Disclosure, Investment and Regulation

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January 26, 2004

Abstract

We develop a model in which a cash-constrained entrepreneur determines what disclosure level that his firm will abide to. The disclosure level determines the probability that the firm's assets are verifiable and hence functions as a mechanism for the entrepreneur to commit not to expropriate investors. If the entrepreneur is not the sole residual claimant at the disclosure date then utilising this commitment device presents a trade-off. A higher disclosure level implies a better price for financial claims issued but reduces the entrepreneur's proceeds from expropriation. A too high disclosure level may discourage the entrepreneur from undertaking value enhancing investments. If expropriation is costly then regulation will be welfare enhancing since it will reduce the amount expropriation. If firms experience decreasing returns to scale when growing then economic growth will lead to higher disclosure levels. The model predicts that firms with financial slack will have lower disclosure levels. Additionally, the optimal disclosure depends of firm characteristics which implies harmonisation of disclosure rules may be harmful.

1 Introduction

A prerequisite for a functioning capital market is that investors have information concerning the value of their stake and that they have the power to protect themselves from expropriation. La Porta et al. (1997, 1998) document that countries with weak legal protection of minority shareholders have less developed and narrower capital markets. So all other things being equal a firm finds it harder to raise financing in a country with weak protection of minority shareholders since it is hard for the firm to commit to not to expropriate outside shareholders.

*Stockholm School of Economics. Supervision by Mike Burkart and Erik Berglöf is gratefully acknowledged. Denis Gromb provided very valuable comments and insights as Licentiate discussant. This research has been funded by Bankforskningsinstitutet. Per Axelson, Andriy Bodnaruk, Erik Grönkvist, Jon Enqvist and seminar participants at the CFS summer school provided helpful comments.

Coffee (1999) and Stulz (1999) argue that firms can use bonding mechanisms to commit not to expropriate investors. One such mechanism is disclosure rules which are found in company laws, security laws and stock exchange regulations. So a firm in a weak legal environment may leapfrog its weak institutions by cross-listing its shares on an exchange with stricter disclosure requirements.

There is empirical evidence supporting this view, Reese and Weisbach (2002) find that firms from countries with weaker legal protection are more likely to issue equity in their home country after a U.S. listing, implying that the U.S. listing is a commitment not to expropriate investors.

Complying to stricter disclosure requirements leads to significant stock price increases[1]. Miller (1999) finds an abnormal return of 1.15% to the announcement of a U.S. listing. Doidge, Karolyi and Stulz (2001) find that exchange-listed firms that choose to cross-list their shares are worth 37% more than firms that choose not to cross-list. Given the significant returns it is puzzling that so few firms choose to cross-list their shares[2].

One possible explanation for firms' apparent reluctance to comply with more comprehensive standards is that firm insiders value the opportunity to expropriate outsiders.

A commitment device like a disclosure level presents a trade-off to insiders: a higher disclosure level results in a better price for future securities issued, but reduces the insider's ability to use the firm's resources in a discretionary manner. This paper analyses an entrepreneur's choice of disclosure level and the circumstances under the entrepreneur chooses to cross-list the firm's stock. If expropriation is costly then the possibility to expropriate future investors is not valuable to the entrepreneur since rational outsiders anticipate the expropriation and require compensation for the expected expropriation, but the possibility to expropriate existing investors is valuable.

Our model shows that if the entrepreneur is not the sole residual claimant at the time of choosing the disclosure level then the better price on the new securities may be dominated by the loss in expected benefits from expropriation. The entrepreneur selects less than complete disclosure when the dead weight cost of expropriation is less than the cost of sharing the returns of a higher disclosure level with other claimants. Hence, firms that have significant residual claimants will only choose to cross-list their shares if they have to. This is a consequence of the entrepreneur being cash constrained. If he would have the resources he could purchase the stake owned by existing shareholders and then he would reap all the benefits of a high disclosure level.

In practice some disclosure decisions are mandatory, such as publishing accounts while others are at the firm's discretion such as cross-listing shares on a foreign exchange. It is important to understand why regulators feel that they can improve the private contracting outcome by legislation. The model predicts that if there are significant residual claimholders the entrepreneur will expropriate as much as possible. If expropriating funds from the firm is costly then

[1] See Karolyi (1998) for a survey of the literature.

[2] Doidge et. al (2001) report that only one in ten large firms choose to list shares on U.S. markets.

a social planner will select a higher disclosure level than the entrepreneur.

In practice, most regulators allow entrepreneurs to privately contract to comply with disclosure standards that are more comprehensive than what is specified in company law. So most entrepreneurs face a menu of possible disclosure levels with a minimum mandatory level. This is somewhat surprising since the above argument implies that an as comprehensive standard as possible would be best for social welfare. However, if the entrepreneur has the opportunity to undertake a positive NPV project he might choose to forfeit it if undertaking the project requires a too comprehensive disclosure level. In this setting the existence of claim holders acts as a debt overhang, too little of the benefits of the project accrue to the entrepreneur which results in the entrepreneur prefers to have a low disclosure level The optimal level of disclosure depends on firm characteristics. Therefore, a "one size fits all" regulation may not be optimal.

It seems that the older and the larger the firm is the higher its disclosure level. Smaller firms merely comply with the mandatory standards whereas larger and more established firms elect to comply with more comprehensive standards of different exchanges. There seems to exist a similar relationship for the mandatory standards across countries. Richer/ more developed economies tend to have higher disclosure levels. In general the U.S. GAAP (United States General Agreed Accounting Principles) is considered the most comprehensive accounting standard. Using the stylized fact that firm growth implies decreasing returns to scale the model predicts that economic growth will imply an increase in the disclosure level.

The model, characterizes the disclosure choice of a risk-neutral entrepreneur with an existing debt claim, and needing financing to undertake an investment. The disclosure level is assumed to determine the probability that the firm's assets are verifiable. So without a disclosure level the entrepreneur cannot raise any financing. Once the finance has been raised and the project possibly undertaken the entrepreneur decides how much of the firm's cash to expropriate. This creates a time consistency problem in that the entrepreneur may not want to expropriate the firm ex-ante since he will not be able to raise finance if outsiders anticipate being expropriated by the entrepreneur, but ex-post once the financing has been raised his stake in the firm has been reduced and hence his incentives to divert funds increased. In this case the entrepreneur might be able to raise the financing by using disclosure rules as a way of credibly committing to not expropriate outsiders.

The crucial assumption is that there exists residual claimholders when the disclosure level decision is made. In an empirical examination of the firm's that choose to go public Casares, Field and Sheehan (2002) find that 83% of all firms going public have an outside blockholder. It is certainly true for all firms that cross-list that they have significant other residual claimants since they have already issued equity on another exchange. Additionally, the government has an equity like residual claim in all firms through the firm's corporate tax liabilities. This residual claimant exists before any contract is written with the firm and cannot be negotiated with.

It is also well known that venture capitalists use other mechanisms to mo-

tivate entrepreneurs and protect themselves from expropriation. They require seats on the board, the ability to veto decisions within the firm and they give financing in stages to ensure that the entrepreneur fulfills his obligations. When a venture capitalist exits his investment the mechanisms employed by the venture capitalist needs to be replaced. For many firms stock market disclosure rules fills this purpose.

There are at least three alternative explanations for the premium that firms earn from cross-listing their shares on other exchanges. First, if capital markets are segmented, cross-listing increases the shareholder base and thereby reduces the cost of capital through more effective risk-sharing. One problem with this explanation is that it cannot explain why firms are reluctant to cross-list their shares. Additionally, it cannot explain why cross-listing have increased during the 1990s even though capital markets have become more integrated. Second, firms might signal their quality by cross-listing shares in a high disclosure environment (see Cantale (1996) and Fuerst (1998)). Third, Lins, Strickland and Zenner (2000) argue that a U.S. listing leads to greater liquidity and hence eases the firm's credit constraint.

Related theoretical literature includes Modigliani and Perotti (2000), but in our model the entrepreneur is given the option to commit not to expropriate the investors by complying with disclosure rules. Bergman and Nicolaievsky (2002) examines charters of Mexican firms and find that private firms more often enhance the protection of minority shareholders than public firms. They explain this result in a theoretical model in which providing extensive legal protection may lead to "overinclusion" which requires renegotiation. Publicly held firms have higher renegotiation costs and hence insiders in a public firm provides lower minority protection than private firms with low renegotiation costs.

The paper is organized as follows. Section 2 outlines the model. Section 3 examines the entrepreneurs choice of disclosure level. Section 4 analyses the disclosure choice of a social planner. Section 5 examines the effect of growth and firm heterogeneity on the disclosure level. Section 6 illustrates cross-listing. Section 7 discusses robustness with respect to renegotiation and giving the entrepreneur an incentive wage. Section 8 discusses applications and extensions. Section 9 concludes.

2 The Model

Consider a firm run by a risk-neutral entrepreneur. Debtholders hold a claim amounting to $\beta \in [0,1]$ of future cashflows. These investors will be referred to as existing outsiders. The rest of the future cashflows are held by the entrepreneur. The model has three dates and there is no discounting. The firm has assets in place consisting of a project whose cashflows realize at date $t = 3$. With probability θ the project will be successful and worth X. With probability $(1-\theta)$ the project will fail in which case it will be worth 0. At date $t = 1$ the risk neutral entrepreneur chooses the disclosure level ($\lambda \in [0,1]$) that the firm

will adhere to. The disclosure level determines the probability that the firms cash flows are verifiable. The lack of disclosure level prior to date $t = 1$ is a normalisation. It is important for the results that the disclosure level prior to date $t = 1$ is less than complete, but it does not have to be zero.

At date $t = 2$ the entrepreneur has the possibility to undertake an investment at financial cost F. The investment increases the success probability of the project from θ to $\theta + \Delta$. We follow Bhattacharya and Faure-Grimaud (2001) in assuming that the investment decision is not verifiable. The entrepreneur is cash constrained so the financial cost F has to be raised from the capital market. Additionally, we assume that the entrepreneur may only issue securities of lower seniority than debt. This is to ensure that we have a debt overhang in place. In fact we only require that the new security is of equal seniority or of lower seniority for the overhang to exist, but if the existing and the new securities are of the same seniority then the lack of diclosure level will result in the existing claim becoming worthless in equilibrium due to the lack of disclosure level at the inception of the firm.

An alternative model specification would be to have a low mandatory disclosure in place prior to the investment decision and allow the entrepreneur to choose a higher disclosure standard. All the results of the paper would still hold.

The seniority of existing shareholders implies that the entrepreneur has to raise F by selling a part of his stake. Thus, a proportion $\alpha \in [0, 1]$ of the entrepreneur's equity is sold to new outsiders. The proportion of the cash flow rights that is still held by the entrepreneur after the sale is denoted by $\gamma \in [0, 1]$. Now we have β, α and γ which means that $\beta + \alpha + \gamma = 1$.

In fact β does not have to represent debt. The model would generate the exactly same results if β was a proportion of the entrepreneur's equity sold to new outsiders. Ritter (1998) notes that "with older companies going public it is common that many of the shares being sold come from existing stockholders (secondary shares)." Thus, the model could equally well represent a situation in which a firm with equityholders goes public, but the equity sold comes from secondary shares.

At date $t = 3$ the cash flow X is realized, if the cashflow is not verifiable the entrepreneur decides how much of the cash flow to expropriate. We follow Burkart et al. (1998) in assuming that expropriation is wasteful. If the entrepreneur decides to expropriate some part of the unverifiable cash flow then a deadweight cost of $\phi \in [0, 1]$ is incurred on the amount of cash that he diverts. The possibility to divert cash ex post results in a potential debt overhang problem, if the disclosure level is less than complete then the entrepreneur's investment decision will deviate from first-best in that the project return has to recover the expected dead-weight cost of expropriation as well as the investment cost. In equilibrium this debt overhang will be mitigated by the use of disclosure.

So the model incorporates two debt overhangs, one due to financing and another due to the entrepreneur's possibility to expropriate funds ex-post. Notice that the disclosure level is intricately linked to both overhangs. Increasing disclosure increases the probability that the project returns are verifiable and

thereby exacerbates the debt overhang while alleviating the expropriating overhang.

It is crucial for the model that a senior (or of equal seniority with a richer model) claim on the cash flows exist that cannot be renegotiatied, but it is not important that the existing claim is a debt contract. There are numerous type of claims/ contracts that would yield the same reuslt.

A possible interpretation of the debt claim β is that it represents a corporate tax liability, a contract which is written prior to the entrepreneur's ability to contract on a disclosure level that is in most instances hard to renegotiate.

The claim β could also represent a business expense such as wages that is paid prior to the entrepreneur and which has significant renegotiation costs.

Another possibility is that during the beginning of the firm's life when a reasonable disclosure level is not available other mechanisms are used as substitutes. Venture capitalists (VCs) tend to use different mechanisms to prohibit entrepreneurs from expropriating them. For example VC firms have a lot of influence in day to day decisions of firms and give financing in stages to increase their bargaining power over entrepreneurs. Kaplan and Strömberg (2002) find that "If the company performs very well, the VCs retain their cash flow rights, but relinquish most of their control and liquidation rights." So at exit, which is often an initial public offering (IPO), the mechanisms used by the VC are removed and replaced by the disclosure rules of the stock exchange. The model presented in this paper attempts to explain the decisions taken by entrepreneurs once the venture capitalist exits, but other residual claimholders still exist.

It is clearly the case that in practice outsiders own a significant part of the firm at the time of IPO or cross-listing.

3 The Entrepreneur's Disclosure Choice

In this section we determine the level of disclosure chosen by the entrepreneur. At date $t = 3$, if the project is successful and the the cash flow is not verifiable the entrepreneur has to choose to what extent he is going to divert funds. If the entrepreneur diverts a fraction d of the cash flow then his payoff will be,

$$\Pi = \left[(1-d)\gamma + d(1-\phi)\right] X \tag{1}$$

Maximizing the above expression with respect to the fraction d that is diverted yields,

$$\left[(1-\phi) - \gamma\right] X \tag{2}$$

This means that if $(1-\phi) > \gamma$ then $d = 1$ and if $(1-\phi) < \gamma$ then $d = 0$. So an entrepreneur will either divert as much as possible or nothing. The intuition for this is that $(1-\phi)$ is the marginal benefit of diversion and γ the marginal cost which are both constant. So we will have a corner solution in which everything possible is diverted or nothing is diverted.

Using that $\gamma = 1 - \alpha - \beta$, equation (2) implies that the entrepreneur will expropriate if $1 - \phi > 1 - \alpha - \beta$. To the entrepreneur the residual stakeholders

are conceptually different. Since the size of the new outsiders' stake is yet to be determined and the new outsiders are rational, the entrepreneur knows that whatever he expropriates from them he will have to bear the cost of in terms of the price that the new outsiders are willing to pay for their stake. The stake of the existing outsiders is already fixed so he does not have to bear the cost of expropriating them.

The decrease in the entrepreneur's stake creates a time inconsistency problem since the cost of expropriation is effectively different before and after the sale of equity. This results in three different cases depending on the realtive size of α,β and ϕ.

Lemma 1 *(i)If* $1-\phi < 1-\alpha-\beta$ *then the entrepreneur is congruent ex-ante and ex-post and the disclosure level is irrelevant. (ii) If* $1-\phi < 1-\beta$ *and* $1-\phi > 1-\alpha-\beta$ *then the entrepreneur is congruent ex-ante and non-congruent ex-post. (iii) If* $1-\phi > 1-\beta$ *(or* $\beta > \phi$*) then the entrepreneur is non-congruent ex-ante and ex-post.*

In case (i) investors know that entrepreneur will never have an incentive to expropriate and hence the disclosure level is irrelevant. In case (ii) then the entrepreneur will not value the possibility of expropriation before the new equity is issued since the cost of expropriating $(1-\beta)$ is greater than the benefit of expropriating $(1-\phi)$. However, he will not be able to credibly commit not to expropriate ex-post without the disclosure rule since once the equity has been issued the benefit expropriating is greater than the benefit of not expropriating $(1-\alpha-\beta)$. In this case the entrepreneur will select complete disclosure to eliminate the time inconsistency problem and will not expropriate anything ex-post. In case (iii), the interesting one, the cost of expropriationg is always less than the benefit which means there will always be a conflict of interest between existing outsiders and the entrepreneur.

From now on we will assume that $\beta > \phi$ to guarantee that we have a conflict of interest between the entrepreneur and the original investors irrespective of how large the investment is.

Assumption 1 $\beta > \phi$

Given *Assumption* 1 the entrepreneur will undertake the investment at date $t = 2$ if

$$(\Delta+\theta)\left[\lambda(1-\alpha-\beta)+(1-\lambda)(1-\phi)\right]X > \theta\left[\lambda(1-\beta)+(1-\lambda)(1-\phi)\right]X \quad (3)$$

$$\lambda < \frac{\Delta(1-\phi)X}{\Delta(\beta+\alpha-\phi)} \quad (4)$$

At date $t = 2$, given that the entrepreneur undertakes the investment and that markets are competitive the investor's participation constraint is given by,

$$\alpha = \frac{F}{\lambda(\Delta+\theta)X} \quad (5)$$

Since the entrepreneur can at most sell $(1-\beta)$ of the verifiable cash flows, investors provide funding if $(1-\beta) \geqslant \alpha = \frac{F}{\lambda(\Delta+\theta)X}$ which can be expressed as,

$$\lambda > \frac{F}{(1-\beta)(\Delta+\theta)X} \tag{6}$$

The above expression illustrates that there is a lower limit on the disclosure level that is consistent with new outsiders being willing to invest in the firm. For future reference let us denote,

$$\lambda_{\min} = \frac{F}{(1-\beta)(\Delta+\theta)X} \tag{7}$$

Replacing the investor's participation constraint (**??**) into the incentive compatability cnstraint (**??**) and rearranging yields,

$$\lambda < \frac{\Delta(1-\phi)X - F}{\Delta(\beta-\phi)X} \tag{8}$$

This expression illustrates that given *Assumption* 1 there is an upper bound on the disclosure level that is consistent with the entrepreneur undertaking the project. The debt claim results in a debt overhang since the entrepreneur pays the entire cost of the investment, but has to share the more of the proceeds with the debtholders the larger λ is. For future reference let us denote,

$$\lambda_{\max} = \frac{\Delta(1-\phi)X - F}{\Delta(\beta-\phi)X} \tag{9}$$

So we can define the set of disclosure levels for which the firm is financed and the and the entrepreneur undertakes the investment as

$$I = [\lambda_{\min}, \lambda_{\max}] \tag{10}$$

Making sure that the interval I exists guarantees that the necessary repayment is less than the highest incentive compatible repayment. If I does not exist then no disclosure level will be chosen, the investment not undertaken and the debtholders claim will be worthless. To make sure that I is non-empty (that the project is feasible) we require that $\lambda_{\max} = \frac{\Delta(1-\phi)X-F}{\Delta(\beta-\phi)X} > \lambda_{\min} = \frac{F}{(1-\beta)(\Delta+\theta)X}$ which can be expressed as,

$$\Delta X > \frac{F}{(\theta+\Delta)}\left[\frac{\Delta}{1-\beta} + \frac{\theta}{1-\phi}\right] \tag{11}$$

The above expression states that the return of the project has to be greater than the total cost, including the agency cost that the existing shareholders and the possibility to expropriate creates. Since $\beta \in [0,1]$ and $\phi \in [0,1]$ it holds that $\frac{F}{(\theta+\Delta)}\left[\frac{\Delta}{1-\beta} + \frac{\theta}{1-\phi}\right]$. The first-best investment decision is to invest if $\Delta X > F$, so if $\beta = 0$ and $\phi = 0$ then the investment decision will be according to the first best.

Assumption 2 $\lambda_{\max} > \lambda_{\min}$, *i.e.* $\Delta X > \frac{F}{(\theta+\Delta)}\left[\frac{\Delta}{1-\beta} + \frac{\theta}{1-\phi}\right]$

Within the interval I, what level of disclosure will the entrepreneur select? The entrepreneurs profit function is given by,

$$\Pi = (\theta + \Delta)\left[\lambda(1-\beta) + (1-\lambda)(1-\phi)\right]X - F \tag{12}$$

Taking the first order condition with respect to the disclosure level yields,

$$\frac{\partial \Pi}{\partial \lambda} = (\phi - \beta)X$$

So if $\beta > \phi$ then the cost to the entrepreneur of having the debt claim is greater than the deadweight cost associated with expropriation. Or in other words, the financing overhang is more costly to the entrepreneur than the expropriation overhang. The amount of outside financing α required to fund the project is not relevant in determining whether the entrepreneur will find it desirable to expropriate or not since the entrepreneur will end up paying for the expropriation of new outsiders.

This implies that the entrepreneur will select as low a disclosure level as possible given that the project is good enough to be financed. At time $t = 1$ the entrepreneur's disclosure choice is linked to whether he invests or not.

At $t = 1$ the entrepreneur's anticipated payoff from undertaking the investment is,

$$(\Delta+\theta)\left[\lambda^I(1-\alpha-\beta) + (1-\lambda^I)(1-\phi)\right]X > \theta[\lambda^{NI}(1-\beta)+(1-\lambda^{NI})(1-\phi)]X \tag{13}$$

Since the entrepreneur's return is decreasing in the disclosure level the entrepreneur will select $\lambda^I = \lambda_{\min}$ if he wishes to undertake the investment and he will choose $\lambda^{NI} = 0$ if he passes up the investment. Replacing λ^I and λ^{NI} in equation (13) shows that the entrepreneur will only undertake the project if,

$$\Delta(1-\beta)X > F \tag{14}$$

The above expression illustrates that given that there is no disclosure level in place at the inception of the firm the entrepreneur will only invest if the expected after debt returns from the project are greater than the investment cost. It is worth noting that this constraint is more restrictive than equation (11). This is due to that (14) allows the entrepreneur to condition on the disclosure level.

Proposition 1 *Given Assumption* 1 *holds and* $\Delta(1-\beta)X > F$ *then the entrepreneur selects* $\lambda_{\min}$ *and undertakes the investment.*

Given *Assumption* 1 the entrepreneur will select the lowest disclosure level possible which is $\lambda_{\min}$. So given that the entrepreneur is facing a significant debt overhang he will select the minimum possible disclosure level that ensres that the participation constraint of investors is fulfilled. A way for young firms to increase their disclosure level is to perform an IPO and thereby follow the regulations of traded firms and that particular exchange. Later we will examine under what circumstances a firm that is listed on one exchange will choose to list its shares on another exchange.

4 The Social Planner's Disclosure Choice

In this section we will determine the level of disclosure that a social planner would choose. In this model we assume that the social planner only has the disclosure level at his disposal, so he cannot force transfers between agents. The social planner maximizes the value of all stakeholders claims, including original and new residual claimants, and hence his welfare function will be given by,

$$\Pi = (\Delta + \theta)\left[\lambda\gamma + (1-\lambda)(1-\phi) + \lambda\beta + \lambda\alpha\right]X - F \quad (15)$$

$$\Pi = (\Delta + \theta)\left[(1-\phi) + \lambda\phi\right]X - F \quad (16)$$

Since the social planner does not care about the division of cash flows he will try to minimize the inefficiency of the expropriation. Taking the first order condition with respect to the disclosure level yields

$$\frac{\partial \Pi}{\partial \lambda} = \phi X$$

Clearly social welfare is increasing in the disclosure level.

Proposition 2 *Under Assumptions* 1 *and* 2*, the social planner always selects the disclosure level* $\lambda_{\max}$*. If* $\Delta(1-\beta)X < F$ *then* $1 > \lambda_{\max}$ *which implies the social planner will select less than complete disclosure.*

Proof. $1 > \lambda_{\max}$ if $\Delta X < \frac{F}{(1-\beta)}$

Assumption 2 requires that $\Delta X > \frac{F}{(\theta+\Delta)}\left[\frac{\Delta}{1-\beta} + \frac{\theta}{1-\phi}\right]$

These two conditions are jointly feasible if $\frac{F}{(1-\beta)} > \Delta X > \frac{F}{(\theta+\Delta)}\left[\frac{\Delta}{1-\beta} + \frac{\theta}{1-\phi}\right]$ which holds if $\beta > \phi$ (Which comes from *Assumption* 1) ■

Since the social welfare is increasing in the disclosure level the social planner will select the highest possible disclosure level. The highest disclosure that is compatible with the entrepreneur undertaking the investment is $\lambda_{\max}$. This result implies that regulation will provide an improvement over the private contracting outcome. This is not a pareto improvement since economic efficiency comes at the expense of the entrepreneur. The difference in the choice of disclosure arises from the existence of shareholders at the time of the disclosure decision. This means the regulator will want to impose a mandatory disclosure level of $\lambda_{\max}$.

Proposition 2 also states that even the regulator will select less than complete disclosure in certain instances. The reason for this is that the financing overhang gets aggravated when the disclosure level is increased because more funds are verifiable which might lead the entrepreneur to not undertake the investment.

5 Growth and Heterogeneity

Growth

The model makes a number of predictions concerning the effect of growth on the disclosure level. The effect of a change in profitability on the disclosure level depends on who chooses the disclosure level. Section 3 has shown that if the entrepreneur chooses the disclosure level he will select $\lambda_{\min}$.

Differentiating $\lambda_{\min}$ with respect to X yields,

$$\frac{\partial \lambda_{\min}}{\partial X} = -\frac{F}{(1-\beta)(\Delta+\theta)X^2} < 0 \tag{17}$$

If the profitability/ return to capital increases (increasing X while keeping everything else constant) then the disclosure level decreases. So, if economic growth implies a decrease in return to capital (all other things being equal) then the model predicts that voluntary disclosure levels will increase. However, it should be noted that larger firms have in general more cash which reduces the amount of cash needed to fund the investment and hence works in the opposite direction of the decrease in profitability. So the model is ambigouos concerning the effect of size on the disclosure level, but predicts that growing firms without cash will increase their disclosure level. Hence, a prediction of the model is that finance junkies (firms with investment opportunities, but little cash flow) will need to select higher disclosure levels than cash cows (firms with cash but little investment opportunities).

Another prediction concerning the size and the disclosure level is that larger firms have more existing claimholders (β is larger). Differentiating $\lambda_{\min}$ with respect to β yields,

$$\frac{\partial (\lambda_{\min})}{\partial \beta} = \frac{F}{(1-\beta)^2(\Delta+\theta)X} > 0 \tag{18}$$

Which also implies that larger firms will have larger disclosure levels. Intuitively, if more of the firm is in the hands of existing claimholders then the firm has to select a higher disclosure level in order to satisfy the investor participation constraint. Note that this result would not hold if existing shareholders did not have seniority.

Larger firms have lower profitability and more existing claimholders, which would predict a higher disclosure level, but at the same time they have more cash and assets which would predict a lower disclosure level.

There is rich and recent empirical evidence concerning the cross-sectional characteristics of the firm's that choose to cros-list their shares. As an anecdote it is worth to note that the NYSE has the most stringent disclosure requirements and many of the worlds largest firms.

Blass and Yafeh (2001) find that those Israeli firms that choose to perform an IPO on NASDAQ are in general more R&D intensive and have higher growth

rates than those firms that choose to list their shares on the Tel Aviv Stock Exchange. This fits well with the models prediction that firms with ample investment opportunities, but little funds will choose to cross-list their shares. Doidge et. al (2001) find that the Tobin's q ratios of firms that cross-list in the United Stated are 16.5% higher than firms that do not, corroborating that it is high-growth firms that cross-list.

If the social planner chooses the disclosure level he will select $\lambda_{\max}$. Differentiating $\lambda_{\max}$ with respect to X yields,

$$\frac{\partial \lambda_{\max}}{\partial X} = \frac{F}{\Delta(\beta - \phi)X^2} > 0 \tag{19}$$

In which case an increase in profitability (X) of the project leads to an increase in the disclosure level. As X increases the entrepreneur is willing to undertake the investment for a higher disclosure level because his stake is more valuable. So an increase in profitability increases the social planners choice of disclosure level. This result would imply that developing countries with relatively young and profitable firms should select higher disclosure levels. However, this result should be taken with cautioun since the social planners decision alters significantly if there is asymmetric information and firms are non-homogenous (as we will see later).

Firm Heterogeneity

The results in the prievous section imply that an increase in profitability widens the discrepancy between the privately and socially optimal levels of disclosure. Or in other words the existence interval ($[\lambda_{\min}, \lambda_{\max}]$) of the firm widens as the profitability of the firm increases.

There is debate among policy makers whether disclosure rules should be harmonized. From (19) we know that $\lambda_{\max}$ is increasing in profitability which means that if we have multiple types of firm that vary in terms of profitability then we will have multiple levels of $\lambda_{\max}$ which means the social planner would select a different disclosure level for each type.

If the economy consists of two firms 1 and 2, they are identical in all respects except that $X_1 > X_2$ and the social planner can implement a different disclosure level for each firm then the social welfare function will be,

$$\Pi = (\theta + \Delta)\left[(1 - \phi) + \lambda_1 \phi\right] X_1 - F + (\theta + \Delta)\left[(1 - \phi) + \lambda_2 \phi\right] X_2 - F \tag{20}$$

Proposition 3 *If there are two types of firm in the economy such that $X_1 > X_2$ then the social planner will not want to harmonize disclosure regulation (i.e. set $\lambda_1 = \lambda_2$)*

Proof. *Differentiating the social welfare function (20) with respect to λ_i yields $\frac{\partial \Pi}{\partial \lambda_i} = \phi X_i > 0$. Hence, selecting $\lambda_1 = \lambda_{1\max}$ and $\lambda_2 = \lambda_{2\max}$ maximizes social welfare. Since $\lambda_{1\max} \neq \lambda_{2\max}$ harmonization will not be beneficial.* ■

6 Crosslisting

The basic model has illustrated the disclosure choice of a firm going public. This section aims to illustrate under what circumstances the firm chooses to cross-list its shares. The only difference with the basic model is that the existing claimholders are now assumed to hold equity (β is an equity claim).

Everything is the same in this case except that all shareholders have their stakes diluted if the investment is undertaken. So after the cross-listing the proportion of the firm owned by the entrepreneur is $(1-\beta)(1-\alpha)$, the proportion owned by existing shareholders is $\beta(1-\alpha)$ and the new investors own α.

Determining the entrepreneur's choice of disclosure level;

At $t=3$, conditional upon success and non-verifiability of the cash flow the payoff to the entrepreneur of diverting a proportion d of the cash flow is,

$$\Pi = (1-d)(1-\beta)(1-\alpha)X + d(1-\phi)X$$

Taking the first order condition with respect to d yields,

$$\frac{\partial \Pi}{\partial d} = \left[\alpha(1-\beta) + \beta - \phi\right] X$$

This expression is always positive since $\alpha \in [0,1]$, $\beta \in [0,1]$ and $\beta > \phi$, by *Assumption* 1. The expression is also constant which means that as long as *Assumption* 1 holds the entrepreneur will select $d = 1$ (the entrepreneur will divert as much as possible).

This means the ex-ante expected payoff of the entrepreneur conditional on undertaking the investment will be,

$$\Pi = (\theta + \Delta)\left[\lambda(1-\beta)(1-\alpha) + (1-\lambda)(1-\phi)\right] X$$

At $t=2$ the entrepreneur will undertake the investment if,

$$(\theta+\Delta)\left[\lambda\left[(\phi-\beta-(1-\beta)\alpha\right] + (1-\phi)\right]X \geq \theta\left[\lambda(\phi-\beta)+(1-\phi)\right]X \quad (21)$$

$$\lambda < \frac{\Delta(1-\phi)}{(\theta+\Delta)\left[(1-\beta)\alpha+\beta-\phi\right]} \quad (22)$$

The investors will invest in the firm if,

$$\alpha(\theta+\Delta)\lambda X \geq F \quad (23)$$

Since α can at most be 1 this implies a lower on the disclosure level of,

$$\lambda_{\min} = \frac{F}{(\theta+\Delta)X} \quad (24)$$

Replacing (23) into (**??**) yields an upper bound on the disclosure level,

$$\lambda_{\max} = \frac{\Delta(1-\phi)X - (1-\beta)F}{\Delta(\beta-\phi)X} \quad (25)$$

The effect of assuming that the stake of existing shareholders are diluted is to widen the existence interval ($\lambda_{\max}$ increases while $\lambda_{\min}$ decreases). The possibility to dilute existing shareholders relaxes both the incentive compatibility constraint of the entrepreneur and the participation constraint of the investors. The investment will be undertaken if ($\lambda_{\max} > \lambda_{\min}$),

$$\Delta X > \frac{F}{(1-\phi)(\theta+\Delta)}\left[\Delta(1-\phi)+\theta(1-\beta)\right] \tag{26}$$

So if the stake of the current shareholders can be diluted the investment decision will be first-best.

The expected payoff to the entrepreneur conditional upon investment and $d = 1$ is,

$$\Pi = (\theta+\Delta)\left[(1-\phi)+\lambda(\phi-\beta)\right]X-(1-\beta)F \tag{27}$$

Maximizing the entrepreneur's profit with respect to the disclosure level yields,

$$\frac{\partial \Pi}{\partial \lambda} = (\theta+\Delta)(\phi-\beta)X$$

Which is always negative which means the entrepreneur will select the lowest possible disclosure (which will be $\lambda_{\min}$). So even if the investment decision is first-best the disclosure level is not.

The social planner's payoff function is described by,

$$\begin{aligned}\Pi &= (\theta+\Delta)\left[\lambda(1-\beta)(1-\alpha)+(1-\lambda)(1-\phi)+\lambda\alpha+\lambda\beta(1-\alpha)\right]X \quad (28)\\ \Pi &= (\theta+\Delta)\left[(1-\phi)+\lambda\phi\right]X\end{aligned}$$

Which implies that the first-order condition with respect to λ is $(\theta+\Delta)\phi X > 0$. As without dilution the social planner will select the highest possible disclosure level (which will be $\lambda_{\max}$).

So assuming that the stake of all stakeholders is diluted upon the cross-listing does not alter that there is divergence of disclosure choice between the entrepreneur and the social planner. However, the possibility to dilute the existing shareholders implies that the value of the existing shareholders' stake after the cross-listing will be zero. As mentioned before this can be avoided with a richer model that incorporates a mandatory minimum standard and then allowing the firm to elect to comply with a higher disclosur level.

As in the growth section, firms with lower profitability have to select higher disclosure levels in order to be financed.

7 Robustness

Renegotiation

The inefficiency in this model is a debt overhang. This section will show that the debtholders will not always want to reduce their claim in order to eliminate the

debt overhang. Reducing the debt claim presents a trade-off, a reduction leads to a higher disclosure at the cost of a reduction in the face value of the claim. Of course in an ideal world side-payments would eliminate the debt overhang, but there are numerous reasons cited in the literature (??) for the debt overhang not being resolved.

Like in Bhattacharya and Faure-Grimaud (2001) the fact that the investment decision is not verifiable means that renegotiating the claim may not lead to the first best.

As long as $\beta > \phi$ the entrepreneur will have incentives to expropriate funds. In what circumstances will existing claimholders have incentives to reduce β to $\beta^{'}$ where $\beta^{'} < \phi$? The payoff from not changing their stake is $\beta\lambda_{\min}X$ and the payoff from changing the stake is $\beta^{'}1X$. The highest stake the residual claimants can retain without the entrepreneur expropriating is ϕ. So if $\lambda_{\min}\beta > \phi$ then the existing claimholders will not have an incentive to reduce their stake in order to achieve congruency. Which is equivalent to,

$$\lambda_{\min}\beta > \phi \Rightarrow \frac{1}{(\Delta+\theta)}\frac{\beta}{(1-\beta)\phi} > \frac{X}{F} \tag{29}$$

This implies that there is an upper bound for how profitable the project can be without the residual claimants having an incentive to reduce their claim. In section 3, *Assumption* 2 was made in order to guarantee existence ($\lambda_{\max} > \lambda_{\min}$) of the firm. This assumption implies a lower bound on the cash flow which is consistent with the firm existing. The upper bound implied by (**??**) is compatible with the lower bound implied by existence (11) if,

$$\begin{aligned} F\left(\Delta\frac{\beta-\phi}{\phi} - \theta\frac{1-\beta}{1-\phi}\right) &> 0 \\ \Delta(1-\phi)(\beta-\phi) - \theta(1-\beta)\phi &> 0 \end{aligned} \tag{30}$$

This expression is increasing β and Δ while it is decreasing in ϕ and θ.

Incentive Contracts

This section will show by example that a wage/ incentive contract that solves the moral hazard problem does not make disclosure redundant. That is, we provide an example where an incentive contract does not work, but disclosure will make the project feasible. We use an example because a complete solution would be much more involved without adding much conceptually.

A wage is a more efficient instrument for motivating the manager than allowing the manager to expropriate in the sense that there is no dead-weight cost associated with the wage. However, if the project is too costly then it may not be possible to make the entrepreneur congruent with original outsiders and satisfy the rationality constraint of the new investors. Since disclosure does not require congruence it may be able to finance projects which the incentive contract fails to finance.

The most effective wage will only be paid out if nothing is expropriated. Since the payoff of the project is binary it will be a proportion δ of the output.

The most efficient solution to the problem of making the firm feasible will in most cases use both an incentive contract and a disclosure device, but below we will consider an example in which only one of the mechanisms is available and show under what conditions a disclosure device can fund a firm that an incentive contract can not. So as to illustrate that the two devices are not perfect substitutes.

It is assumed that the entrepreneur's wage has seniority over all other claims. This means that the wage will dilute old and new residual claimants. It is also assumed that the wage is contracted upon before the disclosure level and before the sale of equity to new outsiders.

To ensure existence of the firm an incentive contract has to make sure that the investor rationality constraint is satisfied as well as make the entrepreneur congruent.

The wage δ has to satisfy the following condition for the entrepreneur to be congruent

$$\begin{aligned} \delta X + (1-\alpha-\beta)(1-\delta)X &> (1-\phi)X \\ \phi &> (1-\delta)(\alpha+\beta) \end{aligned} \tag{31}$$

Since ϕ is positive we know that this condition will always hold if $\delta = 1$. The intuition behind this is that congruency can always be achieved if all other stakeholders have their claims reduced in value in favour of the entrepreneur. However it might not be compatible with the investors breaking even. Replacing $\alpha = \frac{F}{(1-\delta)(\Delta+\theta)X}$ (the IR constraint if the entrepreneur is congruent) into $\phi > (1-\delta)(\alpha+\beta)$ and rearranging yields the following condition for the investors breaking even and the entrepreneur being congruent (both of which are necessary),

$$(\Delta+\theta)\left(\phi - (1-\delta)\beta\right) > \frac{F}{X} \tag{32}$$

If $F/X \geq (\Delta+\theta)\phi$ then there is no positive wage such that both conditions are satisfied.

Consider the example in which $\phi = \frac{F}{(\Delta+\theta)X}$, so that we know that an incentive contract cannot ensure the existence of the firm, is it possible that the firm will exist if we use a disclosure device?

The firm is feasible with a disclosure device if *Assumption* 2 holds. Appendix B shows that *Assumption* 2 may hold (i.e. the firm is feasible) when $\phi = \frac{F}{(\Delta+\theta)X}$.

The above example implies that an incentive contract is not a perfect substitute for disclosure rules. The intuition behind this result is that although an incentive contract may be able to solve the equity overhang problem with investment, but doing so may create an overhang with private benefit extraction. It is clear that using an incentive contract in addition to a disclosure device will result in the first-best (since it has seniority over existing claimholders and the

combination of the devices can solve both agency problems), but an incentive contract on its own will not necessarily do better than the disclosure device.

8 Applications and Extensions

Multiple Financing Rounds

If the firm is has to raise capital for a second project after the realization of the first project then the choice of disclosure will be higher than if only one project would be undertaken even though the profitability is the same for the two projects. In effect the required disclosure level is increasing in the number of opportunities that the manager has to divert funds.

If everything in the game is repeated twice except the disclosure choice of the entrepreneur, what level of disclosure will he choose?

Proposition 4 *If the entrepreneur is given the opportunity to sequentially undertake two identical projects then he will select the disclosure level* $\frac{3}{2}\lambda_{\min}$. *Where* $\lambda_{\min}$ *denotes the level he would choose if there were only one project.*

Proof. *See Appendix C.* ■

Even though the investor rationality constraint is homogenous of degree zero with respect to a proportional increase in cash flow and investment cost, undertaking a second project implies that the entrepreneur will expropriate twice. The second expropriation opportunity implies that the entrepreneur needs a higher disclosure level to be able to finance both investments.

Financing with Retained Earnings

If the firm has retained earnings and the entrepreneur can choose whether to use the assets to reduce the investment cost or increase the cash flow he will always reduce the investment cost as much as possible (*Appendix A* contains an exposition of this). The intuition behind this is that he pays for the entire investment cost, but has to share the cash flow generated by the project with the other residual claimholders.

Additionally, the entrepreneur prefers internal finance as opposed to external finance because external finance implies a higher disclosure level. The marginal cost of increasing the financing requirement (F) is $1/(1-\beta)$ which is greater than 1. So an entrepreneur prefers to use internal financing as far as possible.

9 Conclusion

This paper analyses the disclosure choice of an entrepreneur and a social planner. The disclosure level is assumed to determine the probability that the firm's returns are verifiable. The model developed in the paper shows that if the entrepreneur has issued debt (or other claims) prior to his disclosure choice he may not want to increase disclosure even though it is social welfare enhancing.

Specifically the debt claim and the possibility to expropriate returns from the firm both result in overhangs. Increasing the disclosure aggravates the debt overhang since it increases the probabilty that project returns are verifiable. On the other hand the disclosure level reduces the overhang that arises from the possibility to expropriate.

If the debt overhang dominates then the entrepreneur will have incentives to set an as low disclosure level as possible. The social planner on the other hand will want to select an as high disclosure level as possible without hindering the entrepreneur's investment policy. So the model provides a rationale for disclosure regulation, however a too comprehensive disclosure regulation may be harmful to investment decisions.

The model is able to provide interpretations of a number of empirical regularities, such as why despite the positive stock price reaction relatively few firms cross-list and that more developed economies require higher disclosure levels and that high-growth firms have select higher disclosure levels. A policy implication of the model is that if there is significant heterogeneity in firm types then a social planner will not want to converge legal standards.

Appendix A

With Assets in Place

Divertable Earnings Assume the firm has earnings$A$ and that these earnings can be diverted in the same way project cash flows. If *Assumption* 1 holds then we know that the entrepreneur will want to select an as low disclosure level as possible.

The entrepreneur keep the assets in place and distribute them as dividends at the end of the project. In this case the investor rationality constraint implies the following lower bound on disclosure

$$\lambda_{\min} \geq \frac{F}{(1-\beta)(\Delta+\theta)(X+A)}$$

Compared to the case of no assets in place the disclosure level is reduced because the new investors get a claim on the assets in place.

What happens to the incentive compatibility constraint with divertable assets. Replacing $\alpha = \frac{F}{(\theta+\Delta)\lambda(X+A)}$ into the incentive compatibility constraint yields

$$\lambda_{\max} < \frac{F-\Delta(1-\phi)(X+A)}{\Delta(\phi-\beta)(X+A)}$$

Note that the assets in place has the same effect as an increase in cash flow. This has the same affect as increasing the profitability of the firm (i.e. widening the interval I).

Retained Earnings as Finance These assets can be used to undertake the new project. If $\beta > \phi$ then we know that the entrepreneur will want to select an as low disclosure level as possible. If the entrepreneur uses the earnings to finance the project then the investment cost is reduced to $\max(F-A,0)$.

This implies that the lowest possible disclosure level that can finance the firm is

$$\lambda_{\min} \geq \frac{\max(F-A,0)}{(\theta+\Delta)(1-\beta)}$$

This in turn means that the highest level of disclosure compatible with the entrepreneur undertaking the investment is given by,

$$\lambda_{\max} < \frac{\max(F-A,0)-\Delta(1-\phi)X}{\Delta(\phi-\beta)X}$$

Diversion of Financing with Earnings If the entrepreneur can choose whether to use the earnigns to reduce the outside investment requirement or pay them out as dividends (and divert a proportion) then which option will the entrepreneur prefer (assuming that $F > A$ i.e. that there still exists an external financing constraint)?

The entrepreneur will prefer to divert if

$$\begin{aligned} \frac{F-A}{(1-\beta)(\Delta+\theta)X} &\geq \frac{F}{(1-\beta)(\Delta+\theta)(X+A)} \\ A(F-X-A) &\geq 0 \end{aligned}$$

This expression is clearly negative which implies that the entrepreneur will always use funds to reduce the capital required from outside sources. The intuition behind this is that investors are rational which implies that the entire investment cost is borne by the entrepreneur, but the spoils of the investments are shared between investors and the entrepreneur. Clearly, using the earnings for investment purposes is most beneficial for the entrepreneur. Or put in another way the entrepreneur prefers to use internal financing whenever he can.

Appendix B

For $\lambda_{\max} > \lambda_{\min}$ when $\phi = \frac{F}{(\Delta+\theta)X}$ requires that

$$(\theta+\Delta)X^2 - (1+\frac{\Delta}{1-\beta}+\theta)FX + \frac{\Delta F^2}{(\Delta+\theta)(1-\beta)} > 0$$

The roots are given by $c_{1,2} = \frac{-b\pm\sqrt{D}}{2a}$ and in our case $a = (\theta+\Delta)$, $b = -(1+\frac{\Delta}{1-\beta}+\theta)F$, $c = \frac{\Delta F^2}{(\Delta+\theta)(1-\beta)}$. Simple calculations shows that $D = F^2\left[\theta(2+\frac{2\Delta}{1-\beta}+\theta) + (1-\frac{\Delta}{1-\beta})^2\right] > 0$ which implies that $c_{1,2}$ are both real roots. Since $-b > 0$, $2a > 0$ and $4ac > 0$ both roots will be positive.

Appendix C

As before a fraction $\beta \in [0,1]$ of shares are held by dispersed outsiders. The firm has two projects 1 and 2 whose cashflows realize at date $t = 3$ and $t = 5$ respectively. The two projects are identical and their outcomes are independent. With probability θ project 1 will be worth X_1 and with probability $(1-\theta)$ the project will be worth 0. Likewise project 2 will be worth X_2 with probability θ and 0 with probability $(1-\theta)$. At date $t = 1$ the risk neutral entrepreneur chooses the disclosure level $\lambda \in [0,1]$.

At date $t = 2$ the entrepreneur has the possibility to undertake an investment at cost F. The investment increases the success probability of project 1 from θ to $\theta+\Delta$. To finance this investment a proportion $\alpha_1 \in [0,1]$ of the entrepreneur's equity is sold to new outsiders.

At date $t = 3$ the cash flow of the project 1 is realized. If the cash flow is not verifiable the entrepreneur decides how much of the cash flow to expropriate. If the entrepreneur decides to expropriate some part of the cash flow then a deadweight cost of $\phi \in [0,1]$ is incurred on the funds that he diverts. At date $t = 4$ the entrepreneur has the possibility to undertake an investment at cost F. The investment increases the success probability of project 2 from θ to $\theta+\Delta$.

To finance this investment a proportion $\alpha_2 \in [0,1]$ of the entrepreneur's equity is sold to new outsiders. At date $t = 5$ the cash flow of the project 1 is realized. If the cash flow is not verifiable the entrepreneur decides how much of the cash flow to expropriate (diversion is still costly). We assume that *Assumption* 1 holds (i.e. $\beta > \phi$)

So solving backwards,

At $t = 5$ the entrepreneur will divert funds if,

$$(1 - \alpha_1 - \alpha_2 - \beta)X_2 > (1 - \phi)X_2$$

Since $\beta > \phi$ this will always be the case (he will always divert as much as he can because the marginal cost and benefit of diversion are constant). At $t = 4$ the entrepreneur will undertake the investment if (conditional upon investment in $t = 3$),

$$\begin{aligned}(\Delta + \theta)\left[\lambda(1 - \beta - \alpha_1 - \alpha_2)X_2 + (1 - \lambda)(1 - \phi)X_2\right] &> \theta\left[\lambda(1 - \beta)X_2 + (1 - \lambda)(1 - \phi)X_2\right] \\ \lambda &< \frac{-\Delta(1 - \phi)}{\left[\Delta(\phi - \beta - \alpha_1 - \alpha_2) - \theta\alpha_2\right]}\end{aligned}$$

At $t = 4$ investors require,

$$\alpha_2 \geq \frac{F}{\lambda(\Delta + \theta)X_2}$$

At $t = 3$ the entrepreneur will divert funds if,

$$(1 - \alpha_1 - \beta)X_1 > (1 - \phi)X_1$$

At $t = 2$ the entrepreneur will undertake the investment if,

$$\begin{aligned}(\Delta + \theta)\left[\lambda(1 - \beta - \alpha_1)X_1 + (1 - \lambda)(1 - \phi)X_1\right] &> \theta\left[\lambda(1 - \beta)X_1 + (1 - \lambda)(1 - \phi)X_1\right] \\ \lambda &< \frac{-\Delta(1 - \phi)}{\left[\Delta(\phi - \beta - \alpha_1) - \theta\alpha_1\right]}\end{aligned}$$

At $t = 2$ investors will require,

$$\alpha_1 \geq \frac{F}{\lambda(\Delta + \theta)(X_1 + X_2)}$$

At $t = 1$ the entrepreneur will select disclosure level,

The objective function of the entrepreneur is given by,

$$\Pi = (\theta + \Delta)\left[\lambda(\phi - \beta)(X_1 + X_2) + (1 - \phi)(X_1 + X_2)\right] - 2F$$

The first order condition with respect to λ is given by,

$$\frac{\partial \Pi}{\partial \lambda} = (\theta + \Delta)(\phi - \beta)(X_1 + X_2)$$

Given that $\beta > \phi$ this expression is always negative. Hence the entrepreneur will choose the lowest possible disclosure standard. The lowest possible disclosure level which will satisfy the second investor is

$$\begin{aligned}(1-\alpha_1-\beta) &\geq \alpha_2(\Delta+\theta)\lambda X_2 \geq F \\ 1 &\geq \alpha_2 \geq \frac{F}{(\Delta+\theta)(1-\alpha_1-\beta)\lambda X_2}\end{aligned}$$

$$\begin{aligned}\alpha_1\lambda(\Delta+\theta)(X_1+X_2) &\geq F \\ \alpha_1 &\geq \frac{F}{\lambda(\Delta+\theta)(X_1+X_2)}\end{aligned}$$

Competitive markets imply that the above expression will hold with equality. Using that $X_1 = X_2$ and replacing α_1 into α_2 yields,

$$\lambda \geq \frac{3F}{2(1-\beta)(\Delta+\theta)X}$$

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