}}^* = \min\left\{I_1^*, \max\left\{I_2^*, I_3^*\right\}\right\} < \tfrac{1}{2}.$$

Proof of Proposition 2

As proof is almost identical to the proof of proposition 1, we only sketch it here briefly. The socially efficient contractual foreign investment maximizes expected net investment returns, which are given by

$$\Pi^{\text{eff}} = p\left[R\left(1-\iota_g\left(I^*\right)\right) + R(\iota_g\left(I^*\right))\right] + \left(1-p\right)\left[R\left(1-\iota_b\left(I^*\right)\right) + R(\iota_b\left(I^*\right))\right] - 1.$$

Again restricting attention to $I^* \leq \min\left\{\frac{1}{2}, I_1^*\right\}$, we can again distinguish two cases.

First, when $W \geq 1 - \Psi_b\left(\frac{1}{2}\right)$ and thus $I_2^* \geq \min\left\{\frac{1}{2}, I_1^*\right\}$ holds true, it follows that $\frac{\partial \Pi^{\text{eff}}}{\partial I^*} = 0 \;\forall\; I^* \leq \min\left\{\frac{1}{2}, I_1^*\right\} \leq I_2^*$. Consequently, the contract with $I^* = \frac{1}{2}$ is socially efficient, i. e.

$$I_{\text{eff}}^* = \tfrac{1}{2}.$$

Second, when $1 - \Psi_b\left(\frac{1}{2}\right) > W \geq 1 - \Psi_b\left(0\right) - \frac{p}{2}\left(\Psi_g\left(0\right) - \Psi_b\left(0\right)\right)$ and thus $I_2^* < \min\left\{\frac{1}{2}, I_1^*\right\}$ holds true, it follows that $\frac{\partial \Pi^{\text{eff}}}{\partial I^*} = 0$ if $I^* \leq I_2^*$ and, since $R'\left(\frac{1}{2}\right) - R'\left(\frac{1}{2}\right) = 0$,

$$\frac{\partial \Pi^{\text{eff}}}{\partial I^*} = -\left(2-p\right)\frac{\beta_b}{\beta_g}\left[R'\left(\iota_g\left(I^*\right)\right) - R'\left(1-\iota_g\left(I^*\right)\right)\right] + \left(1-p\right)\left[R'\left(I^*\right) - R'\left(1-I^*\right)\right], \quad (44)$$

if $I_2^* < I^* \leq \min\left\{\frac{1}{2}, I_1^*\right\}$. Note that (9) implies $\iota_g(I_2^*) = \frac{1}{2}$ so that it follows from $I_2^* < \frac{1}{2}$ and (29) that $\max\left\{I_2^*, I_4^*\right\} = I_4^*$.

Therefore, we can conclude that in the subcase $1 - \Psi_b\left(\frac{1}{2}\right) > W \geq 1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right]$, in which $I_1^* \geq \frac{1}{2}$ holds true, the socially efficient contract is

$$I_{\text{eff}}^* = \max\left\{I_2^*, I_4^*\right\} = I_4^* = \tfrac{1}{2},$$

where $I_4^* = \frac{1}{2}$ is true since (9) and (15) implies that $\iota_g(I^*) = \frac{1}{2}\ \forall\ I^* \leq \min\left\{\frac{1}{2}, I_1^*\right\}$.

In the subcase $1-\Psi_b\left(\frac{1}{2}\right)-\frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right] > W \geq 1-\Psi_b\left(0\right)-\frac{p}{2}\left(\Psi_g\left(0\right) - \Psi_b\left(0\right)\right)$, however, in which $I_1^* < \frac{1}{2}$ holds true, the socially efficient contract is

$$I_{\text{eff}}^* = \min\left\{I_1^*, \max\left\{I_2^*, I_4^*\right\}\right\} = \min\left\{I_1^*, I_4^*\right\},$$

and a comparison of (24) and (29) directly implies $I_4^* \geq I_3^*$ and thus $I_{\text{eff}}^* \geq I_{\text{opt}}^*$. Furthermore, note that if $1 - p > \frac{\beta_b}{\beta_g - \beta_b}$, it follows from (44) that $\frac{\partial \Pi^{\text{eff}}}{\partial I^*} \geq 0\ \forall\ I^* \leq \min\left\{\frac{1}{2}, I_1^*\right\}$ so that $I_4^* \geq \min\left\{\frac{1}{2}, I_1^*\right\}$. Consequently, the socially efficient contract then is

$$I_{\text{eff}}^* = I_1^*.$$

If, however, $1 - p \leq \frac{\beta_b}{\beta_g - \beta_b}$ holds true, it follows that $I_4^* \leq I_1^*$ so that the socially efficient contract then is

$$I_{\text{eff}}^* = I_4^*.$$

Proof of Proposition 4

We proof the proposition in three steps. First, consider entrepreneurs with $W \geq 1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right]$. For them, it follows from (25) and (26) that I_{eff}^* and thus $\tilde{k}$ does not depend on PD.

Second, consider entrepreneurs with $1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right] > W \geq 1 - \Psi_b\left(0\right) - \frac{p}{2}\left[\Psi_g\left(0\right) - \Psi_b\left(0\right)\right]$ when $1 - p > \frac{\beta_b}{\beta_g - \beta_b}$ holds true. Then, it follows from (27) that $I_{\text{eff}}^* = I_1^*$, and from (22) that I_1^* and thus $\tilde{k}$ increases when PD decreases.

Third, consider entrepreneurs with $1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right] > W \geq 1 - \Psi_b\left(0\right) - \frac{p}{2}\left[\Psi_g\left(0\right) - \Psi_b\left(0\right)\right]$ when $1 - p \leq \frac{\beta_b}{\beta_g - \beta_b}$ holds true and suppose that p increases from p_1 to p_2. Then, the efficient contractual foreign investment increases at least for entrepreneurs with $1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p_1}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right] > W \geq 1 - \Psi_b\left(\frac{1}{2}\right) - \frac{p_2}{2}\left[\Psi_g\left(\frac{1}{2}\right) - \Psi_b\left(\frac{1}{2}\right)\right]$, since for them, it follows from lemma 2 that $I_{\text{eff}}^* = \min\left\{I_1^*, I_4^*\right\} < \frac{1}{2}$ when $p = p_1$ and $I_{\text{eff}}^* = \frac{1}{2}$ when $p = p_2$.

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