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Abstract

We consider a signaling model with a good and a bad type of firm. The market does à priori not know the firm's type. The firms, which are run by equally qualified managers, can use their debt level to signal their true value to the market. In addition to debt, the manager chooses his effort level, which directly affects the firm's product market returns. The effort choice interacts with the signaling mechanism of debt issue and affects the equilibrium debt level. As a result, it is not always possible to derive the type of firm from its capital structure.

JEL Classification: G32, D82, J33

Key Words: corporate finance, signaling with capital structure, asymmetric information, manager behavior

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1 Introduction

The existing literature on signaling with capital structure, both on the theoretical and on the empirical side, is well developed. Besides the debt level, firms can use dividend policy, management share ownership schemes as well as investment decisions for signaling. The information asymmetry refers either to the assets-in-place or the firm's growth opportunities, and there can be uncertainty about the mean or the variance of these values.

Ravid and Sarig (1991), for instance, consider a model in which firms use debt service obligations and dividends to signal their quality. They demonstrate that higher valued firms, which are characterized by a higher mean of their cash flow, are more highly leveraged and pay more dividends than lower valued firms. These results stand in line with most other signaling models.[1]

More recent work by Brick et al. (1998), however, arrives to the opposite result. In their model with debt and dividends as signaling mechanisms, firms differ with respect to the volatility of their cash flow.[2] Higher valued firms have a lower cash flow variance than the lower valued ones. A high cash flow variance is bad since it is negatively related to the tax benefits of debt issue. Defining the firm type as a function of second rather than of first moments results in a lower leverage of the higher valued firms. This result questions the usefulness of financial policy as a signaling mechanism since it becomes more difficult to deduce the firm type from its signaling variables.

The traditional debt signaling models have been widely tested with firm data.[3] The empirical evidence, however, reveals a very inconclusive picture. The results are often not compatible with what the theoretical models predict, i.e., most studies find no systematic relationship, neither positive nor negative, between a firm's announced change in leverage and its market valuation.

All these signaling models are in the tradition of classical financial theory. The underlying assumption is that the choice of the financial structure is independent of other decisions the management of a firm faces. Accordingly, the product market returns are

[1] Classical papers on signaling with capital structure and dividend payments include, e.g., Ross (1977), Leland and Pyle (1977) and Bhattacharya. See also Luo et al. (2002) for an overview of signaling models.

[2] In most other work the quality of the firm is defined with respect to the mean of the cash flow.

[3] See for example Asquith and Mullins (1986), Masulis and Korwar (1986), Mikkelson and Partch (1986), Eckbo (1986).

exogenously given and independent of the capital structure choice. Since the pioneering work of Brander&Lewis (1986), however, we know that the choice of the financial structure interacts with other strategic decisions of the firm.[4] More importantly, these models do not take into account any frictions which can arise between the separation of ownership and control within a firm, i.e., the role of the manager and the related agency conflict are not explicitly modeled. Given this incomplete view, the equivocal results from the classical signaling models, both on the theoretical and the empirical side, should not really surprise.

Based on Brick et al. (1998), we consider a debt signaling model with a moral hazard problem stemming from an agency conflict between the manager and the owner of the firm. The market cannot recognize the good and bad firms, which differ in their cash flow volatility. The firms are run by equally qualified managers, who choose the firm's optimal debt level. Besides the choice of this signaling variable, the manager of the firm can provide effort, which positively affects the product market returns and thus the value of the firm. Providing effort is costly for the manager, and the effort level is not directly observable. The manager, who is remunerated as a function of the firm's value, thus balances the costs of his effort against the increase in firm value. This additional dimension of effort choice interacts with the signaling mechanism and affects the equilibrium debt level of the firm. Accordingly, we need to take into account both kind of decisions to appropriately understand the firm's capital structure choice as signaling mechanism.

This setup with the manager affecting the firm's product market returns is motivated by the observation that the success of most businesses heavily depends on the personal effort with which the manager is carrying out his job duties. The Economist[5], for instance, notices in relation with share options: ‚*(...) a first-class boss can make so large a difference to a company's performance that almost any price is worth paying for his services*'. By linking the choice of the financial structure to the manager's effort provision, our setup extends the classical signaling framework to a more complete characterization of decisionmaking processes inside the firm.

There exist a few other papers which do not only consider dividend and debt deci-

[4] Brander&Lewis (1986) were the first to show that capital structure choice interacts with the firm's output market strategy.

[5] See The Economist, The trouble with share options, p. 11-12, Aug 7th 1999.

sions as signaling mechanism. Luo et al. (2002) consider a model where firms can use investment decisions besides debt and dividends to convey private information to the market. In contrast to other papers, the information asymmetry does not only refer to the mean, but also to the variance of the cash flow. The choice of the signals then depends on the relative importance of these two sources of asymmetric information and on the simultaneous strategic interactions between the use of the three instruments. As a result, high value firms signal by higher investments and dividends. Contrary to most other papers, however, the high quality firm does not always have the higher debt level: a lower volatility is signaled by an increased equity share, whereas only a higher expected cash flow goes together with a higher leverage.

Gertner, Gibbons and Scharfstein (1988) consider a two audience signaling with signaling to capital and products markets. There is an informed firm, who first issues debt and then competes with its product market rival, who does not the level of demand. The choice of the debt level by the informed party may not only reveal information to the capital market but also to its uninformed rival, who adjusts his behavior depending on the transactions it observes between the informed firm and the capital market. By doing so, the uninformed firm affects the profits of the informed firm. The character of the capital market equilibrium is thus determined by the structure of the product market.

The novel aspect of this paper is that it extends the capital structure choice as signaling mechanism to the unobservable effort choice of the manager. This additional dimension of an agency conflict between the owner and the manager of the firm, which introduces a moral hazard problem, challenges some former results of the classical signaling models.

The main results of our paper are as follows: the good firm does not always choose a lower debt level than the bad firm. It depends on the characteristics of the output markets, i.e., we need to take into account the volatility of product market returns in addition to the debt level to identify the firms' type. This result is driven by the fact that the manager can affect the firm's product market returns, and it stands in contrast with the outcomes from the classical signaling models, where there exists a monotonic relationship between the quality of the firm and their debt levels. The equilibrium effort level of the firm's manager depends on the firm type as well, but is also affected by the output market characteristics.

The paper is structured as follows: we present the basic model in section 2. Section 3 contains the symmetric information analysis. The asymmetric information case is in section 4. Section 5 concludes. All the proofs are relegated to the appendix.

2 The model

There are two types of firms i, $i \in \{H, L\}$, in the economy, which are either of high quality H or of low quality L. The firms have the same cash flow mean, but differ in the variance of their cash flow: the high quality type has a lower variance than the low quality type. A high cash flow variance is bad because the tax benefit of debt issue is decreasing in the cash flow variance.[6]

In $t = 0$, the firms can issue debt in form of bonds B_i, with $B_i \geq 0$. B_i is observable. The total payments to bondholders are tax deductible when the firm can make the promised payments to bondholders. The tax benefit of debt issue is $\max\{0; TB_i\}$, i.e., in case the firm is solvent the tax benefit is TB_i, and zero otherwise, where T is the marginal corporate tax rate, with $0 < T < 1$.[7] The only reason of debt issue is to save taxes; and it is assumed that the raised money is paid to existing shareholders.[8] The interest rate is zero, the agents are risk-neutral and there are no conflicts between stock- and bondholders.

The firm is run by a manager, who is hired by the owners of the firm. In $t = 0$, after the choice of the debt level B_i, the manager of firm i chooses his effort level e_i, with $e_i \geq 0$, which directly affects the cash flow of the firm. The effort level e_i is not observable. The manager incurs a cost $S(e_i) = \beta e_i^2$, with $\beta \in [0, 1]$, to provide effort level e_i.

These decisions together with the given investment decisions[9] in $t = 0$ produce a

[6] See footnote 14.

[7] When the firm is not solvent, the due payments exceed its net income. The tax benefit is zero in this case because we exclude negative corporate tax payments, which is a highly realistic assumption. As is outlined in Brick and Fisher (1987), allowing the firm to unlimitedly deduce interest payments would encourage the formation of essentially dummy corporations whose only receipts would be corporate tax refunds.

[8] A similar approach is taken in Brander and Lewis (1986), where debt issue serves strategic reasons only.

[9] We assume the manager to have no discretion over the investment decision, which we consider as exogenous.

stochastic cash flow, which is realized in period $t = 1$. The cash flow of firm i is given by

$$X_i = \alpha + e_i + \xi_i \tag{1}$$

$\alpha \geq 1$ is the constant term of the cash flow, and is assumed to be the same for both firms. ξ_i is a random term which is uniformly distributed over the interval $[-z_i, z_i]$, with $f(\xi_i) = 1/(2z_i)$, $E(\xi_i) = 0$ and $\beta z_i > 0.25$.[10] Furthermore, $z_L > z_H$, which reflects that the L firm has a higher variance of the cash flow than the H type. For simplicity, we also assume that $z_L = 2z_H$. Outsiders of the firm can only observe the cash flow X_i.[11]

The expected present value of firm i is a function of the debt level B_i and the manager's effort level e_i, net of the costs of dividend issue, and is given by (2). L_i is the insolvency point with $L_i = (B_i - \alpha - e_i)$:

$$\begin{aligned} V_i(B_i, e_i) &= (1-T)(\alpha + e_i) + \int_{L_i}^{z_i} TB_i f(\xi_i) d\xi_i = \\ &= (1-T)(\alpha + e_i) + \frac{TB_i(\alpha + e_i + z_i - B_i)}{2z_i} \end{aligned} \tag{2}$$

The first term of (2) represents the expected net operating income.[12] It is supposed that the effective tax rate T on net operating income is constant in all states, implying that there is always a positive net operating income. Accordingly, the tax rate T applies over the whole interval $[-z_i, z_i]$ of ξ_i.[13] The second term is the expected tax benefit of debt issue. It only exists in case the firm is solvent, i.e., when the cash flow

[10] This is to assure that debt and effort level are positive.

[11] Brick, Frierman and Kim (1998) consider the case of simultaneous debt and dividend issue as signaling mechanisms. In contrast to other work, there is no commitment effect of dividend signaling in the sense that firms are reluctant to cut dividend payments in the future, but dividend payments are simply 'money-burning' exercises. Therefore, we do not incorporate dividend payments in our model, which does not affect our main results.

[12] Given that X_i is assumed to be always positive, the tax rate T applies over the whole interval $[-z_i, z_i]$ of ξ_i . Alternatively to the assumption of $X_i > 0$ for all values of z_i,we can suppose that the effective tax rate T on net operating income is constant in all states, implying that there will always be a positive net operating income.

[13] As an alternative, we can assume that z_i is such that $X_i > 0$ for all ξ. See, e.g., Brick, Frierman and Kim (1998).

X_i is sufficient to pay back the debt B_i to the bondholders.[14] We assume that the firm cannot go bankrupt within the considered time horizon.

The compensation of the manager is a linear function of the firm's perceived value in $t = 0$, denoted by V_i^0, and of its true value in $t = 1$, denoted by V_i^1, i.e., the manager obtains the fraction γ of $(V_i^0 + V_i^1)$, from which he has to deduce his costs.[15] This remuneration scheme, with $0 < \gamma < 1$, ties the manager's compensation to the performance of the firm. It aligns the interests of the firm owner with those of the manager.[16] The compensation of the manager of firm i net of his effort costs is then

$$W_i(V_i) = W_i(B_i, e_i) = \gamma(V_i^0 + V_i^1) - S(e_i) \tag{3}$$

Figure 2.1 summarizes the sequence of events.

[insert figure 2.1 about here]

3 Symmetric information

3.1 The maximization problem

The information whether a firm is a high or a low quality type is publicly available in $t = 0$. In the second stage, the manager of firm i, $i = H, L$, chooses his effort level e_i, when he also has to bear his private costs $S(e_i)$. He maximizes

$$\begin{aligned} \max_{e_i} W_i(B_i, e_i) &= \gamma(V_i^0 + V_i^1) - S(e_i) \qquad (4) \\ &= 2\gamma[(1-T)(\alpha + e_i) + \frac{TB_i(\alpha + e_i + z_i - B_i)}{2z_i}] - \beta e_i^2, \\ & \quad i = H, L \end{aligned}$$

[14] Note that the tax benefit of debt decreases with the variance of the cash flow, i.e., $\frac{\partial \int_{L_i}^{R_i} TB_i f(\xi_i) d\xi_i}{\partial z_i} = \frac{TB_i(B_i-(\alpha+e_i)}{2z_i^2} \leq 0$ since $(\alpha + e_i) \geq B_i$ for the solvency case.

[15] An objective function that takes into account present and future values of the firm is used, for instance, by Bhattacharya (1979). A linear compensation function for the manager can be found in Salas Fumás (1992) or in Aggrawal and Samwick (1999).

[16] Note, however, that the manager does not exacltv what the owner would like. As long as $\gamma < 1$, we are in a second-best world where the manager chooses a lower effort. This is no longer true when $\gamma = 1$.

The effort level $e_i(B_i)$ as a function of the debt level B_i is then

$$e_i(B_i) = \frac{\gamma[T(B_i - 2z_i) + 2z_i]}{2\beta z_i} \tag{5}$$

In the first stage, the manager maximizes $W_i(B_i, e_i(B_i)) = W_i(B_i)$ with respect to B_i. Inserting (5) in (4) and maximizing with respect to B_i, yields the equilibrium debt level B_i^*:

$$B_i^* = \frac{2z_i(\alpha\beta + \gamma(1 - T) + \beta z_i)}{(4\beta z_i - \gamma T)} \tag{6}$$

From inserting (6) into (5), we obtain the equilibrium effort level e_i^* in (7).

$$e_i^* = \frac{\gamma(z_i(4 - 3T) + \alpha T)}{(4\beta z_i - \gamma T)} \tag{7}$$

3.2 The choice of the effort level

Proposition 1 *In the symmetric information case, the manager of the high quality firm always chooses a higher effort level than the manager of the low quality firm, i.e.,* $e_H^* > e_L^*$.

This can best be seen by looking at the partial derivative of (4) with respect to e_i, which is the first order condition of the second stage maximization problem:

$$\frac{\partial[W_i(B_i, e_i)]}{\partial e_i} = 2\gamma[(1 - T) + \frac{TB_i}{2z_i}] - 2\beta e_i \tag{8}$$

Providing additional effort has two opposite effects for the compensation of the manager: the first term in brackets of (8) represents the positive productivity effect, as higher effort increases the cash flow and thus the value of the firm. As z_i appears in the denominator and $z_L > z_H$, this effect is lower for the L firm for a given value of B_i. The second term of (8) captures the cost effect, which has a negative impact on the manager's compensation. To compensate for the lower productivity effect, the managers of the low quality type thus provides a lower effort level.

Proposition 2 *In the symmetric information case, the effort level e_i^*, for $i = H, L$, increases with the fraction γ of firm value as compensation and decreases with the costs of effort of the manager, i.e. $\partial e_i^*/\partial\gamma > 0$ and $\partial e_i^*/\partial\beta < 0$.*

Proposition 2 simply reflects the effectiveness of the managers' compensation schedule. The firm owner can affect the manager's effort level by appropriately choosing the parameter γ. Similarly, the effort provision can be influenced by a lower β, resulting from a professional training for the manager for instance .

3.3 The choice of the debt level

Proposition 3 *In the symmetric information case the high quality firm has a higher debt level than the low quality firm for low values of z_H, whereas the low quality firm has a higher debt level than the high quality firm for high values of z_H, i.e., with $z_L = 2z_H$, $B_H^* > B_L^*$ for $z_H < \overset{M}{z}$ and $B_L^* > B_H^*$ for $z_H > \overset{M}{z}$, and , where $\overset{M}{z} = [3\gamma T + \sqrt{\gamma T(32\alpha\beta + \gamma(32 - 23T))}]/16\beta$.*

The interesting point to note is that the H type does not always choose the lower debt level, which holds in the case without effort provision by the manager.[17] Accordingly, the additional dimension of effort provision by the manager, which interacts with the choice of the debt level, is responsible for the absence of monotony between the debt level and the quality of the firm.

To explain this, we can isolate two different effects. The first effect refers to the well known mechanism outlined in Brick, Frierman and Kim (1998): The debt level can be considered as if the government owned a call option on the revenue of the firm with exercise price B. The value of this call option is positively related to the cash flow variance. In order to decrease the value of the government'ss claim, the firm can increase the exercise price, i.e., to increase the debt level B. Therefore, the L firm chooses a higher debt level than the H firm. The second effect refers to the effort provision by the manager. The marginal tax benefit of debt issue is increasing in the effort level e_i, i.e., $\partial^2 TB_i/\partial B_i \partial\, e_i > 0$. Given proposition 1, this effect is stronger for the H firm, which chooses a higher debt level.

[17]See Appendix for a formal derivation of the case without effort provision of the manager.

For low values of the shock level z_H, the first effect is dominating, and we reach the same result as in the case without effort provision. For higher values of z_H, however, the first effect is stronger and leads to a higher leverage of the high quality firm. As a consequence, it is not possible to derive the type of firm from its relative debt level, but we need to take into account the absolute level of the cash flow variability as well.

4 Asymmetric information

4.1 The maximization problem

In the asymmetric information case, managers have better information about the firm's performance than the market, i.e., the market does a priori not know whether a firm is a high or a low quality type. This information becomes publicly available in $t = 1$ only.

The compensation of the manager, $W_i(V_i^o(B_i,), V_i^1(B_i))$, is an increasing function of the firm's market valuation in $t = 0$ and in $t = 1$. Therefore, the manager of the low quality firm has incentives to mimic the high quality firm in order to be perceived as a high quality type in $t = 0$ and to obtain a higher compensation. The manager of the high quality firm, however, can reveal its private information to the market by choosing its debt level B_H such that the low quality firm cannot afford mimicking its higher valued competitor anymore.

In what follows, we are uniquely interested in the separating equilibrium of this game. We apply the concept of sequential Nash equilibrium, which was proposed by Milgrom and Roberts (1986). This equilibrium concept eliminates separating Nash equilibria in which low quality firms deviate from their full information optimal behavior. It further rules out separating equilibria with excessive and thus inefficient amounts of signaling by the high quality firm. Finally, it also eliminates pooling equilibria.

In any separating equilibrium, the expected value of each firm has to be equal to its actual value, i.e., $V_i^0(B_i) = V_i^1$, for $i = H, L$. This is known as the competitive-rationality condition. In a signaling equilibrium, the incentive compatibility condition requires the compensation of both firms' managers being maximized, subject to the market correctly believing that each firm's value equals its true value. Therefore, the managers choose their debt level to correctly signal the true value of the firm, without attempts to mimic the competitors.

In equilibrium, the low quality firm picks its full information optimum, i.e., $\hat{B}_L = B_L^*$, whereas the high quality firm chooses its debt level $\hat{B}_H$ such that it does just enough signaling to distinguish itself from its low quality competiter. This signaling activity involves costs for the H type firm, as it deviates from its full information optimal debt level.

To derive the separating equilibrium, we proceed as follows. In the second stage, the manager solves the same problem as in the symmetric information case, i.e., he computes the effort level as a function of the debt level according to equation (4). The L type, who mimics his higher valued competitor, not only has to pick B_H, but he also has to choose his effort level accordingly. Otherwise, the market can eventually deduce the firm's type from the signaling variable. In the first stage, the manager derives the optimal debt level, which forms a sequential Nash equilibrium of the first stage signaling game, as follows: let $W_{i/j}$ denote the compensation received by the manager of a firm which is of type i, but the market believes to be of type j :

$$\begin{aligned} W_{i/j} &= \gamma[V_j^0(B_j) + V_i^1(B_j)] - S(e(B_j)) \quad (9) \\ &= \gamma[(1-T)(\alpha + e_j) + \frac{TB_j(\alpha + e_j + z_j - B_j)}{2z_j} \\ &\quad +(1-T)(\alpha + e_j) + \frac{TB(\alpha + e_j + z_i - B_j)}{2z_i}] - \beta e_j^2 \end{aligned}$$

Note that the true type of the firm becomes publicly known in period $t = 1$. Therefore, the upper level of the shock interval z_i corresponds to the true value in $t = 1$. The signaling variables as well as the effort level, however, depend on the perceived type j. As the manager determines their level in $t = 0$, they take the same value in both periods.

When the manager of the low quality firm imitates the high quality type, his compensation has to be as much as when he correctly signals the true value, i.e.,

$$W_{L/H}(B) - W_{L/L}(B^*) \geq 0 \quad (10)$$

A similar condition holds for the high quality firm. Let B^0 denote the optimal level of debt in case the high quality type is perceived to be a low quality firm. The manager of the high quality type has to receive a higher compensation when the firm is correctly evaluated at its true value than when it is perceived as a low quality firm, i.e.,

$$W_{H/H}(B) - W_{H/L}(B^0) \geq 0 \tag{11}$$

(10) and (11) can be combined to (12), which is the condition for the existence of a separating equilibrium:

$$W_{H/H}(B) - W_{H/L}(B^0) \geq 0 \geq W_{L/H}(B) - W_{L/L}(B^*) \tag{12}$$

The first part of inequality (12) requires that the benefit of the H type manager of being correctly perceived as a high quality firm is positive or equal to zero. This is the necessary condition for the H type firm to signal the true quality of the firm and not simply to mimic its lower valued rival. Similarly, the second part of the inequality refers to the benefit of the L type manager, who does not have any incentives to mimic the H type, as the benefit of mimicking would be negative or equal to zero.

To find the efficient separating equilibrium point, we solve the maximization given by (13) subject to (14). It enables the manager of the higher valued firm to achieve the highest level of compensation possible without allowing the manager of the lower valued firm to receive a compensation more than that given by B_L^*. The manager of the high quality firm chooses B_H such that his compensation in (13) is maximized, subject to the nonmimicry constraint in (14).

$$\max_{B_H} \gamma[V_H^0(B_H) + V_H^1(B_H)] \tag{13}$$

s.t.

$$W_{L/L}(B_L^*) \geq W_{L/H}(B_H) = \gamma[V_H^0(B_H) + V_L^1(B_H)] \tag{14}$$

The high quality firm chooses a debt level $\hat{B}_H$ such that the first-order condition of the maximization problem (15) holds, i.e.,

$$\frac{\partial V_H^1}{\partial B_H} = \frac{\partial V_L^1}{\partial B_H} \tag{15}$$

In the equilibrium of the asymmetric information case, the H type firm chooses its debt level $\hat{B}_H$ according to (16).

$$\hat{B}_H = \frac{z_H[\alpha\beta + \gamma(1 - T)]}{(2\beta z_H - \gamma T)} \quad (16)$$

The L type firm, in contrast, chooses the same debt level as in the symmetric information case, i.e.,

$$\hat{B}_L = B_L^* = \frac{4z_H(\alpha\beta + \gamma(1 - T) + 2\beta z_H)}{(8\beta z_H - \gamma T)} \quad (17)$$

The equilibrium effort levels for both firms are given by (18) and (19).

$$\hat{e}_H = \frac{\gamma[(4\beta z_H - \gamma T)(1 - T) + T\alpha\beta]}{\beta(2\beta z_H - \gamma T)} \quad (18)$$

$$\hat{e}_L = e_L^* = \frac{\gamma(z_H(8 - 6T) + \alpha T)}{(8\beta z_H - \gamma T)} \quad (19)$$

4.2 The choice of the effort level

Proposition 4 *In the asymmetric information case, the manager of the high quality firm always chooses a higher effort level than the manager of the low quality firm, i.e.,* $\hat{e}_H > \hat{e}_L$.

This result stands in line with the symmetric information case, where the manager of the H type firm always chooses the higher effort level as well. It is driven by the relative benefits and costs of effort provision, which the new information distribution does not fundamentally alter.

Proposition 5 *In the asymmetric information case, the manager of the high quality firm provides a higher effort level for low values of* z_H *and a lower effort level for high values of* z_H *compared to the symmetric information case, i.e.,* $\hat{e}_H > e_H^*$ *for* $z_H < \overset{\approx}{z}$ *and* $\hat{e}_H < e_H^*$ *for* $z_H > \overset{\approx}{z}$, *where* $\overset{\approx}{z} = [\gamma T + \sqrt{\gamma T(4\alpha\beta + \gamma(4 - 3T))}]/4\beta$.

There exists a critical value $\tilde{\tilde{z}}$ for which e_H^* and $\hat{e}_H$ are equal. It is interesting to compare these two outcomes because it shows the effect of using debt as signaling mechanism on the effort provision of the manager. This observation also points out to one source of inefficiency due to asymmetric information. When we consider the situation with symmetric information as benchmark case, the manager of the H firm chooses an inefficient effort level except for $z_H = \tilde{\tilde{z}}$. Figure 4.1 summarizes the choice of the effort level of both firms under the two informational regimes.

[insert figure 4.1 about here]

To fully understand this result, we also need to take into account the first stage choice of the debt level, which is outlined in the next subsection.

4.3 The choice of the debt level

The debt level is used as key signaling mechanism and can suppositionally reveal the firm's true value to the market. To again determine how the debt level of both firms and information distributions compare to each other, we compute the following differences in debt levels:

$$\triangle B_1 = \hat{B}_H - \hat{B}_L \tag{20}$$

$$\triangle B_2 = \hat{B}_H - B_H^* \tag{21}$$

Proposition 6 *In the asymmetric information case, the high quality firm has a higher debt level than the low quality firm for low values of z_H and a lower debt level for high values of z_H, i.e.,* $\triangle B_1 > 0$ *for* $z_H < \check{z}$ *and* $\triangle B_1 < 0$ *for* $z_H > \check{z}$*, and, where* $\check{z} = \gamma T + \sqrt{\gamma T(3\alpha\beta + \gamma(3 - 2T))}/4\beta$.

The L type firm does, therefore, not always choose the higher debt level, but it depends on the upper limit of the shock interval z_H. Similar to the case with symmetric information, there exists a break point $\check{z}$, above which the H type has a relatively higher leverage.

This result restricts the use of debt as signaling mechanism: it is no more possible to differentiate the firms by looking at their capital structure. To know about the type of firm, we additionally have to take into account the size of the cash flow volatility, which is captured by z_H.[18]. We can explain this result again by the two opposing effects of effort provision on debt issue (see Proposition 3) on the one side, and the additional signaling dimension of debt issue on the other side.

Such an conclusion challenges the results from the setup without effort provision by the manager, where the manager of the H type always chooses a policy of underleverage to differentiate his firm from the low quality rivals.

Proposition 7 *In the asymmetric information case, the high quality firm chooses a policy of overleverage for low values of z_H and a policy of underleverage for high values of z_H compared to the symmetric information case, i.e.,* $\Delta B_2 > 0$ *for* $z_H < \check{z}$ *and* $\Delta B_2 < 0$ *for* $z_H > \tilde{\tilde{z}}$*, where* $\tilde{\tilde{z}} = \gamma T + \sqrt{\gamma T(4\alpha\beta + \gamma(4-3T))}/4\beta$.

Proposition 7 mirrors Proposition 5 for the debt level. This result nicely shows the interaction between debt issue and effort provision, with the identical break-point for z_H. Figure 4.2 shows the different debt levels for specific parameter values.

[insert figure 4.2 about here]

5 Conclusions

We interpret this paper as a further contribution to explain capital structure decisions of firms in a asymmetric information environment. It stresses the role of debt as a signaling mechanism and takes explicitly into account the additional dimension of moral hazard induced by the fact that the manager can affect the firm's product market returns. The work provides some insights concerning the interactions between the signaling mechanism and the effort choice by the manager and its effects on the firm's financial structure choice.

In contrast to former work, we find that the debt level in the signaling game does not only depend on the firms' type, but also on factors such as the cash flow volatility or

[18] Note that the size of z_H is known by the parties. What is not known a priori is whether the firm is a high or a low type.

the characteristics of the managers' compensation scheme. These results are driven by the agency conflict between the manager and the owner of the firm. As a result, it is no more sufficient to look at the level of the firm's signaling variables to identify its type. Such an outcome weakens the effectiveness of debt issue as a signaling mechanism.

More work is needed to investigate further interesting issues within this context. One topic refers to the impact of different incentive schemes for the manager on the signaling activity. In addition, we should allow for unequally skilled managers, which introduces another source of heterogeneity between the firms. Furthermore, the model should account for the possibility of firms going bankrupt during the period of consideration, as debt issue affects the firm's risk exposure. Finally, it remains an empirical question whether our setup with this additional moral hazard problem contributes to better understand the inconclusive picture from the empirical tests of the classical signaling models. At least, our theoretical model may provide one source of explanation for these inconclusive results. Future work should, therefore, also concentrate on empirically testing the model with firm data.

6 Appendix

6.1 The symmetric information case

6.1.1 Proof of proposition 1

Differentiating e_i^* with respect to $\bar{z}_i$ yields

$$\frac{\partial e_i^*}{\partial \bar{z}_i} = \frac{\gamma T[\gamma(3T-4) - 4\alpha\beta]}{(-\gamma T + 4z_i)^2} \tag{22}$$

which is always negative: the numerator is negative due to the $T < 1$, and the denominator is always positive.

6.1.2 Proof of proposition 2

Differentiating e_i^* with respect to γ yields

$$\frac{\partial e_i^*}{\partial \gamma} = \frac{4z_i[z_i(4-3T) + \alpha T]}{(-\gamma T + 4\beta z_i)^2} \tag{23}$$

which is always positive: The numerator is positive due to the $T < 1$, and the denominator is positive as well.

Differentiating e_i^* with respect to β yields

$$\frac{\partial e_i^*}{\partial \beta} = \frac{2\gamma z_i[z_i(3T-4) - \alpha T]}{(-\gamma T + 4\beta z_i)^2} \tag{24}$$

which is always negative: the numerator is negative due to the $T < 1$, and the denominator is positive.

6.2 The asymmetric information case

6.2.1 The maximization problem

As is outlined in section 4.1, the following equality has to hold:

$$\frac{\partial V_H^1}{\partial B_H} = \frac{\partial V_L^1}{\partial B_H} \tag{25}$$

where

$$V_H^1 = \gamma(1-T)(\alpha + \frac{\gamma(2z_H(1-T)+TB_H)}{2\beta z_H} + \frac{\gamma TB_1(\alpha + \frac{\gamma(2z_H(1-T)+TB_H)}{2\beta z_H}}{2z_H} \tag{26}$$
$$+\frac{z_H - B_H}{2z_H} - \frac{\gamma^2(2z_H(1-T)+TB_H)^2}{4\beta z_H^2}$$

$$\frac{\partial V_H^1}{\partial B_H} = \frac{\gamma T(\alpha + z_H - 2B_H}{2z_H} \tag{27}$$

and

$$V_L^1 = \gamma(1-T)(\alpha + \frac{\gamma(2z_H(1-T)+TB_H)}{2\beta z_H} + \tag{28}$$
$$+\frac{\gamma TB_H(\alpha + \frac{\gamma(2z_H(1-T)+TB_H)}{2\beta z_H} + 0.5z_H - B_H}{z_H} - \frac{\gamma^2(2z_H(1-T)+TB_H)^2}{4\beta z_H^2}$$

$$\frac{\partial V_L^1}{\partial B_H} = \frac{\gamma T[(T-1)\gamma z_H + \alpha\beta z_H - \gamma TB_H + 2\beta z_H(z_H - B_H)]}{4\beta z_H} \tag{29}$$

$$\frac{\partial V_H^1}{\partial B_H} - \frac{\partial V_L^1}{\partial B_H} = \frac{\gamma T[\gamma z_H(1-T) + \gamma TB_H + \beta z_H(\alpha + 2z_H B_H)]}{4\beta z_H^2} \tag{30}$$

Solving (30) for B_H yields

$$\hat{B}_H = \frac{z_H[\alpha\beta + \gamma(1-T)]}{(2\beta z_H - \gamma T)} \tag{31}$$

6.2.2 Proof of existence of the equilibrium

For some B :

$$W_{H/H}(B,e) - W_{H/L}(B^0,e) \geq 0 \geq W_{L/H}(B,e) - W_{L/L}(B_L^*,e) \tag{32}$$

Equation (32) holds by assuming $B = B_H^*$. In this case, we need to show that each of the following three equations hold:

$$W_{H/H}(B_H^*, e_H^*) - W_{H/L}(B^0, e^0) \geq 0 \tag{33}$$

$$W_{L/H}(B_H^*, e_H^*) - W_{L/L}(B_L^*, e_L^*) \leq 0 \tag{34}$$

$$\begin{aligned} & W_{H/H}(B_H^*, e_H^*) - W_{H/L}(B^0, e^0) - \\ [W_{L/H}(B_H^*, e_H^*) - W_{L/L}(B_L^*, e_L^*)] \;\; \geq & \;\; 0 \end{aligned} \tag{35}$$

B^0 and $e^0$and are the debt and effort levels which maximize $W_{H/L}(B, e)$. To find the corresponding values of B^0 and e^0, we take the derivative of $W_{H/L}(B, e)$ with respect to e,set it equal to zero and solve for $e(B)$, plug it in again in $W_{H/L}$, take the derivative with respect to B, set it equal to zero and solve for $B = B^0$. We then find $e = e^0$ by substituting $B = B^0$ in $e(B)$:

$$\begin{aligned} W_{H/L}(B^0, e^0) \;\; = \;\; & \gamma[(1-T)(\alpha + e^0) + \frac{TB^0(\alpha + e^0 + 2z_H - B^0)}{4z_H} \\ & +\gamma[(1-T)(\alpha + e^0) + \frac{TB^0(\alpha + e^0 + z_H - B^0)}{2z_H} - \beta(e^0)^2 \end{aligned} \tag{36}$$

$$\frac{\partial W_{H/L}(B^0, e^0)}{\partial e^0} = \gamma(1 - T + \frac{TB^0}{4z_H}) + \gamma(1 - T + \frac{TB^0}{2z_H}) - 2\beta e^0 \overset{!}{=} 0 \tag{37}$$

$$e^0(B^0) = \frac{\gamma(8z_H - 8Tz_H + 3TB^0}{\beta z_H} \tag{38}$$

$$\frac{\partial W_{H/L}(B^0, e^0(B^0))}{\partial B^0} = \frac{\gamma T(24\gamma z_H(1 - T + \alpha\beta) + 9\gamma TB^0 + 32\beta z_H^2 - 48\beta z_H B^0)}{32\beta z_H^2} \tag{39}$$

$$B^0 = \frac{8z_H(3\gamma(1-T) + 3\alpha\beta + 4\beta z_H)}{3(16\beta z_H - 3\gamma T)} \tag{40}$$

$$e^0 = \frac{\gamma(16z_H - 12Tz_H + 3\alpha T)}{(16\beta z_H - 3\gamma T)} \tag{41}$$

$$W_{H/H}(B_H^*, e_H^*) - W_{H/L}(B^0, e^0) = \tag{42}$$

$$\frac{\gamma T z_H(12\alpha^2\beta^2 + 24\alpha\beta\gamma - 18\alpha\beta\gamma T + 12\gamma^2 - 18\gamma^2 T}{3(16\beta z_H - 3\gamma T)(4\beta z_H - \gamma T))} +$$

$$\frac{6\gamma^2 T^2 - 16\beta^2 z_H^2 + 7\beta\gamma T z_H}{3(16\beta z_H - 3\gamma T)(4\beta z_H - \gamma T))}$$

$$W_{L/H}(B_H^*, e_H^*) - W_{L/L}(B_L^*, e_L^*) = \tag{43}$$

$$\frac{\gamma T z_H[16\alpha^2\beta^3 z_H + \alpha\beta\gamma z_H(32\beta - 24\beta T) - \beta^2 z_H^2(48\beta - 30\gamma T}{2(8\beta z_H - \gamma T)(4\beta z_H - \gamma T)^2}$$

$$+\frac{\beta\gamma z_H(3T^2 + 16 - 24T) - \alpha\beta\gamma T(6\alpha\beta + 12\gamma - 9\gamma T)}{2(8\beta z_H - \gamma T)(4\beta z_H - \gamma T)^2}$$

$$-\frac{\gamma^3 T(6 - 9T)]}{2(8\beta z_H - \gamma T)(4\beta z_H - \gamma T)^2}$$

$$W_{H/H}(B_H^*, e_H^*) - W_{H/L}(B^0, e^0) - \tag{44}$$

$$[W_{L/H}(B_H^*, e_H^*) - W_{L/L}(B_L^*, e_L^*)] =$$

$$\frac{\gamma T z_H[\beta^2 z_H^2(1280\beta^2 z_H^2 - 1040\beta\gamma T z_H + 310\gamma^2 T^2)}{6(8\beta z_H - \gamma T)(16\beta z_H - 3\gamma T)(4\beta z_H - \gamma T)^2}$$

$$+\frac{\alpha\beta^2\gamma T z_H(144\alpha\beta + 288\gamma - 216\gamma T)}{6(8\beta z_H - \gamma T)(16\beta z_H - 3\gamma T)(4\beta z_H - \gamma T)^2}$$

$$+\frac{\beta\gamma^3 T z_H(41T^2 - 216T + 144)}{6(8\beta z_H - \gamma T)(16\beta z_H - 3\gamma T)(4\beta z_H - \gamma T)^2}$$

$$+\frac{\alpha\beta\gamma^2 T^2(45\gamma T - 30\alpha\beta - 60\gamma) + \gamma^4 T^2(45T - 30 - 15T^2)]}{6(8\beta z_H - \gamma T)(16\beta z_H - 3\gamma T)(4\beta z_H - \gamma T)^2}$$

(42), (43) and (44) hold for the possible parameter values.

6.2.3 Proof of proposition 3

$$B_H^* - B_L^* = \frac{2z_H(\alpha\beta\gamma T + \gamma^2 T(1 - T) + 3\beta\gamma T z_H - 8\beta^2 z_H^2)}{(4\beta z_H - \gamma T)(8\beta z_H - \gamma T)} \tag{45}$$

which is positive for the possible parameter values.

$B_H^* - B_L^* = 0$ for a value of $z_H = \overset{\mathsf{M}}{z}$, $B_H^* - B_L^* > 0$ for $z_H < \overset{\mathsf{M}}{z}$, and $B_H^* - B_L^* < 0$ for $z_H > \overset{\mathsf{M}}{z}$, where

$$\overset{\mathsf{M}}{z} = \frac{3\gamma T + \sqrt{\gamma T(32\alpha\beta + \gamma(32 - 23T)}}{16\beta} \tag{46}$$

6.2.4 Proof of proposition 4

$$\hat{e}_H - \hat{e}_L = \frac{\gamma T(\gamma^2 T + 4\beta\gamma z_H - \gamma^2 T - 8\beta^2 z_H^2 + \alpha\beta\gamma T + 4\alpha\beta^2 z_H)}{2\beta(2\beta z_H - \gamma T)(8\beta z_H - \gamma T)} \tag{47}$$

which is positive for the possible parameter values.

6.2.5 Proof of proposition 5

$$\hat{e}_H - e_H^* = \frac{\gamma T(\gamma^2 T(1-T) + 2\beta\gamma T z_H - 4\beta^2 z_H^2 + \alpha\beta\gamma T)}{2\beta(2\beta z_H - \gamma T)(4\beta z_H - \gamma T)} \tag{48}$$

$\hat{e}_H - e_H^* = 0$ for a value of $z_H = \overset{\approx}{z}$, $\hat{e}_H - e_H^* > 0$ for $z_H < \overset{\approx}{z}$, and $\hat{e}_H - e_H^* < 0$ for $z_H > \overset{\approx}{z}$, where

$$\overset{\approx}{z} = \frac{\gamma T + \sqrt{\gamma T(4\alpha\beta + 4\gamma - 3\gamma T)}}{4\beta} \tag{49}$$

6.2.6 Proof of proposition 6

$$\hat{B}_H - \hat{B}_L = \frac{z_H(3\gamma^2 T(1-T) + 8\beta\gamma T z_H + 3\alpha\beta\gamma T - 16\beta^2 z_H^2}{(2\beta z_H - \gamma T)(8\beta z_H - \gamma T)} \tag{50}$$

$\hat{B}_H - \hat{B}_L = 0$ for a value of $z_H = \tilde{z}$, $\hat{B}_H - \hat{B}_L > 0$ for $z_H < \tilde{z}$, and $\hat{B}_H - \hat{B}_L < 0$ for $z_H > \tilde{z}$, where

$$\tilde{z} = \frac{\gamma T + \sqrt{\gamma^2 T(3 - 2T) + 3\alpha\beta\gamma T}}{4\beta} \tag{51}$$

6.2.7 Proof of proposition 7

$$\hat{B}_H - B^*_H = \frac{z_H(\gamma^2T^2 - \gamma^2T - 2\beta\gamma T z_H - \alpha\beta\gamma T + 4\beta^2 z_H^2)}{(2\beta z_H - \gamma T)(4\beta z_H - \gamma T)} \tag{52}$$

$\hat{B}_H - B^*_H = 0$ for a value of $z_H = \approx z$, $\hat{B}_H - B^*_H > 0$ for $z_H < \approx z$, and $\hat{B}_H - B^*_H < 0$ for $z_H > \approx z$, where

$$\approx z = \frac{\gamma T + \sqrt{\gamma T(4\alpha\beta + 4\gamma - 3\gamma T)}}{4\beta} \tag{53}$$

6.3 Exogenous product market returns

6.3.1 The symmetric information case without effort

When we consider the case of exogenous product market return, i.e., the manager is not able to affect the firm's cash flow by providing any effort, the maximization problem looks as follows:

$$\max_{B_i} V_i(B_i) = (1-T)(\alpha) + \int_{L_i}^{z_i} TB_i f(\xi_i) d\xi_i = (1-T)(\alpha) + \frac{TB_i(\alpha + z_i - B_i)}{2z_i} \tag{54}$$

The first-order condition is

$$\frac{\partial V_i(B_i)}{\partial B_i} \frac{T(\alpha + z_i + 2B_i)}{2z_i} = 0 \tag{55}$$

which yields the equilibrium debt

$$\tilde{B}_i = \frac{\alpha + z_i}{2} \tag{56}$$

6.3.2 The asymmetric information case without effort

The maximization problem of the case with asymmetric information reduces to

$$\max_{B_i} \gamma[V_1^0(B_1) + V_1^1(B_1)] \tag{57}$$

subject to

$$C_{2/2}(B_2^*) \geq C_{2/1}(B_1) = \gamma[V_1^0(B_1) + V_2^1(B_1)] \tag{58}$$

where

$$V_1^0 = (1-T)\alpha + \frac{T}{2z_H}[(\alpha + z_H)B - B^2], V_1^1 = (1-T)\alpha + \frac{T}{2z_H}[(\alpha + z_H)B - B^2] \tag{59}$$

and

$$V_2^1 = (1-T)\alpha + \frac{T}{2z_L}[(\alpha + z_L)B - B^2] \tag{60}$$

This maximization problem reduces to

$$\frac{\partial V_1^1}{\partial B} = \frac{\partial V_2^1}{\partial B} \tag{61}$$

where

$$\frac{\partial V_1^1}{\partial B} = \frac{T}{2z_H}[(\alpha + z_H) - 2B) \tag{62}$$

$$\frac{\partial V_2^1}{\partial B} = \frac{T}{2z_L}[(\alpha + z_L) - 2B) \tag{63}$$

Equalizing (63) and (64) leads to

$$\frac{\alpha + z_H - 2B}{z_H} = \frac{\alpha + z_L - 2B}{z_L} \tag{64}$$

Solving for B yields

$$\overset{\approx}{B}_1 = \frac{\alpha}{2} \tag{65}$$

The low quality firm chooses the same value of B than in the symmetric information case, i.e., $\tilde{B}_2 = \overset{\approx}{B}_2$.

7 References

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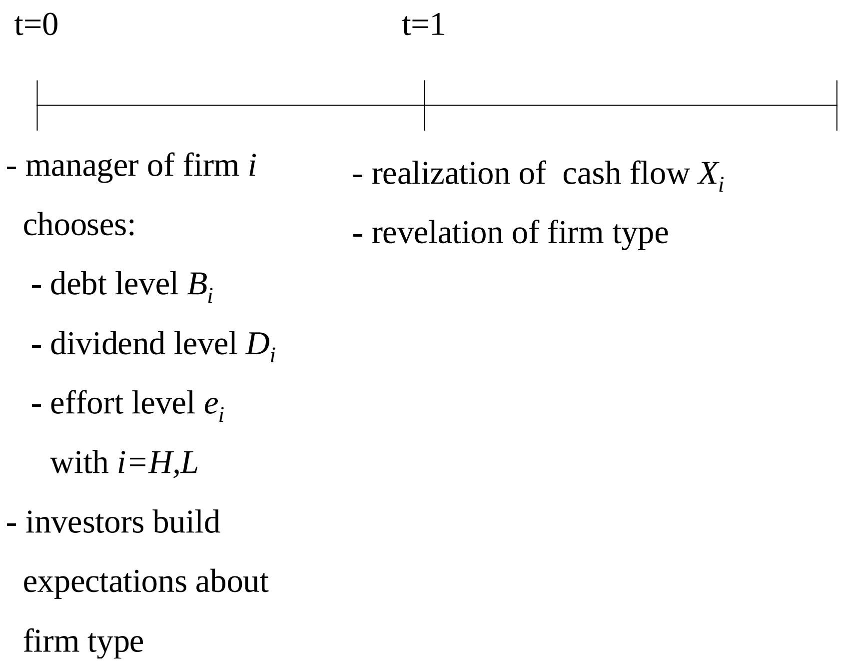

Figure 2.1. Sequence of events

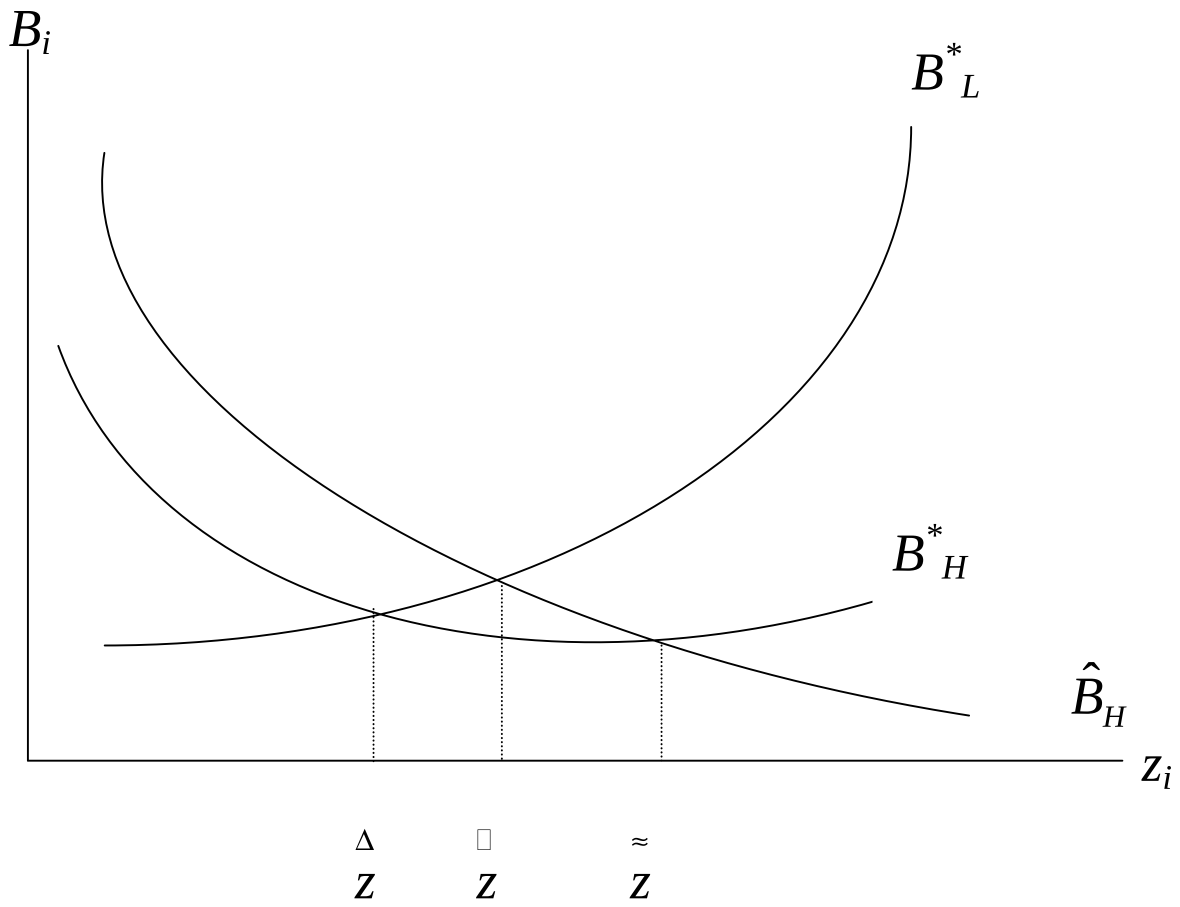

Figure 4.1 Equilibrium debt levels
for $\alpha = 1, \beta = 0.5, T = 0.2$

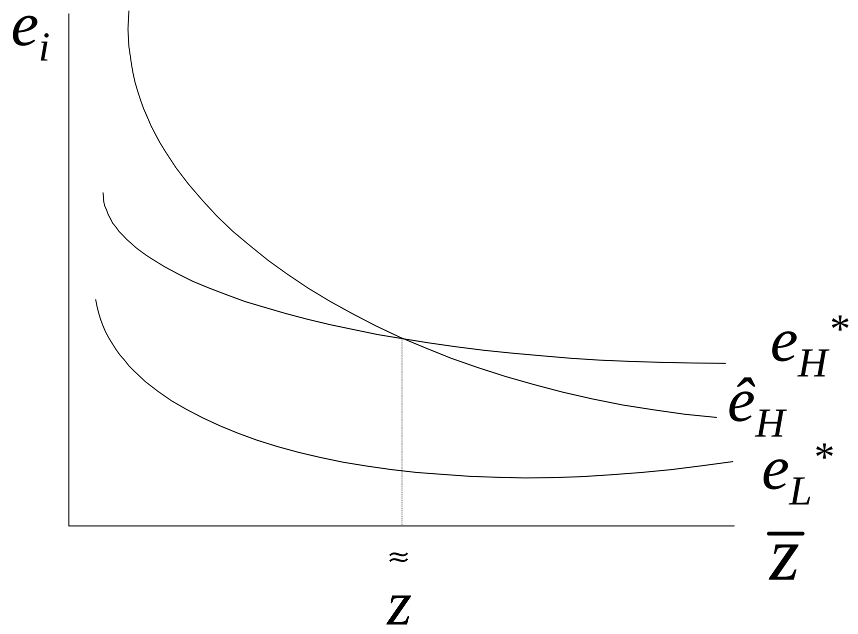

Figure 4.2. Equilibrium effort levels for $\alpha = 1, \beta = 0.5, \gamma = 0.5, T = 0.2$