Asset Measurement, Loanable Funds and the Cost of Capital

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Abstract

In the capital market, accounting measurements of assets serve two primary functions, to help the firm access loanable funds by pledging its own assets as collateral, and to identify and liquidate unproductive assets whose return is below the cost of capital demanded by investors. This paper shows that these two roles are generally in conflict. The optimal measurement rule reports asymmetrically either low or high assets to fulfill the dual role of facilitating credit and/ or to guide firms toward value-enhancing investments. When credit is widely available, i.e., the cost of capital is low, an accounting rule prescribing liberal measurements of high-value assets is optimal. However, as credit tightens, the optimal measurement system will feature impairments over low-value assets. After a collateral squeeze (e.g., a reduction in the value of existing assets), the cost of capital increases with liberal accounting and decreases with impairment accounting. After a credit crunch (e.g., a reduction in available loanable funds), the cost of capital and the precision of the measurement system increases.

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1 Introduction

Firms are, more than ever, evolving in a global economy, where their investment choice is contingent not only on the financing of their own project but also the attractiveness of outside investment opportunities. The efficient capital allocation in this economy is facilitated by mandatory disclosures. As explicitly expressed in the objectives of the U.S. Securities and Exchange Commission, *"...SEC requires public companies to disclose meaningful financial and other information to the public... The result of this information flow is a far more active, efficient, and transparent capital market that facilitates the capital formation so important to our nation's economy."*[1]

This paper examines whether mandatory disclosures can improve investment efficiency when firms do not observe the value of their assets that they can pledge to capital providers. If access to financing for economically viable productive investments is undeniably one facet of the inefficiencies that regulation faces, evaluating the potential of productive investments relative to outside investment opportunities is equivalently crucial in selecting value enhancing investments. We study a simple general equilibrium model in which mandatory disclosures condition firms' investment choice between a productive investment in a risky technology subject to moral hazard and external financing, and a financial investment that returns the cost of capital. In particular, we derive the optimal mandatory disclosures that report asymmetrically low and high assets and their complex feedbacks with cost of capital, access to external financing and investment efficiency. We analyze the dual role of mandatory disclosures in alleviating inefficiencies - they facilitate credit and guide firms in optimally choosing value-enhancing investments. We further explore capital tightening shocks and their consequences on investment efficiency, cost of capital and mandatory disclosures.

Goex and Wagenhofer (2009) has shown that mandatory disclosures reporting firms with low assets is welfare improving when absent any information firms cannot run their economically viable projects. Firms disclosing their low assets are squeezed out and allow the remaining non-disclosing firms to meet the lenders' collateral requirements for financing. The optimal regulation maximizes the amount of projects funded but cannot succeed to finance all the firms due to moral hazard. We enrich this framework by introducing an outside investment opportunity that offers the cost of capital similar to Holmström and Tirole (1997). If a firm does not run the project, it invests in the open market. This competing financial investment introduces an additional tension that might deter firms from running the project even if they can find financing and put forward the role of capital

[1] See http://www.sec.gov/about/whatwedo.shtml.

markets in determining mandatory disclosures and aggregate investment. Given that the resource cost for a firm to run the project diminishes in the value of its assets, the productive investment is less attractive for capital rich firms, and disclosure of high assets help capital rich firms to optimally select the efficient investment. Alternatively capital rich firms have assets with high values but are unproductive. As a result, regulation is confronted with inefficiencies that might require opposing disclosures to be mitigated.

Once we model capital markets, we want to understand how mandatory disclosures, cost of capital and investment efficiency are intertwined. To this end, we first take the cost of capital as given, then endogenously determine the supply and cost of capital.

The starting point of this paper consists of analyzing the optimal disclosures and the investment efficiency when the supply is perfectly elastic and firms' investment choice does not affect the cost of capital. The analysis reveals that the determining factors in the selection of mandatory disclosures are the level of aggregate wealth in the economy and the financing conditions dependent on the cost of capital. When the economy is wealthy and all firms can find financing without information, disclosures of high values is optimal and low values of costs of capital allow to achieve first best. For high values of cost of capital, some capital rich firms do not disclose and run the productive investment, whereas had they learned their assets' value, they would have invested in the financial opportunity. When aggregate wealth decreases, disclosures of high assets remains optimal only for low costs of capital, and are substituted by disclosures of low assets for high costs of capital as the aggregate wealth is insufficient to guarantee financing. When the aggregate wealth further drops, no matter the cost of capital, disclosures of low assets are the only optimal mandatory disclosures. Disclosures of low assets partially offset the productive distortion of capital poor firms at the expense of capital rich firms which take the inefficient investment, the productive investment. We refer to disclosures of low (high) assets as impairment like (liberal) disclosures. In all scenarios, we find that optimal mandatory disclosures prescribe partial information where non disclosing firms run the productive investment and disclosing firms take the financial investment.

We next expand the analysis to a more realistic framework by considering the supply and the cost of capital as endogenous. This general equilibrium approach takes into account that resources in the economy are limited. To this end, we assume that firms running the productive investment are financed by firms foregoing the project and an exogenous supply. Our results in general equilibrium can be diametrically different in partial equilibrium. In particular liberal disclosures thresholds decrease (more disclosure) in general equilibrium in response to a capital tightening shock while increase (less disclosure) in partial equilibrium. The shrinkage in capital is adjusted through the cost of capital that in turn affects the optimal disclosure thresholds. Also unlike partial equilibrium, liberal and impairment like disclosure thresholds are unaffected by changes in the project's attributes in general equilibrium as the cost of capital fully offsets these effects. The endogenous adjustment of the cost of capital to changes in macroeconomic fundamentals is thus driving the results.

As a consequence the interaction between the endogenous cost of capital and aggregate wealth is again a key determinant for the existence of a single stable general equilibrium or two stable general equilibria. If the economy is wealthy and without information firms can find financing, the optimal cost of capital coincides with the cost of capital without moral hazard, and implements the efficient investment by disclosing assets with high values. In contrast, if the economy is poor and absent any information firms cannot find financing, the optimal cost of capital is associated with disclosures of low assets and cannot implement the efficient investment. There exists an economy that is half way between the rich and the poor economy, that admits simultaneously the two stable costs of capital. In this economy the cost of capital associated with disclosures of high assets and implementing first best, is lower than the cost of capital associated with disclosures of low assets. Both equilibrium costs of capitals are affected similarly by changes in the project's attributes. More attractive productive projects or less moral hazard call for higher equilibrium cost of capital to counterbalance the increased demand. However depending on the nature of the macroeconomic shock, their response might differ. If we consider additional capital providers outside the financing firms and their amount of capital suddenly decreases, there is a credit crunch. To counterbalance this shock, both equilibrium costs of capital increase. Counter-intuitively, they respond in opposite directions to a collateral squeeze: the cost of capital related to liberal disclosures increases while the equilibrium cost of capital related to impairment disclosures decreases. So a reduction of internal resources affects differently the costs of capital relatively to a reduction of external resources. However these capital tightening shocks have similar consequences on the aggregate investment by reducing the productive investment and expanding disclosures.

Our paper builds on the insights of three main strands of prior literature: cost of capital, disclosure and debt financing. Recent analytical and empirical research on accounting rules, regulation and cost of capital focuses on the interaction between information precision in the economy and cost of capital. More specifically, some papers, e.g. Diamond and Verrecchia (1991), Easley, Hvidkjaer, and O'Hara (2002), Easley and O'Hara (2004), Lambert, Leuz, and Verrecchia (2007), Lambert, Leuz, and Verrecchia (2010), Christensen, de la Rosa, and Feltham (2010) and Bertomeu, Beyer, and Dye (2011), study the relation between information asymmetry among investors and cost of capital. In contrast other studies, e.g. Botosan (1997), Core, Guay, and Verdi (2008), Cheynel (2013), model homogeneous investors and look at their perception of disclosure on the cost of capital. Our paper contributes to this literature by studying the impact of mandatory disclosures on the cost of capital when firms and investors share the same information and there is asymmetry of disclosures across firms leading to different investment decisions.

The link between the type of accounting disclosure and debt financing has been studied extensively. For example, Beyer (2012) considers aggregate reports of asset values and shows that debt contracts are more efficient when covenants are written in terms of conservative reports as long as the required capital is not too high. Otherwise, fair value accounting may lead to more efficient debt contracts. Other papers that consider the preferred accounting system in a single firm economy are, for example, Smith (2007), Gigler, Kanodia, Sapra, and Venugoplan (2009), Li (2012), Caskey and Hughes (2012). Our paper endogenizes the accounting information system and finds the optimal one in a multiple firm economy. In that respect our paper is closely related to Goex and Wagenhofer (2009) who show that absent outside investment opportunity and capital markets it is optimal to set mandatory disclosures on low value assets that will allow firms with high value assets to fund their projects. Our paper prescribes the optimal information system in conjunction with fundamentals of the economy and firms' investment opportunities and offers new implications to the current findings.

The idea that disclosure affects not only market prices but also production and investment decisions is central to the real effects of accounting literature. It was first pioneered by Kanodia (1980) and further analyzed in Kanodia and Lee (1998), Kanodia, Sapra, and Venugopalan (2004), Melumad, Weyns, and Ziv (1999), Kanodia, Mukherji, Sapra, and Venugopalan (2000), Sapra (2002), Plantin, Sapra, and Shin (2008). Gao (2010) further studies the link between cost of capital and real effects of information precision. While Gao (2010) focuses on risk sharing issues due to disclosures in a single firm economy, our study stresses the importance of limited resources in a multiple-firm economy and the effect on the cost of capital and investment efficiency.

The notion of limited resources is a core ingredient in general equilibrium literature. We endogenously determine the supply and cost of capital since resources are limited, as part of the firms become financing firms and transfer their assets to the entrepreneurial firms. In that sense our paper is related to Boot and Thakor (1997) who create a resource transfer theory in a model with postlending moral hazard that can affect payoffs to creditors. While Boot and Thakor (1997) concentrate on determining which borrowers will turn to banks and which to capital markets for financing of their project, we endogenously derive investigate which firms become financing firms and entrepreneurial firms respectively. In our model the firm's ability and preference to become provider or user of capital is determined based on an endogenous information system and a resource constraint.

Limited resources and credit constraints create the need for intermediaries. Papers investigating the role of intermediaries as efficient providers of liquidity and/or monitors in a general equilibrium framework are, for example, Chen (2001), Michelacci and Suarez (2004), Allen and Gale (2004) etc. The paper most closely related to ours is Holmström and Tirole (1997). The focus of their paper is to analyze how, in a general equilibrium setting, the distribution of wealth across firms, intermediaries, and uninformed investors affects investment, interest rates, and the intensity of monitoring when the value of the assets are common knowledge. We assume instead that firms do not observe the value of their assets and focus on the optimal mandatory disclosure rules and their interaction with access to financing, investment opportunities and the cost of capital in the context of capital markets. By doing so we expand the general equilibrium framework to accounting disclosures.

The paper proceeds as follows. Section 2 outlines the economic setting, Section 3 describes the optimal information system with exogenous cost of capital and Section 4 solves for the equilibrium cost of capital.

2 Model

There is a continuum of firms in the economy. These firms can either invest in a project (thereafter: "productive investment") and become entrepreneurial firms or invest in the open market (thereafter: "financial investment") and become financing firms.[2] Firms are run by risk neutral owners-managers who are protected by limited liability. All firms have access to the same technology but they are endowed with a different amount of unobservable pledgeable assets A. The distribution of assets across firms follows a probability density function $f(.) > 0$ and a cumulative density function $F(.)$, which are common knowledge. To run the project entrepreneurial firms need to raise debt and pledge their assets to guarantee financing. Before entering the debt contract, firms establish an information system that reports information about their pledgeable assets. Firms update their belief regarding the value of their assets conditional on the information released from the information system and choose the productive investment or the financial investment.

[2] We assume that firms cannot invest simultaneously in their project and provide capital. If the firm could operate the new project by selling its assets, it would mean that the old and new projects of the firm would be independent of each other. This discussion is at the essence of the theory of the firm. We view the firm as an economic entity that needs to manage old and new projects simultaneously. When it comes to financing the new project, this decision is made at the firm level, coordinating the old and new projects.

There are three periods. In the first period an optimal information system is set up. In the second period investment choices are made and contracts between entrepreneurial and financing firms are signed. In the third period, the outcome of the investment is realized and the entrepreneurial and financing firms receive their claims.

Figure 1: Timeline

Assume that the entrepreneurial firm needs $I > 0$ of capital to finance a new project, which is obtained from a competitive market with risk-neutral lenders. The firm has some assets $\tilde{A} \geq 0$ independent from the new project and which can be pledged as collateral. The assets cannot be liquidated to finance the project. The firm needs these assets to maintain the good functioning of its old and new projects. Assume that $\tilde{A}$ is not observable absent any information system. We assume that these pledgeable assets are either cash or cash equivalents, or assets that can be liquidated. The uncertainty of the measurement of these assets is a common issue in practice.[3] The project can yield two outcomes "Success" with value $H > 0$ and "Failure" with value normalized to zero. The project succeeds with probability $p \in (0, 1)$ if the manager provides effort $e = 1$ and succeeds with probability $p - \Delta p$, where $\Delta p \in (0, p)$ if the manager provides no effort $e = 0$. The cost of effort is $c > 0$. The project is only economically viable if the manager exerts effort, i.e. $pH - c - \gamma I > 0 > (p - \Delta p)H - \gamma I$, where γ is the expected rate of return required by the market. There is no heterogeneity in the projects across firms.[4] A capital rich firm has the same project as a capital poor firm.[5]

[3]A precise assessment of the assets require a careful analysis and inventory of all the pledgeable assets. Existing transactions on similar assets might be hard to find. Even a correct assessment of cash inside a large group is an issue. Tracking all the cash transfers between the different entities of the firm requires careful checking of these flows by reconciling the different accounting systems.

[4]Therefore project outcomes are assumed to be perfectly correlated.

[5]The value of the collateral is not correlated with the type of project. There is little evidence to support a positive relation between good projects and capital rich firms. Capital rich firms own usually a lot of assets as they are more mature and less innovative on average, and have fewer new projects to run. If capital rich firms have worse projects, this would reinforce the findings of our paper.

The entrepreneurial firm issues debt with face value $F \in [I, H]$. Conditional on the high outcome, it pays back F and conditional on the low outcome, it transfers all pledgeable assets to the lenders. In case of a success the firm keeps its assets and values them at ηA, where $\eta \geq 1$ reflects the appreciation of its assets if they are not liquidated. The parameter η captures the difference between the retention value and the liquidation value of the pledgeable assets. There are two main reasons for this difference. On one hand, lenders face information asymmetry and incur transaction costs to liquidate the firms' assets. On the other hand, firms create synergies between old and new projects. This interpretation is in line with Goex and Wagenhofer (2009). Firms' ability to enhance the value of their assets is increasing the minimum expected rate of return on the financial investment, that deters some of the firms to run the project. Firms that do not run projects, invest in the open market and demand a rate of return $\gamma > \gamma_{\min} \equiv \eta p + (1-p)$.[6] We consider values of cost of capital such that the financial investment is at least attractive for some firms if they know the value of their pledgeable assets. The financial investment offers a safe alternative to the firm and a saving on effort cost. At the same time if the firm forgoes the project, it also gives up on the upside potential to receive cash flows, if the project succeeds. The resource cost for a firm to become an entrepreneurial firm is A, and thus the opportunity cost of becoming an entrepreneurial firm equal to γA increases with firms' initial wealth. Equivalently, firms with less wealth have a relatively more productive entrepreneurial technology.

Regulation might improve the functioning of capital markets by helping firms and lenders acquire information necessary to guarantee trading and common agreements. To abide by the rules, firms can commit to implement an accounting system that provides information about the firm's assets before the negotiation of the debt contract.[7] The information system is defined by a function $\theta(A) \in [0, 1]$ such that A is disclosed with probability $1 - \theta(A)$ and not disclosed with probability $\theta(A)$. The firm can credibly commit to disclose the information and cannot bias the information.[8] The information on the pledgeable assets is common knowledge. Post disclosure, firms differ in the disclosure of their pledgeable assets. If the amount of pledgeable assets is not disclosed, the amount of pledgeable assets is valued at $E(A|\emptyset)$, the conditional expectation after no disclosure. If

[6]At $\gamma \leq \gamma_{min}$, all the firms in the economy prefer the productive investment.

[7]Alternatively we can assume that the lenders implement an accounting system to prevent firms from lying about the outcome of the information system. An auditor can also be hired to set up the mandatory information system. Each one of these assumptions implies that the firms do not have superior knowledge about the value of their assets than the investors.

[8]If the manager of the firm lies and investors or regulatory institutions discover that he has inappropriately distorted the information, he would be severely punished. Furthermore, a deliberate failure to disclose information is more reprehensible under mandatory disclosure than under voluntary disclosure.

the amount of pledgeable assets is disclosed, the value of the assets is A where $A \in \mathbb{R}^+$.[9] After observing the disclosure outcomes, firms choose between the productive and the financial investment.

Finally the choice between the productive and the financial investment determines the cost of capital and is at the essence of capital markets' functioning. As a first path, we assume that γ is exogenous and that there is an infinite supply of financial investment opportunities that return γ. We later determine endogenously the level of cost of capital that clears the markets. Restraining the supply might represent a more autarchic economy in comparison to a perfectly elastic supply in a small open economy. To relate mandatary disclosures, investment efficiency and cost of capital to macroeconomic shocks, we model two types of macroeconomic shocks tightening capital. First we model a collateral squeeze as a proportional decrease in the assets of all firms in the economy by a share $\varepsilon \in (0, 1)$. The collateral squeeze also reduces the aggregate wealth in the economy by ε. When we consider the endogenous cost of capital, we further introduce an additional source of capital tightening. The supply comes from financing firms abandoning the project and also from an exogenous supply $K \in [0, I]$.[10] We interpret a reduction in this exogenous supply by $\kappa \in (0, 1)$ as a credit crunch.

3 Exogenous Cost of Capital

We first study the optimal information system if there is an infinite supply of financial investment opportunities that offer a rate of return γ. This assumption is standard in the literature when the cost of capital is taken as given and the focus is on a partial equilibrium.[11] This analysis examines the impact of disclosure and cost of capital in a "partial equilibrium" framework, that is, within the context of a single market, neglecting any induced effects on other markets due to a change in investment choice. Although relevant only when such effects can reasonably be assumed to be unimportant, this approach shows how mandatory disclosures depend on market conditions and how they induce

[9] We assume that disclosing any event is cost free. We isolate the driving forces relating mandatory disclosures and the cost of capital from any effect due to cost specifications. Adding a fixed cost when firms disclose would not change qualitatively the results. However if the cost is a function of the value of the assets, the optimal information system would change and not surprisingly, low cost events would be more likely to be disclosed.

[10] If $K > I$, there would be excess supply and an equilibrium with a negative interest rate would exists. More realistically these outside capital providers would invest in the open market so that the cost of capital equals the γ_{min} and then would keep their capital (hoarding their money rather than investing at a negative interest rate).

[11] See for example Modigliani and Miller (1958), Gennotte and Pyle (1991) and Mailath and Mester (1994), Arya and Glover (2003), Goex and Wagenhofer (2009) and Li, Liang, and Wen (2011).

firms to prefer productive over financial investments and vice versa. This setting also corresponds to a small open economy as discussed in the macroeconomic literature where firms can borrow and lend without altering the world cost of capital.[12] We study as a benchmark for this partial equilibrium setting, the first best that determines the efficient investment. We refer to this first best as *unconstrained first best* that one should observe if a benevolent social planner has full information. We also derive the optimal information system without moral hazard to single out the effects due to moral hazard in the rest of the analysis. We then move to a second best analysis, taking the information system as given. In section 3.3, we complete the partial equilibrium analysis by finding the optimal information system with moral hazard.

3.1 Benchmarks

Unconstrained First-Best: Full Information

We assume that there is a benevolent social planner observing the level of effort and the value of the pledgeable assets. He acts as a representative agent that optimally allocates the type of investment across firms. The productive investment is selected when in expectation it offers a better opportunity than the financial investment : $pH - \gamma I + (\eta p + (1-p))A - c > \gamma A$. The unconstrained first-best solution maximizes the sum of individual firms' utilities. Proposition 1 characterizes the efficient investment:

Proposition 1

(i) The first-best aggregate utility is

$$\begin{aligned} U^{FB} &= \int_0^{A_H} (pH - \gamma I + (\eta p + (1-p))A - c) f(A) dA + \int_{A_H}^{\infty} \gamma A f(A) dA, \\ \text{where } A_H &= \frac{pH - \gamma I - c}{\gamma - (\eta p + (1-p))} > 0 \end{aligned} \tag{2}$$

(ii) A_H is increasing in p, H and η, and decreasing in γ, I and c.

(iii) In case of a collateral squeeze A_H increases.

[12] This assumption is also similar to a two period model, where the firms in the economy maximize their utility by optimally shifting their consumption from one period to the next and create capital at a cost γ by substituting their consumption in the first period. To see this let us define the firm's utility by $U = c_1 + \frac{1}{\gamma}c_2$. If the firm gives up one unit of consumption in the first period it will get $1/\gamma$ in the future. The cost of capital can then also be a measure of the firms' impatience.

In equilibrium, there will be a cut-off A_H that determines the type of investment the firms make. Firms with $A \leq A_H$ choose to run the project and become entrepreneurial firms and those with $A > A_H$ choose to be financing firms. This result is related to the assumption that projects are the same across firms and that if a firm chooses the financial investment, it liquidates its assets[13] and invest their money at the cost of capital. The direct cash flow a firm receives by running the productive investment is independent of the size of its initial wealth, i.e. $pH - \gamma I - c$. In contrast, a firm liquidating its assets invest the integrality of its wealth in the outside investment opportunity that offers the same return per unit of investment to all the firms. The magnitude of the outside gains is equal to γA and will differ across firms should they choose the outside investment. Hence, a firm with a high (low) value of asset A has a comparative advantage in becoming a financing (an entrepreneurial) firm. This unconstrained first best generalizes the first best in Goex and Wagenhofer (2009). In their paper the cost of capital is normalized to 1 and thus the social surplus is maximized if all firms run the productive investment.

The heterogeneity in wealth might capture the firms' maturity. In practice firms starting their activities do not own a lot of assets and need external financing to grow their business. Mature firms are more likely to have accumulated assets and if they choose to run a new project, it needs to add value to the entire business. Even if the project is economically viable, the firm needs to retain its assets to run it and forgoes the return on the outside investment opportunity. The model predicts that firms that liquidate their assets, have accumulated a lot of wealth and their new project does not create enough synergies with the older projects to justify further productive investment in the same business relatively to the outside investment opportunity.[14]

More firms with valuable assets lead to more aggregate financial investment. Therefore, when the value of the assets is reduced by the same proportion for all firms and the aggregate wealth in the economy decreases it is immediate to observe that the efficient investment choice shifts toward more productive investment. If this reduction in asset value is interpreted as a collateral squeeze and the world cost of capital is not affected, the productive investment is increasing. This counterintuitive effect relies on the assumption that the cost of capital is maintained at the same level because more supply of outside in-

[13]Broadly speaking the liquidation of these assets does not necessarily mean the termination of the firm per se but the termination of its old business model.

[14]Our model does not refer to firms in financial difficulty, liquidating their assets to meet their obligations or because their old projects were most likely not profitable. In our setting firms liquidate their assets because they want to realize the gains of past profitable projects and the future project does not bring enough returns overall. In other words they keep their assets if they keep growing as these assets are necessary for their business model.

vestment compensates for the squeeze in collateral. The remaining comparative statics are intuitive: if the project is more risky (lower p and H or higher I) or more costly (higher c) or the financial investment is more attractive (higher γ) or the firm creates less synergy (lower η), the cut-off A_H decreases and so does the aggregate productive investment.

Optimal Disclosure without Moral Hazard

We now derive the optimal information system when there is no moral hazard but assets' values are not observable. This second benchmark removes the distortions due to moral hazard. Absent any information on assets' values the first best is not attained as firms are pooled and take the same investment. More mandatory disclosures can resolve the investment inefficiencies by screening out the capital rich firms as disclosing firms ($A > A_H$). The remaining non disclosing firms will then invest in the productive investment. Any information system that discloses the assets' values above A_H will attain first best. The range of these information systems vary from full disclosure to the liberal disclosures of assets above A_H. If there is a small cost to disclose information disclosing assets only above A_H would be optimal.

Proposition 2 *If there is no moral hazard but the assets are not observable, any information system prescribing disclosure of assets above A_H is optimal and the first best is attained.*

Without moral hazard firms will exert effort and find financing should they invest. Knowing the value of their assets, firms at the top will select the financial investment and non disclosing firms will in turn select the efficient investment, the productive investment. Firms at the top need to know the liquidation value of their assets to invest in the financial investment. Liberal disclosures are thus not in contradiction with the conservative principle as disclosing firms liquidate their assets to realize their gains. They report gains only when there is no uncertainty remaining on the value of their assets.

3.2 Moral Hazard, Full Disclosure and No Disclosure

Moral Hazard and Full Disclosure

In the second best, lenders do not observe effort should the firm run the project. We first consider a case in which the information system prescribes full disclosure. The lenders will only finance the project if they are protected against downside risk, while the firm will run the project if and only if the project is funded and returns more value than the financial investment. We first determine the maximum amount of pledgeable assets to prefer the productive investment. Next we look at the minimum level of pledgeable assets that a firm needs in order to obtain financing.

Productive Investment

Using a cost and benefit analysis we find the condition guaranteeing that a firm prefers to run the project. The productive investment must return sufficiently high returns to deter the entrepreneurial firm from investing in the open market (financial investment). The entrepreneurial firm earns an expected utility $pH - \gamma I + (\eta p + (1-p))A - c$ when undertaking the project. The project remains attractive as long as the firm expects a higher utility than investing in the open market: $pH - \gamma I + (\eta p + (1-p))A - c \geq \gamma A$. This condition is identical to the first-best condition and thus firms with $A \leq A_H$ would optimally run the project whereas firms with $A > A_H$ would select the financial investment. From proposition 1, the financial investment is more attractive if it offers higher returns or if the operating project provides lower cash flows, requires higher capital or the cost of effort is large.

We next determine the condition guaranteeing the financing of the project. If the entrepreneur-manager exerts high effort his utility is given by:

$$U = p(H - F + \eta A) - c$$

The debt contract must discipline the manager of the firm into exerting high effort. To ensure that the manager provides high effort, the incentive compatibility (IC) constraint needs to be satisfied:

$$\Delta p(H - F + \eta A) - c \geq 0$$

For lenders to be willing to provide financing, they need to break even should the entrepreneurial firm invest.

$$pF + (1-p)A = \gamma I$$

Thus, the face value of the debt must be equal to: $F = \frac{\gamma I - (1-p)A}{p}$. Substituting F in the (IC) leads to:

$$A \geq A_L = \frac{1}{\eta p + (1-p)} \left(\frac{pc}{\Delta p} + \gamma I - pH \right)$$

The debt contract secures the repayment of the loan with collateral. The firm will find financing if its pledgeable assets are greater than A_L.[15] We assume that $A_L > 0$ so that firms need collateral to fund the project. This condition is identical to Holmström and Tirole (1997) and corresponds to $pH - \gamma I < \frac{pc}{\Delta p}$, which means that the surplus of the project is insufficient to compensate for the disutility to induce the manager to exert high effort. The firm must be able to commit a significant portion of its own wealth to the contract to convince the lenders to provide capital. This minimum amount of collateral disciplines the firm to provide effort and run an economically viable productive investment and simultaneously protects lenders against downside risk. However, since firms with pledgeable assets below A_L do not receive financing and cannot run the project, the moral hazard creates a distortion for capital poor firms that are not financed.

Lemma 1 *The minimum collateral to find financing A_L is increasing in c, γ and I, and decreasing in Δp, p, η and H. In case of a collateral squeeze A_L increases.*

Lenders require more collateral if the project is more risky (lower p and H or higher I), the moral hazard problem is more severe (higher c, smaller Δp), the financial investment is more attractive (higher γ) or the firm creates less synergies between its old and new projects (lower η). If there is a collateral squeeze, lenders require higher amount of pledgeable assets and capital poor firms will thus be more affected by a collateral squeeze, as they will find it harder to achieve funding. Combining the maximum asset requirement to prefer the productive investment and the minimum collateral to find financing we derive the condition for the productive investment to be undertaken:

Proposition 3 *There exists a unique γ_{max} such that $A_H(\gamma_{max}) = A_L(\gamma_{max})$. γ_{max} is decreasing in c and I and increasing in H, η, Δp and p, and is not affected by a collateral squeeze.*

(i) If $\gamma \leq \gamma_{max}$, firms with $A_L \leq A \leq A_H$ run the productive investment. The remaining firms choose the financial investment. The amount of projects in the economy is increasing in H, Δp, p and η, and decreasing in c, γ and I. A collateral squeeze has ambiguous effects on the aggregate amount of projects.

(ii) If $\gamma > \gamma_{max}$, none of the firms runs the productive investment. All firms invest in the open market.

The minimum of pledgable assets required by lenders, A_L, can be greater than the maximum of pledgeable assets A_H that the firm is willing to give as collateral to invest in

[15] As firms are risk neutral, they are indifferent to pledge A_L or all their assets, should they invest.

the project. However, in this case none of the firms undertakes the productive investment. The investment choice will differ across firms if and only if $A_L < A_H$. Firms with $A < A_L$ prefer the productive investment but short of financing take the financial investment. Firms with $A > A_H$ prefer the financial investment. Thus firms with $A_L < A < A_H$ run the operating project. The aggregate productive investment is larger when financing requirements are looser and the outside investment opportunity is less attractive. These two conditions are simultaneously met if A_L moves downward while A_H moves upward or does not change. Except for a collateral squeeze, these two cut-offs are inversely affected by exogenous parameters. If the project is less risky (higher p and H or lower I), the moral hazard problem is less severe (lower c), the financial investment is less attractive (lower γ) or the firm creates more synergies between its old and new projects (higher η) lenders require less collateral and at the same time firms need more collateral to prefer the financial investment. Furthermore, when the probability of success for the project changes a lot due to the exerted effort (high Δp), managers have less incentives to shirk and hence lenders require less collateral (low A_L). However, the change in probability of success does not affect the attractiveness of the outside investment opportunity (no change in A_H), because once the firm runs the project, it will provide effort in equilibrium and its investment choice does not depend on Δp . Thus, the higher the incremental contribution of the exerted effort, the higher the aggregate productive investment.

In contrast, the effect of a collateral squeeze on the aggregate productive investment is ambiguous. It increases simultaneously the minimum collateral requirement and the maximum collateral to prefer productive investment. As a result, both capital rich firms and capital poor firms are hit. Firms with initial assets $A \in [A_L, \frac{A_L}{1-\varepsilon}]$ cannot find financing anymore. This effect of the collateral squeeze replicates the effect in Holmström and Tirole (1997) . The new prediction relates to the effect on capital rich firms: the firms with initial collateral $A \in [A_H, \frac{A_H}{1-\varepsilon}]$ switch to the productive investment. If the proportion of capital rich firms preferring the productive investment outweighs the proportion of capital poor firms squeezed out, the amount of productive investment increases. Left-skewed distributions are more likely to result in more productive investment. If the ratio of entrepreneurial firms over financing firms declines, a collateral squeeze pushes firms to seek the financial investment.

Distortions with Full Disclosure

It follows from Proposition 3 that full disclosure is not efficient. On one hand, if $A_L > A_H$ all the firms with $A < A_H$ take the financial investment whereas they should have taken the productive investment. On the other hand, if $A_L \leq A_H$ firms with $A < A_L$ cannot find financing for their project and are hence forced to take the financial investment. This distortion at the bottom is worsened by a collateral squeeze. Everything else equal, if $A_L < A_H$, a collateral squeeze affecting all the firms will prevent more capital poor firms from producing as A_L increases. It will also attract more capital rich firms to run the project but this effect coincides with the first-best investment choice. As a result, a reduction in asset value has adverse effects on the amount of aggregate productive investment but clearly worsens the distortion at the bottom. If $A_L > A_H$, the distortion on the productive investment is unaffected by a collateral squeeze.

We want to investigate whether we can find an information system that can alleviate the investment distortion. On one hand, if $A_L < A_H$ (i.e if $\gamma < \gamma_{max}$) an information system that does not disclose information for firms with asset value $A \in [A_L - \delta, A_H]$ where δ is small, will improve the productive investment. Non disclosing firms can find financing and run the project. Firms with asset value $A \in [A_L - \delta, A_L]$ pooled with capital richer firms take the efficient investment. On the other hand, if $A_L > A_H$ (i.e if $\gamma > \gamma_{max}$) providing only partial information cannot alleviate the distortion and all firms take the financial investment. Lemma 2 summarizes these findings:

Lemma 2

(i) Full disclosure creates underproduction distortion for firms with $A < A_L$. A collateral squeeze weakly worsens the investment distortion.

(ii) There exists an information system with partial disclosure that weakly dominates full disclosure.

The observability of the assets cannot solve the distortion due to moral hazard. Pooling firms with intermediate values $A_L \leq A \leq A_H$ with some capital poorer firms mitigates the distortion at the bottom. We next investigate if the investment choice can be optimal if there is no information about the pledgeable assets.

Moral Hazard and No Disclosure

We keep unobservable effort and study the information system prescribing no disclosure. We will later use this analysis as a helpful benchmark to evaluate the incremental benefit of the optimal information system.

Productive Investment

If we do not observe the value of the assets, firms will not differ in their investment choice. We can face two scenarios. If $A_L < E(A) < A_H$ the firms run the projects, otherwise they take the financial investment.

Proposition 4 *There exist unique γ_L and γ_H, given by:*

$$\begin{aligned}\gamma_L &\equiv \frac{pH - \frac{pc}{\Delta p} + E(A)(\eta p + (1-p))}{I} \\ \gamma_H &\equiv \frac{pH - c + E(A)(\eta p + (1-p))}{E(A) + I},\end{aligned}$$

so that:

(i) If $\gamma \leq \min(\gamma_L, \gamma_{max}, \gamma_H)$, all projects are financed and run by the firms. ($A_L < E(A) < A_H$).

(ii) Else the firms conduct the financial investment.

(iii) Both γ_L and γ_H are increasing in H, η and p and decreasing in I and c. γ_L is decreasing in a collateral squeeze and decreasing in Δp, while γ_H is increasing in a collateral squeeze.

The intuition behind this result is shown in Figure 2. Case 1 corresponds to a limiting case where for all costs of capital the aggregate wealth defined as W^{max} is larger than A_H, and all firms prefer the financial investment. Case 3 is the cut-off scenario where the aggregate wealth is equal to $W^{imp} = A_L(\gamma_{max})$, that is, for all costs of capital firms find financing and always prefer the productive investment. We end up with case 5 where the aggregate wealth is equal to or less than $W^{low} = A_L(\gamma_{min})$ and for all costs of capital firms short of financing take the financial investment. Case 2 and case 4 are intermediary cases between the pivotal cases. From case 1 to case 3, productive investment continues to expand up to a turning point when the wealth in the economy is equal to the minimum collateral requirement for the highest cost of capital, defined as $W^{imp} = A_L(\gamma_{max})$. At W^{imp}, no matter the level of cost of capital firms run the productive investment. From any wealth below W^{imp} , productive investment shrinks until it completely disappears for very low wealth in the economy short of financing (Case 5).

Distortions with No Disclosure

No disclosure creates distortions in investment choice. No disclosure policy pools all the firms in the economy: capital poor firms as well as capital rich firms run the project if $A_L < E(A) < A_H$ (i.e. $\gamma \leq \min(\gamma_L, \gamma_{max}, \gamma_H)$). The investment choice is suboptimal as capital rich firms with $A > A_H$ should have taken the financial investment. There is overproduction in the economy. Otherwise, all firms in the economy take the financial investment and firms with $A < A_H$ would have been better off running the project, but absent any information they cannot discriminate between investments. In this case there is underproduction in the economy. These distortions depend on the cost of capital and the aggregate wealth.

Lemma 3

(i) No disclosure creates investment distortion.

- *If $\gamma \leq \min(\gamma_L, \gamma_{max}, \gamma_H)$ there is overproduction for all firms relative to first-best.*
- *Otherwise there is underproduction for all firms relative to first-best.*

(ii) Define W^{shock} as the aggregate wealth after the collateral squeeze,

- *If $W^{shock} < W^{imp}$ and $\gamma_L(W^{shock}) \leq \gamma \leq \min(\gamma_L(E(A)), \gamma_H(E(A)), \gamma_{max})$, firms switch from the productive investment to the financial investment. Else firms keep the productive investment.*
- *If $W^{imp} > W^{shock} > W^{low}$ and the cost of capital $\gamma_H(E(A)) \leq \gamma \leq \min(\gamma_H(W^{shock}), \gamma_L(E(A)), \gamma_L(W^{shock}), \gamma_{max})$ firms switch from the financial to the productive investment. Else firms keep the financial investment.*

(iii) Partial disclosure weakly dominates no disclosure.

To understand the dynamics at play with a collateral squeeze, we change the aggregate wealth without altering the pre-squeeze cost of capital. On one hand if we start with overproduction (for example case 3), a collateral squeeze make the firms change to the financial investment if the wealth stay above W^{low} but falls below W^{imp} and the pre-squeeze cost of capital is sufficiently large. Alternatively once the wealth drops below W^{low}, firms always switch to the financial investment. On the other hand if we start with underproduction (for example Case 1), firms switch to the productive investment if the wealth after the collateral squeeze is above W^{imp} and the pre-squeeze cost of capital is relatively low. At $E(A) > W^{shock} = W^{imp}$, they all switch to the productive investment.

In all scenarios we can find an information system that achieves a better investment allocation. If $E(A) < A_L < A_H$ setting up an information system that discloses pledgeable assets with values $A \in [A_L, A_H]$ is more efficient than no disclosure. In this case the disclosing firms will run the productive investment and the non-disclosing firms will conduct the financial investment. This information system alleviates partially the distortion on the productive investment for firms with intermediate pledgeable assets $A \in [A_L, A_H]$. On the other hand, if $A_L < E(A) < A_H$ and there is no information all firms run the productive investment. An information system disclosing information for the firm with the highest value of pledgeable asset dominates no disclosure as the most capital rich firm knowing its information will prefer the financial investment, which is the efficient investment. The remaining non disclosing firms keep the productive investment.

3.3 Moral Hazard and Optimal Information System

We have established in the preceding section that for $\gamma < \gamma_{max}$ partial information is welfare improving and dominates both full disclosure and no disclosure. This happens because partial information might facilitate financing of projects or determine the type of investment undertaken by the firm. In the remainder of the paper we restrict our attention only to cost of capital values below γ_{max}, which implies that $A_L(\gamma) < A_H(\gamma)$.

Impairment like Disclosures vs Liberal Disclosures

The optimal information system prescribes partial disclosure and separates firms into disclosing and non-disclosing firms. Based on the value of their assets, the disclosing firms will select the most value enhancing investment. The regulator needs to determine the investment choice for the non-disclosing firms - financial or productive investment. Assuming that non-disclosing firms take the financial investment, the best way to design the information system would return the same inefficient allocation of investment across firms as the one under full disclosure. Hence, it is optimal to prescribe the productive investment to non-disclosing firms.

Lemma 4 *The optimal information system prescribes the non disclosing firms to take the productive investment.*

Once the regulator knows that the optimal strategy is to ask non disclosing firms to take the productive investment, he needs to determine the set of non disclosing firms. Firms with $A \in [A_L, A_H]$ will *always* be non disclosing firms. The optimal information system coincides with the first-best choice for those firms. The regulator is left with determining the investment choice for the firms at the bottom ($A < A_L$) and at the top ($A > A_H$). Firms at the bottom need to be non-disclosing firms to find financing for their project. In contrast firms at the top need to disclose to take the efficient investment. The regulator cannot usually implement the desired disclosures for firms at the bottom and at the top simultaneously. The issue remains whether it is optimal to offset the distortion only for firms at the bottom and not improve the investment choice for firms at the top, or vice versa. To this end, the regulator solves the following optimization program:

$$\begin{aligned}
\max_{\theta(A)} U(\theta(A)) &= \int_0^{A_L} \gamma A(1-\theta(A))f(A)dA + \int_{A_H}^{\infty} \gamma A(1-\theta(A))f(A)dA \\
&+ \int_{A_L}^{A_H} (pH - \gamma I + (\eta p + (1-p))A - c)(1-\theta(A))f(A)dA \\
&+ \int_0^{\infty} (pH - \gamma I + (\eta p + (1-p))A - c)\theta(A)f(A)dA \\
&\text{s.t. } \frac{\int_0^\infty A\theta(A)f(A)dA}{\int_0^\infty \theta(A)f(A)dA} \geq A_L \quad if \quad \theta(A) \neq 0 \quad \text{for some} \quad A \qquad (3)
\end{aligned}$$

Constraint (3) allows financing for non disclosing firms so that they can run the project. The type of optimal mandatory disclosure depends on the wealth in the economy and the investment distortion at the bottom is always mitigated. This feature of the optimal information system stems from satisfying the constraint that secures financing for non-disclosing firms.

Proposition 5

(i) If $E(A) < A_L(\gamma_{max}) = W^{imp}$, an impairment-like information system with impairment threshold $A_{imp} < A_L$ is implemented. A_{imp} is uniquely defined by:

$$\int_{A_{imp}}^{\infty} Af(A)dA - A_L \int_{A_{imp}}^{\infty} f(A)dA = 0$$

Firms with $A \leq A_{imp}$ disclose and do not undertake the project whereas firms above A_{imp} do not disclose and undertake the project. A_{imp} is increasing in γ, I and c and decreasing in H, η, p and Δp. In case of collateral squeeze the impairment threshold increases.

(ii) If $E(A) > A_L(\gamma_{min}) = W^{low}$, a liberal information system with liberal threshold

$\max\{A_{lib}, A_H\}$ *is implemented.* A_{lib} *is uniquely defined by:*

$$\int_0^{A_{lib}} Af(A)dA - A_L \int_0^{A_{lib}} f(A)dA = 0$$

Firms with $A \geq \max\{A_{lib}, A_H\}$ *disclose and do not undertake the project whereas firms below* $\max\{A_{lib}, A_H\}$ *do not disclose and undertake the project.* A_{lib} *is increasing in* γ*,* I *and* c *and decreasing in* H*,* η*,* p *and* Δp*. In case of collateral squeeze the liberal threshold increases.*

Proposition 5 describes two types of disclosures - impairment-like disclosure and liberal disclosure. Impairment-like disclosures are more informative about low type events, whereas liberal disclosures are more informative about high type events. Liberal disclosures are less common in practice than impairment disclosures. A classic example is the capitalization of Research and Development expenses once technological feasibility is met. This can be interpreted as a disclosure of good news. Furthermore, revenues (disclosure of good news) are recognized when earned and if it is reasonably expected that payment will be received no bad debt expense is recognized (no bad news). An additional example is the upward revaluation allowed under IFRS[16]. If the economy is overall wealthy and the asset values are not expected to decline this will lead to disclosure of good events. A common feature of these three examples is that the economic prospects are good (feasibility is met and the technology product is likely to succeed, the client is expected to have sufficiently high wealth and be able to pay, the asset is in good condition and the economy is strong so no reduction in value is expected). If there is a small collateral squeeze (local change), the set of disclosing firms decrease for liberal disclosures whereas this set expands for impairment like disclosures. Intuitively non disclosing firms need to find financing and in response to collateral squeeze, their conditional expectation after the release of information need to increase to meet the tighter financing requirements. The disclosing thresholds adapt to the shock by increasing. In contrast, the other comparative statics for A_H and A_{lib} (or A_{imp}) are diametrically different. If the project is more attractive (H, p, η higher or I or γ lower) or the moral hazard is less severe (c or $1 - \Delta p$ lower), A_{lib} (or A_{imp}) decreases while A_H increases. However these opposite reactions reflect a better allocation of investment: A_{lib} (resp. A_{imp}) moves down as the financing conditions are less demanding, which reduces the distortion at the top

[16]IAS 16 *Property, Plant and Equipment* allows firms to choose revaluation method to measure their fixed assets. If a firm adopts the revaluation method and the value of an asset increases the firm can adjust upward the value of the asset. In the U.S. upward revaluation of fixed assets is not allowed as per FASB Statement No. 144, *Accounting for the Impairment or Disposal of Long-Lived Assets*

(resp. at the bottom). Comparing the optimal disclosures with and without moral hazard, liberal disclosures above A_{lib} and impairment disclosures are second best disclosures due to the presence of moral hazard. The distortion due to moral hazard is decreasing in the economy's wealth. If the economy is extremely wealthy, there is no financing issue and optimal disclosures are in line with the disclosures without moral hazard.

As Proposition 5 shows when the aggregate wealth in the economy is large ($E(A) > W^{low}$), the optimal information system can implement first best for low values of the cost of capital: firms with $A \in [0, A_H]$ receive financing and run the project, while firms with $A > A_H$ take the financial investment. In this case liberal mandatory disclosures resolve the distortion at the top without altering the financing issue of firms at the bottom. For higher costs of capital, only firms with $A > A_{lib}$ take the financial investment. Firms with $A \in [A_H, A_{lib}]$ take the inefficient investment and there is overproduction. When the wealth in the economy is below W^{imp}, impairment disclosures becomes optimal for high values of the cost of capital to squeeze some firms at the bottom to allow the remaining non-disclosing firms to meet the financing requirements. In the impairment equilibrium, disclosing firms are too risky from the lenders' perspective while in the liberal equilibrium, disclosing firms are very safe firms to lend money but forgo voluntarily to run the project. The distortion on the bottom is only partially resolved as only firms with $A \in [A_{imp}, A_L]$ receive financing and run the projects at the expense of the distortion at the top which is not alleviated.

Cost of Capital and Optimal Disclosure

We have just discussed two types of disclosure: impairment and liberal. The impairment-like disclosure is similar to the optimal information system in Goex and Wagenhofer (2009). In their setting, if $E(A) > A_L$, absent any information all firms take the productive investment and there is no distortion. In contrast if $E(A) \leq A_L$ absent any information all firms lose their productive investment. There is no alternative investment and thus A_L is independent of the cost of capital. In the paper the financing conditions are not the only constraint to run the project. The financial investment can deter firms to take the productive investment and might create new distortions.

The liberal disclosure occurs as a result of the new tension between productive and financial investments. Our next result links the optimal information system to the exogenous cost of capital.

Corollary 1

(i) If $\gamma_{min} < \gamma < \min(\max(\gamma_L, \gamma_{min}), \gamma_{max})$, a liberal information system is optimal. There exists a unique cost of capital $\gamma_{lib} \in (\gamma_{min}, \min(\max(\gamma_L, \gamma_{min}), \gamma_{max}))$ such that $A_H(\gamma_{lib}) = A_{lib}(\gamma_{lib})$ and:

- *If $\gamma_{min} < \gamma < \gamma_{lib}$, firms above A_H disclose.*
- *If $\gamma_{lib} < \gamma < \min(\gamma_L, \gamma_{max})$, firms above A_{lib} as defined in Lemma 5 disclose.*

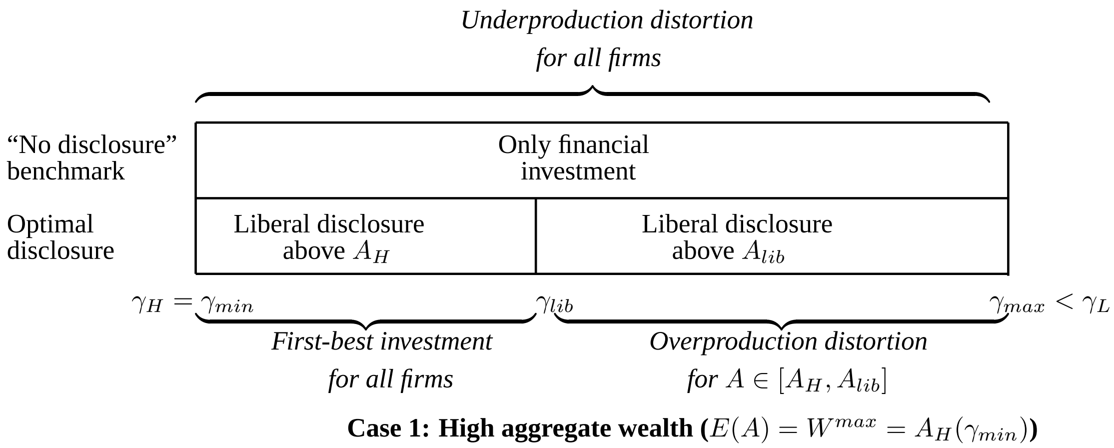
γ_{lib} is increasing in p, H, and η, decreasing in I and c. If there is a collateral squeeze γ_{lib} increases (decreases) if expression (4) *is positive (negative):*

$$\frac{A_H(\gamma_{lib})}{A_L(\gamma_{lib})} \cdot \frac{(A_H(\gamma_{lib}) - A_L(\gamma_{lib}))}{(1-\varepsilon)} - \underbrace{\frac{\int_0^{\frac{A_H(\gamma_{lib})}{1-\varepsilon}} f(A)dA}{f\left(\frac{A_H(\gamma_{lib})}{1-\varepsilon}\right)}}_{inverse \;\; hazard \;\; rate} \tag{4}$$

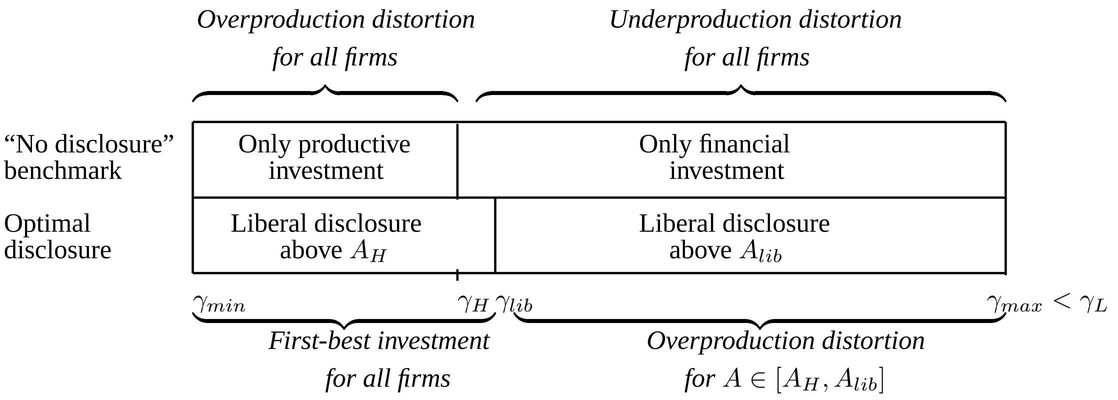
(ii) If $\min(\max(\gamma_L, \gamma_{min}), \gamma_{max}) < \gamma < \gamma_{max}$ an impairment-like information system is optimal. Firms below the threshold A_{imp} as defined in Lemma 5 disclose.

(iii) If $\gamma > \gamma_{max}$, firms take the financial investment and are indifferent between any information system.

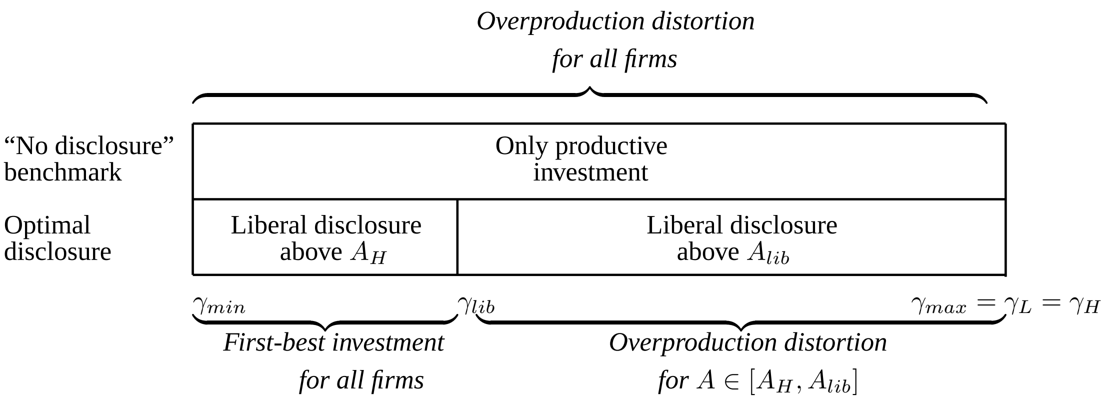
In Figure 2 below we provide an example comparing the equilibrium investment choice without information and with optimal partial disclosure. To expose the effect of regulation relatively to no regulation, we keep fixed all parameters and gradually change the aggregate wealth in the economy. Recall that γ_{max} is independent of a reduction of the assets in the same proportion for all firms. In this example γ_{lib} is increasing in the aggregate wealth. However, γ_L is increasing in $E(A)$ and γ_H is decreasing in $E(A)$, which affects the optimal disclosure, the investment choice and distortion.



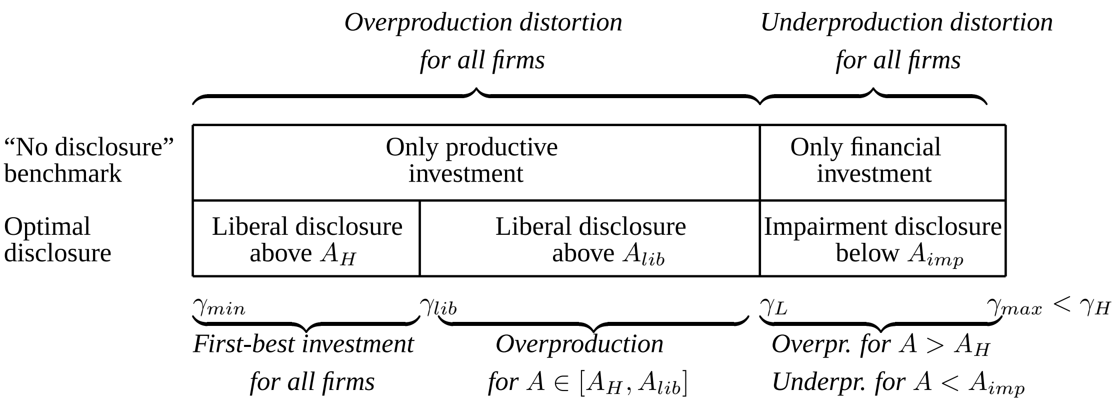
Case 1: High aggregate wealth ($E(A) = W^{max} = A_H(\gamma_{min})$)
($E(A) > A_H > A_L$ for $\gamma \in (\gamma_{min}, \gamma_{max})$)



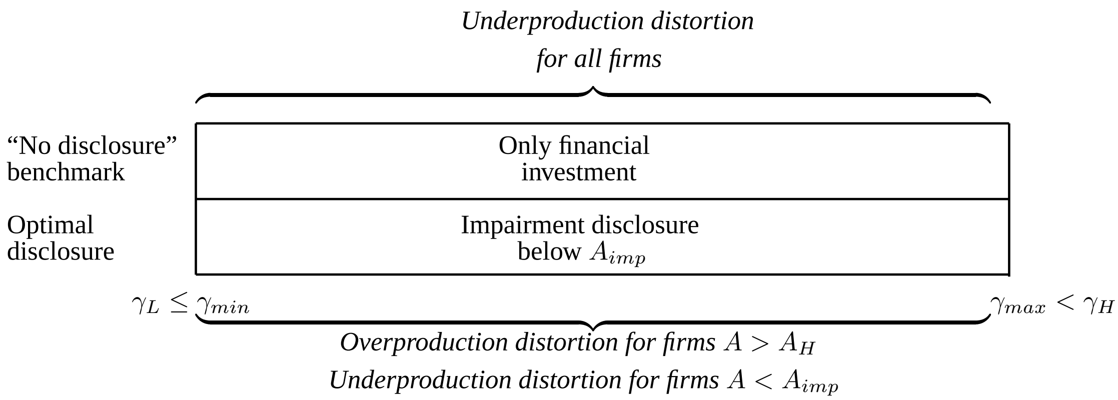
Case 2: Above intermediate aggregate wealth ($E(A) > A_L(\gamma_{max}) = W^{imp}$)
($A_H > E(A) > A_L$ for $\gamma \in (\gamma_{min}, \gamma_H)$ and $E(A) > A_H > A_L$ for $\gamma \in (\gamma_H, \gamma_{max})$)



Case 3: Intermediate aggregate wealth ($E(A) = W^{imp} = A_L(\gamma_{max})$)
($A_H > E(A) > A_L$ for $\gamma \in (\gamma_{min}, \gamma_{max})$)



Case 4: Low aggregate wealth ($A_L(\gamma_{min}) = W^{low} < E(A) < W^{imp} = A_L(\gamma_{max})$)
($A_H > E(A) > A_L$ for $\gamma < \gamma_L$, else $A_H > A_L > E(A)$)



Case 5: Very low aggregate wealth ($E(A) \leq W^{low} = A_L(\gamma_{min})$)
$(A_H > A_L > E(A))$

Figure 2: Disclosure, investment choice and distortion

If the amount of aggregate wealth $E(A) \in [W^{max}, W^{imp}]$, firms can receive funding for their project (cases 1, 2 and 3) even without information and impairment disclosures are never implemented. It is optimal to prescribe liberal disclosure that either achieves first best or creates overproduction only for a small proportion of the firms (those with $A \in [A_H, A_{lib}]$). From Case 1 to case 3 the wealth decreases and thus the set of liberal disclosures attaining first best shrinks to satisfy the financing requirements for non disclosing firms. When the aggregate wealth fall below W^{imp}, lenders require higher amount of collateral and financing becomes an issue for high costs of capital (in case 4 this happens for $\gamma \in [\gamma_L, \gamma_{max}]$). If the wealth further drop below W^{low}, impairment disclosures are optimal no matter the cost of capital. Firms with pledgeable assets below the impairment threshold are squeezed out to allow the rest of the firms to receive financing. Relatively to first best there will be underproduction for firms below the impairment threshold and overproduction for firms above A_H.

The underlying force of mandatory disclosures is the level of aggregate wealth in the economy relatively to the financing conditions that depend on the cost of capital. The model predicts that a rich economy exhibits liberal disclosures and the level of cost of capital is irrelevant. A poorer economy prescribes respectively liberal accounting for low costs of capital and impairment disclosures for high values. However first best is attained if and only if liberal disclosures are optimal and the cost of capital is relatively low.

4 Endogenous Cost of Capital

The assumption that capital is in perfectly elastic supply at an exogenous cost of capital is a simplification. We complete the analysis by recognizing the endogeneity of the supply and the cost of capital. To do so we assume that the entrepreneurial firms receive capital from two sources: from an exogenous supply $K > 0$ and from firms that do not run the project.

4.1 Benchmarks

We first define two relevant benchmarks. We first define the *constrained first-best* that captures the transfer of capital between entrepreneurial and financing firms. Then we solve for the endogenous cost of capital in absence of moral hazard to isolate the effects of moral hazard on the cost of capital and optimal disclosures in section 4.2.

Constrained First Best

To describe the constrained first best we introduce the notion of a benevolent social planner, who observes effort and the asset values, and maximizes the aggregate wealth in the economy by optimally allocating the existing resources. The only limitation that he is facing is the scarcity of resources. Although the productive investment is economically viable, the social planner cannot fund all firms. He can finance the productive projects with the exogenous supply K and with the assets of firms that do not run the project, i.e. financing firms. The financing firms can only lend what they own, i.e. their pledgeable assets. In this constrained first-best, a firm with pledgeable assets A generates a net present value of $pH + \eta A - c$ if the productive investment is funded, otherwise zero. When deciding which firms should run the productive investment the social planner maximizes the sum of individual utilities. Proposition 6 summarizes the characteristics of the socially optimal productive investment:

Proposition 6 *The social optimal productive investment is:*

$$\int_0^{A^*} (pH + \eta A - c) f(A) dA$$
$$\textit{where } \; I \int_0^{A^*} f(A) dA = K + \int_{A^*}^{\infty} A f(A) dA \tag{5}$$

The social planner wants to fund as many projects as possible, but the resource constraint (5) limits his choice. This constraint reflects the transfer of capital between capital providers and entrepreneurial firms. In our benchmark firms with pledgeable assets below A^* run the productive investment and become entrepreneurial firms whereas firms above A^* become financing firms. Our constrained first-best is defined differently relatively to the partial equilibrium setting. There is no cost of capital as the firms abandoning the project transfer their assets to the other firms to fill the financing gap. We find that in such a setting it is optimal for the capital rich firms to finance the capital poorer firms. Given that running the project requires the same external investment and that capital rich firms are not endowed with better projects, the transfer of high value assets to the poorer firms is optimal. The allocation of resources across firms can be better understood by rearranging condition (19) as follows:

$$\underbrace{K + E(A)}_{Resources} = \underbrace{\int_0^{A^*} (I + A) f(A) dA}_{Invested\ \ Capital} \tag{6}$$

The resources in the economy are equal to the initial aggregate wealth in the economy from the firms and the outside investors providing capital K. These resources are dispatched to the entrepreneurial firms: the entrepreneurial firms keep their initial wealth A and receive the supplemental outside capital I to run their project. Since resources are limited, if external financing I increase or projects are less attractive (lower p, H and η or higher c), the overall productive investment in the economy reduces. Similarly, a collateral squeeze is compensated by more firms lending their assets. As a consequence, if there is a collateral squeeze, the productive investment decreases leading to less social surplus. This last result is in sharp contrast with the unconstrained first-best in the partial equilibrium setting. The partial equilibrium setting was neglecting the offsetting effect of less wealth on the capital providers, if they are determined endogenously. Less wealth for the capital providers means that they cannot finance as many entrepreneurial firms as before. The effect of macroeconomic factors on the constrained first-best investment threshold A^* and the total social surplus are summarized in the following Corollary:

Corollary 2

(i) A^* decreases in I and in a collateral squeeze or credit crunch in the economy.

(ii) The total social surplus increases in K, p, H and η, and decreases in I and c.

In general equilibrium, we can address the effect of a credit crunch. This alternative shock that tightens capital has similar effects on the aggregate productive investment. The shrinkage in capital is also compensated by more firms lending their assets. However a lower exogenous supply affects directly the left hand side of resource constraint (6) without altering directly the right hand side, in contrast to a collateral squeeze. The amount of capital invested in entrepreneurial firms is indirectly adjusted through the threshold A^*. Thus although the net effect of the collateral squeeze or the credit crunch on the aggregate productive investment is qualitatively the same, their impact on the threshold A^* are in magnitude different. This latter response will explain different outcomes on the cost of capital in presence of a collateral squeeze or credit crunch in the subsequent analysis.

General Equilibrium without Moral Hazard

Before solving the general equilibrium with moral hazard, we study the general equilibrium when effort is observable which we will use as an additional benchmark. From proposition 2, we know that firms above A_H disclosing their information and becoming financing firms and the remaining non-disclosing firms demanding capital is one of the optimal information system and would be the "least cost" information system should the firms pay a cost to disclose. Hence, the net demand without moral hazard is defined as follows:

$$I \int_0^{A_H} f(A)dA - K - \int_{A_H}^{\infty} Af(A)dA \tag{7}$$

A_H is decreasing in the cost of capital and thus the net demand defined above decreases in the cost of capital. We show the existence of a unique cost of capital that clears the markets. Not surprisingly without moral hazard, we can achieve the constrained first best. We will use the cost of capital γ^{FB} as a benchmark when we define the optimal cost of capital with moral hazard.

Proposition 7 *Without moral hazard, there exists a unique general equilibrium that achieves the constrained first best:*

(i) Markets clear at γ^{FB} such that:

$$I \int_0^{A_H(\gamma^{FB})} f(A)dA = K + \int_{A_H(\gamma^{FB})}^{\infty} Af(A)dA \tag{8}$$

(ii) Firms above $A_H(\gamma^{FB}) = A^*$ disclose and invest in the financial investment. Firms below $A_H(\gamma^{FB}) = A^*$ run the project

The comparative statics on $A_H(\gamma^{FB})$ are identical to A^*, and differ from our findings in the partial equilibrium analysis:

Corollary 3

(i) γ^{FB} *is increasing in* p*,* H *and* η*, and decreasing in* c *and* K*. A change in* I *has ambiguous effects on* γ^{FB}*.*

(ii) $A_H(\gamma^{FB})$ *is not affected by changes in* p*,* H*,* η *and* c*, but is decreasing in* I*. If there is a collateral squeeze or credit crunch* $A_H(\gamma^{FB})$ *decreases.*

Except for I, the disclosure threshold $A_H(\gamma^{FB})$ is the only channel through which the market clearing condition is adjusted. The endogenous cost of capital can perfectly offset the change in the economic environment on this threshold so that the optimal investment allocation is preserved. However, $A_H(\gamma_{FB})$ decreases in the outside capital raised. The direct effect of an increase in I is to move up the demand while a higher I decreases indirectly the disclosure threshold, and drives down the demand. All in all, both credit crunch and collateral squeeze also call for lower $A_H(\gamma^{FB})$, achieved through lower γ^{FB}. The intuition behind this result is that both credit crunch (leading to lower exogenous supply) and collateral squeeze need to be compensated by more firms lending their assets and less firms taking the project.

4.2 Moral Hazard and Cost of Capital

In Section 3.3, we have discussed the optimal disclosure for a given cost of capital, i.e. in a partial equilibrium setting. We now derive the general equilibrium by taking into account the effects of endogenous supply. To this end, we introduce the market clearing condition, stating that the demand in capital needs to equal the supply of capital. We study conditions on the cost of capital to clear the markets. We also characterize the possible general equilibria as a function of the exogenous parameters.

Net Demands

In presence of moral hazard, the determination of the cost of capital is more complex. Due to the the different mandatory disclosures enforced, the net demand (demand net of supply) is a piecewise function defined by:

$$Q(\gamma) = I\int_0^{A_H(\gamma)} f(A)dA - K - \int_{A_H(\gamma)}^{\infty} Af(A)dA, \quad \text{if } \gamma \in (\gamma_{min}, \gamma_{lib}],$$
$$T(\gamma) = I\int_0^{A_{lib}(\gamma)} f(A)dA - K - \int_{A_{lib}(\gamma)}^{\infty} Af(A)dA, \quad \text{if } \gamma \in (\gamma_{lib}, \min(\gamma_L, \gamma_{max})],$$
$$Z(\gamma) = I\int_{A_{imp}(\gamma)}^{\infty} f(A)dA - K - \int_0^{A_{imp}(\gamma)} Af(A)dA, \quad \text{if } \gamma \in (\min(\gamma_L, \gamma_{max}), \gamma_{max}).$$

The net demands $Q(\gamma)$ and $T(\gamma)$ are associated with liberal disclosures. In both cases the entrepreneurial firms are the ones "at the bottom" and the financing firms are the ones "at the top". The net demand in $Z(\gamma)$ corresponds to impairment-like disclosure in which case the entrepreneurial firms are the ones "at the top" and the financing firms are the ones "at the bottom". Although net demands $Q(\gamma)$ and $Z(\gamma)$ differ in their mandatory disclosures, they both decrease in the cost of capital and are affected similarly by a change in the exogenous parameters and in particular in I. On the demand side, higher outside capital shrinks the proportion of firms financed while increasing the per firm outside capital. On the supply side, higher outside capital unambiguously increases the supply as it makes the financing requirements tighter. In this case, the shift of the net demand is intuitive. In contrast, the net demand $T(\gamma)$ moves in the opposite direction. Counter-intuitively, it increases in the cost of capital and also in the outside capital raised.

Lemma 5

(i) If $\frac{I}{A_L(\gamma_{max})} \geq \frac{K+\int_0^{A_{imp}(\gamma_{max})} Af(A)dA}{\int_{A_{imp}(\gamma_{max})}^{\infty} Af(A)dA}$*, impairment-like disclosures are never optimal.*

(ii) If $\frac{I}{A_L(\gamma_{lib})} \geq \frac{K+\int_{A_H(\gamma_{lib})}^{\infty} Af(A)dA}{\int_0^{A_{lib}(\gamma_{lib})} Af(A)dA}$ *or* $A^* < A_H(\gamma_{lib})$*, liberal disclosures are never optimal.*

Lemma 5 outlines sufficient conditions to rule out disclosures in general equilibrium. If the above conditions are met, there is excess demand. Excess demand emerges if capital providers' wealth relatively to entrepreneurial firms' wealth is lower than their revenue shortfall in the worst case scenario, i.e., when the project fails and they get possession of the minimum collateral. This is more likely to happen if the amount of outside capital to finance the project is relatively high or if the minimum collateral to guarantee financing is low and/or if the exogenous capital is low. The ratio $\frac{I}{A_L(\gamma)}$ evaluated at γ_{lib} or γ_{max} can also be interpreted as a measure of the riskiness of the project or a solvency ratio. The higher the more risky the project is. Alternatively this ratio captures the outside financing relatively to internal financing. To guarantee the existence of impairment-like disclosures or liberal disclosures, we need more structure than in the partial equilibrium setting. Lenders' assets need to be higher than the revenue shortfall that they can incur.The solvency ratio is higher for liberal disclosures compared to impairment-like disclosures. In other words capital providers do not need to be as wealthy so that impairment-like disclosures arise in equilibrium. A sufficient condition to rule out liberal disclosures in general equilibria is to have the constrained first-best threshold A^* lower than the liberal threshold where the two types of liberal disclosures meet $A_{lib}(\gamma_{lib}) = A_H(\gamma_{lib})$.[17] If this is the case there will be not enough firms funding the entrepreneurial firms and there will be excess demand.[18]

General Equilibria

If one or both of the conditions described in Lemma 5 are not satisfied, there exists at least one optimal cost of capital that clears the markets. We next derive the general equilibria as a function of the aggregate wealth in the economy:

Proposition 8

- *If* $\frac{I}{A_L(\gamma_{lib})} < \frac{K+\int_{A_H(\gamma_{lib})}^{\infty} Af(A)dA}{\int_0^{A_{lib}(\gamma_{lib})} Af(A)dA}$ *and* $E(A) > W^{low}$*, there are two general equilibria:*

  GE_1: *the optimal disclosure prescribes firms to disclose above* $A_H(\gamma^*)$ *and the optimal cost of capital* $\gamma^* = \gamma^{FB} < \gamma_{lib}$ *achieves first-best and is defined by* $I\int_0^{A_H(\gamma^*)} f(A)dA = K + \int_{A_H(\gamma^*)}^{\infty} Af(A)dA$.

  GE_2: *the optimal disclosure prescribes firms to disclose above* $A_{lib}(\gamma^{**}) > A_H(\gamma^{**})$ *and the optimal cost of capital* $\gamma_{lib} < \gamma^{**} < \gamma_{max}$ *achieves first-best and is defined by* $I\int_0^{A_{lib}(\gamma^{**})} f(A)dA = K + \int_{A_{lib}(\gamma^{**})}^{\infty} Af(A)dA$.

- *If* $\frac{I}{A_L(\gamma_{max})} \geq \frac{K+\int_0^{A_{imp}(\gamma_{max})} Af(A)dA}{\int_{A_{imp}(\gamma_{max})}^{\infty} Af(A)dA}$ *and* $W^{low} < E(A) \leq W^{imp}$*, there is an equilibrium* GE_3 *defined by:*

  GE_3: *the optimal disclosure prescribes firms to disclose below* $A_{imp}(\gamma^{***})$ *and the optimal cost of capital* $\gamma_L < \gamma^{***} < \gamma_{max}$ *is defined by* $I\int_{A_{imp}(\gamma^{***})}^{\infty} f(A)dA = K + \int_0^{A_{imp}(\gamma^{***})} Af(A)dA$.

- *If* $\frac{I}{A_L(\gamma_{max})} \geq \frac{K+\int_0^{A_{imp}(\gamma_{max})} Af(A)dA}{\int_{A_{imp}(\gamma_{max})}^{\infty} Af(A)dA}$, $\frac{I}{A_L(\gamma_{min})} \leq \frac{K+\int_0^{A_{imp}(\gamma_{min})} Af(A)dA}{\int_{A_{imp}(\gamma_{min})}^{\infty} Af(A)dA}$ *and* $E(A) \leq W^{low}$*, there is a unique general equilibrium* GE_3.

  In all three general equilibria disclosing firms invest in the open market while non disclosing firms run the project.

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[17] Given that $A_H(\gamma)$ is decreasing in γ and A_{lib} is increasing in γ the lowest possible liberal threshold is $A_H(\gamma_{lib}) = A_{lib}(\gamma_{lib})$.

[18] However if there is always excess demand for $\gamma < \gamma_{max}$, there exits an equilibrium at γ_{max}, where the non-disclosing firms are indifferent between the productive and the financial investment. This equilibrium is stable.

The lowest feasible cost of capital γ^* clears net demand $Q(\gamma)$ and is associated with liquidation of capital rich firms. When it exists, γ^* is equal to γ^{FB}. The intermediate cost of capital γ^{**} clears net demand $T(\gamma)$ and also attains first best. The highest feasible cost of capital γ^{***} clears $Z(\gamma)$ and is associated with disclosure of capital poor firms. The latter cost of capital introduces distortions in the productive investment, because both capital poor firms and capital rich firms are selecting a suboptimal investment.[19]

Corollary 4

(i) *If $\gamma_{min} < \gamma_{lib} < \gamma_{max} < \gamma_L$ and if $A^* > A_H(\gamma_{lib})$, there are two general equilibria, described by GE_1 and GE_2.*

(ii) *Assume $\gamma_{min} < \gamma_{lib} < \gamma_L < \gamma_{max}$. Then,*

- *if $A^* > A_H(\gamma_{lib})$ and $I \int_{A_{imp}(\gamma_{max})}^{\infty} f(A)dA - \int_0^{A_{imp}(\gamma_{max})} Af(A)dA < 0$, there are three general equilibria, described by GE_1, GE_2 and GE_3.*
- *if $A^* > A_H(\gamma_{lib})$ and $I \int_{A_{imp}(\gamma_{max})}^{\infty} f(A)dA - \int_0^{A_{imp}(\gamma_{max})} Af(A)dA > 0$, there are two general equilibria, described by GE_1 and GE_2.*
- *if $A^* < A_H(\gamma_{lib})$ and $I \int_{A_{imp}(\gamma_{max})}^{\infty} f(A)dA - \int_0^{A_{imp}(\gamma_{max})} Af(A)dA < 0$, there is one general equilibrium, described by GE_3.*

(iii) *If $\gamma_L < \gamma_{min} < \gamma_{max}$ and $I \int_{A_{imp}(\gamma_{max})}^{\infty} f(A)dA - \int_0^{A_{imp}(\gamma_{max})} Af(A)dA < 0$, there is one general equilibrium described by GE_3.*

In Figure 3 below we pursue the analysis of the five cases illustrated in Figure 2 and present the possible general equilibria when the conditions in the economy ensure market clearing.

[19] At γ^*, the first best for a given cost of capital and the first best in the economy with limited resources are equal. At γ^{**}, the constrained first best is attained but not the unconstrained first best. However at γ^{***}, $A^* > A_H$ and hence, there is a distortion relative to both types of first best .

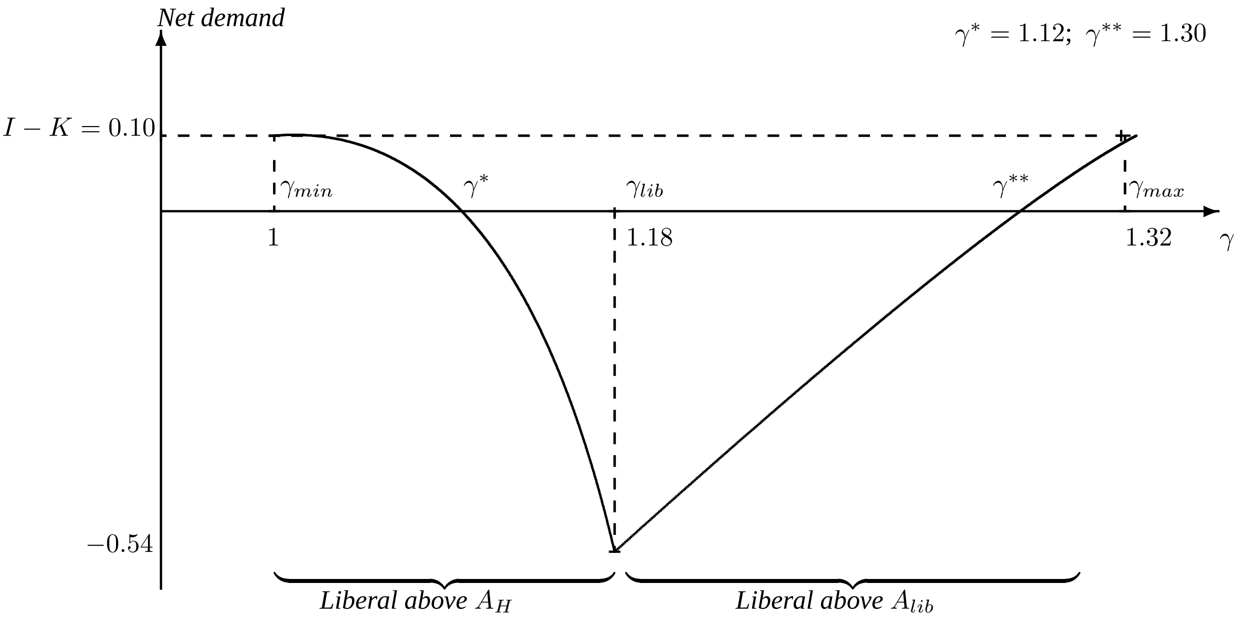


Figure 3a: High aggregate wealth ($\varepsilon = 0$)

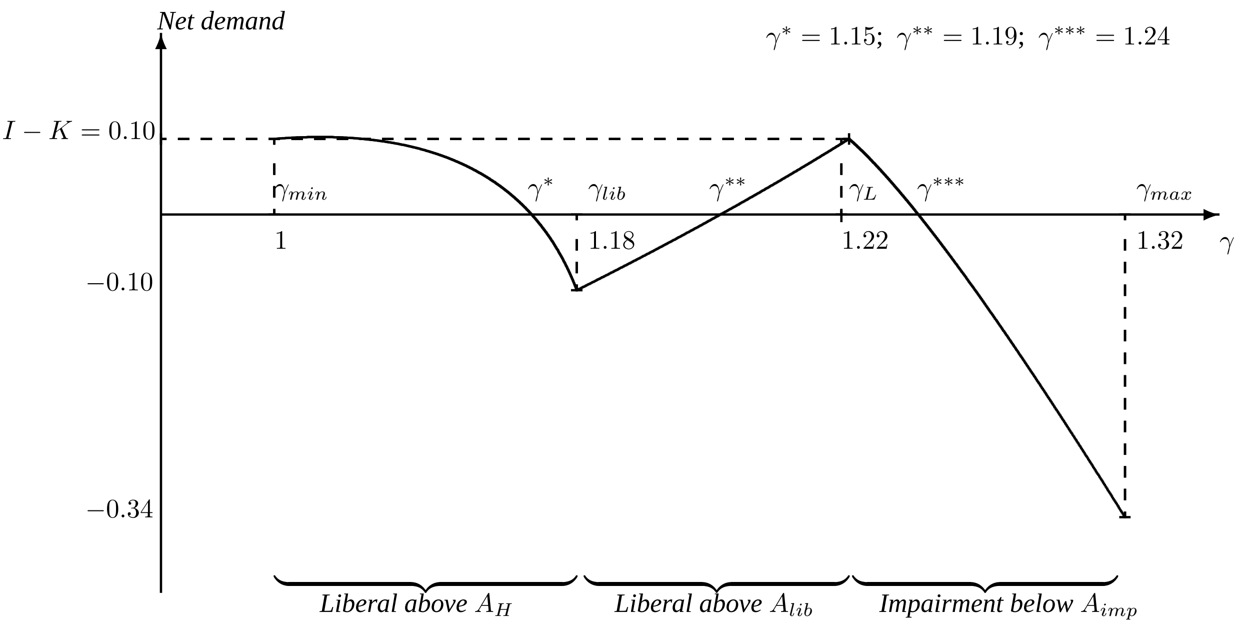


Figure 3b: Low aggregate wealth ($\varepsilon = 0.23$)

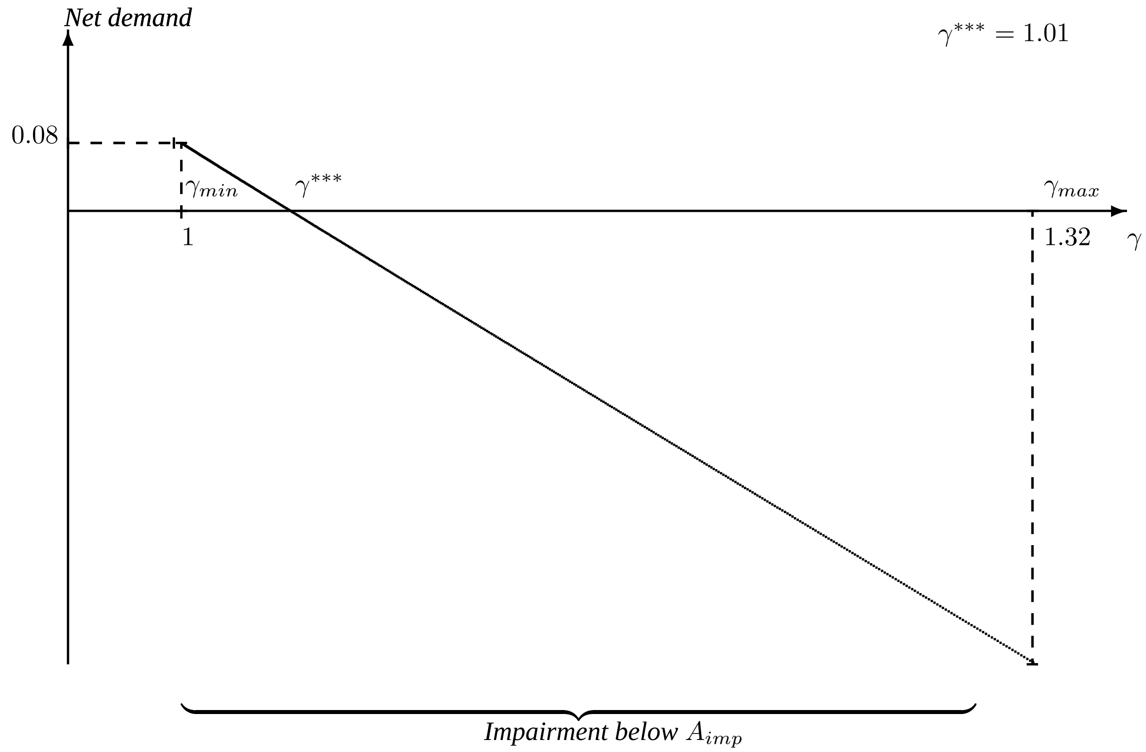


Figure 3c: Very low aggregate wealth ($\varepsilon = 0.67$)

$p = \frac{1}{2}$; $\Delta p = \frac{3}{32}$; $c = \frac{1}{4}$; $H = 6$; $I = 2$; $K = 1.9$; $f(A) = \lambda e^{-\lambda A}$; $\lambda = 1$; $E(A) = 1$; $\eta = 1$

Figure 3: Example of General Equilibrium as a Function of Aggregate Wealth

4.3 Macroeconomic Shocks & General Equilibrium Impact

We analyze the effects of macroeconomic factors on the equilibrium costs of capital and the disclosure thresholds with moral hazard. Macroeconomic shocks can effect all the exogenous parameters in the economy. We study first the potential impacts of macroeconomic shocks on the characteristics of the productive investment, then investigate how the different players could rather coordinate towards one equilibrium rather than another one and finally study the effects of capital tightening shocks, namely credit crunch and collateral squeeze on the costs of capital and mandatory disclosures.

Changes in the characteristics of the Productive investment

The net demands determining γ^* and γ^{***} are affected similarly by changes in the fundamentals of the productive Investment. Intuitively more returns on the project (higher p, H or η) or less moral hazard (lower c) translate into more demand in capital. A higher cost of capital can counterbalance this surge in demand so that the market clearing condition is preserved. If the outside capital I increases, entrepreneurial firms need easier financing conditions, a decrease of the cost of capital fulfills that goal for impairment disclosure. For liberal disclosures the increase in I depends on the characteristics of the distribution. On the contrary, the net demand related to γ^{**}, is atypical and shifts in an opposite direction to the other net demands after a change in a parameter of the economy. As a result, a better project, less severe moral hazard or lower outside capital raised decrease the demand and a lower cost of capital would counterintuitively worsen the excess supply. To address an excess supply the cost of capital in equilibrium moves upward. The costs of capital γ^{**} and γ^{***} are similarly affected by Δp, while the cost of capital γ^{*} is independent of Δp. This feature is consistent with the cost of capital γ^{*} being the only equilibrium cost of capital in line with the equilibrium cost of capital in absence of moral hazard γ^{FB}. The comparative statics of the equilibrium costs of capital are summarized below:

Corollary 5

(i) *γ^{*}, γ^{**} and γ^{***} are increasing in p and H, and decreasing in c. γ^{*} is unaffected by a change in Δp and I has ambiguous effects on γ^{FB}, while γ^{**} and γ^{***} are decreasing in Δp and I.*

(ii) *$A_H(\gamma^{*})$, $A_{imp}(\gamma^{***})$ and $A_{lib}(\gamma^{**})$ do not change in response to a change in p, c, Δp, η or H. An increase in I increases $A_{imp}(\gamma^{***})$ and decreases $A_H(\gamma^{*})$ and $A_{lib}(\gamma^{**})$.*

(iii) *$A_L(\gamma^{*})$, $A_L(\gamma^{**})$ and $A_L(\gamma^{***})$ are unaffected by p, c, Δp, η or H. An increase in I increases $A_L(\gamma^{***})$ and decreases $A_L(\gamma^{*})$ and $A_L(\gamma^{**})$.*

In contrast to the partial equilibrium, the equilibrium thresholds are not affected in response to a change in p, Δp, η or H. An increase in these parameters is exactly offset by an increase in the cost of capital so that the market clearing condition is preserved. Similarly, a lower cost of capital c charged counterbalances the increase in c, which leaves the thresholds unaffected. An increase in I increases A_{imp}, which is the same effect as in partial equilibrium and counterintuitively decreases A_{lib} . In response to a raise in I, the cost of capital decreases and A_{lib} moves downward. The maximum collateral to prefer productive investment A_H when it defines the optimal disclosures does not adjust to any change in the parameters in the economy except the amount of raised capital I, which ambiguously moves it either upward if it increases. The feedback effects on the minimum collateral required to obtain financing A_L are in correspondence with the thresholds A_{imp}, A_{lib} or A_H depending on the general equilibrium selected. In particular during a recession

p and H are more likely to decrease and the minimum collateral to find financing A_L remains the same as the equilibrium cost of capital increases. In other terms if the change is local and we stay in the same general equilibrium, the disclosure thresholds remain the same and all the shocks on p or H are absorbed by the change in cost of capital.

If the aggregate wealth is sufficiently large, the moral hazard can be resolved by the markets and efficient investment is implemented (cases 1, 2 and 3). There exist two equilibrium costs of capital, $\gamma^* = \gamma^{FB}$ and γ^{**}, and $A_H(\gamma^*) = A_{lib}(\gamma^{**}) = A^*$. A decrease in the aggregate wealth (case 3) adds the inefficient equilibrium GE_3. In this scenario, the cost of capital γ^{***} is always higher than the cost of capital without moral hazard γ^{FB}. A further drop in aggregate wealth leaves the economy with only the inefficient equilibrium. As illustrated in cases 4 and 5, we move from an economy with three general equilibria to an economy with a unique equilibrium without being confronted with an intermediate economy facing two equilibria. All in all a reduction in aggregate wealth creates inefficient investment. The model predicts that when there is multiplicity of equilibria in an economic environment with the same aggregate wealth we could observe diametrically opposite disclosures. The model could capture how fair value accounting is related to the cost of capital. An economy with the same wealth could feature two types of disclosure: if financing requirements are loose, firms with fair value accounting would recognize gains whereas if the financing conditions are tighter, they would recognize losses. With the same wealth, an economy with a low cost of capital is more informative about high type events, whereas an economy with a high cost of capital is more informative about low type events. This would mean that recognition of losses and high cost of capital is not necessarily a sign of a decrease in assets' values.

Alternatively, one could interpret the multiplicity of equilibria by the existence of different disclosure requirements for different type of events. On one hand, incurred administrative or marketing costs are expensed immediately as they cannot be linked to the expected benefits. This is an example for disclosure of bad news. On the other hand, certain types of costs such as the costs to produce inventory for sale, research and development costs[20] or borrowing costs of qualifying assets (formerly FAS 34) for US GAAP and IAS 23 *Borrowing Costs* for IFRS can be capitalized when it is probable that they will result in future economic benefits to the entity, which is a disclosure of good news.[21]

[20]Under IFRS development costs are capitalized when technical and economic feasibility of a project can be demonstrated in accordance with specific criteria. Some of the stated criteria include: demonstrating technical feasibility, intent to complete the asset, and ability to sell the asset in the future, as well as others. Under IFRS this is done only for computer software development costs under ASC 985-20 and ASC 350-40.

[21]Borrowing costs may include interest on banks overdrafts and short and long term borrowings; amortization of discounts and premiums relating to borrowings; amortization of ancillary costs incurred in connec-

Lastly, one can think of the co-existense of IFRS and US GAAP as two different disclosure requirements under two general equilibria. Generally speaking IFRS allows for more liberal type disclosures, while US GAAP allows for more impairment type disclosures. For example, IFRS allows for all types of development costs to be capitalized as long as there is economic and technical feasibility of the project, while US GAAP allows this only for computer software developed for external use. Another example is that IFRS allows upward revaluation of assets, while US GAAP does not permit that. There are two ways to interpret the current co-existence of these two disclosure requirements. First, one can claim that difference in aggregate wealth, exogenous supply or other economy parameters between US and the countries adopting the international standards may have led to two separate equilibria. Second, in a global environment the difference between the macroeconomic factors of different countries might not be significant. If this is so, the co-existence of IFRS and US GAAP can be interpreted as multiplicity of equilibria (case 4 in our descriptive examples in Figure 4).

Stability of the General Equilibria

In the preceding analysis we have shown that multiplicity of equilibria may arise. The common issue is to know how agents in the economy will coordinate towards one equilibrium rather than another one. To better understand the dynamics at play for converging towards one equilibrium over another, we introduce the concept of Walrasian tatonnement. The tatonnement process is a model for investigating stability of equilibria, under which no transactions and no production take place at disequilibrium prices. Instead, the cost of capital decreases (increases) if there is excess supply (demand). This concept clarifies how players in the economy would react to a small shock, potentially due to macroeconomic fundamentals.

Corollary 6 *There are only two stable general equilibria: GE_1 and GE_3.*

The counterintuitive features of the net demand associated with γ^{**} violate the tatonnement process and the cost of capital γ^{**} is ruled out. On one hand, the lowest cost of capital $\gamma^* = \gamma^{FB}$, if exists, is stable and associated with liberal disclosures and efficient investment. At this cost of capital, the constrained first best coincides with the first best when the cost of capital is taken as exogenous. On the other hand, the highest cost of

tion with the arrangement of borrowings etc. An example of such assets is inventories that need substantial time to bring them to their saleable condition. Borrowing costs that are directly attributable to the acquisition, construction or production of a qualifying asset shall be capitalized as part of the cost of the asset as per ASC 835-20 *Capitalization of Interest*.

capital γ^{***}, if it exists, is also stable, but is associated with inefficient investment. This cost of capital elicits all firms "at the top" to run the project, which is suboptimal, while forcing firms "at the bottom" to take the financial investment, which is not efficient. However this concept does not select a unique equilibrium. Selecting the liberal equilibrium over the impairment equilibrium on the grounds of Pareto efficiency is not a good criteria as experiments have shown that players do not necessarily coordinate on the Pareto efficient equilibrium.[22] The multiplicity of equilibria could also be seen as a richness as a change in aggregate wealth could lead from an economy with one stable equilibrium to an economy with two stable equilibria. Although the two equilibria are stable, it is hard to coordinate all the players to the other type of equilibrium. All the players have to change their anticipations to "adopt" the alternative equilibrium. This question of coordination especially arises when capital tightening shocks decrease the aggregate wealth. If the reduction in aggregate wealth is sufficiently large, we might switch from an economy with one stable equilibrium to an economy with two stable equilibria as illustrated in Figure 4.

Effect of Capital Tightening

We further analyzes the impact of macroeconomic shocks changing the net demand. We derive the effect of a collateral squeeze and a credit crunch if these shocks are local shocks.

Corollary 7

If there is a collateral squeeze,

(i) γ^* *increases, while* γ^{**} *and* γ^{***} *decrease.*

(ii) $A_H(\gamma^*)$ *and* $A_{lib}(\gamma^{**})$ *decrease, while* $A_{imp}(\gamma^{***})$ *increases.*

(iii) $A_L(\gamma^*)$ *and* $A_L(\gamma^{**})$ *decreases while* $A_L(\gamma^{***})$ *increases.*

If there is a credit crunch,

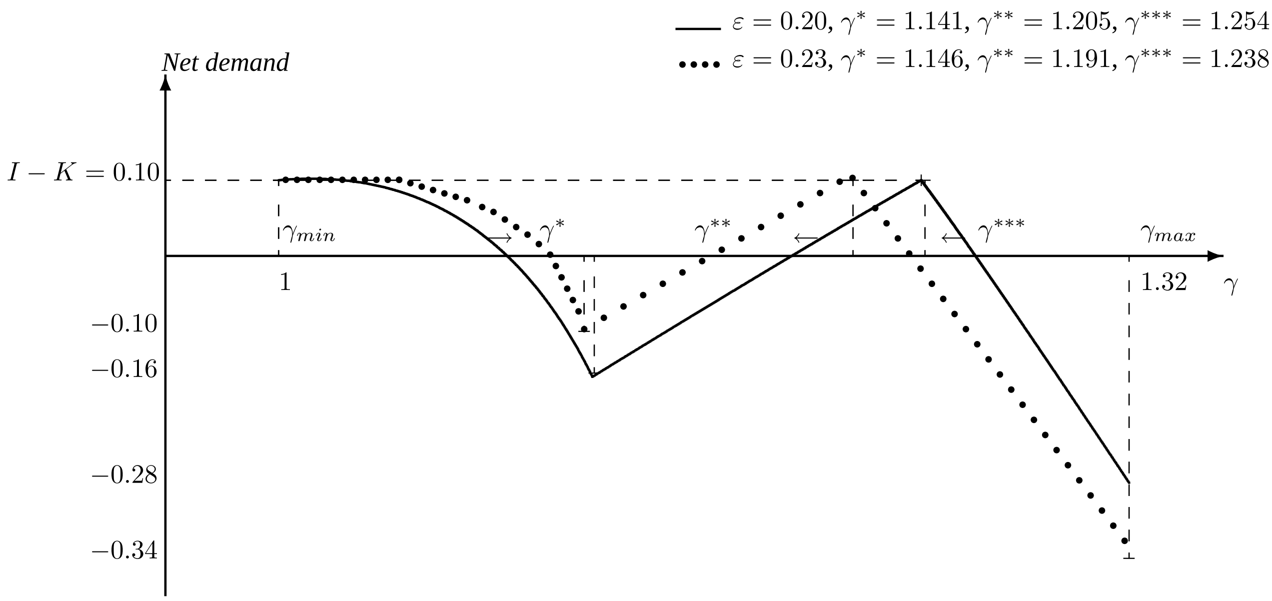
(i) γ^* *and* γ^{***} *increase, while* γ^{**} *decreases.*

(ii) $A_H(\gamma^*)$ *and* $A_{lib}(\gamma^{**})$ *decrease, while* $A_{imp}(\gamma^{***})$ *increases.*

(iii) $A_L(\gamma^*)$ *and* $A_L(\gamma^{**})$ *decreases while* $A_L(\gamma^{***})$ *increases.*

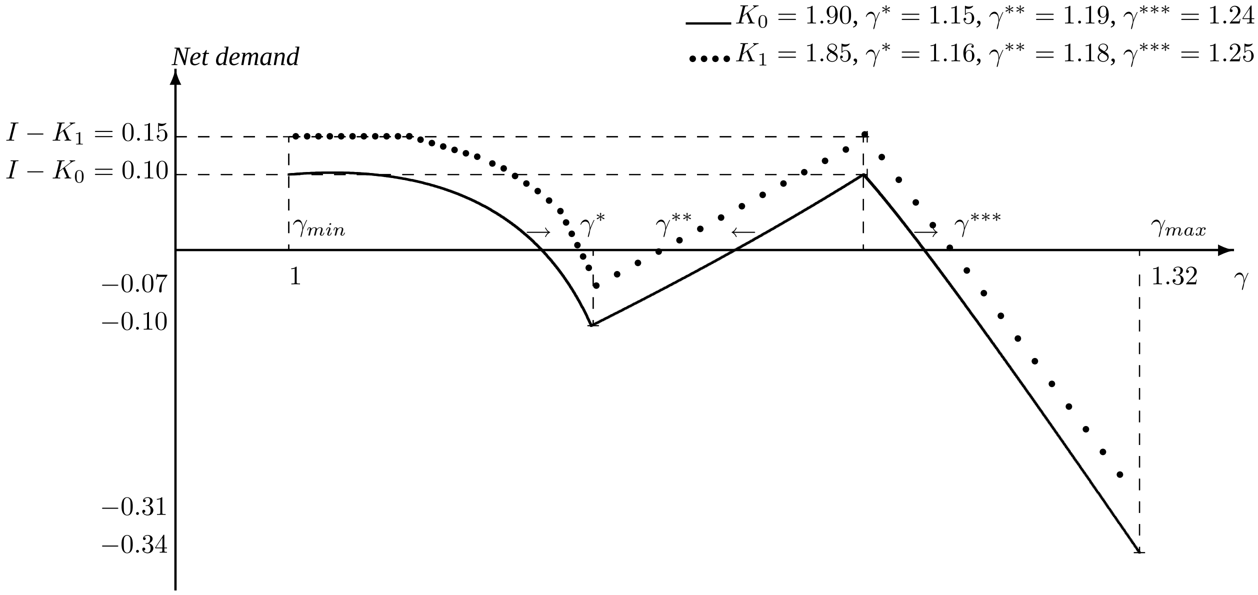
[22] Devetag and Ortmann (2007) review findings in the experimental literature on coordination failures and in particular when subjects fail to coordinate on the Pareto efficient equilibrium. Bloomfield and Kadiyali (2005) also show how subjects might select an equilibrium, that is ruled out by Cho-Kreps intuitive criteria and give support to the co-existence of multiple equilibria.

If there is a small collateral squeeze, the aggregate wealth decreases and the two stable equilibria move in opposite directions. Although their associated net demands are affected similarly by a change in cost of capital, they adapt differently to a collateral squeeze. For the "first best" equilibrium the excess demand is offset by a higher cost of capital and more firms take the financial investment, while for the "impairment" equilibrium as the financing conditions are tighter a lower cost of capital partially compensates for the decrease in wealth. This decrease in the cost of capital is not sufficient and more firms at the bottom take the inefficient investment short of financing. The liberal unstable equilibrium decreases in response to excess demand. The effect of the collateral squeeze moves the allocation of investment for liberal disclosures in the opposite direction relatively to the partial equilibrium analysis.



$p = \frac{1}{2}$; $\Delta p = \frac{3}{32}$; $c = \frac{1}{4}$; $H = 6$; $I = 2$; $K = 1.9$; $f(A) = \lambda e^{-\lambda A}$; $\lambda = 1$; $E(A) = 1$; $\eta = 1$

Figure 4: Example of the Effect of Collateral Squeeze on GE



$p = \frac{1}{2}$; $\Delta p = \frac{3}{32}$; $c = \frac{1}{4}$; $H = 6$; $I = 2$; $\varepsilon = 0.23$; $f(A) = \lambda e^{-\lambda A}$; $\lambda = 1$; $E(A) = 1$; $\eta = 1$

Figure 5: Example of the Effect of Credit Crunch on GE

The nature of the two shocks affect differently the financing constraint and the net demand: a collateral squeeze directly affects simultaneously the financing constraint and the net demand, while a credit crunch only directly changes the net demand. A credit crunch and a collateral squeeze affect similarly the "liberal" equilibria. However, the effect of a credit crunch on the impairment equilibrium is reversed compared to the collateral squeeze. With a credit crunch the equilibrium cost of capital increases while it decreases with a collateral squeeze. This difference is related to the fact that the collateral squeeze shifts the maximum net demand with impairment disclosures to the left and is attained at a lower cost of capital. In contrast a credit crunch moves the net demand upward without altering the costs of capital where the minimum and maximum net demand are attained. We illustrate these effects in Figures 4 and 5. Although the net demand shift under the two types of shocks is not identical, the effect on the aggregate investment allocation is similar. Both credit crunch and collateral squeeze deter firms from taking the productive investment and benefit the financial investment. These findings could provide some rational in explaining the decrease in the short term interest rate during recession - the impairment equilibrium moves the cost of capital downward with a collateral squeeze.

To summarize, although capital tightening shocks move the impairment cost of capital in the opposite direction and the liberal costs of capital in the same direction, they both decrease the productive investment.

5 Conclusion

This paper relates optimal disclosure policies to the cost of capital when resources in the economy are limited. Depending on the economic environment different optimal disclosures can be implemented. A wealthy economy features liberal disclosures that achieve first best, while impairment like disclosures might arise in a less rich economy. The latter disclosures are associated with inefficient investment. Capital poor firms find financing at the expense of capital rich firms which short of information take the productive investment. Changes in macroeconomic fundamentals shape the supply and demand of capital markets, affecting simultaneously mandatory disclosures and the cost of capital. We study more specifically the effect of a collateral squeeze and a credit crunch. Their effects on the impairment cost of capital differ but have similar consequences on the investment allocation. In the impairment equilibrium a small decrease in the value of the pledgeable assets similar to a small negative collateral shock or a small decrease in the amount of capital squeezes collateral-poor firms out of the credit market while attracting more capital rich firms to invest in the open market in the liberal equilibrium. These macroeconomic shocks might also lead to different optimal disclosures and thus equilibria if their magnitude is relatively large. Thus a very wealthy economy can switch from an economy with liberal disclosures and no investment distortions to an economy with possibly impairment disclosures and investment inefficiencies.

Depending on the optimal disclosures that prevails in equilibrium, negative macroeconomic shocks can worsen investment inefficiencies. The model suggests that the regulatory environment can mitigate inefficiencies by designing more liberal disclosures and help the players coordinating on the efficient equilibrium. The model offers new insight on the relation between mandatory disclosures and cost of capital in a general equilibrium setting. The paper isolates the effects of the credit market and cost of capital in a static model and homogenous lenders. Future research could further expand our analysis in a dynamic general equilibrium environment or provide a deeper analysis on the role of banking intermediation.

Appendix

Proof of Proposition 1

Part(i): The firm with pledgeable assets A_H is indifferent between running the productive investment and taking the financial investment. A_H is defined as follows:

$$pH - \gamma I + (\eta p + (1-p))A_H - c = \gamma A_H \tag{9}$$

Solving equation (9) in A_H yields $A_H = \frac{pH-\gamma I - c}{\gamma - (\eta p + (1-p))} > 0$.

Part(ii):

$$\begin{aligned}
\frac{\partial A_H}{\partial p} &= \frac{H}{\gamma - (\eta p + (1-p))} > 0 \\
\frac{\partial A_H}{\partial H} &= \frac{p}{\gamma - (\eta p + (1-p))} > 0 \\
\frac{\partial A_H}{\partial I} &= \frac{-\gamma}{\gamma - (\eta p + (1-p))} < 0 \\
\frac{\partial A_H}{\partial c} &= \frac{-1}{\gamma - (\eta p + (1-p))} < 0 \\
\frac{\partial A_H}{\partial \gamma} &= \frac{(1+p(1-\eta))I - (pH-c)}{(\gamma - (\eta p + (1-p)))^2} < 0 \\
\frac{\partial A_H}{\partial \eta} &= \frac{p(pH-\gamma I - c)}{(\gamma - (\eta p + (1-p)))^2} > 0
\end{aligned}$$

Part(iii): Let assume that the exogenous shock causes a decrease in asset values by $\varepsilon > 0$. Then, equation (9) becomes: $pH - \gamma I + (\eta p + (1-p))(1-\varepsilon)A_H^{shock} - c = \gamma(1-\varepsilon)A_H^{shock}$. Rearranging, $A_H^{shock} = \frac{1}{1-\varepsilon}\frac{pH-\gamma I - c}{\gamma-(\eta p+(1-p))} = \frac{1}{1-\varepsilon}A_H > A_H$.

Proof of Proposition 2

The regulator solves the following optimization program:

$$\begin{aligned}
\max_{\theta(A)} U(\theta(A)) = & \int_0^{A_H} (pH - \gamma I + (\eta p + (1-p))A - c)(1-\theta(A))f(A)dA \\
& + \int_{A_H}^{\infty} \gamma A(1-\theta(A))f(A)dA \\
& + \int_0^{\infty} (pH - \gamma I + (\eta p + (1-p))A - c)\theta(A)f(A)dA
\end{aligned}$$

Taking the first order condition (FOC) yields:

$$\frac{\partial U(\theta(A))}{\partial \theta(A)} = \begin{cases} f(A)((pH - \gamma I + (\eta p + (1-p))A - c) - \gamma A) < 0 \text{ if } A > A_H \\ 0 \text{ otherwise} \end{cases},$$

The solution is $\theta(A) = 0$ for $A > A_H$. Otherwise any $\theta(A)$ can be set. As a result, firms with asset values $A > A_H$ disclose and run the productive investment, while the rest of the firms take the financial investment, which is the unconstrained first-best result.

Proof of Lemma 1

Let derive the comparative statics for $A_L = \frac{1}{\eta p + (1-p)}(\frac{pc}{\Delta p} + \gamma I - pH)$:

$$\begin{aligned}
\frac{\partial A_L}{\partial H} &= \frac{-p}{(\eta p + (1-p))} < 0 \\
\frac{\partial A_L}{\partial I} &= \frac{\gamma}{(\eta p + (1-p))} > 0 \\
\frac{\partial A_L}{\partial c} &= \frac{p}{\Delta p(\eta p + (1-p))} > 0 \\
\frac{\partial A_L}{\partial \gamma} &= \frac{I}{(\eta p + (1-p))} > 0 \\
\frac{\partial A_L}{\partial \eta} &= -\frac{p(pc/\Delta p - pH + \gamma I)}{(\eta p + (1-p))^2} < 0 \\
\frac{\partial A_L}{\partial \Delta p} &= -\frac{pc}{\Delta p^2(\eta p + (1-p))} < 0 \\
\frac{\partial A_L}{\partial p} &= \frac{c - \Delta pH - \Delta p(\eta - 1)\gamma I}{\Delta p(\eta p + (1-p))} < 0,
\end{aligned}$$

as $pH - c > (p - \Delta p)H$ implies $c - \Delta pH < 0$.

After a collateral squeeze, the financing condition becomes:

$$\begin{aligned}
(1-\varepsilon)A &\geq \frac{1}{\eta p + (1-p)}\left(\frac{pc}{\Delta p} + \gamma I - pH\right) \\
A &\geq \frac{1}{(1-\varepsilon)}A_L = A_L^{shock}.
\end{aligned}$$

Proof of Proposition 3

Let us denote the difference between $A_H(\gamma)$ and $A_L(\gamma)$ by:

$$J(\gamma) = \frac{pH - \gamma I - c}{\gamma - (\eta p + (1-p))} - \frac{1}{\eta p + (1-p)}\left(\frac{pc}{\Delta p} + \gamma I - pH\right) \tag{10}$$

If $\gamma \to \gamma_{min}$, $A_H \to \infty$ and $A_L \to \frac{1}{\eta p+(1-p)}\left(\frac{pc}{\Delta p} - pH\right) + I$ and $J(\gamma) > 0$. If $\gamma \to \infty$, $A_H \to 0$ and $A_L \to +\infty$ then $J(\gamma) < 0$. Thus there exists a γ_{max} such that $A_L(\gamma_{max}) = A_H(\gamma_{max})$. Since $\frac{\partial J(\gamma)}{\partial \gamma} = \frac{\partial A_H(\gamma)}{\partial \gamma} - \frac{\partial A_L(\gamma)}{\partial \gamma} < 0$ it follows that γ_{max} is unique.

Applying the Implicit Function Theorem,

$$\begin{aligned}
\frac{\partial \gamma_{max}}{\partial H} &= -\frac{\frac{\partial J(\gamma_{max})}{\partial H}}{\frac{\partial J(\gamma_{max})}{\partial \gamma}} = -\frac{\frac{\partial A_H(\gamma_{max})}{\partial H} - \frac{\partial A_L(\gamma_{max})}{\partial H}}{\frac{\partial A_H(\gamma_{max})}{\partial \gamma} - \frac{\partial A_L(\gamma_{max})}{\partial \gamma}} > 0 \\
\frac{\partial \gamma_{max}}{\partial c} &= -\frac{\frac{\partial J(\gamma_{max})}{\partial c}}{\frac{\partial J(\gamma_{max})}{\partial \gamma}} = -\frac{\frac{\partial A_H(\gamma_{max})}{\partial c} - \frac{\partial A_L(\gamma_{max})}{\partial c}}{\frac{\partial A_H(\gamma_{max})}{\partial \gamma} - \frac{\partial A_L(\gamma_{max})}{\partial \gamma}} < 0 \\
\frac{\partial \gamma_{max}}{\partial I} &= -\frac{\frac{\partial J(\gamma_{max})}{\partial I}}{\frac{\partial J(\gamma_{max})}{\partial \gamma}} = -\frac{\frac{\partial A_H(\gamma_{max})}{\partial I} - \frac{\partial A_L(\gamma_{max})}{\partial I}}{\frac{\partial A_H(\gamma_{max})}{\partial \gamma} - \frac{\partial A_L(\gamma_{max})}{\partial \gamma}} < 0 \\
\frac{\partial \gamma_{max}}{\partial \eta} &= -\frac{\frac{\partial J(\gamma_{max})}{\partial \eta}}{\frac{\partial J(\gamma_{max})}{\partial \gamma}} = -\frac{\frac{\partial A_H(\gamma_{max})}{\partial \eta} - \frac{\partial A_L(\gamma_{max})}{\partial \eta}}{\frac{\partial A_H(\gamma_{max})}{\partial \gamma} - \frac{\partial A_L(\gamma_{max})}{\partial \gamma}} > 0 \\
\frac{\partial \gamma_{max}}{\partial \Delta p} &= -\frac{\frac{\partial J(\gamma_{max})}{\partial \Delta p}}{\frac{\partial J(\gamma_{max})}{\partial \gamma}} = -\frac{\frac{\partial A_H(\gamma_{max})}{\partial \Delta p} - \frac{\partial A_L(\gamma_{max})}{\partial \Delta p}}{\frac{\partial A_H(\gamma_{max})}{\partial \gamma} - \frac{\partial A_L(\gamma_{max})}{\partial \gamma}} > 0 \\
\frac{\partial \gamma_{max}}{\partial p} &= -\frac{\frac{\partial J(\gamma_{max})}{\partial p}}{\frac{\partial J(\gamma_{max})}{\partial \gamma}} = -\frac{\frac{\partial A_H(\gamma_{max})}{\partial p} - \frac{\partial A_L(\gamma_{max})}{\partial p}}{\frac{\partial A_H(\gamma_{max})}{\partial \gamma} - \frac{\partial A_L(\gamma_{max})}{\partial \gamma}} > 0.
\end{aligned}$$

The fact that γ_{max} is not affected by collateral squeeze follows from the fact that $A_H^{shock} = \frac{1}{(1-\varepsilon)} A_H$ and $A_L^{shock} = \frac{1}{(1-\varepsilon)} A_L$.

If $\gamma \leq \gamma_{max}$ then $A_L < A_H$ and it is optimal for firms with $A_L < A < A_H$ to choose the productive investment and the remaining firms to select the financial investment. If $\gamma > \gamma_{max}$, $A_L > A_H$ and the financial investment is always selected. The amount of projects is represented by $F(A_H) - F(A_L)$. The derivative of $F(A_H) - F(A_L)$ with respect to any exogenous parameter is of the form:

$$A_H^{'} f(A_H) - A_L^{'} f(A_L) \tag{11}$$

where A'_H and A'_L are the derivatives with respect to the exogenous parameter. Given that when A_H is increasing/decreasing in any of the exogenous parameters, A_L moves in the opposite direction, the comparative statics of $F(A_H) - F(A_L)$ follows immediately from the comparative statics of $A_L(\gamma)$ and $A_H(\gamma)$. For Δp, $A'_H = 0$ and $A'_L < 0$, hence $F(A_H) - F(A_L)$ is increasing in Δp.

Proof of Lemma 2

Part (i): By Proposition 3 firms with assets $A < A_L$ cannot find financing and do not run the project. Hence, there is an underproduction distortion for those firms. In case of collateral squeeze the financing threshold increases (by Proposition 2, $A_L^{shock} = \frac{1}{(1-\varepsilon)}A_L > A_L$) and the proportion of firms that cannot find financing and do not run the project increases. Hence, the underproduction distortion worsens.

Part (ii): If $A_L < A_H$ (i.e if $\gamma < \gamma_{max}$) an information system that does not disclose information for firms with asset value $A \in [A_L - \delta, A_H]$ where δ is small, will alleviate the underinvestment distortion for firms with $A \in [A_L - \delta, A_L]$, because the latter are pooled with firms $A \in [A_L, A_H]$ and can find financing to run their project. As a result, the proportion of firms running the project increases. However, if $A_L > A_H$ (i.e if $\gamma > \gamma_{max}$) all firms prefer the financial investment even if they can find financing. In this case the underinvestment distortion cannot be alleviated.

Proof of Proposition 4

Parts (i) and (ii): We want to determine the cost of capital γ_L that makes the financing threshold A_L equal to $E(A)$:

$$E(A) = A_L(\gamma_L) = \frac{1}{\eta p + (1-p)}\left(\frac{pc}{\Delta p} + \gamma_L I - pH\right)$$

Rearranging the expression yields the expression for γ_L. Similarly, we determine γ_H as the cost of capital that makes the investment choice A_H equal to $E(A)$:

$$E(A) = A_H(\gamma_H) = \frac{pH - \gamma_H I - c}{\gamma_H - (\eta p + (1-p))}$$

Rearranging the expression yields the the expression for γ_H.

When $\gamma \leq min(\gamma_L, \gamma_{max}, \gamma_H)$ then $A_H(\gamma) \geq E(A) \geq A_L(\gamma)$ and firms prefer the productive investment (because $A_H(\gamma) \geq E(A)$) and can find financing (because $E(A) \geq A_L(\gamma)$).[23] Hence, if $\gamma \leq min(\gamma_L, \gamma_{max}, \gamma_H)$ and absent any information all firms run the productive investment. Otherwise, all firms run the financial investment either because $\gamma > \gamma_H$ (i.e. $E(A) > A_H$) and they prefer the financial investment or because $\gamma > \gamma_L$ (i.e. $E(A) < A_L$) and they cannot find financing for the project without information.

Part (iii) Noting that $\Delta pH - c > 0$ (because $pH - c - \gamma I > 0$ and $(p - \Delta p)H - \gamma I < 0$

[23] Note that when $\gamma_L = \gamma_{max}$ then $A_H(\gamma_{max}) = A_L(\gamma_{max}) = A_L(\gamma_L) = E(A) = A_H(\gamma_H)$. Thus when $\gamma_L = \gamma_{max}$, it must be the case that $\gamma_L = \gamma_H$.

by assumption),

$$\begin{aligned}
\frac{\partial \gamma_L}{\partial H} &= \frac{p}{I} > 0 \\
\frac{\partial \gamma_L}{\partial c} &= -\frac{p}{\Delta p I} < 0 \\
\frac{\partial \gamma_L}{\partial \eta} &= \frac{E(A)p}{I} > 0 \\
\frac{\partial \gamma_L}{\partial I} &= -\frac{E(A)\Delta p(\eta p + (1-p)) + p(\Delta p H - c)}{\Delta p I^2} < 0 \\
\frac{\partial \gamma_L}{\partial p} &= \frac{E(A)\Delta p(\eta - 1) + (\Delta p H - c)}{\Delta p I} > 0 \\
\frac{\partial \gamma_L}{\partial \Delta p} &= -\frac{E(A)(\eta p + (1-p))}{\Delta p I}\left(\frac{1}{\Delta p} - 1\right) - \frac{pc}{\Delta p^2 I} < 0 \\
\frac{\partial \gamma_L}{\partial E(A)} &= \frac{\eta p + (1-p)}{I} > 0.
\end{aligned}$$

Further, the comparative statics of γ_H is:

$$\begin{aligned}
\frac{\partial \gamma_H}{\partial H} &= \frac{p}{E(A) + I} > 0 \\
\frac{\partial \gamma_H}{\partial c} &= -\frac{1}{E(A) + I} < 0 \\
\frac{\partial \gamma_H}{\partial \eta} &= \frac{E(A)p}{E(A) + I} > 0 \\
\frac{\partial \gamma_H}{\partial I} &= -\frac{E(A)(\eta p + (1-p)) + pH - c}{(E(A) + I)^2} < 0 \\
\frac{\partial \gamma_H}{\partial p} &= \frac{E(A)(\eta - 1) + H}{E(A) + I} > 0 \\
\frac{\partial \gamma_H}{\partial \Delta p} &= 0 \\
\frac{\partial \gamma_H}{\partial E(A)} &= \frac{-(\eta p + (1-p))}{(E(A) + I)^2}\underbrace{(pH - c - (\eta p + (1-p))I)}_{> pH - c - \gamma I > 0 \text{ by assumption}} < 0.
\end{aligned}$$

Proof of Lemma 3

Part (i): By Proposition 4 when $\gamma \leq min(\gamma_L, \gamma_{max}, \gamma_H)$ all firms run the productive investment and hence, there is overinvestment distortion. Otherwise, all firms run the financial investment and hence, there is underproduction distortion.

Part (ii): Let assume that initially before the collateral squeeze the cost of capital is $\gamma \leq min(\gamma_L(W^I), \gamma_H(W^I), \gamma_{max})$ so that at the lockstep all firms run the productive investment. If the aggregate wealth after the collateral squeeze W^{shock} falls below W^{imp} and $\gamma \geq \gamma_L(W^{shock})$ none of the firms can find financing, because $W^{shock} < A_L$. As a result none of the firms runs the project and all firms take the financial investment. The economy switches from overproduction to underproduction. However, if $\gamma > \gamma_L(W^{shock})$ firms still prefer the productive investment.

Let now assume that initially before the collateral squeeze the cost of capital is such that $\gamma_H(E(A)) \leq \gamma \leq min(\gamma_L(E(A)), \gamma_{max})$ so that at the lockstep all firms take the financial investment because $E(A) > A_H$. If the aggregate wealth drops so that $\gamma \leq (\gamma_H(W^{shock})$, then $W^{shock} < A_H$ and firms prefer the productive investment. If at the same time $\gamma \leq min(\gamma_L(W^{shock}), \gamma_{max})$ (which can only happen if $W^{shock} > W^{low}$), then $W^{shock} < A_L$ and firms can find financing for their project. As a result all firms take the productive investment. The economy switches from underproduction to overproduction.

Part (iii): If $E(A) < A_L < A_H$ none of the firms can find financing and all firms take the financial investment. Information system that discloses $A \in [A_L, A_H]$ allows the disclosing firms to find financing and run the project and hence alleviates partially the distortion on the productive investment. If $A_L < E(A) < A_H$ all firms run the productive investment. An information system disclosing $A > A_H$ dominates no disclosure as the disclosing firms will prefer the financial investment and this alleviate the overproduction distortion.

Proof of Lemma 4

If the non-disclosing firms are prescribed to take the financial investment the regulator solves the following maximization problem:

$$\begin{aligned}
\max_{\theta(A)} U(\theta(A)) &= \int_0^{A_L} \gamma A(1-\theta(A))f(A)dA + \int_{A_H}^{\infty} \gamma A(1-\theta(A))f(A)dA \\
&+ \int_{A_L}^{A_H} (pH - \gamma I + (\eta p + (1-p))A - c)(1-\theta(A))f(A)dA \\
&+ \int_0^{\infty} \gamma A\theta(A)f(A)dA
\end{aligned}$$

Taking the first order condition (FOC) yields:

$$\frac{\partial U(\theta(A))}{\partial \theta(A)} = \begin{cases} f(A)(\gamma A - (pH - \gamma I + (\eta p + (1-p))A - c)) < 0 \text{ if } A \in (A_L, A_H) \\ 0 \text{ otherwise} \end{cases},$$

The solution is $\theta(A) = 0$ for $A_L < A < A_H$. Otherwise any $\theta(A)$ can be set. As a result, firms with asset values $A_L < A < A_H$ disclose and run the productive investment, while the rest of the firms take the financial investment. This leads to the same distribution of productive and financial investments across firms as with full disclosure and as we have proved before this is not optimal. It follows that it is never optimal to encourage non-disclosing firms to take the financial investment.

Proof of Proposition 5

The Lagrangian $L(\theta(A))$ is given by:

$$L(\theta(A)) = U(\theta(A)) + \mu \left(\int_0^\infty (A - A_L)\theta(A) f(A) dA \right)$$

The FOC yields:

$$\text{For } A_L < A < A_H, \ \frac{\partial L(\theta(A))}{\partial \theta(A)} = \mu(A - A_L) f(A) \geq 0$$
$$\text{Else, } \frac{\partial L(\theta(A))}{\partial \theta(A)} = (pH - \gamma I + (\eta p + (1-p))A - c - \gamma A) + \mu(A - A_L)) f(A) \quad (12)$$

The sign of the FOC given in (12) is ambiguous:

if $A < A_L$, $pH - \gamma I + (\eta p + (1-p))A - c - \gamma A > 0$ and $\mu(A - A_L) < 0$

if $A > A_H$, $pH - \gamma I + (\eta p + (1-p))A - c - \gamma A < 0$ and $\mu(A - A_L) > 0$

We study the expression (12):

(i) For $\mu > \gamma - (\eta p + (1-p))$, it is increasing in A

(ii) For $\mu = \gamma - (\eta p + (1-p))$, it is flat.

(iii) For $\mu < \gamma - (\eta p + (1-p))$, it is decreasing in A.

Hence, we have four cases to consider to determine the optimal disclosure.

CASE 1: $\mu = 0$

If the constraint is not binding then $\mu = 0$.

(i) For $A < A_L$, $\frac{\partial L(\theta(A))}{\partial \theta(A)} > 0$ and $\theta(A) = 1$.

(ii) For $A_L < A < A_H$, $\frac{\partial L(\theta(A))}{\partial \theta(A)} = 0$ and $\theta(A)$ can be either 0 or 1.

(iii) For For $A > A_H$, $\frac{\partial L(\theta(A))}{\partial \theta(A)} < 0$ and $\theta(A) = 0$.

We can achieve first-best in this case by prescribing no disclosure for $A_L < A < A_H$. To summarize, this case returns optimal disclosures if $\int_0^{A_H} Af(A)dA / \int_0^{A_H} f(A)dA > A_L$ and prescribes firms above A_H to disclose and the others not to disclose.

CASE 2: $\mu > \gamma - (\eta p + (1-p))$

When the constraint is binding and $\mu > \gamma - (\eta p + (1-p))$, there exists a unique $A_{imp} < A_L$ such that:

(i) For $A < A_{imp}$, $pH - \gamma I + (\eta p + (1-p))A - c - \gamma A + \mu(A - A_L) < 0$ and $\frac{\partial L(\theta(A))}{\partial \theta(A)} < 0$. Thus $\theta(A) = 0$.

(ii) For $A \geq A_{imp}$, $pH - \gamma I + (\eta p + (1-p))A - c - \gamma A + \mu(A - A_L) > 0$ and $\frac{\partial L(\theta(A))}{\partial \theta(A)} > 0$. Thus $\theta(A) = 1$.

A_{imp} is defined by:

$$\int_{A_{imp}}^{\infty} Af(A)dA - A_L \int_{A_{imp}}^{\infty} f(A)dA = 0$$

Let us define $G(\underline{A})$

$$G(\underline{A}) = \int_{\underline{A}}^{\infty} Af(A)dA - A_L \int_{\underline{A}}^{\infty} f(A)dA$$

$$\begin{aligned} G(0) &= E(A) - A_L \\ G(A_L) &= \int_{A_L}^{\infty} Af(A)dA - A_L \int_{A_L}^{\infty} f(A)dA > 0 \end{aligned}$$

For this case to exist, we need $E(A) < A_L$. Further, $\frac{\partial G(\underline{A})}{\partial \underline{A}} = f(\underline{A})(A_L - \underline{A}) > 0$ and if $E(A) < A_L$, A_{imp} is unique. To summarize, this case returns optimal disclosures when $E(A) < A_L$ and prescribes firms above A_L to disclose while the remaining do not disclose.

CASE 3: $\mu = \gamma - (\eta p + (1-p))$

Lastly, when the constraint is binding and $\mu = \gamma - (\eta p + (1-p))$, we have:

(i) For $A < A_L$, $pH - \gamma I + (\eta p + (1-p))A - c - \gamma A > 0$ and $\frac{\partial L(\theta(A))}{\partial \theta(A)} > 0$. Thus $\theta(A) = 1$.

(ii) For $A_L < A < A_H$, $\frac{\partial L(\theta(A))}{\partial \theta(A)} > 0$. Thus $\theta(A) = 1$.

(iii) For $A \geq A_H$, $\mu(A_H - A_L) > 0$ and $\frac{\partial L(\theta(A))}{\partial \theta(A)} > 0$. Thus $\theta(A) = 1$.

This case prescribes no disclosure, which is never optimal and can be ruled out.

CASE 4: $\mu < \gamma - (\eta p + (1-p))$

When the constraint is binding and $\mu < \gamma - (\eta p + (1-p))$, there exists a unique $A_{lib} > A_H$ such that

(i) For $A < A_{lib}$, $pH - \gamma I + (\eta p + (1-p))A - c - \gamma A + \mu(A - A_L) > 0$ and $\frac{\partial L(\theta(A))}{\partial \theta(A)} > 0$. Thus $\theta(A) = 1$.

(ii) For $A \geq A_{lib}$, $pH - \gamma I + (\eta p + (1-p))A - c - \gamma A + \mu(A - A_L) < 0$ and $\frac{\partial L(\theta(A))}{\partial \theta(A)} < 0$. Thus $\theta(A) = 0$.

A_{lib} is given by:

$$\int_0^{A_{lib}} Af(A)dA - A_L \int_0^{A_{lib}} f(A)dA = 0 \tag{13}$$

Let us define $M(\overline{A})$:

$$M(\overline{A}) = \int_0^{\overline{A}} Af(A)dA - A_L \int_0^{\overline{A}} f(A)dA$$

As $M(A_L) = \int_0^{A_L} Af(A)dA - A_L \int_0^{A_L} f(A)dA < 0$ and when $\overline{A} \to \infty$, $M(\overline{A}) = E(A) - A_L$. To have this case we need $E(A) > A_L$ and $\int_0^{A_H} Af(A)dA - A_L \int_0^{A_H} f(A)dA < 0$. Under those conditions, A_{lib} exists. Further $M(\overline{A})$ is increasing as $\frac{\partial M(\overline{A})}{\partial \overline{A}} = f(\overline{A})(\overline{A} - A_L) \geq 0$. Thus A_{lib} is unique. To summarize case 4 returns optimal disclosures when $E(A) > A_L$ and $\int_0^{A_H} Af(A)dA - A_L \int_0^{A_H} f(A)dA < 0$, and prescribe firms to disclose above A_{lib} and the others not to disclose.

We turn to the comparative statics of the thresholds. The impairment threshold A_{imp} is affected by a change in the exogenous parameters as follows:

$$
\begin{aligned}
\frac{\partial A_{imp}}{\partial \gamma} &= -\frac{\partial G(A_{imp})/\partial \gamma}{\partial G(A_{imp})/\partial A_{imp}} = \frac{(\partial A_L/\partial \gamma)\int_{A_{imp}}^{\infty} f(A)da}{f(A_{imp})[A_L - A_{imp}]} = \frac{\frac{I}{(\eta p+(1-p))}\int_{A_{imp}}^{\infty} f(A)dA}{f(A_{imp})[A_L - A_{imp}]} > 0 \\
\frac{\partial A_{imp}}{\partial I} &= -\frac{\partial G(A_{imp})/\partial I}{\partial G(A_{imp})/\partial A_{imp}} = \frac{(\partial A_L/\partial I)\int_{A_{imp}}^{\infty} f(A)da}{f(A_{imp})[A_L - A_{imp}]} = \frac{\frac{\gamma}{(\eta p+(1-p))}\int_{A_{imp}}^{\infty} f(A)dA}{f(A_{imp})[A_L - A_{imp}]} > 0 \\
\frac{\partial A_{imp}}{\partial H} &= -\frac{\partial G(A_{imp})/\partial H}{\partial G(A_{imp})/\partial A_{imp}} = \frac{(\partial A_L/\partial H)\int_{A_{imp}}^{\infty} f(A)da}{f(A_{imp})[A_L - A_{imp}]} = \frac{\frac{-p}{(\eta p+(1-p))}\int_{A_{imp}}^{\infty} f(A)dA}{f(A_{imp})[A_L - A_{imp}]} < 0 \\
\frac{\partial A_{imp}}{\partial c} &= -\frac{\partial G(A_{imp})/\partial c}{\partial G(A_{imp})/\partial A_{imp}} = \frac{(\partial A_L/\partial c)\int_{A_{imp}}^{\infty} f(A)da}{f(A_{imp})[A_L - A_{imp}]} = \frac{\frac{p}{\Delta p(\eta p+(1-p))}\int_{A_{imp}}^{\infty} f(A)dA}{f(A_{imp})[A_L - A_{imp}]} > 0 \\
\frac{\partial A_{imp}}{\partial \Delta p} &= -\frac{\partial G(A_{imp})/\partial \Delta p}{\partial G(A_{imp})/\partial A_{imp}} = \frac{(\partial A_L/\partial \Delta p)\int_{A_{imp}}^{\infty} f(A)da}{f(A_{imp})[A_L - A_{imp}]} = \frac{\frac{-cp}{\Delta p^2(\eta p+(1-p))}\int_{A_{imp}}^{\infty} f(A)dA}{f(A_{imp})[A_L - A_{imp}]} < 0 \\
\frac{\partial A_{imp}}{\partial \eta} &= -\frac{\partial G(A_{imp})/\partial \eta}{\partial G(A_{imp})/\partial A_{imp}} = \frac{(\partial A_L/\partial \eta)\int_{A_{imp}}^{\infty} f(A)da}{f(A_{imp})[A_L - A_{imp}]} = \frac{-\frac{p(pc/\Delta p - pH + \gamma I)}{(\eta p+(1-p))^2}\int_{A_{imp}}^{\infty} f(A)dA}{f(A_{imp})[A_L - A_{imp}]} < 0 \\
\frac{\partial A_{imp}}{\partial p} &= -\frac{\partial G(A_{imp})/\partial p}{\partial G(A_{imp})/\partial A_{imp}} = \frac{(\partial A_L/\partial p)\int_{A_{imp}}^{\infty} f(A)dA}{f(A_{imp})[A_L - A_{imp}]} = \frac{\frac{c-\Delta p(H+(\eta-1)\gamma I)}{\Delta p(\eta p+(1-p))}\int_{A_{imp}}^{\infty} f(A)dA}{f(A_{imp})[A_L - A_{imp}]} < 0.
\end{aligned}
$$

We next show that A_{imp} is increasing in a collateral squeeze. Let us define the function $G_{imp}(X) = \frac{\int_X^{\infty} Af(A)dA}{\int_X^{\infty} f(A)dA}$. The derivative is:

$$
G'_{imp}(X) = \frac{f(X)\left(\int_X^{\infty} Af(A)\,dA - X\int_X^{\infty} f(A)\,dA\right)}{\left(\int_X^{\infty} f(A)\,dA\right)^2} > 0 \tag{14}
$$

When there is a collateral shock, A_{imp}^{shock} is defined by:

$$
\frac{\int_{A_{imp}^{shock}}^{\infty} Af(A)dA}{\int_{A_{imp}^{shock}}^{\infty} f(A)dA} = \frac{A_L}{1-\varepsilon} > A_L \tag{15}
$$

Thus $A_{imp}^{shock} > A_{imp}$ as $G_{imp}(.)$ is increasing.

The liberal threshold is affected as follows by the exogenous parameters:

$$
\begin{aligned}
\frac{\partial A_{lib}}{\partial \gamma} &= -\frac{\partial M(A_{lib})/\partial \gamma}{\partial M(A_{lib})/\partial A_{lib}} = \frac{(\partial A_L/\partial \gamma)\int_0^{A_{lib}} f(A)dA}{f(A)[A_{lib}-A_L]} = \frac{\frac{I}{(\eta p+(1-p))}\int_0^{A_{lib}} f(A)dA}{f(A_{lib})[A_{lib}-A_L]} > 0 \\
\frac{\partial A_{lib}}{\partial I} &= -\frac{\partial M(A_{lib})/\partial I}{\partial M(A_{lib})/\partial A_{lib}} = \frac{(\partial A_L/\partial I)\int_0^{A_{lib}} f(A)dA}{f(A_{lib})[A_{lib}-A_L]} = \frac{\frac{\gamma}{(\eta p+(1-p))}\int_0^{A_{lib}} f(A)dA}{f(A_{lib})[A_{lib}-A_L]} > 0 \\
\frac{\partial A_{lib}}{\partial H} &= -\frac{\partial M(A_{lib})/\partial H}{\partial M(A_{lib})/\partial A_{lib}} = \frac{(\partial A_L/\partial H)\int_0^{A_{lib}} f(A)dA}{f(A_{lib})[A_{lib}-A_L]} = \frac{\frac{-p}{(\eta p+(1-p))}\int_0^{A_{lib}} f(A)dA}{f(A_{lib})[A_{lib}-A_L]} < 0 \\
\frac{\partial A_{lib}}{\partial c} &= -\frac{\partial M(A_{lib})/\partial c}{\partial M(A_{lib})/\partial A_{lib}} = \frac{(\partial A_L/\partial c)\int_0^{A_{lib}} f(A)dA}{f(A_{lib})[A_{lib}-A_L]} = \frac{\frac{p}{\Delta p(\eta p+(1-p))}\int_0^{A_{lib}} f(A)dA}{f(A_{lib})[A_{lib}-A_L]} > 0 \\
\frac{\partial A_{lib}}{\partial \Delta p} &= -\frac{\partial M(A_{lib})/\partial \Delta p}{\partial M(A_{lib})/\partial A_{lib}} = \frac{(\partial A_L/\partial \Delta p)\int_0^{A_{lib}} f(A)dA}{f(A_{lib})[A_{lib}-A_L]} = \frac{\frac{-cp}{\Delta p^2(\eta p+(1-p))}\int_0^{A_{lib}} f(A)dA}{f(A_{lib})[A_{lib}-A_L]} < 0 \\
\frac{\partial A_{lib}}{\partial \eta} &= -\frac{\partial M(A_{lib})/\partial \eta}{\partial M(A_{lib})/\partial A_{lib}} = \frac{(\partial A_L/\partial \eta)\int_0^{A_{lib}} f(A)da}{f(A_{lib})[A_{lib}-A_L]} = \frac{-\frac{p(pc/\Delta p-pH+\gamma I)}{(\eta p+(1-p))^2}\int_0^{A_{lib}} f(A)dA}{f(A_{lib})[A_{lib}-A_L]} < 0 \\
\frac{\partial A_{lib}}{\partial p} &= -\frac{\partial M(A_{lib})/\partial p}{\partial M(A_{lib})/\partial A_{imp}} = \frac{(\partial A_L/\partial p)\int_0^{A_{lib}} f(A)dA}{f(A_{lib})[A_{lib}-A_L]} = \frac{\frac{c-\Delta p(H+(\eta-1)\gamma I)}{\Delta p(\eta p+(1-p))}\int_0^{A_{lib}} f(A)dA}{f(A_{lib})[A_{lib}-A_L]} < 0.
\end{aligned}
$$

We next show that A_{lib} is increasing in a collateral squeeze. Let us define the function $G_{lib}(X) = \frac{\int_0^X Af(A)dA}{\int_0^X f(A)dA}$. The derivative is:

$$G'_{lib}(X) = \frac{f(X)\left(X\int_0^X f(A)\,dA - \int_0^X Af(A)\,dA\right)}{\left(\int_0^X f(A)\,dA\right)^2} > 0 \tag{16}$$

When there is a collateral shock, A_{lib}^{shock} is defined by:

$$\frac{\int_0^{A_{lib}^{shock}} Af(A)dA}{\int_0^{A_{lib}^{shock}} f(A)dA} = \frac{A_L}{1-\varepsilon} > A_L. \tag{17}$$

Thus $A_{lib}^{shock} > A_{lib}$ as $G_{lib}(.)$ is increasing.

Proof of Corollary 1

Part (i): A liberal accounting system is optimal when $E(A) > A_L$, which corresponds to $\gamma < \gamma_L$. We start by noting that:

- If $A_{lib} > A_H$ then $\int_0^{A_H} Af(A)dA - A_L\int_0^{A_H} f(A)dA < 0$.
- If $A_{lib} < A_H$ then $\int_0^{A_H} Af(A)dA - A_L\int_0^{A_H} f(A)dA > 0$.

- If $A_{lib} = A_H$ then $\int_0^{A_H} Af(A)dA - A_L \int_0^{A_H} f(A)dA = 0$.

Next we note that A_{lib} and A_H are increasing and decreasing in γ, respectively and that $g(\gamma) \equiv \int_0^{A_H(\gamma)} Af(A)dA - A_L(\gamma) \int_0^{A_H(\gamma)} f(A)dA$ is decreasing in γ, because:

$$\frac{\partial g(\gamma)}{\partial \gamma} = \frac{\partial A_H(\gamma)}{\partial \gamma} f(A_H(\gamma))[A_H(\gamma) + A_L(\gamma)] - \frac{\partial A_L(\gamma)}{\partial \gamma} \int_0^{A_H(\gamma)} f(A)dA < 0.$$

Finally, we observe that:

- At $\gamma \to \gamma_{min}$, $A_H \to \infty$ and

$$g(\gamma_{min}) = \int_0^{A_H} Af(A)dA - A_L \int_0^{A_H} f(A)dA = E(A) - A_L, \tag{18}$$

  if $E(A) > A_L$, expression (18) is positive and this turns out o be true when we have optimal liberal disclosures.

- At $\gamma = \gamma_L$, $A_{lib} \to \infty$ as $A_L(\gamma_L) = E(A)$ and $A_H(\gamma_L) = \frac{pH - \gamma_L I - c}{\gamma_L - (\eta p + (1-p))} < A_{lib}(\gamma_L)$. It follows that $g(\gamma_L) = \int_0^{A_H(\gamma_L)} Af(A)dA - E(A) \int_0^{A_H(\gamma_L)} f(A)dA < 0$.

- At $\gamma = \gamma_{max}$, $A_L(\gamma_{max}) = A_H(\gamma_{max})$ and

$$g(\gamma_{max}) = \int_0^{A_H(\gamma_{max})} (A - A_H(\gamma_{max}))f(A)dA < 0.$$

Thus, there exists a unique $\gamma_{lib} \in (\gamma_{min}, min(\gamma_L, \gamma_{max}))$, such that $\int_0^{A_H(\gamma_{lib})} Af(A)dA - A_L(\gamma_{lib}) \int_0^{A_H(\gamma_{lib})} f(A)dA = 0$, i.e. $A_H(\gamma_{lib}) = A_{lib}(\gamma_{lib})$.

When there is a collateral shock, $g(\gamma)$ is redefined as $g_{Shock}(\gamma)$ as follows

$$g_{shock}(A_H(\gamma)) = \int_0^{\frac{A_H(\gamma)}{1-\varepsilon}} Af(A)dA - \frac{A_L(\gamma)}{1-\varepsilon} \int_0^{\frac{A_H(\gamma)}{1-\varepsilon}} f(A)dA.$$

Applying the Implicit function theorem,

$$\begin{aligned} \frac{\partial \gamma_{lib}}{\partial \varepsilon} &= -\frac{\frac{\partial g_{shock}(\gamma_{lib})}{\partial \varepsilon}}{\frac{\partial g_{shock}(\gamma_{lib})}{\partial \gamma_{lib}}} \\ &= -\frac{A_H(\gamma_{lib}) f\left(\frac{A_H(\gamma_{lib})}{1-\varepsilon}\right)(A_H(\gamma_{lib}) - A_L(\gamma_{lib})) - (1-\varepsilon) A_L(\gamma_{lib}) \int_0^{\frac{A_H(\gamma_{lib})}{1-\varepsilon}} f(A)dA}{(1-\varepsilon)\left(\frac{\partial A_H(\gamma_{lib})}{\partial \gamma_{lib}} f\left(\frac{A_H(\gamma_{lib})}{(1-\varepsilon)}\right)(A_H(\gamma_{lib}) - A_L(\gamma_{lib})) - \frac{\partial A_L(\gamma_{lib})}{\partial \gamma_{lib}} \int_0^{\frac{A_H(\gamma_{lib})}{1-\varepsilon}} f(A)dA\right)} \end{aligned}$$

The denominator is negative, hence it follows that the comparative statics of γ_{lib} is determined by the sign of the numerator. This, however, depends on the parameters in the economy. Specifically, the numerator is equal to

$$\begin{aligned} & A_H(\gamma_{lib}) f\left(\frac{A_H(\gamma_{lib})}{1-\varepsilon}\right)\left(A_H(\gamma_{lib}) - A_L(\gamma_{lib})\right) \\ & -(1-\varepsilon) A_L(\gamma_{lib}) \int_0^{\frac{A_H(\gamma_{lib})}{1-\varepsilon}} f(A) dA \\ = \; & \frac{(1-\varepsilon) A_L(\gamma_{lib})}{f\left(\frac{A_H(\gamma_{lib})}{(1-\varepsilon)}\right)} \left(\frac{A_H(\gamma_{lib})}{A_L(\gamma_{lib})} . \frac{(A_H(\gamma_{lib}) - A_L(\gamma_{lib}))}{(1-\varepsilon)} - \frac{\int_0^{\frac{A_H(\gamma_{lib})}{1-\varepsilon}} f(A) dA}{f\left(\frac{A_H(\gamma_{lib})}{1-\varepsilon}\right)}\right). \end{aligned}$$

Given that $\frac{(1-\varepsilon)A_L(\gamma_{lib})}{f\left(\frac{A_H(\gamma_{lib})}{(1-\varepsilon)}\right)} > 0$, the change in γ_{lib} depends only on the sign of the expression $\frac{A_H(\gamma_{lib})}{A_L(\gamma_{lib})} . \frac{(A_H(\gamma_{lib}) - A_L(\gamma_{lib}))}{(1-\varepsilon)} - \frac{\int_0^{\frac{A_H(\gamma_{lib})}{1-\varepsilon}} f(A) dA}{f\left(\frac{A_H(\gamma_{lib})}{1-\varepsilon}\right)}$.

Part (ii): If $E(A) < A_L$, i.e. $\gamma > \gamma_L$ the optimal information system is impairment-like. Combining the conditions, requiring information system, we obtain result *(ii)*.

Part (iii): If $\gamma > \gamma_{max}$ all firms make the financing investment and hence, they are indifferent between any information system.

Proof of Proposition 6

When setting the investment threshold the benevolent social planner maximizes:

$$\begin{aligned} max_{\bar{A}} \int_0^{\bar{A}} (pH + \eta A - c) f(A) dA \\ \text{s.t } I \int_0^{\bar{A}} f(A) dA = K + \int_{\bar{A}}^{\infty} A f(A) dA \end{aligned}$$

The solution to this program is $\bar{A} = A^*$, where A^* satisfies:

$$I \int_0^{A^*} f(A) dA = K + \int_{A^*}^{\infty} A f(A) dA. \tag{19}$$

As long as $K < I$, then $A^* < \infty$.

Proof of Corollary 2

Part (i): The threshold A^* is determined by the resource constraint (19). Let denote $N(X) = I \int_0^X f(A) dA - \int_X^{\infty} A f(A) dA - K$. Then applying the implicit function theorem,

$$\frac{\partial A^*}{\partial I} = -\frac{\frac{\partial N(A^*)}{\partial I}}{\frac{\partial N(A^*)}{\partial A^*}} = -\frac{\int_0^{A^*} f(A)dA}{f(A^*)(I + A^*)} < 0$$

If there is a collateral squeeze decreasing the assets' value by $\varepsilon > 0$, we define $N_{shock}(X) = I\int_0^X f(A)dA - K - \int_X^\infty (1-\varepsilon)Af(A)dA$. Then,

$$\frac{\partial A^*_{shock}}{\partial \varepsilon} = -\frac{\frac{\partial N_{shock}(A^*_{shock})}{\partial \varepsilon}}{\frac{\partial N_{shock}(A^*_{shock})}{\partial A}} = -\frac{\int_0^{A^*_{shock}} Af(A)dA}{f(A^*_{shock})(I + A^*_{shock}(1-\varepsilon))} < 0$$

If there is a credit crunch decreasing K by $\kappa > 0$, we define $N_{crunch}(X) = I\int_0^X f(A)dA - (1-\kappa)K - \int_X^\infty Af(A)dA$. Then,

$$\frac{\partial A^*_{crunch}}{\partial \kappa} = -\frac{\frac{\partial N_{crunch}(A^*_{crunch})}{\partial \kappa}}{\frac{\partial N_{crunch}(A^*_{crunch})}{\partial A}} = -\frac{K}{f(A^*_{crunch})(I + A^*_{crunch}(1-\varepsilon))} < 0$$

Part (ii): It is straightforward to see that the total social surplus $\int_0^{A^*}(pH + \eta A - c)f(A)dA$ is increasing in p, H and η, and decreasing in c. Since A^* is increasing in K (decreasing in κ) and decreasing in I it follows that the total social surplus is increasing in K and decreasing in I.

Proof of Proposition 7

The net demand without moral hazard is defined as

$$Net(\gamma) = I\int_0^{A_H(\gamma)} f(A)dA - K - \int_{A_H(\gamma)}^\infty Af(A)dA \tag{20}$$

and is decreasing in γ:

$$\frac{\partial Net(\gamma)}{\partial \gamma} = A_H(\gamma)(1+I)\frac{\partial A_H(\gamma)}{\partial \gamma} f(A_H(\gamma)) < 0$$

- At $\gamma \to \gamma_{min}$, $A_H \to \infty$ and $Net(\gamma_{min}) = I - K > 0$.
- Let define $\gamma_0 = \frac{pH-c}{I}$, such that $A_H(\gamma_0) = 0$. Note that $\gamma_0 > \gamma_{max}$, because $A_L > 0$ by assumption. Then, at $\gamma = \gamma_0$, $Net(\gamma_{max}) = -K - E(A) < 0$.

Hence, there exists a unique $\gamma^{FB} \in (\gamma_{min}, \gamma_0)$, such that $Net(\gamma_{FB}) = 0$. By construction, $A_H(\gamma^{FB}) = A^*$.

Proof of Corollary 3

The comparative statics of γ^{FB} is as follows:

$$\begin{aligned}
\frac{\partial \gamma^{FB}}{\partial p} &= -\frac{\frac{\partial Net(A_H(\gamma^{FB}))}{\partial p}}{\frac{\partial Net(A_H(\gamma^{FB}))}{\partial \gamma}} = -\frac{\frac{\partial A_H(\gamma^{FB})}{\partial p} f(A_H(\gamma^{FB}))(I + A_H(\gamma^{FB}))}{\frac{\partial A_H(\gamma^{FB})}{\partial \gamma} f(A_H(\gamma^{FB}))(I + A_H(\gamma^{FB}))} > 0 \\
\frac{\partial \gamma^{FB}}{\partial H} &= -\frac{\frac{\partial Net(A_H(\gamma^{FB}))}{\partial H}}{\frac{\partial Net(A_H(\gamma^{FB}))}{\partial \gamma}} = -\frac{\frac{\partial A_H(\gamma^{FB})}{\partial H} f(A_H(\gamma^{FB}))(I + A_H(\gamma^{FB}))}{\frac{\partial A_H(\gamma^{FB})}{\partial \gamma} f(A_H(\gamma^{FB}))(I + A_H(\gamma^{FB}))} > 0 \\
\frac{\partial \gamma^{FB}}{\partial c} &= -\frac{\frac{\partial Net(A_H(\gamma^{FB}))}{\partial c}}{\frac{\partial Net(A_H(\gamma^{FB}))}{\partial \gamma}} = -\frac{\frac{\partial A_H(\gamma^{FB})}{\partial c} f(A_H(\gamma^{FB}))(I + A_H(\gamma^{FB}))}{\frac{\partial A_H(\gamma^{FB})}{\partial \gamma} f(A_H(\gamma^{FB}))(I + A_H(\gamma^{FB}))} < 0 \\
\frac{\partial \gamma^{FB}}{\partial \eta} &= -\frac{\frac{\partial Net(A_H(\gamma^{FB}))}{\partial \eta}}{\frac{\partial Net(A_H(\gamma^{FB}))}{\partial \gamma}} = -\frac{\frac{\partial A_H(\gamma^{FB})}{\partial \eta} f(A_H(\gamma^{FB}))(I + A_H(\gamma^{FB}))}{\frac{\partial A_H(\gamma^{FB})}{\partial \gamma} f(A_H(\gamma^{FB}))(I + A_H(\gamma^{FB}))} > 0
\end{aligned}$$

For I,

$$\frac{\partial \gamma^{FB}}{\partial I} = -\frac{\frac{\partial Net(A_H(\gamma^{FB}))}{\partial I}}{\frac{\partial Net(A_H(\gamma^{FB}))}{\partial \gamma}} = -\frac{\int_0^{A_H(\gamma^{FB})} f(A)dA + \frac{\partial A_H(\gamma^{FB})}{\partial I} f(A_H(\gamma^{FB}))(I + A_H(\gamma^{FB}))}{\frac{\partial A_H(\gamma^{FB})}{\partial \gamma} f(A_H(\gamma^{FB}))(I + A_H(\gamma^{FB}))}$$

We know that

$$\frac{\partial A_H(\gamma^{FB})}{\partial I} f(A_H(\gamma^{FB}))(I + A_H(\gamma^{FB})) = -\frac{\gamma}{\gamma - (\eta p + (1-p))} f(A_H(\gamma^{FB}))(I + A_H(\gamma^{FB})).$$

We conclude that $\frac{\partial \gamma^{FB}}{\partial I}$ can be negative or positive.

For K,

$$\frac{\partial \gamma^{FB}}{\partial K} = -\frac{\frac{\partial Net(A_H(\gamma^{FB}))}{\partial K}}{\frac{\partial Net(A_H(\gamma^{FB}))}{\partial \gamma}} = \frac{1}{\frac{\partial A_H(\gamma^{FB})}{\partial \gamma} f(A_H(\gamma^{FB}))(I + A_H(\gamma^{FB}))} < 0.$$

The cost of capital γ^{FB} can offset the changes in p, H, η and c, so that the threshold $A_H(\gamma^{FB})$ does not change, $A_H(\gamma^{FB}) = A^*$ is not violated and the markets clear. As shown in Corollary 2 changes in I, aggregate wealth and outside capital affect A^*. The comparative statics of $A_H(\gamma)$ follow those of A^*. $A_H(\gamma^{FB})$ is decreasing in I, collateral squeeze and credit crunch.

Proof of Lemma 5

Part (i): We start by noting that for $\gamma \in (\gamma_{min}, \gamma_{lib})$ the net demand

$$Q(\gamma) = I \int_0^{A_H(\gamma)} f(A)dA - K - \int_{A_H(\gamma)}^{\infty} Af(A)dA$$

is decreasing in γ, because $\frac{\partial Q(\gamma)}{\partial \gamma} = f(A_H(\gamma))\frac{\partial A_H(\gamma)}{\partial \gamma}(I + A_H(\gamma)) < 0$. At $\gamma = \gamma_{min}$ the net demand $Q(\gamma_{min}) = I - K > 0$, because $A_H \to \infty$.

Next, we note that for $\gamma \in (\gamma_{lib}, \min(\gamma_L, \gamma_{max}))$ the net demand

$$T(\gamma) = I \int_0^{A_{lib}(\gamma)} f(A)dA - K - \int_{A_{lib}(\gamma)}^{\infty} Af(A)dA$$

is increasing in γ, because $\frac{\partial T(\gamma)}{\partial \gamma} = f(A_{lib}(\gamma))\frac{\partial A_{lib}(\gamma)}{\partial \gamma}(I + A_{lib}(\gamma)) > 0$. At $\gamma = min(\gamma_L, \gamma_{max})$, the net demand $T(\min(\gamma_L, \gamma_{max})) = I - K > 0$, because $A_{lib} \to \infty$.

At $\gamma = \gamma_{lib}$, $A_{lib}(\gamma_{lib}) = A_H(\gamma_{lib})$ and

$$\int_0^{A_H(\gamma_{lib})} Af(A)dA - A_L(\gamma_{lib}) \int_0^{A_H(\gamma_{lib})} Af(A)dA = 0$$

For a liberal information system to be optimal it has to be the case that $Q(\gamma_{lib}) = T(\gamma_{lib}) < 0$. Combining the two conditions leads to the result *(i)*.

Part (ii): We note that for $\gamma \in (\min(\gamma_L, \gamma_{max}), \gamma_{max})$ the net demand

$$Z(\gamma) = I \int_{A_{imp}(\gamma)}^{\infty} f(A)dA - K - \int_0^{A_{imp}(\gamma)} Af(A)dA$$

is decreasing in γ: $\frac{\partial Z(\gamma)}{\partial \gamma} = -f(A_{imp}(\gamma))\frac{\partial A_{imp}(\gamma)}{\partial \gamma}(I + A_{imp}(\gamma)) < 0$. If this net demand exists, at $\gamma = \gamma_L$, the net demand $Z(\gamma_L) = T(\gamma_L) = I - K > 0$. For an impairment-like information system to be optimal it has to be the case that $Z(\gamma_{max}) < 0$. Combining this condition with the financing condition for non-disclosing firms,

$$\int_{A_{imp}(\gamma_{max})}^{\infty} Af(A)dA - A_L(\gamma_{max}) \int_{A_{imp}(\gamma_{max})}^{\infty} Af(A)dA = 0,$$

leads to result *(ii)*.

Proof of Proposition 8

- If $E(A) > W^{low}$ then $\gamma_{min} < \gamma_L$. As shown for $\gamma \in (\gamma_{min}, \gamma_{lib})$ the net demand $Q(\gamma)$ is decreasing in γ and at $\gamma = \gamma_{min}$, $Q(\gamma_{min}) = I - K > 0$. As shown, if

$\frac{I}{A_L(\gamma_{lib})} < \frac{K+\int_{A_H(\gamma_{lib})}^{\infty} Af(A)dA}{\int_0^{A_{lib}(\gamma_{lib})} Af(A)dA}$, then $Q(\gamma_{lib}) < 0$ and there exists a unique $\gamma^* < \gamma_{lib}$ such that $Q(\gamma^*) = 0$. By construction, $\gamma^* = \gamma^{FB}$.

- Also, as shown for $\gamma \in (\gamma_{lib}, \min(\gamma_L, \gamma_{max}))$ the net demand $T(\gamma)$ is increasing in γ and at $\gamma = min(\gamma_L, \gamma_{max})$, $T(\gamma) = I - K > 0$. If $\frac{I}{A_L(\gamma_{lib})} < \frac{K+\int_{A_H(\gamma_{lib})}^{\infty} Af(A)dA}{\int_0^{A_{lib}(\gamma_{lib})} Af(A)dA}$, then $T(\gamma_{lib}) < 0$ and there exists a unique $\gamma^{**} \in (\gamma_{max}, \gamma_{lib})$ such that $T(\gamma^{**}) = 0$.

  Hence, if $E(A) > W^{low}$ and $\frac{I}{A_L(\gamma_{lib})} < \frac{K+\int_{A_H(\gamma_{lib})}^{\infty} Af(A)dA}{\int_0^{A_{lib}(\gamma_{lib})} Af(A)dA}$, there exist GE_1 and GE_2.

- If $W^{low} < E(A) \leq W^{imp}$ then $\gamma_{min} < \gamma_{lib} < \gamma_L < \gamma_{max} < \gamma_H$. If $\frac{I}{A_L(\gamma_{max})} \geq \frac{K+\int_0^{A_{imp}(\gamma_{max})} Af(A)dA}{\int_{A_{imp}(\gamma_{max})}^{\infty} Af(A)dA}$ there exist a general equilibrium GE_3, defined by $Z(\gamma^{***}) = 0$. To see this start by recalling that $Z(\gamma)$ is decreasing in γ and that $Z(\gamma_L) = T(\gamma_L) = I - K > 0$. Noting that if $\frac{I}{A_L(\gamma_{max})} \geq \frac{K+\int_0^{A_{imp}(\gamma_{max})} Af(A)dA}{\int_{A_{imp}(\gamma_{max})}^{\infty} Af(A)dA}$, then $Z(\gamma_{max}) < 0$, we can conclude that there exists a unique γ^{***}, such that $Z(\gamma^{***}) = 0$.

- Finally, if $E(A) \leq W^{low}$, then $\gamma_L \leq \gamma_{min} < \gamma_{max} < \gamma_H$ and only impairment-like disclosures can be optimal. As shown above, GE_3, defined by $Z(\gamma^{***}) = 0$ exists if $\frac{I}{A_L(\gamma_{max})} \geq \frac{K+\int_0^{A_{imp}(\gamma_{max})} Af(A)dA}{\int_{A_{imp}(\gamma_{max})}^{\infty} Af(A)dA}$ and $\frac{I}{A_L(\gamma_{min})} \leq \frac{K+\int_0^{A_{imp}(\gamma_{min})} Af(A)dA}{\int_{A_{imp}(\gamma_{min})}^{\infty} Af(A)dA}$ (so that $Z(\gamma_{min}) > 0$).

Proof of Corollary 4

The proof of Corollary 4 follows directly from the proof of Proposition 8 and is omitted.

Proof of Corollary 5

Comparative statics of γ^*:

γ^* is defined by $Q(\gamma^*) = 0$, where $\gamma_{min} < \gamma^* < \gamma_{lib} < \min(\max(\gamma_L, \gamma_{min}), \gamma_{max})$.

Applying the Implicit function Theorem,

$$\begin{aligned}
\frac{\partial \gamma^*}{\partial p} &= -\frac{\frac{\partial Q(\gamma^*)}{\partial p}}{\frac{\partial Q(\gamma^*)}{\partial \gamma}} = -\frac{\frac{\partial A_H(\gamma^*)}{\partial p} f(A_H(\gamma^*))(I + A_H(\gamma^*))}{\frac{\partial A_H(\gamma^*)}{\partial \gamma} f(A_H(\gamma^*))(I + A_H(\gamma^*))} > 0 \\
\frac{\partial \gamma^*}{\partial H} &= -\frac{\frac{\partial Q(\gamma^*)}{\partial H}}{\frac{\partial Q(\gamma^*)}{\partial \gamma}} = -\frac{\frac{\partial A_H(\gamma^*)}{\partial H} f(A_H(\gamma^*))(I + A_H(\gamma^*))}{\frac{\partial A_H(\gamma^*)}{\partial \gamma} f(A_H(\gamma^*))(I + A_H(\gamma^*))} > 0 \\
\frac{\partial \gamma^*}{\partial c} &= -\frac{\frac{\partial Q(\gamma^*)}{\partial c}}{\frac{\partial Q(\gamma^*)}{\partial \gamma}} = -\frac{\frac{\partial A_H(\gamma^*)}{\partial c} f(A_H(\gamma^*))(I + A_H(\gamma^*))}{\frac{\partial A_H(\gamma^*)}{\partial \gamma} f(A_H(\gamma^*))(I + A_H(\gamma^*))} < 0 \\
\frac{\partial \gamma^*}{\partial \eta} &= -\frac{\frac{\partial Q(\gamma^*)}{\partial \eta}}{\frac{\partial Q(\gamma^*)}{\partial \gamma}} = -\frac{\frac{\partial A_H(\gamma^*)}{\partial \eta} f(A_H(\gamma^*))(I + A_H(\gamma^*))}{\frac{\partial A_H(\gamma^*)}{\partial \gamma} f(A_H(\gamma^*))(I + A_H(\gamma^*))} > 0.
\end{aligned}$$

For I,

$$\frac{\partial \gamma^*}{\partial I} = -\frac{\frac{\partial Q(\gamma^*)}{\partial I}}{\frac{\partial Q(\gamma^*)}{\partial \gamma}} = -\frac{\int_0^{A_H(\gamma^*)} f(A)dA + \frac{\partial A_H(\gamma^*)}{\partial I} f(A_H(\gamma^*))(I + A_H(\gamma^*))}{\frac{\partial A_H(\gamma^*)}{\partial \gamma} f(A_H(\gamma^*))(I + A_H(\gamma^*))}$$

We know that:

$$\frac{\partial A_H(\gamma^*)}{\partial I} f(A_H(\gamma^*))(I + A_H(\gamma^*)) = -\frac{\gamma}{\gamma - (\eta p + (1-p))} f(A_H(\gamma^*))(I + A_H(\gamma^*)),$$

We conclude that $\frac{\partial \gamma^*}{\partial I}$ is ambiguous. By construction $A_H(\gamma^*) = A^*$ and thus has the same comparative statics as A^*.

Comparative statics of γ^{**}:

γ^{**} is defined by $T(\gamma^{**}) = 0$, where $\gamma_{min} < \gamma_{lib} < \gamma^{**} < \min(\max(\gamma_L, \gamma_{min}), \gamma_{max})$. Let denote

$$\begin{aligned}
\Psi_1(A_{lib}, \gamma) &= \int_0^{A_{lib}} A f(A)dA - A_L(\gamma) \int_0^{A_{lib}} f(A)dA \\
\Psi_2(A_{lib}, \gamma) &= I \int_0^{A_{lib}} f(A)dA - K - \int_{A_{lib}}^{\infty} A f(A)dA
\end{aligned}$$

We define the Jacobian J_{lib} as follows:

$$J_{lib} = \begin{bmatrix} (A_{lib} - A_L(\gamma)) f(A_{lib}) & -\frac{\partial A_L(\gamma)}{\partial \gamma} \int_0^{A_{lib}} f(A)dA \\ (A_{lib} + I) f(A_{lib}) & 0 \end{bmatrix}$$

Applying the Implicit Function Theorem yields:

$$\begin{bmatrix} \frac{\partial A_{lib}}{\partial q} \\ \frac{\partial \gamma^{**}}{\partial q} \end{bmatrix} = -J_{lib}^{-1} \times \begin{bmatrix} \frac{\partial \Psi_1(A_{lib},\gamma)}{\partial q} \\ \frac{\partial \Psi_2(A_{lib},\gamma)}{\partial q} \end{bmatrix},$$

where q is equal to any exogenous parameter in the economy.
If q is p, H, η or c, $\frac{\partial \Psi_2(A_{lib},\gamma)}{\partial q} = 0$. If $q = I$, $\frac{\partial \Psi_2(A_{lib},\gamma)}{\partial I} = \int_0^{A_{lib}} f(A)dA$.
Simplifying, if $q = p$ or H or η or c:

$$\begin{bmatrix} \frac{\partial A_{lib}}{\partial q} \\ \frac{\partial \gamma^{**}}{\partial q} \end{bmatrix} = \begin{bmatrix} 0 \\ -\frac{\frac{\partial A_L}{\partial q}}{\frac{\partial A_L(\gamma)}{\partial \gamma}} \end{bmatrix}$$

and $\frac{\partial \gamma^{**}}{\partial q}$ follows the sign of $-\frac{\partial A_L}{\partial q}$.

If $q = I$:

$$\begin{bmatrix} \frac{\partial A_{lib}}{\partial q} \\ \frac{\partial \gamma^{**}}{\partial q} \end{bmatrix} = \begin{bmatrix} -\frac{\int_0^{A_{lib}} f(A)dA}{(A_{lib}+I)f(A_{lib})} < 0 \\ -\frac{A_{lib}-A_L+\frac{\partial A_L}{\partial I}(A_{lib}+I)}{\frac{\partial A_L(\gamma)}{\partial \gamma}(A_{lib}+I)} < 0 \end{bmatrix}.$$

Comparative statics of γ^{***}:
$\gamma^{***} \in (\min(\max(\gamma_L, \gamma_{min}), \gamma_{max}), \gamma_{max})$ is defined by $Z(\gamma^{***}) = 0$. Let denote

$$\begin{aligned} \Psi_3(A_{imp}, \gamma) &= \int_{A_{imp}}^{\infty} Af(A)dA - A_L(\gamma) \int_{A_{imp}}^{\infty} f(A)dA \\ \Psi_4(A_{imp}, \gamma) &= I \int_{A_{imp}}^{\infty} f(A)dA - K - \int_0^{A_{imp}} Af(A)dA \end{aligned}$$

We define the Jacobian J_{imp} as follows:

$$J_{imp} = \begin{bmatrix} (A_L(\gamma) - A_{imp})f(A_{imp}) & -\frac{\partial A_L(\gamma)}{\partial \gamma} \int_{A_{imp}}^{\infty} f(A)dA \\ -(A_{imp} + I)f(A_{imp}) & 0 \end{bmatrix}$$

Applying the Implicit Function Theorem yields:

$$\begin{bmatrix} \frac{\partial A_{imp}}{\partial q} \\ \frac{\partial \gamma^{***}}{\partial q} \end{bmatrix} = -J_{imp}^{-1} \times \begin{bmatrix} \frac{\partial \Psi_3(A_{imp},\gamma)}{\partial q} \\ \frac{\partial \Psi_4(A_{imp},\gamma)}{\partial q} \end{bmatrix},$$

where q is equal to any exogenous parameter in the economy. If q is p, H, η or c, $\frac{\partial \Psi_4(A_{imp},\gamma)}{\partial q} = 0$. If $q = I$, $\frac{\partial \Psi_4(A_{imp},\gamma)}{\partial I} = \int_{A_{imp}}^{\infty} f(A)dA$. Simplifying, If $q = p$ or H or η or c:

$$\begin{bmatrix} \frac{\partial A_{imp}}{\partial q} \\ \frac{\partial \gamma^{***}}{\partial q} \end{bmatrix} = \begin{bmatrix} 0 \\ -\frac{\frac{\partial A_L}{\partial q}}{\frac{\partial A_L(\gamma)}{\partial \gamma}} \end{bmatrix}$$

and $\frac{\partial \gamma^{***}}{\partial q}$ follows the sign of $-\frac{\partial A_L}{\partial q}$.
For $q = I$,

$$\begin{bmatrix} \frac{\partial A_{imp}}{\partial q} \\ \frac{\partial \gamma^{***}}{\partial q} \end{bmatrix} = \begin{bmatrix} \frac{\int_{A_{imp}}^{\infty} f(A)dA}{(A_{imp}+I)f(A_{imp})} > 0 \\ -\frac{A_{imp}-A_L+(A_{imp}+I)\frac{\partial A_L}{\partial I}}{\frac{\partial A_L(\gamma)}{\partial \gamma}(A_{imp}+I)} < 0 \end{bmatrix},$$

$$\begin{aligned} \text{because} \qquad & -(A_{imp} - A_L + (A_{imp} + I)\frac{\partial A_L}{\partial I}) \\ = \ & -(\frac{\gamma}{\eta p + (1-p)} + 1)A_{imp} + A_L - \frac{\gamma}{\eta p + (1-p)} I \\ = \ & -(\frac{\gamma}{\eta p + (1-p)} + 1)A_{imp} - \frac{1}{\eta p + (1-p)}(pH - p\frac{c}{\Delta p}) < 0 \end{aligned}$$

Proof of Corollary 6

We use the Walrasian tatonnement process to investigate the stability of the general equilibria. Assume $\delta > 0$

GE_1:
- Let us assume that there is a small perturbation δ that is leading to a higher (lower) cost of capital $\gamma + \delta > \gamma^*$ resp. ($\gamma - \delta < \gamma^*$). At $\gamma + \delta$ resp ($\gamma - \delta$), there is excess supply (excess demand) and to fix it, as the net demand Q is decreasing, the cost of capital needs to be lower (higher).

$\Rightarrow$ GE_1 is a stable equilibrium as in response to a small perturbation on the cost of capital, the net demand adjusts so that we converge back to the equilibrium cost of capital γ^*.

GE_2:
- Let us assume that there is a small perturbation that is leading to a higher (lower) cost of capital $\gamma + \delta > \gamma^{**}$ resp. ($\gamma - \delta < \gamma^{**}$). At $\gamma + \delta$ resp ($\gamma - \delta$), there is excess supply (excess demand) and to fix it, as the net demand T is increasing, the cost of capital needs to be higher (lower).

$\Rightarrow$ GE_2 is *not* a stable equilibrium as in response to a small perturbation on the cost of capital, the net demand adjusts so that we diverge from the equilibrium cost of capital γ^{**}.

GE_3:
- Let us assume that there is a small perturbation that is leading to a higher (lower) cost of capital $\gamma + \delta > \gamma^{***}$ resp. ($\gamma - \delta < \gamma^{***}$). At $\gamma + \delta$ resp ($\gamma - \delta$), there is excess supply (excess demand) and to fix it, as the net demand Z is decreasing, the cost of capital needs to be lower (higher).

$\Rightarrow$ GE_1 is a stable equilibrium as in response to a small perturbation on the cost of capital, the net demand adjusts so that we converge back to the equilibrium cost of capital γ^{***}.

Proof of Corollary 7

When there is a collateral squeeze the net demand functions become:

$$Q^{shock}(\gamma) = I\int_0^{A_H(\gamma)/(1-\varepsilon)} f(A)dA - K - \int_{A_H(\gamma)/(1-\varepsilon)}^{\infty}(1-\varepsilon)Af(A)dA,$$
$$T^{shock}(\gamma) = I\int_0^{A_{lib}(\gamma)} f(A)dA - K - \int_{A_{lib}(\gamma)}^{\infty}(1-\varepsilon)Af(A)dA,$$
$$Z^{shock}(\gamma) = I\int_{A_{imp}(\gamma)}^{\infty} f(A)dA - K - \int_0^{A_{imp}(\gamma)}(1-\varepsilon)Af(A)dA.$$

Consequently,

$$\begin{aligned}
\Psi_1^{shock}(A_{lib},\gamma) &= \int_0^{A_{lib}}(1-\varepsilon)Af(A)dA - A_L(\gamma)\int_0^{A_{lib}} f(A)dA \\
\Psi_2^{shock}(A_{lib},\gamma) &= I\int_0^{A_{lib}} f(A)dA - K - \int_{A_{lib}}^{\infty}(1-\varepsilon)Af(A)dA \\
\Psi_3^{shock}(A_{imp},\gamma) &= \int_{A_{imp}}^{\infty}(1-\varepsilon)Af(A)dA - A_L(\gamma)\int_{A_{imp}}^{\infty} f(A)dA \\
\Psi_4^{shock}(A_{imp},\gamma) &= I\int_{A_{imp}}^{\infty} f(A)dA - K - \int_0^{A_{imp}}(1-\varepsilon)Af(A)dA
\end{aligned}$$

The Jacobian J_{lib}^{shock} is now defined as:

$$J_{lib}^{shock} = \begin{bmatrix} (A_{lib}(1-\varepsilon) - A_L(\gamma))f(A_{lib}) & -\frac{\partial A_L(\gamma)}{\partial\gamma}\int_0^{A_{lib}} f(A)dA \\ (A_{lib}(1-\varepsilon)+I)f(A_{lib}) & 0 \end{bmatrix}$$

and the Jacobian J_{imp}^{shock} as:

$$J_{imp}^{shock} = \begin{bmatrix} (A_L(\gamma) - A_{imp}(1-\varepsilon))f(A_{imp}) & -\frac{\partial A_L(\gamma)}{\partial\gamma}\int_{A_{imp}}^{\infty} f(A)dA \\ -(A_{imp}(1-\varepsilon)+I)f(A_{imp}) & 0 \end{bmatrix}$$

For γ^* the comparative statics is as follows:

$$\frac{\partial\gamma^*}{\partial\varepsilon} = -\frac{\frac{\partial Q^{shock}(\gamma)}{\partial\varepsilon}}{\frac{\partial Q^{shock}(\gamma)}{\partial\gamma}} = -\frac{\frac{A_H f(A/(1-\varepsilon))}{(1-\varepsilon)^2}(I + A_H(1-\varepsilon)) + \int_{A_H(\gamma^*)}^{\infty} Af(A)dA}{\frac{\partial A_H}{\partial\gamma}(I + A_H(\gamma^*))f(A_H(\gamma^*))} > 0,$$

and $A_H(\gamma^*)$ decreases.

For γ^{**} and $A_{lib}(\gamma^{**})$ the comparative statics is as follows:

$$\begin{bmatrix} \frac{\partial A_{lib}}{\partial\varepsilon} \\ \frac{\partial\gamma^{**}}{\partial\varepsilon} \end{bmatrix} = -J_{lib}^{shock\ -1} \times \begin{bmatrix} \frac{\partial\Psi_1^{shock}(A_{lib},\gamma)}{\partial\varepsilon} \\ \frac{\partial\Psi_2^{shock}(A_{lib},\gamma)}{\partial\varepsilon} \end{bmatrix}.$$

Simplifying,

$$\begin{bmatrix} \frac{\partial A_{lib}}{\partial\varepsilon} \\ \frac{\partial\gamma^{**}}{\partial\varepsilon} \end{bmatrix} = \begin{bmatrix} -\frac{\int_{A_{lib}}^{\infty} Af(A)dA}{f(A)(A_{lib}(1-\varepsilon)+I)} < 0 \\ -\frac{(A_{lib}(1-\varepsilon)+I)\int_0^{A_{lib}} Af(A)dA + (A_{lib}(1-\varepsilon)-A_L)\int_{A_{lib}}^{\infty} Af(A)dA}{\frac{\partial A_L}{\partial\gamma}(A_{lib}(1-\varepsilon)+I)\int_0^{A_{lib}} f(A)dA} < 0 \end{bmatrix}.$$

For γ^{***} and $A_{lib}(\gamma^{***})$ the comparative statics is as follows:

$$\begin{bmatrix} \frac{\partial A_{imp}}{\partial\varepsilon} \\ \frac{\partial\gamma^{***}}{\partial\varepsilon} \end{bmatrix} = -J_{imp}^{shock\ -1} \times \begin{bmatrix} \frac{\partial\Psi_3^{shock}(A_{imp},\gamma)}{\partial\varepsilon} \\ \frac{\partial\Psi_4^{shock}(A_{imp},\gamma)}{\partial\varepsilon} \end{bmatrix}.$$

Simplifying,

$$\begin{bmatrix} \frac{\partial A_{imp}}{\partial\varepsilon} \\ \frac{\partial\gamma^{***}}{\partial\varepsilon} \end{bmatrix} = \begin{bmatrix} \frac{\int_0^{A_{imp}} Af(A)dA}{f(A)(A_{imp}(1-\varepsilon)+I)} > 0 \\ -\frac{(A_L - A_{imp}(1-\varepsilon))\int_0^{A_{imp}} Af(A)dA - (A_{imp}(1-\varepsilon)+I)\int_{A_{imp}}^{\infty} Af(A)dA}{\frac{\partial A_L}{\partial\gamma}(A_{imp}(1-\varepsilon)+I)\int_{A_{imp}}^{\infty} f(A)dA} > 0 \end{bmatrix},$$

because

$$\begin{aligned} M(\gamma^{***}) &= (A_L - A_{imp}(1-\varepsilon))\int_0^{A_{imp}} Af(A)dA - (A_{imp}(1-\varepsilon)+I)\int_{A_{imp}}^{\infty} Af(A)dA \\ &= A_L\left(\int_0^{A_{imp}} Af(A)dA - I\int_{A_imp}^{\infty} f(A)dA\right) - A_{imp}E(A) \\ &= -KA_L - A_{imp}E(A) \\ &< 0 \end{aligned}$$

When there is a credit crunch the net demand functions become:

$$Q^{crunch}(\gamma) = I\int_0^{A_H(\gamma)} f(A)dA - (1-\kappa)K - \int_{A_H(\gamma)}^{\infty} Af(A)dA,$$
$$T^{crunch}(\gamma) = I\int_0^{A_{lib}(\gamma)} f(A)dA - (1-\kappa)K - \int_{A_{lib}(\gamma)}^{\infty} Af(A)dA,$$
$$Z^{crunch}(\gamma) = I\int_{A_{imp}(\gamma)}^{\infty} f(A)dA - (1-\kappa)K - \int_0^{A_{imp}(\gamma)} Af(A)dA.$$

Consequently,

$$\begin{aligned}\Psi_2^{crunch}(A_{lib},\gamma) &= I\int_0^{A_{lib}} f(A)dA - (1-\kappa)K - \int_{A_{lib}}^{\infty} Af(A)dA\\ \Psi_4^{crunch}(A_{imp},\gamma) &= I\int_{A_{imp}}^{\infty} f(A)dA - (1-\kappa)K - \int_0^{A_{imp}} Af(A)dA\end{aligned}$$

For γ^* the comparative statics is as follows:

$$\frac{\partial\gamma^*}{\partial\kappa} = -\frac{\frac{\partial Q^{crunch}(\gamma)}{\partial\kappa}}{\frac{\partial Q^{crunch}(\gamma)}{\partial\gamma}} = -\frac{1}{\frac{\partial A_H}{\partial\gamma}(I + A_H(\gamma^*))f(A_H(\gamma^*))} > 0,$$

and $A_H(\gamma^*)$ decreases.

For γ^{**} and $A_{lib}(\gamma^{**})$ the comparative statics is as follows:

$$\begin{bmatrix} \frac{\partial A_{lib}}{\partial\kappa} \\ \frac{\partial\gamma^{**}}{\partial\kappa} \end{bmatrix} = -J_{lib}^{-1} \times \begin{bmatrix} \frac{\partial\Psi_1(A_{lib},\gamma)}{\partial\kappa} \\ \frac{\partial\Psi_2^{crunch}(A_{lib},\gamma)}{\partial\kappa} \end{bmatrix},$$

where J_{lib}^{-1} is as defined in the proof to Corollary 5. This is equivalent to

$$\begin{bmatrix} \frac{\partial A_{lib}}{\partial\kappa} \\ \frac{\partial\gamma^{**}}{\partial\kappa} \end{bmatrix} = \begin{bmatrix} -\{(A_{lib}+I)f(A_{lib})\}^{-1} < 0 \\ -\frac{A_{lib}-A_L}{\frac{\partial A_L}{\partial\gamma}(A_{lib}+I)\int_0^{A_{lib}} f(A)dA} < 0 \end{bmatrix}.$$

For γ^{***} and $A_{lib}(\gamma^{***})$ the comparative statics is as follows:

$$\begin{bmatrix} \frac{\partial A_{imp}}{\partial\kappa} \\ \frac{\partial\gamma^{***}}{\partial\kappa} \end{bmatrix} = -J_{imp}^{-1} \times \begin{bmatrix} \frac{\partial\Psi_3(A_{imp},\gamma)}{\partial\kappa} \\ \frac{\partial\Psi_4^{crunch}(A_{imp},\gamma)}{\partial\kappa} \end{bmatrix},$$

where J_{imp}^{-1} is as defined in the proof to Corollary 5. This is equivalent to

$$\begin{bmatrix} \frac{\partial A_{imp}}{\partial \kappa} \\ \frac{\partial \gamma^{***}}{\partial \kappa} \end{bmatrix} = \begin{bmatrix} \{(A_{imp}+I)f(A_{imp})\}^{-1} > 0 \\ -\frac{A_{imp}-A_L}{\frac{\partial A_L}{\partial \gamma}(A_{imp}+I)\int_{A_{imp}}^{\infty} f(A)dA} > 0 \end{bmatrix}.$$

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