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Abstract

Building on the work of Stulz (1990), this paper analyzes the impact of managerial discretion on optimal leverage within an agency cost model of corporate financing. Under the assumption that stockholders do not know with certainty the mean of the cash flow distribution, we argue that leverage fails to control for the amount of cash the manager can misappropriate in personal projects. We develop a model of a firm's value maximization problem that predicts that as expected earnings uncertainty increases the firm will decrease its optimal level of borrowing. In a second part, we test this proposition on a panel of non–financial UK firms, by investigating the determinants of firms' performance and allowing for endogeneity of capital structure decisions. The estimates confirm that earnings uncertainty, as measured by the volatility in monthly consensus forecasts of individual companies' earnings per share, negatively affects corporate leverage. Furthermore, new empirical support is found to the agency cost view that corporate performance is positively correlated with leverage when poorly managed firms are selected.

JEL classifications: D92; E22; G32.

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1 Introduction

The importance of leverage in alleviating manager-shareholders agency conflicts is well recognized in the finance literature. Although stockholders want managers to make optimal (value-maximizing) choices on their behalf, managers might have a personal agenda and derive utility from consuming perks. Leverage induces the obligation to pay out cash, because the coupon payments on the bond are not at the management's disposal. If the obligations are not met, creditors can have a firm declared bankrupt.

While the formal development of this theory starts from Grossman and Hart (1982), who formalize these conflicting interests and firstly identify the bonding role of firm's debt, it is Jensen (1986) who popularizes the last idea, giving a name to the cash flow available for discretionary spending, the so-called free-cash-flow. Building on Jensen's original insight, Stulz (1990) tries to illustrate how committed payouts can reduce not only the over-investment problem, but also the under-investment one. He sketches a setting in which a professional manager derives personal benefits from expanding the size of a firm. To mitigate this agency cost of managerial discretion, the shareholders, facing stochastic cash flows, choose the optimal debt level to balance the costs of over-investment and the costs of under-investment.

More recently but on the same vein, Westphalen (2002) employs a continuous-time contingent-claims approach to show that debt can reduce agency costs of free-cash-flow. The optimal capital structure is then determined by the trade-off between the agency cost shield, i.e. the benefits of reducing the cash flow subject to managerial discretion, and the implicit bankruptcy costs arising from the loss of the agency cost shield.

Although theoretically important, at face value these analytical findings do not explain simple stylized facts, in that firms are usually observed to carry both a relatively little debt and huge amounts of cash reserves in their capital structures.

The first problem refers to the observation that, for example, the median corporate debt to capital ratio in the U.S. averages only 30-35% over the last four decades, with two out of five firms having an average debt to capital ratio of less than 20% (Strebulaev, 2007).[1] Morellec

[1]These estimates are based on COMPUSTAT data on the book value of debt and market value of equity. Otherwise,

(2004) tries to bridge the gap between agency theory and the "low leverage puzzle", and develops a model of leverage choices where debt financing increases firm value by constraining management's choice of an investment policy. In his model, the manager has specific human capital in administering the firm's assets and thus is partially entrenched. But because of private benefits she derives from investment, the manager tends to over-invest, thereby giving rise to agency costs of free-cash-flow. The model shows that the impact of manager-stockholders conflict on leverage decisions varies across firms and generally is significant, explaining both the low debt levels observed in practice and the fact that high growth options firms tend to use less debt.

Nonetheless, it is worth noting that several empirical studies not only find evidence for the so-called "low leverage puzzle", but they also show huge amount of cash reserves in corporations' capital structure, which is the main reason of failure for the leverage to be an effective bonding device in an optimal financing strategy (Ozkan and Ozkan, 2004; Dittmar and Mahrt-Smith, 2007). All this evidence casts doubts on the reliability of the agency costs literature. Intuitively, the free-cash-flow hypothesis fails to explain this evidence for either of two reasons. One is that agency costs associated with the existence of free-cash-flow are not sufficiently large to cover the additional costs of taking on debt. The second one is that managerial discretion is ineffectively controlled when the amount of free cash is reduced through debt payments. It is precisely this line of argument that motivates the theoretical part of this contribution.

To address the inconsistency with the stylized facts, the first part of this paper develops a simple optimal financing model which captures the basic ideas of Jensen (1986) and Stulz (1990) to show that debt may help to reduce the agency costs of free-cash-flow. In so doing, it extends Stulz's (1990) model in order to include situations where the shareholders do not know the true mean of the cash flow distribution over a longer-time horizon. Within this new framework, the optimal debt level of a firm is chosen by the board of directors, conditional on an estimate of the mean of the cash flow distribution. After observing a realization of the cash flow, one period subsequent to the decision on debt, the manager updates her beliefs about the distribution of the

according to Parrino and Weisbach (1999), the typical U.S. firm on Compustat has about 24% long-term debt to market value of total capital. See also Almeida et al. (2002) and Dittmar et al. (2003) for international comparison.

cash flow. Since the mean of the cash flow is not known with certainty, the manager receives additional information from this observation and can update her set of information to her advantage. The new structure provides other mechanisms that can possibly account for the inconsistency between the role of debt as discipline device in free-cash-flow agency models and the empirical facts.

First, the derivation of the optimal financing choice captures the impact of expected cash flow uncertainty on the role of debt financing in controlling under-investment and over-investment costs due to potential managerial discretion behavior. As an equilibrium outcome, it shows that an outside shareholder may decide to engage less in debt financing, seen as the bonding device, due to the uncertainty of expected cash flows.

Second, the development of the model is able to capture some of the complexities of long-term debt. The original analysis of Stulz (1990) rules out any significant role for long-term debt, which is at odds with practical experience of modern corporations. With long-term debt, an unexplored asymmetrical information problem exists, since the manager would have the opportunity to observe cash flow realizations, prior to the debt payment, during the period when the manager decides how to cover the debt payment that is looming in the future. Furthermore, the model explores the role of manager's risk aversion through a specified cash holding rule, showing that the amount of optimal debt is inversely related to manager's risk aversion.

Although previous papers have provided important insights on the issues I address in this contribution, none has focused on the power of the debt discipline mechanism under expected cash flow uncertainty. This model is rich enough, in terms of scope, and yet simple enough in terms of modeling, to allow us to be quite specific about how changes in the firm's informational environment affect optimal financing choices. The success of limiting a manager's actions through restricting the amount of available free-cash-flow is dependent on the distributional characteristics of the expected stream of future cash flow.

The differential effect of the informational context on firm's optimal financing choices allows us to derive a testable implication about how firms behave across different states. To wit, my theory implies that, because leverage is supposed to be chosen optimally and expected cash flow uncertainty decreases debt's disciplining role, firms exhibiting a high variance of predicted

values of future cash show should be observed to carry less debt (and/or a shorter debt maturity) in their capital structure. The effect of leverage on firm's value is actually left as an open question by the model and, of course, it lends itself to the empirical scrutiny.

Previous contributions to the managerial discretion agency literature has dealt with this relationship in different ways. McConnell and Servaes (1995), among the first, empirically investigate, on a large sample of US non-financial firms, the relation between corporate value and a set of independent variables, such as leverage and other bonding mechanisms. Their evidence supports the free-cash-flow contention that, for low-growth firms, leverage acts as a monitoring mechanism to enhance firm value, but their analysis do not take into account the endogeneity of financial structure.

This complexity becomes important if there are characteristics which affect both the firm's choice of capital structure and firm's value.[2] Allowing for the existence of this endogeneity problem, Agrawal and Knoeber (1996) conduct cross-sectional regressions, over a sample of large US firms, where Tobin's *Q* is simultaneously determined with seven control mechanisms, finding a lack of a relationship between leverage and firm value.[3] More recently, De Jong (2002)[4] reformulate such approach by defining a model consisting of two equations, for leverage and Tobin's *Q*, explaining each other, and finding a negative significant correlation among these variables.

Building on these premises and on the empirical implication of the theoretical model, an econometric investigation on a panel of microeconomic data is developed in the second part of the paper. Here, I examine the interplay between earnings uncertainty, leverage and firm's value. In particular, I try to pin down the exogenously driven variations of the firm's financial structure in order to avoid the endogeneity problems that would otherwise affect a regression of firm's performance on leverage. The approach followed here is related *inter alia* to Himmelberg *et al.* (1999), who use panel data to study the link between managerial equity ownership, instead of

[2]A recent article by Larcker and Rusticus (2007), questioning about the relation between managerial equity ownership and firm value, corroborates this point on view.
[3]Capital structure literature sometimes has also assumed Tobin's *Q* to be simply an exogenous in a leverage regression. For example, Smith and Watts (1992) document that industries with potentially the greatest agency costs - those with fewer growth opportunities - have higher dividend yields, suggesting that payouts are used as a bonding mechanism to control agency costs.
[4]Similarly, Ghosh (2007).

debt, and expected firm performance as measured by Tobin's *Q*. They address the endogeneity issue by instrumenting managerial equity ownership in their *Q* regression.

In the empirical analysis I use microeconomic panel data, which are drawn from two different sources, for a sub-sample of non-financial FTSE (U.K.) firms from 1996 to 2005. Annual balance sheet and income statement data are taken from the Osiris Database held by Bureau van Dijk. I also make use of data on forecasts of future profits for each individual company, issued each month by professional securities analysts, and released by Institutional Brokers Estimate System, a service by Thompson Financial. These data allow me to construct an indicator of the level of expected profits uncertainty facing a particular firm in a given period, based on the disagreement or dispersion in the profits' forecasts issued by different analysts for that firm at that time.

The regression results lend empirical support for the model's theoretical prediction, showing a negative and statistically significant effect of forecasts uncertainty on firm's leverage. However, the baseline regression outcome documents also that firms with lower leverage have a higher level of performance, a result which casts some doubts on the ex-post effectiveness of debt as a value-enhancing discipline device against agency problems.

In the last part of the paper, I further investigate this issue to discover whether negative relationship between leverage and *Q* is driven by firms' heterogeneity in growth opportunities and agency characteristics. To this purpose, I estimate a censored normal regression model where the dependent variable is a measure of potential agency costs, proxied by an indicator of low growth opportunities multiplied by balance sheet's free cash flow (as in Doukas *et al.*, 2000; Doukas *et al.*, 2005) and endogenous leverage is one of the regressors. The new results are consistent with the agency costs literature, since the censored model lends empirical support to the view that the level of debt plays a positive effect in reducing the potential non-value-maximizing conduct of managers. At the same time, the negative coefficient of cash flow uncertainty in the first stage's leverage equation remains statistically significant, consistent with the theoretical prediction of the theoretical framework.

The rest of the paper is organized as follows. The theoretical model is developed in Section 2. The shareholders optimal debt choice and comparative statics on the optimal debt level are

reported in Section 3. The effects of uncertainty of the mean of the cash flow in reported in Section 4. A discussion of the implications of prior belief follows in Section 5. Section 6 summarizes the empirical implications of the model. Section 7 describes and discuss the empirical methods and the testing strategy, while section 8 presents the main findings. Section 9 concludes the paper. Appendix collects all the proofs.

$t = 1$	$t = 2$	$t = 3$	$t = 4$
The level of debt F is chosen by the board	First cash flow realization (from assets in place) R_1 is observed. The manager updates her belief about the mean of the cash flow distribution. According to a *cash rule*, the manager invests all the cash flow net of the cash held for debt payment (at time $t = 3$)	Second cash flow realization (from assets in place) R_2 is observed. All debt is paid back	Investment pays off. The firm is liquidated

2 The model

Consider the following model, whose baseline version was firstly laid out by Stulz (1990). Assume that capital markets are complete with no transaction costs. A firm, consisting of assets in place and investment opportunities, exists at four given dates: 0, 1, 2, 3. The firm's assets in place at date 0 yield, at dates 1 and 2, a non-negative cash flow, which is assumed to be randomly distributed, that a manager can either invest in new projects or pay out. The firm has also investment opportunities at date 1 that managers and shareholders want to exploit, but at date 0 it does not. The available investment opportunities are assumed to fall into two ranges: value increasing (good) investments and value decreasing (bad) investments.[5] At date 0, the board of directors choose a debt level as in Stulz (1990), based on expectations of future cash flow. In the second one, a realization of cash flow is observed; the manager updates her beliefs about the cash flow distribution, and invests all the cash flow net of the cash held for debt

[5]Recently, such specification for the investment function is also assumed by Morellec (2004) and by Morellec and Smith (2007).

payment. In the third period, a second realization of cash flow is observed, and the debt payment is made. Finally in the fourth period, the returns from investment are realized. The time line of the firm is depicted above.

Although manager-shareholder conflicts may take different forms, I introduce this agency problem by presuming that the manager receives private benefits from any investment. As in Stulz (1990), a stringent assumption is considered, in that it always is optimal for the manager to invest. Agency costs of managerial discretion typically depend on the allocation of control rights within the firm. Consistent with previous literature,[6] we may assume shareholders as represented by a stockholder-elected board that acts in their best interest, by choosing a capital structure which maximizes shareholder value. From a contract-theoretic perspective, bankruptcy laws ensure that management can credibly pledge to honor the debt contract decided by the board. However, the board cannot dictate investment policy because investment decisions, although observable, are not verifiable and, thus, are not contractible.[7]

The board of directors maximizes firm value by choosing a debt level in period one. It knows the distribution of the cash flow R, which is a random variable taken from a normal distribution with mean μ and variance σ^2, which is assumed known. After the manager observes the cash flow realization R, she updates her belief about the mean of the cash flow realization. To this end, I now introduce an assumption which implies this decision process. I employ a simple Bayesian updating approach previously suggested, *inter alia*, by Holmström (1999) in the context of his "career concerns" model.[8] The manager shares the prior belief about the cash flow with the shareholders, and we assume that her prior is normally distributed with mean m and variance τ^2.[9] Since a posterior constructed from a normal prior and a normal

[6]For example, Westphalen (2002) or Morellec and Smith (2002).
[7]Anyway, in what follows, I use the terms shareholders and board as synonyms.
[8]While other Bayesian updating representations could ostensibly be used, the normal conjugate importantly allows for tractable results.
[9]The normal distribution is a reasonable choice for the prior distribution of the mean, for several reasons. First of all, the normal distribution is quite flexible, since the prior mean can take any value along the real line, while the prior variance can be chosen so that our prior beliefs are influential determinants of the posterior mean and variance. Besides, the normal distribution may be a close representation of our prior beliefs, if our prior beliefs are symmetric and uni-modal about some point along the real line. Finally, it is conjugate, so the posterior will be normal. Bayes' theorem moves from one member of the conjugate family to another member. Because of this, we don't need to perform the integration in order to evaluate the posterior.

stochastic variable is also normal, a simple updating rule exists for the posterior belief of the mean of the cash flow (Bolstad, 2007).

Assumption 1 *Let the learning process of the manager satisfy*:

$$m' = R - \frac{\sigma^2}{\sigma^2 + \tau^2}(R - m) \qquad (1)$$

The posterior, m', is the manager updated belief about the expected value of the cash flow, after observing a realization of the cash flow variable. Obviously, if the observed cash flow is greater (less) than the estimated mean, m, the mean of the posterior, m', increases (decreases). The manager bases her investment decision on the updated belief of cash flow.

Following Stulz (1990), the manager has infinite investment opportunities to pursue. Let the first I^* investment be value-increasing (good) projects and any investment beyond I^* be value decreasing (bad) projects.[10] Furthermore, I assign rates of return to the good and bad investments to be p_G and p_B, respectfully. The rate of return of the good investments, p_G, is greater than zero, while the rate of return from bad investments, p_B, is less than zero.

The debt payment is made at date three and the returns from the investment are realized at date four, so the manager must hold some cash in the second period to repay the debt and avoid possible default. Within the literature, the manager is modeled to either expand all cash flow to fund all available investment projects regardless of expected return (Jensen, 1986; Stulz, 1990; Hart and Moore, 1995) or abscond with all cash flow outright (Fluck, 1996, Hart and Moore, 1998). In this model the manager is less opportunistic, because here she is assumed to face some costs of bankruptcy and, therefore, holds cash for the future debt payment. The problem is to model the manager's action as a simple rule justified by the evidence. In the recent literature on ownership and control is commonly assumed that managers are risk-averse.[11] The main reason why self-interested managers are assumed to be risk-averse is the fear of bankruptcy. It is even argued that managers have a tendency to be more risk averse than shareholders, because outside

[10]The exact form of the manager's utility function is not an issue here. However, it seems reasonable to assume a decreasing marginal utility of consuming perquisites and over-investing. For tractability reasons, I assume, as in Stulz (1990), Vogt (1994) and Morellec (2004), a manager whose utility is linear in the currency amount of investment. This specification allows us to capture Jensen's idea that the overinvestment problem is more severe for firms that generate large cash flows.

[11]For an overview, see Grinblatt and Titman (2002).

shareholders can avoid unsystematic risk by means of diversification. On the empirical side, Opler *et al*. (1999) concludes that a significant amount of cash holding within the corporate structure is attributable to manager's risk aversion.

Consistent with this literature, I hypothesize that the representative manager acts to shield himself from an imprecise prior, according to a cash holding function which I assume to depend upon the updated belief of the mean cash flow.

Assumption 2 *Let the cash holding rule of the manager satisfy*:

$$F - \theta_1 m' - \theta_2$$

where F is the amount of debt due in next period, m' is the updated belief of the mean of the cash flow, θ_1 and θ_2 are the cash holding rule parameters that capture the relevant characteristics of the manager and any bankruptcy costs borne by the manager. This characterization acknowledges the possibility of reputational and other costs, here expressed by two parameters included in the rule. First, a parameter, θ_1 $(0 \le \theta_1 \le 1)$, measuring the manager's risk aversion and any bankruptcy costs due unprofitable empire-building investments. Second, a measure of the effects of the precision of the prior estimate of the mean of the cash flow distribution, θ_2, is included. If $\theta_1 = 1$ and $\theta_2 = 0$, the manager holds the amount of the debt payment minus the expected value of the next period's cash flow. As the reputational costs of bankruptcy increase and/or the manager's aversion to risk increases, θ_1 decreases, so that the manager holds more cash for the repayment of the debt. As to the other parameter, it is worth to note that θ_2 is an increasing function of τ^2. In this construction, θ_2 captures the relationship of reputational and other costs to the precision of the prior. If $\theta_2 = 0$, there are no additional costs borne out by the manager with respect to the prior, while if it increases, it lets the cash holding rule capture the manager's desire to shield himself from an imprecise prior. This development of the cash holding rule is therefore consistent with the recent empirical studies on corporate cash holdings cited above.

As derived in Appendix 1, the shareholder's problem simplifies to the following:

$$V(F/m) = E(R_1) + E(R_2) + \int_{F-\theta_1 m-\theta_2}^{\infty} I^* p_G g(R_1) dR_1 + \int_{F-\theta_1 m-\theta_2}^{F-\theta_1 m-\theta_2+I^*} (F-\theta_1 m' -\theta_2 + I^* - R_1) p_G g(R_1) dR_1 +$$
$$+ \int_{F-\theta_1 m-\theta_2}^{\infty} (F-\theta_1 m' -\theta_2 + I^* - R_1) p_B g(R_1) dR_1$$

Here, $V(F/m)$ is the value of the firm. The cash flow from assets in place, R_i, is a nonnegative stochastic variable with a cumulative distribution function $G(R_i)$ and differentiable density $g(R_i)$ which is strictly positive for all $R_i > 0$ (i =1,2). F, the firm's negative net financing, is the choice variable, and m is the prior estimate of the mean of the cash flow distribution. The posterior of the estimated mean of the cash flow distribution, m', is as defined in Assumption 1.

Without managerial discretion, the value of the firm would be the expected value of the cash flow realizations and the return from the optimal level of investment, assuming the cash flow is large enough to finance the optimal investment level. The first three expressions, in the above value function, represent the value of the firm without sub-optimal investment. The last two expressions are the costs of managerial discretion. The second to last expression is the expected cost associated with under-investment. If the first realization of cash flow is less than the cash holding rule plus the optimal level of debt, some of the positive *NPV* investments are forgone. The value of the firm is reduced by the return lost by not pursuing the optimal level of investment. The last expression is the expected cost associated with over-investment. If the first realization of cash flow is greater than the sum of the optimal investment level and the cash holding rule, the residual cash flow is invested in value-decreasing investments. The value of the firm is reduced by the losses generated by these bad projects.

Furthermore, it must be noted that I assume that the manager cannot raise additional financing in the second period. If the cash in the second period is less than the cash holding rule, the manager is assumed to liquidate the firm at a value of $E(R_2)$. The assumption of the liquidation value of the firm is made for notational ease and does not change the results of the model. Investments are assumed to be specific to the assets in place and the current manager. The interest rate is assumed to be zero for analytical simplicity.

3 Optimal debt level

This section shows that a solution to the simple stakeholder optimization problem exists and analyzes the relevant comparative statics at the optimal debt level. The board of directors chooses the optimal level of debt to constraint the manager from financing value-decreasing projects, at the potential cost of the manager investing less than the optimal level of investment. The board knows the optimal level of investment, the manager's cash holding rule parameters, the estimated mean of the cash flow distribution, the precision of the estimate and the true variance of the cash flow distribution.

Proposition 1. *If the value of the firm increases by issuing a positive amount of debt in the neighborhood of* $F = \theta_1 m + \theta_2$*, then a single finite optimal debt level exists.*
Proof. *See Appendix 2*

The existence and sign of the first and second derivative of the value function guarantee the existence of an optimum. The second derivative is negative for all non-negative values of F under the restriction of $F \geq \theta_1 m + \theta_2$. This restriction prevents the manager from holding more cash in the first period than the firm owes in the third period. The manager would not do otherwise, since her incentives are tied to investing all possible cash flows.

The board chooses the optimal debt level to balance the costs associated with under-investment and over-investment, given the estimated mean of the cash flow. Not surprisingly, the solution equates these marginal costs:

$$\int_{F-\theta_1 m-\theta_2}^{I^*} p_G g(R_1) dR_1 + I^* p_G g(F-\theta_1 m-\theta_2) = -\int_{I^*}^{\infty} p_B g(R_1) dR_1 \qquad (2)$$

The right hand side of the above equation is the marginal cost of over-investment and the left hand side is the marginal cost of under-investment. For the firm to issue debt at all, the marginal cost of over-investment has to exceed marginal cost of under-investment when F=0. The debt level that satisfies this condition is the optimal debt level, given the estimated mean of the cash flow distribution.

Proposition 2. *The optimal level of debt,* F^* *is: (i) decreasing in the return from the good investment,* p_G*, and increasing in the return from bad investment,* p_B*; (ii) decreasing in the optimal level of investment,* I^**; (iii) increasing in the estimated mean of the cash flow,* m*; (iv)*

increasing in the cash holding parameters, θ_1 and θ_2.
Proof. *See Appendix 3*

The results are intuitively straightforward and *(i)* and *(ii)* are consistent with those of Stulz' (1990) seminal model. If the rate of return on good investment increases, the marginal cost of under-investment increases. In other words, the shareholders are more concerned with possible under-investment than before and the level of debt should be decreased to compensate for the increase in the rate of return on good investment. Similarly, if the rate of return on the bad investment increases, the marginal cost of over-investment decreases. The stockholders are less concerned about over-investment and the optimal level of debt decreases.

If the firm's optimal level of investment increases, the cost associated with under-investment increases and the costs associated with over-investment decreases. The optimal debt level decreases. In this manner, the manager has more cash flow to pursue the additional value-increasing investments.

Parts *(iii)* and *(iv)* of the proposition analyze the effects of the manager's cash holding rule. These are new findings of this model. The manager is assumed to hold a scalar multiple of the estimated mean of the cash flow to repay the long-term debt in the third period. An increase in the scalar increases the amount of cash the manager will hold for this repayment and decreases the amount available to finance investment. This increases the marginal cost of under-investment and decreases the marginal cost of over-investment. Thus, the optimal debt level decreases with the increase in the manager's cash holding parameter. For example, a more risk-averse manager could be characterized to have a larger cash holding parameter, θ_1. The board knows the manager is more risk-averse and can reduce the optimal level of debt accordingly.

The cash holding precision parameter, θ_2, captures the effects of the uncertainty surrounding the cash flow distribution. This parameter is included to capture the effects of the precision on the reputational and bankruptcy costs borne by the manager. If she is risk-averse, the cash holding precision parameter will be greater than zero. The manager will hold additional cash for the repayment of debt and, thus, the shareholders can reduce the amount of debt used to prevent over-investment.

The estimate of the mean of the cash flows affects the optimal level of debt in a way similar to the effect of the cash holding scalar. The optimal level of debt is increasing in the estimated mean.

4 Effect of the uncertain mean

The effects of the uncertain mean are dependent upon the value of the realization of the cash flow the manager observes. I divide the analysis into two cases.

4.1 Over-investment

In the first case, the manager observes a high cash flow state and updates her beliefs. The observed cash flow is greater than the estimate; thus the updated estimate of the cash flow mean is greater than the prior estimate. Since the manager believes the prospects of the ongoing concern are better than expected, she reserves less cash for the repayment of the debt. This reduction in the amount of cash held increases the size of the investment made by the manager.

Proposition 3. *If the observed realization of cash flow is greater than the estimated mean of this variable, the manager finances more investment than expected by the stakeholders, i.e. managerial discretion increases*.
Proof. *See Appendix 4*

The manager updates her beliefs after observing a realization of the cash flow. Her updated estimate of the mean is greater than her prior and, therefore, the manager invests beyond the level intended by the board. If the manager could not update her beliefs, or invest based on those beliefs, she would invest less.

4.2 Under-investment

Similarly, in the second case, the manager observes a low cash flow state and updates her beliefs. Since the updated estimation of the mean is less than the previous estimate, she under-invests.

Proposition 4. *If the observed realization of cash flow is less than the estimated mean of this variable, the manager finances less investment than expected by the stakeholders, i.e. managerial discretion increases*.
Proof. *See Appendix 5*

Author

This case is similar to the above case. If the manager could not update her beliefs, or invest based on those beliefs, she would invest more and the managerial discretion increases beyond the level established by earlier literature.

5 Discussion of the prior belief

We have shown that the level of managerial discretion within a firm can change with the informational content of the cash flow realizations. When the manager observes a value of cash flow different from the estimated mean, she updates her belief about the mean of the cash flow distribution, thus leading to under- or over-investments. The remaining question to be explored is the effect of the precision of the estimate of the mean of the cash flow. The precision of the estimate of this variable determinates the informational content of the first realization of the cash flow.

Proposition 5. *The magnitude of the increase in costs from managerial discretion increases in the variance of the stakeholders estimated mean of the cash flow distribution*.
Proof. *See Appendix 6*

Let $I^{UNDER/OVER}$ be the managerial discretion agency cost (under-investment or over-investment) and τ^2 the variance of the estimate of the mean of the cash flow distribution, the proposition above set an increasing relationship between the two terms. In other words,

$$\frac{d\, I^{UNDER/OVER}}{d\, \tau^2} \geq 0$$

holds. The precision of the estimate affects the outcome of the model in two ways. First a more precise estimate of the cash flow allows the stakeholders to better control the manager's action by choosing the optimal debt level. Second, the informational content of the estimate, as a result of the precision of the estimate, determines the extent to which the manager updates her beliefs after observing the cash flow.

6 Empirical implication

The theory's key empirical implication concerns how firms should choose their capital structure according to the effect of the information environment on the agency cost of free cash flow. As

emphasized above, the ability of debt to restrict a manager's value decreasing actions is reduced if the distribution of the cash flow is not known with certainty. In the model, uncertainty is introduced in the form of an unknown mean of the cash flow distribution. When the observed cash flow is greater than the shareholder's estimate of the mean, the manager finances value-decreasing investments beyond the level he would choose under certainty. Otherwise, when the observed cash flow is less than the shareholders' estimate of the mean, the manager under-invests and some *NPV* projects are not pursued. The magnitude of both of these value-reducing actions by the manager decreases with the precision of the shareholders' estimate of the mean of the cash flow. The related empirical implication derives directly from Proposition 5:

Implication *The ability of debt to restrict managerial discretion is dependent upon the precision of the estimate of the cash flow distribution, so firms with high variance between different financial analysts' predicted value of future cash flow (or earnings), should be observed to carry less debt in their capital structures*.

The crux of the model is that the optimal debt level is chosen without perfect information about the cash flow distribution. Prior research has skirted around the fact that characteristics of the cash flow determine those of the instruments used to finance the firm. The theoretical contribution has shown, within a simple agency cost model, that not only the characteristics of the cash flow distribution are important, but the certainty of the knowledge surrounding the cash flow distribution as well as the informational content of individual cash flow realizations is significant.

7 Empirical tests

This section focuses on the empirical strategy, in order to test the implications of my theoretical model. The main implication of the model developed in previous sections is that if leverage plays some disciplining role on potential managerial discretion costs, consistently with the agency cost theory, then it should be negatively correlated to the dispersion of earnings forecasts. Leverage level, in turn, should have a value enhancing effect on firm's performance. In order to implement a test to this argument, I need to specify an empirical model relating firm's performance to leverage and showing how the interplay of earnings forecasts uncertainty and financing choices impinges upon firm valuation. I will tackle this issue shortly. Since the following empirical

analysis is going to make use of earnings' forecasts dispersion as a measure of uncertainty, I presents a preliminary discussion of this connection. Then, I describe the firm-level data used in my tests and the empirical model.

7.1 The relationship between forecast disagreement and earnings uncertainty

The question of how to evaluate evidence and assess confidence has been investigated experimentally by psychologists and decision researchers. To use an analogy from the psychology literature, consensus forecasts can be understood as a letter of recommendation for a stock. In their seminal paper on the weighing of evidence and formation of beliefs in human thought, Griffin and Tversky (1992) use the example of a letter of recommendation for a graduate student written by a former teacher to illustrate how people form beliefs. They point out that one should consider two separate aspects: how positive it is and how credible or knowledgeable the writer. In the context of earnings forecasts, it is possible to distinguish between the strength of a recommendation, which is equivalent to the upward or downward changes in earnings expectations, and of its weight or validity, which is represented by the dispersion in forecasts.

The first point to note is that what is not being measured by disagreement is a subjective assessment of earnings uncertainty. That is, we have no data on how confident any of the forecasters is about his/her point estimate. In theory, a group of forecasters could all agree about the mean of the distribution while each being hugely uncertain. Conversely, they could all place enormous confidence in their own estimates while differing from each other. Despite this possibility, it is common practice throughout the social sciences to view the variation across a survey of respondents' assessments of an unknown quantity as a proxy for the true uncertainty in their environment. Intuitively, an observer of the survey with no other information about the quantity, or about the respondents, might well view each estimate as being as good as the next, and so treat them as separate noisy signals of the true value. In aggregating this information, the observer would then construct a posterior distribution whose variance would be directly proportional to the variance across signals.

This interpretation raises some concern anyhow. First of all, there is no consensus explanation for analysts' behavior in the burgeoning literature about the properties of earnings

expectations.[12] Besides, it is still not clear if and how much the level of dispersion and the forecast itself may be a function of some incentives or distortions.[13] Nevertheless, it is worth noting that Keane and Runkle (1998) find no evidence that analysts profit forecasts deviate from rational expectations. Besides, since the focus of this paper is about the effect of differences in dispersion across stocks on firm leverage, issues of bias or incentives matter less.

There is empirical support for viewing disagreement as a proxy for uncertainty surrounding the expected value of a variable. In a review of the literature concerning forecasts of earnings by analysts in the U.S., Givoly and Lakonishok (1984) argue that the level in earnings forecasts is perceived by investors as valuable information about the level of uncertainty concerning firms' future economic performance, but the evidence reported in the first empirical research is mixed and difficult to interpret, because the tests are based on (summary) dispersion measures heavily influenced by old and outdated forecasts.[14] The development of standardized methods and processes for collecting and using these data has however evolved rapidly over the last two decades. Barron *et al.* (1998) and Barron and Stuerke (1998), by using a detailed analyst earnings forecast dataset to estimate dispersion and revision proxies, provide strong evidence consistent with arguments that dispersions in earnings forecasts can be used by market participants as an indicator of uncertainty about firms' future economic performance. More recently, Bond and Cummins (2004) and Bond *et al.* (2004), consider some indicators based on summary analysts' forecasts to investigate the empirical relationship between company investment and uncertainty about expected future profitability. A number of other studies have also related disagreement among inflation forecasts to uncertainty about inflation. For example, Mankiw *et al.* (2003) have argued that disagreement about expected inflation may be a key to better understanding macroeconomic dynamics. However, Zarnowitz and Lambros (1987) caution that disagreement and uncertainty are distinct concepts, even though they turn out to be positively correlated in their sample of professional inflation forecasters. Bomberger (1996, 1999) compares the

[12]A survey is provided by Kothari (2001).

[13]For example, Leuz *et al.* (2003) suggest that managers can abuse accounting discretion to expand or maintain private control rights and to prevent outside monitoring. Bernhardt and Campello (2007) show that successfully managing analyst forecasts is a primary determinant of weather a firm generates a positive earnings surprise. On the other hand, there is empirical evidence (e.g., Bhat *et al.*, 2006) of a positive association between proxies of governance transparency and forecast accuracy, in countries that mandate extensive disclosure (such as the U.S. and the U.K.).

[14]For example, Daley *et al.* (1988) and Stickel (1989).

dispersion of inflation forecasts from the Livingston survey to subsequent realized variance of forecast errors and also finds a strong positive relationship.

Therefore, caution is warranted in extrapolating to the current setting. Yet, these findings suggest that the link between the divergence of opinion among analysts and uncertainty of the underlying earnings rests on solid ground. The following analysis will build on that foundation, taking that nexus as a maintained hypothesis.

7.2 Sample selection criteria

I use firm-level accounting and share-price data for UK-quoted companies over the period 1996-2005 with data available from the Osiris database, provided by Bureau van Dijk.[15] Then, I merge balance sheet data with analysts' earnings forecasts, obtained from the Institutional Brokers Estimate System (I/B/E/S) database, a service of Thomson Financial, which covers a sub-sample of UK-quoted companies from 1987 onwards.[16]

To build the panel, I started with an initial sample of 308 companies taken from Osiris. Firms under the direct or indirect control of the government, banks, insurance companies and other financial companies and firms with non reported industry code are set aside from the sample. To ensure the reliability of the data, I exclude firms which are reporting non credible values such as negative debt and negative total assets. To ensure that outliers do not drive the results, the extreme low and high 1**%** of each variable are winsorized. I avoid exacerbating the sample by not requiring a balanced panel (Baltagi, 2001).

Data on analysts' profits forecasts are kindly made available by I/B/E/S International Inc. I/B/E/S reports forecasts only from analysts who meet a set of criteria designed to ensure that they are well informed about the business situation of individual companies. The forecasts we use were issued early in the current-year accounting period, and comprise forecasts of earnings

[15]Osiris is a comprehensive database of listed companies, banks and insurance companies around the world. In addition to the income statement, balance sheet, cash flow statement and ratios, this database contains (where available) news, ownership, subsidiaries, ratings, earnings estimates and stock data to make it a well-established source of global listed companies' information. Bureau Van Dijk also provides its products to Universities and Business schools, which use the databases for research information.

[16]I/B/E/S data are available for over 45 countries and over 12,000 companies. I/B/E/S International Inc. created its Academic Research Program over 30 years ago to provide both summary and individual analyst forecasts of company earnings, cash flows, and other important financial items, as well as buy-sell-hold recommendations. I/B/E/S is available electronically through Wharton Research Data Services (WRDS), a database centre maintained by the Wharton School of the University of Pennsylvania.

per share for the current year and for the following year. I/B/E/S reports the (unweighted) mean of the analysts forecasts issued for a particular firm, known as the consensus forecast, as well as the standard deviation across these individual forecasts. I make use of both the mean and the standard deviation in our measures of expected uncertainty, since it is a mean of coefficients of variations during the accounting year. The measure of earnings corresponds to that agreed on by the majority of analysts tracking a particular firm. In broad terms, this definition corresponds to a measure of net profits after interest and taxes, and it removes a larger set of non-recurrent items than extraordinary items reported in published accounts. In addition to the availability of accounting and stock market data, I require that firms were tracked by at least two securities analysts in the mean of the year. This requirement likely introduces a sample selection bias, although to the extent that selection into the set of firms tracked by multiple analysts is determined by time-invariant characteristics, this should be controlled for by the inclusion of firm-specific fixed effects in the econometric specifications.[17] The final sample forms an unbalanced panel of 188 publicly-traded companies (1111 firm-year observations) for estimation.[18]

7.3 Testing strategy

In this section, I first introduce a model specification that captures the argument I propose. I subsequently describe the implementation of empirical proxies for the variables considered.

7.3.1 The model

My empirical analysis is based on the following estimation framework. First, I identify exogenous variations in firms' financial structure induced by factors that do not directly affect firm value. Second, I investigate whether the exogenous variations in leverage induce firms to change their performance. The reason for considering exogenously driven variations of the firm's financial structure is that a straight regression of firm's performance measure on leverage would be subject to serious endogeneity problems. Causality may run in both directions.[19] At the same time, the theoretical model in the previous section, predicts that disagreement across future earnings forecasts may negatively affect leverage. I test the empirical validity of such a

[17]Clearly, the condition would have been stronger if it was imposed month-by-month.
[18]A list of U.K. companies included in the sample is available upon request.
[19]On this point, see, e.g., Nucci *et al.* (2005).

relationship and weather the interplay with leverage affect only indirectly firm value. I adopt the following instrumental variable specification:

$$\begin{cases} Q_{it} = \alpha_q + \beta_q Lev_{it} + \mathbf{X}_{it}\gamma_q + \eta_i + u_{it} \\ Lev_{it} = \alpha_{lev} + \mathbf{Z}_{it}\beta_{lev} + \mathbf{X}_{it}\gamma_{lev} + \upsilon_i + w_{it} \end{cases}$$

where Q_{it} is the measure of performance of firm *i* at time *t* and Lev_{it} is the leverage of firm *i* at time *t*. The leverage regression is the first stage equation, X_{it} and Z_{it} denote vectors of observable exogenous variables, η_i and υ_i reflects the fixed latent heterogeneity and u_{it} and w_{it} are random error terms, assumed to be independently and identically distributed (i.i.d.) with mean zero and variance σ_j^2 ($j = u$ or w). The coefficient's vectors are denoted with the initial of the dependent variable they belong to, and I estimate the above equation using the fixed effect instrumental-variable estimator, which accounts for within-firm variations in the dependent variable.

7.3.2 Implementing empirical proxies

In this section, I describe the variables used in the empirical specification (see also Table 1 below).

Tobin's Q. Following a common practice in the agency literature,[20] the explanatory variable to measure firm performance is the Tobin's *Q*-ratio.[21] Hermalin and Weisbach (1991: 104) state that in the absence of market power, "a divergence of *Q* from one represents the value of the assets not included in the denominator of *Q*, such as the value of the internal organization or the value of expected agency costs. A *Q* above one indicates that the market views the firm's internal organization as exceptionally good or the expected agency costs as particularly small." It is not trivial to note that the way we are using *Q* here is not the same as in the investment literature, where it is interpreted as measuring the marginal increment to profitability from the investment decision. Here *Q* merely captures the effectiveness with which given managers operate their capital stock, so it is mainly a measure of performance. There remain of course

[20]For example: Morck *et al.* (1988), Hermalin and Weisbach, (1988; 1991), McConnell and Servaes (1990), Agrawal and Knoeber (1996); Short and Keasy (1999). Interestingly, all of these studies empirically investigate what is the relationship between managerial ownership, voting control or other governance mechanism, and firm performance, measure by Tobin's *Q*.

[21]It might, in fairness, be called 'Tobin and Brainard's q' since the concept now known as Tobin's q was first introduced (and discussed at length) in Brainard and Tobin (1968).

substantial difficulties in accurately measuring *Q*, for instance we observe the book value of the company, rather than the replacement cost of the assets which is probably the more relevant measure. Because of the impracticality of calculating the theoretical *Q*, as estimated by Lindenberg and Ross (1981) and Lang and Litzenberger (1989), this work uses a simplified version of Tobin's *Q*, which is defined as the ratio of market value of total assets to the book value of asset. The market value of total assets is defined as: book value of asset less book value of equity (*BE*) plus market value of equity (*MCAP*). *BE* is calculated following Fama and French (1997) as stockholders' equity, plus balance sheet deferred taxes.[22]

Leverage. Following Datta *et al.* (2005) and Aggarwal and Zhao (2007), leverage is defined in market terms, that is, as the ratio of total debt to the market value of total assets. There is no clear consensus in the empirical literature on whether firm's leverage should be measured in book or market terms. On the one hand, Barclay *et al.* (2003) point out that book leverage is theoretically preferable in regressions of financial leverage, arguing that using market values in the denominator might spuriously correlate with explanatory variables, such as Tobin's *Q*. On the other, Welch (2004) strongly argues against book leverage in favor of market leverage since, in his words, "the book value of equity is primarily a "plug number" to balance the left-hand side and the right-hand side of the balance sheet - and it can even be negative." (Welch 2004: 125). In light of this controversy, as a robustness check, I also rerun my regressions using some alternative measures of book leverage, but all the results (not reported, to save space) are quite robust to changes in the definition of leverage ratio.[23]

Other variables. In order to instrument leverage, this study selects the following variables ($\mathbf{Z}_{it}$): a) *Tangibility*, measured as the ratio of net Property Plant and Equipment (*Net PPE*) to Total Assets.; b) *Earnings forecasts dispersion*.

[22]Due to data availability limitations, we not include the last part of Fama and French's (2002) calculation of *BE*, namely: investment tax credit and postretirement benefit liabilities, minus the book value of preferred stocks order of the redemption, liquidation. All of these, however, are suggested by the authors according to their availability.
[23]In principle, book and market leverage may also move in opposite directions. This intuition is supported by several studies (e.g. Fama and French, 1992; Gomes and Schmid, 2007), who document different cyclicality properties of book and market leverage ratios: whereas market leverage moves strongly counter-cyclically, book leverage is strongly pro-cyclical (Covas and Den Haan, 2006).

The first instrument, *Tangibility*, is a definition of collateral assets (e.g., Baker and Wurgler, 2002) and has a long tradition of explanatory variable in leverage equations.[24] Previous empirical studies[25] argue that this or similar measures of collateral assets (e.g. the ratio of fixed assets over total assets) are an important determinant of leverage. However, the direction of influence is not *ex ante* clear. On the one hand, alleviating the classical bondholder-shareholder conflict (e.g., Galai and Masulis, 1976; Jensen and Meckling, 1976) with more tangible assets, the creditors have an improved guarantee of repayment. Moreover, tangibility increases the value of assets in case of bankruptcy.[26] Even in the worst state, firm assets retain more value in liquidation. Accordingly, the trade-off theory predicts a positive relationship between measures of leverage and the proportion of tangible assets. On the other hand, managers of highly levered firms will be less able to consume excessive perquisites, since bondholders more closely monitor such firms (Grossman and Hart, 1982).

The other chosen instrument, in the debt equation, is represented by *Earnings forecast uncertainty*, measured by the *Dispersion* in earnings forecasts, which will be illustrated in the subsection below. From a theoretical point of view, the theoretical model shows a way this variable can affect the choice of the debt level. In that setting, optimal capital structure is determined by trading off benefits of managerial access to funds for good investment opportunities with costs of access to bad ones. Since magnitude of the costs from managerial discretion is shown to be an increasing function of the precision of the stockholders' forecasts, a low dispersion in the expected cash flow (here proxied by expected earnings) would allow them to better control the manager's action by choosing the optimal debt level. As a consequence, I predict a negative relationship between forecasts' uncertainty and leverage. Instrument validity requires that the first variable do not explain *Q*.

[24]Campello (2007) empirically examines the role of asset tangibility in influencing firm performance under external financing. Toward this end, he explicitly considers the potential for endogeneity in tests involving asset tangibility. His strategy builds on the notion that managers' incentives to adopt performance-enhancing policies under external financing grows with the tangibility of their firms' assets after financing takes place. Although my empirical strategy, as prior research studies, considers tangibility only as an exogenous characteristic in the leverage equation, the two stage model I present, also recognizes a "moral hazard problem" of firm performance under external financing, but it attempts to understand this interplay under expected earnings uncertainty.
[25]For example, Titman and Wessels (1988), Rajan and Zingales (1995), and Fama and French (2002).
[26]As Booth *et al.* (2001, p. 101) state: "The more tangible the firm's assets, the greater its ability to issue secured debt".

Although some empirical evidence shows that the dispersion effect may be a manifestation of financial distress[27] (Avramov *et al.*, 2008), therefore justifying a negative correlation between analysts' earnings forecast dispersion and leverage along the traditional lines, it is not trivial to note that corporations selected for coverage by analysts are likely to be relatively profitable firms in industries of interest to I/B/E/S customers. Carpenter and Guariglia (2006), commenting a passage of a paper by Cummins *et al.* (2006),[28] signal that firms facing constraints are less likely to be followed by I/B/E/S analysts. It seems reasonable to suppose that the empirical sample used in the present research is biased towards financially healthy firms, which would not normally be the focus of a study on the potential for financing constraints to affect performance.

As for the exogenous variables ($\mathbf{X}_{it}$) that determine both *Q* and leverage, this study includes: a) *Profitability*, measured the ratio of Earnings Before Interest, Taxes, Depreciation and Amortization (*EBITDA*) to Total Assets; b) *Size*, measured by the natural logarithm of Total Assets in 1996 million pounds.

Profitability is considered to explain the past and potential future performance of a firm. This idea is traditionally consistent with sales accelerator models: higher levels of sales enhance the production capacity in order to meet an enlarged demand (Fazzari *et al.*, 1988). So, firm's market value, whatever measured, should be related to profitability of the firm as well as current profits. However profitability may be due to factors other than profitable growth opportunities (e.g. market power). To the extent that realized profitability is positively correlated with profitable growth opportunities and with managerial ability, this is consistent with the agency approach. Nonetheless, it is also consistent with Myers' pecking order hypothesis, which states that more profitable firms have more internal financing available and, therefore, rely less on external financing, including debt. By contrast, there are no consistent theoretical predictions on the effect of profitability on leverage, especially on market leverage,[29] even if it is often included as explanatory variable. From the point of view of the trade-off theory, more profitable companies should have higher leverage, because they have more income to shield from taxes.

[27] As proxied, e.g., by credit risk.
[28] In an earlier version of their paper, Cummins *et al.* (1997) state: "Our results suggest that the constrained group excludes firms covered by securities analysts, consistent with theories based on asymmetric information." (1997: 28)
[29] When leverage is measured in book terms, accounting rules imply that the book value of equity increases with historical cash flows and decreases with asset depreciation. So, not surprisingly, profitability and fixed assets are the important predictors of book value based debt ratios (e.g., Shyam-Sunder and Myers, 1999).

The free-cash-flow theory would suggest that more profitable companies should use more debt in order to discipline managers, to induce them to pay out cash instead of spending money on inefficient projects. On the other hand, from the point of view of the pecking order theory, firms prefer internal financing to external one. So, more profitable companies have a lower need for external financing and, therefore, should have lower leverage.

As to the last common explanatory variable, company *Size*, it can be correlated in many ways with firm value (Moeller *et al.*, 2005; Connolly and Hirschey, 2005). For example, large firms may have greater agency problems, because it is harder to monitor them or because of the free-cash-flow argument *à la* Jensen (1986). Alternatively, small firms may have better growth opportunities and, as implied by the argument above, greater need for external finance and better governance mechanisms. For these reasons, we believe to use size not just in the leverage equation but also as a variable in the *Q*-regression. From the theoretical point of view, the effect of size on leverage is ambiguous, too. There may be several competing effects. Larger firms tend to be more diversified, exhibiting more stable cash flow. They also tend to fail less often, so size may be an inverse proxy for the probability of bankruptcy. Therefore, size should have a positive impact on the supply debt. On the other hand, some papers, e.g. Fama and Jensen (1983), point out that larger firms provide more information. This lowers information asymmetry, increasing the attraction of equity for investors (Rajan and Zingales, 1995).

Table 1 Accounting variable descriptions

Q	Tobin's *Q*, defined as the ratio of market value of total assets to the book value of asset. The market value of total assets is defined as: book value of asset - book value of equity (*BE*) + market value of equity (*MCAP*). *BE* is calculated following Fama and French (1997) as stockholders' equity, plus balance sheet deferred taxes and investment tax credit (if available). *MCAP* is defined as stock price times the number of shares outstanding at the end of the fiscal year.
Lev	Market Leverage, defined as the ratio of total debt to market value of total assets.
Size	The natural logarithm of total assets, in 1996 million pounds.
Tang	Tangibility, defined as the ratio of net property plant and equipment (*net PPE*) to total assets.
Profit	Profitability, defined as the ratio of earnings before interest, taxes, depreciation and amortization (*EBITDA*) to total assets.

7.3.3 Uncertainty measure

The particular measure of dispersion across individual analysts' earnings forecasts that I use, denoted *Disp*, is the mean of the coefficient of variation in the forecasts of earnings per share for each accounting period (Bond and Cummins, 2004). A scale invariant measure for each coefficient of variation is warranted because the variation across firms in the level of earnings per share reflects measurement in arbitrary, and economically meaningless, units. It is calculated from the earliest month on which at least two analysts issue a forecast. The intuition underlying this measure is that disagreement among analysts is likely to be lower when a firm's future profits are more certain. Since we observe only the mean and the standard deviation of the distribution, we are somewhat limited in the measures of relative dispersion we can compute. Practical considerations call for focusing on disagreement in the one-year-ahead forecasts; typically, we observe more analysts issuing forecasts for profits one year ahead than for longer time horizons. The *Coefficient of Variation* (*CV*), for the period indicated, expressed as a percent of the absolute value of the mean estimate, is a measure of the relative dispersion of estimates around the mean estimate. A small *CV* indicates a tight consensus (or, much agreement among the analysts). A large *CV* indicates that analysts disagree on the company's future. It is calculated as follows:

$$CV_i = \left(\frac{S_i}{\_x_i} \right) 100$$

where $\_x$ is the mean forecast, that is, the arithmetic average of estimates for the fiscal period indicated and *S* is the standard deviation, that is, the basic statistical measure of dispersion of estimates for the fiscal period indicated. The standard deviation is the average variance from the mean expressed in local currency.

The *Dispersion* (*Disp*) would then be calculated as follows:

$$Disp = \frac{\sum_{i=1}^{n} CV_i}{n}$$

where *n* is the number of estimates for the fiscal period indicated.

Author

7.3.4 Data Description

Table 2 displays summary statistics for the various accounting measure. The figures represent averages (medians) of firm's averages (medians) over the years. The data are not skewed at all, since the mean and median values roughly coincide. Notably, Tobin's *Q* has a mean (median) of 1.70 (1.46), which implies that the average (median) firm has valuable performance, and thus potentially facing under-investment problems. However, *Q* varies widely across firms as evidenced by the inter-quartile range of 0.75.

Table 3 contains a matrix of pairwise correlation coefficients among the alternative proxies chosen for Tobin's *Q*, Leverage, Tangibility, Profitability, Size and the measure of Forecasts' Dispersion. The matrix gives also Variance Inflation Factors (*VIF*) for all potential exogenous variable. There does not appear to be high correlation between any two of the explanatory variables. The only exception is between Profitability and *Q*, with correlation value higher than 50%. Importantly, the correlation between Leverage and the Dispersion measure is negative and significant, the same between Leverage and Tobin's *Q*. While the former result is consistent with the main prediction of the agency model of previous section, the latter contrasts with a disciplining and value-enhancing role for leverage and suggests that the relationship between leverage and performance should be subject to further empirical scrutiny.

Finally, to assess more directly whether multicollinearity is present, the Variance Inflation Factor (*VIF*) procedure is undertaken.[30] As can be observed from Table 3, none of the *VIF* values exceeds two, confirming that the sample data do not suffer from multicollinearity.

[30] $VIF(X_k)$ can be interpreted as the ratio of the actual variance of the estimated coefficient, $VAR(X_k)$, to what it would have been in the absence of multicollinearity. In the latter case, the coefficient of multiple determination, R_k^2, in a regression of the explanatory variable, X_k, on all other explanatory variables, is zero.

Table 2 Summary statistics for financial data (all firms)

Characteristic	Mean	Median	St. dev.	IQR*
Q	1.70	1.46	0.81	0.75
Lev	0.17	0.16	0.11	0.16
Tang	0.30	0.24	0.23	0.28
Prof	0.15	0.14	0.06	0.08
Size	13.7	13.6	1.27	1.7
Disp	7.75	4.95	9.65	5.35

The summary statistics are for an unbalanced panel dataset of 188 firms (1111 firm-year observations) from 1996 to 2005.
Tobin's *Q* (*Q*) is the ratio of the value of the firm divided by a proxy for the replacement value of assets. Market Leverage (*Lev*) is the ratio of total debt to market value of total assets. Tangibility (*Tang*), is the ratio of net property plant and equipment to total assets. Profitability (*Prof*) is the ratio of earnings before interest, taxes, depreciation and amortization to total assets. *Size* is the natural logarithm of total assets, in 1996 million pounds.
* IQR is the interquartile range, the distance between the 75th percentile and the 25th percentile.

Table 3 Correlation Matrix for Financing Data

	Q	Lev	Tang	Prof	Size	VIF **
Q	1					
Lev	-0.40*	1				1.23
Tang	-0.18*	0.35*	1			1.18
Prof	0.52*	-0.15*	0.10*	1		1.16
Size	-0.14*	0.21*	0.09*	-0.20*	1	1.08
Disp	-0.08*	-0.15*	0.05*	-0.27*	0.09*	1.10

The correlations are for an unbalanced panel dataset of 188 firms from 1996 to 2005 (1,111 firm-year observations).
Tobin's *Q* (*Q*) is the ratio of the value of the firm divided by a proxy for the replacement value of assets. Market Leverage (*Lev*) is the ratio of total debt to market value of total assets. Tangibility (*Tang*) is the ratio of net property plant and equipment to total assets. Profitability (*Prof*) is the ratio of earnings before interest, taxes, depreciation and amortization to total assets. *Size* is the natural logarithm of total assets, in 1996 million pounds.
* Indicates that the correlation is significantly different from zero at the 0.05 level or higher.
** $VIF=1/(1-R^2)$ is the Variance Inflation Factor, where R^2 is derived from a regression of the explanatory variable listed on the left most column on a constant and the rest of the explanatory variables.

8 The empirical results

8.1 Baseline specification

As can be seen from Table 4 below, the suggested instruments for the first-stage equation show a highly significant effect in the leverage equation. The soundness of the empirical specification is

confirmed by a number of tests, including the Sargan-Hansen test aimed at verifying the validity of the specification.

The sign of the coefficient of *Dispersion* is consistent with the main prediction of the theoretical model of previous sections. This measure of variance is equivalent to an uncertainty in expectations. An empirical concern is that it is possible for future profits to be highly uncertain, in the sense that the distribution perceived at a particular point in time has a high variance, and yet for the expectation of future profits to be completely stable, if no relevant new information is revealed during a particular time interval. It is clearly possible for the level of future profits to be highly uncertain, and yet to observe a set of analysts using similar information in a similar way, with similar objectives, arriving at a similar set of issued forecasts. Nevertheless, theoretical reasons explained above let us expect the tendency to be for more observed disagreement to be associated with more underlying uncertainty.

As to other results, I find a significant negative relationship between leverage and current profitability. To the extent that realized profitability is correlated with profitable growth opportunities and managerial ability, this evidence is consistent with the agency approach. Nonetheless, it is consistent with pecking order theory, since this theory predicts that more profitable firms have more internal resources and therefore, rely on less external financing, including debt.[31] Although we should be careful about the precise measure of leverage employed in each research to make a comparison (I adopt a measure of market leverage), most empirical studies confirm the observed sign, finding a negative relationship between leverage and profitability.[32]

Leverage results positively correlated with tangibility and size. The sign of tangibility may be at odds with the free-cash-flow hypothesis, since - as explained - the monitoring costs tend to be higher for firms with less collateralizable assets (i.e. lesser tangibility). However, the result may be driven by other considerations, since collateral value is a major determinant of the level of debt finance available to companies (Harris and Raviv, 1990). A positive relationship between

[31]For a deeper discussion on this theory, see section 2.4.

[32]For example, Toy *et al.* (1974), Kester (1986), Friend and Lang (1988), Titman and Wessels (1988), Rajan and Zingales (1995) for G7 companies except for Germany, Wald (1999), Wiwattanakantang (1999), Bevan and Danbold (2000), Booth *et al.* (2001), Huang and Song (2002), and Gaud *et al.* (2005). Frank and Goyal (2004), among the few, experience positive relationship between profitability and leverage in some models.

debt and collateral assets is also broadly consistent with a large body of the empirical literature: Bradley *et al.* (1984), Titman and Wessels (1988) and Rajan and Zingales (1995) uncover evidence of a significant positive relationship between tangibility and total gearing, while Marsh (1982) and Walsh and Ryan (1997) find the probability of debt issues to be positively related to the fixed asset ratio.[33]

Instead, the positive relationship between size and debt is consistent with agency theory. It is argued that larger firms may have lower agency costs associated with the asset substitution and the under-investment problems (Chung, 1993). A further reason for smaller firms to have lower leverage ratios might be that smaller firms are more likely to be liquidated when they are in financial distress (Ozkan, 1996). To the extent that larger firms are less likely to be liquidated following poor performance, agency theories suggest that higher leverage may be needed to provide managerial incentives in these firms. Again, empirical studies provide support to this sign.[34]

The results for the *Q* equation are also broadly as expected. *Q* is positively related to current profitability and negative with size, perhaps reflecting the fact that large firms have lower growth opportunities. The key thing to note is that leverage is found to have a significantly negative impact on firm performance. One might argue that this result is apparently at odds with a disciplining and value-enhancing role for leverage. In particular, it might suggest that low-growth firms tend to have less debt in their capital structure, in contrast with what would be expected on the basis of Jensen's free-cash-flow hypothesis. I disagree with this contention and I now provide evidence that lends support to the agency approach.

[33]More recently, Chittenden *et al.* (1996) and Bevan and Danbolt (2002; 2004) find the relationship between tangibility and gearing to depend on the measure of debt applied, so this result is open to further research.

[34]At the aggregate level, Crutchley and Hanson (1989), Bennett and Donnelly (1993), Rajan and Zingales (1995), Barclay and Smith (1996), and Bevan and Danbolt (2002) find a significant positive correlation between company size and gearing, while Marsh (1982) observes that debt issues are positively correlated with company size. Barclay and Smith (1996), Stohs and Mauer (1996), Demirguc-Kunt and Maksimovic (1999) all find debt maturity to be positively correlated with company size. However, Remmers et al. (1974) found no size effect and Kester (1986) reports an insignificant negative correlation between gearing and company size.

Table 4 Instrumental variable regression on panel data for Leverage and Q (all firms)

All firms	Lev_{it}	Q_{it}
Lev_{it}	-	-4.678*** (-3.97)
$Tang_{it}$	0.177*** (3.21)	
$Disp_{it}$	-0.042*** (-2.62)	
$Prof_{it}$	-0.375*** (-4.31)	2.413*** (3.33)
$Size_{it}$	0.052*** (4.70)	-0.(2006)** (-1.85)
Hansen J stat.		0.009 (P-val. 0.92)
Number of obs.	1101	

Legend: Tobin's *Q* (*Q*) is the ratio of the value of the firm divided by a proxy for the replacement value of assets. Market Leverage (*Lev*) is the ratio of total debt to market value of total assets. Tangibility (*Tang*) is the ratio of net property plant and equipment to total assets. Profitability (*Prof*) is the ratio of earnings before interest, taxes, depreciation and amortization to total assets. *Size* is the natural logarithm of total assets, in 1996 million pounds.
* Statistical significance at the 10% level.
** Statistical significance at the 5% level.
*** Statistical significance at the 1% level.

8.2 Sample splitting

The finding that less leveraged firms have on average a lower performance might be analyzed in greater detail by testing for the presence of non linearities in the relationship between financial structure and agency costs of managerial discretion. The argument in favor of these non linearities is that the whole sample regression may uncover a degree of difference across firms in the sensitivity of Tobin's *Q* to leverage. A natural way to address this issue is by splitting the entire sample of firms according to some exogenous characteristic and investigating whether the estimated effect of leverage on the performance variable varies across the two groups of firms and is magnified by the presence of this characteristic.

The hypothesis I test here is whether the negative *Q*-leverage relationship is weaker for firms with a large size. The rationale for this hypothesis is that conflicts of interest between manager and shareholders are potentially more important in the case of large size, which we have seen to be a statistically significant variable in the performance regression. On the theoretical side, Jensen (1986) argues that agency problems are more likely to prevail in large mature firms. Thus, if debt mitigates agency costs, we would expect large firms to show a less negative or a positive coefficient on leverage in *Q* equation.

Following Bond *et al.* (2004) the sample split is achieved as follows: each firm is assigned to a high (resp. low) category according to its position in the first year it enters the sample relative to the median across all firms in the first year they enter the sample. For example, a firm is categorized as a large size firm if its value in 1996, the first year it enters the sample, is above the median log value of total assets across all firms in the first year they entered the sample.[35]

Table 5 presents the results from estimating equation on the two different sub-samples. We find that the effect of leverage on productivity is always negative, but it is higher for firms with a small size. The estimated coefficient associated to leverage is -5.65 in the sub-sample of firms with smaller size. On the contrary, the estimated effect is -4.47 in the other sub-sample. At the same time, uncertainty is negative and significant in the leverage equation. Although the sign between leverage and performance is not comfortable, certainly it comes closer to agency cost theoretical predictions.

[35]I also experimented with several different methods for splitting the sample, which produced similar results.

Table 5 Instrumental variable regression on panel data for Leverage and Q (small vs. large size)

	Lev_{it}	Q_{it}	Lev_{it}	Q_{it}
	Small Size		Large Size	
Lev_{it}	-	-5.65*** (1.46)	-	-4.47* (2.08)
$Tang_{it}$	0.23*** (0.07)	-	0.08 (0.08)	-
$Disp_{it}$	-0.005*** (0.00)	-	-0.004* (0.00)	
$Profit_{it}$	-0.45*** (0.14)	1.54 (1.12)	-0.31*** (0.11)	2.77*** (1.02)
$Size_{it}$	0.54*** (0.02)	-0.34** (0.14)	0.05*** (.01)	-0.02 (0.14)
J stat.		.001 (P-val. .97)		.682 (P-val. .40)
N. of obs.	493		608	

Legend: I divide firms in two groups following to this criterion: each firm is assigned to a high (resp. low) category according to its position in the first year it enters the sample relative to the median across all firms in the first year they enter the sample (Bond *et al.*, 2004). We adjust the standard errors for heterogeneity and correlation within different years of the same firm. Variable definitions for the acronyms are given in other Table.
Tobin's *Q* (*Q*) is the ratio of the value of the firm divided by a proxy for the replacement value of assets. Market Leverage (*Lev*) is the ratio of total debt to market value of total assets. Tangibility (*Tang*) is the ratio of net property plant and equipment to total assets. Profitability (*Prof*) is the ratio of earnings before interest, taxes, depreciation and amortization to total assets. *Size* is the natural logarithm of total assets, in 1996 million pounds.
* Statistical significance at the 10% level.
** Statistical significance at the 5% level.
*** Statistical significance at the 1% level.

8.3 Tobit regression

In order to investigate whether the interplay between leverage and uncertainty on firm's performance is sensitive to potential agency costs, I extend my analysis by estimating an instrumental variable Tobit regression.

In line with agency costs argument, we may argue that the managerial discretion problem is mainly relevant for firms with bad prospects. Several papers in the past have identified a suitable proxy by dividing the sample to select for low levels of Tobin's *Q*. For example, Hoshi *et al.* (1991) distinguish between firms with bad and good prospects of performance, and allow for two separate cash flow coefficients, in their studying of financial constraint problems. More interestingly for our research, Vogt (1994) discriminates between asymmetric and managerial discretion problems by including, among the regressors, an interaction between *Q* and cash flow, reporting evidence in support of free-cash-flow theory.

More recently, Doukas *et al.* (2000)[36] look further into this approach and model potential agency costs of managerial discretion by an interaction variable of the company's growth opportunities with its free-cash-flow. Notably, their measure is employed as the dependent variable of their estimation. This measure is given by the following calculation. Growth opportunities are measured as a dummy variable, which takes the value of 1 for a firm-year observation if the Tobin's *Q* is less than year-by-year cross-sectional mean, and the value of 0 otherwise. Following Lehn and Poulsen (1989), free-cash-flow is measured as operating income before depreciation minus the sum of taxes plus interest expense and dividends paid, standardized by total assets. In other words, *Agency* is defined as *Q*-dummy multiplied to free-cash-flow.[37]

Model below combines this methodology of selection for potential misconduct of management, with the instrumental variable approach (used in the baseline specification) to take care of potential endogeneity problems between leverage and the new measure of low performance.

A few econometric issues are worth noting regarding the estimation of this kind of model. In our case, the observed dependent variable takes the form:[38]

$$Agency = \begin{cases} Agency^* & \text{if} \quad Agency^* > 0 \\ & \text{if} \quad Agency^* < 0 \end{cases}$$

being $Agency^*$ the latent dependent variable of interest. That is, as in Doukas *et al.* (2000), the measure of potential mismanagement is a zero-inflated continuous variable. In light of this approach, I re-estimate the baseline equation for the variable *Agency*, so that the model can be presented as follows:

$$\begin{cases} Agency_{it} = \max\left(\ 0\ ,\ \alpha_a + \beta_a Lev_{it} + \mathbf{X}_{it}\gamma_a + \eta_i + u_{it}\ \right) \\ Lev_{it} = \alpha_{lev} + \mathbf{Z}_{it}\beta_{lev} + \mathbf{X}_{it}\gamma_{lev} + \upsilon_i + w_{it} \end{cases}$$

[36] Also, Doukas *et al.* (2005).

[37] As Doukas *et al.* (2005: 499) state: "(...) poorly managed firms are more likely to be exposed to higher agency costs than well-managed firms and consequently waste free cash flows in negative NPV projects, while well-managed firms are expected to be involved in value-maximising activities where free cash flows are not expected to be wasted. Specifically, a high value for the interactive Agency variable would be indicative of a firm with high agency costs arising from the existence of high free cash flows at the discretion of its managers and being poorly managed."

[38] See, e.g., Cameron and Trivedi (2005: 532).

As to the empirical specification, while the instruments of the leverage equation are the same of the basic model, I now drop from both equations (that is, from matrix $\mathbf{X}_{it}$) the profitability variable, since it is by definition collinear with free cash flow (they are also correlated over 90%).

Testing for this model by a Tobit regression, I find an insignificant effect of firm's size (result not reported), due to possible misspecification problems. I accounted for this and I tried to solve the problem in several ways. The inclusion, among $\mathbf{X}_{it}$ variables, of squared-Size, to account for possible curvilinear effects on agency costs,[39] solves the misspecification problem and gives my final estimation.

Regression results are given in Table 6, for which I can't use the fixed-effect instrumental variable estimator.[40] A Wald test does not reject the endogeneity of firm leverage. The most striking finding is that the estimated effect of leverage on the *Q*-based *Agency* variable, which is now positive and significant.

Therefore, the censored model allows us to select situations where leverage explains better its discipline device role. At the same time, it is interesting to note that the instruments of the first stage equation preserve the sign of the previous estimation and are significant at the 1 percent level. In particular, consistently with our a priori, dispersion of earnings' forecasts exerts a constraining effect on leverage.

[39]Barclay *et al.* (2003) and Johnson (2003), use firm size and its square to control for the effect of credit quality on debt maturity. Diamond (1991) predicts a positive coefficient for firm size since larger firms have higher credit quality and can obtain long-term debt. The nonlinear relation predicted by Diamond implies that the square of firm size is expected to have a negative coefficient.

[40]In fact, there is no command in Stata for a parametric conditional fixed-effects Tobit (with or without instrumental variables) model, as there does not exist sufficient statistics allowing fixed effects to be conditioned out of the likelihood.

Table 6 Instrumental variable Tobit regression on panel data for Leverage and Q

All firms	Lev_{it}	$Agency_{it}$
Lev_{it}		0.615*** (-3.97)
$Tang_{it}$	0.159*** (3.21)	
$Disp_{it}$	-0.006*** (-2.62)	
$Size_{it}$	0.229*** (-4.31)	0.215*** (3.33)
$Sg\text{-}Size_{it}$	-0.007*** (4.70)	-0.008*** (-1.85)
_cons	-1.56*** (0.28)	-1.47*** (0.55)

Legend: Wald test of exogeneity: 1.25 (P-val. 0.06)
Tobin's *Q* (*Q*) is the ratio of the value of the firm divided by a proxy for the replacement value of assets. Market Leverage (*Lev*) is the ratio of total debt to market value of total assets. Tangibility (*Tang*) is the ratio of net property plant and equipment to total assets. Profitability (*Prof*) is the ratio of earnings before interest, taxes, depreciation and amortization to total assets. *Size* is the natural logarithm of total assets, in 1996 million pounds.
* Statistical significance at the 10% level.
** Statistical significance at the 5% level.
*** Statistical significance at the 1% level.

9 Concluding remarks

Building on the seminal agency-cost model laid out by Stulz (1990), this paper explores both theoretically and empirically the implications of the free-cash-flow hypothesis under cash flow uncertainty. Stulz shows that debt can mitigate the managerial incentive to over-invest, but at the cost of having under-investment in certain states of nature, hence an equity holders' maximization problem. Whilst preserving this trade-off scheme, the model above extends this baseline framework to include situations where there is uncertainty surrounding the mean of the cash flow.

This simple, yet realistic, extension increases the manager's information and, thus, her ability to pursue value-decreasing investment opportunities, even in presence of an independent board having control over financial decisions and allowing for managerial risk-aversion. It is shown that the magnitude of value-reducing actions decreases with the precision of the shareholders' estimate of the mean of the cash flow.

The interpretation of the capital structure optimization problem in a context of expected uncertainty lead also to some empirically testable hypotheses. First, the ability of debt to restrict managerial discretion is dependent upon the precision of the estimate of the cash flow distribution, so firms with high variance between different financial analysts' predicted value of

future cash flow (or earnings), should be observed to carry less debt in their capital structures. Second, stakeholders could force the debt to be repaid immediately and then reissue debt after reassessing their estimate of the mean of the cash flow. This is consistent with the argument that firms typically use bank debt instead of private debt because private debt can be renegotiated outside of bankruptcy (Diamond, 1994).

The relationship between leverage and uncertainty is later explored on the empirical side. In this part, the paper provides new evidence supporting a causal link between leverage and performance, showing how the interplay of earnings forecasts uncertainty and financing choices impinges upon firm valuation. Consistently with the theoretical predictions, it is found a significant causal relationship from a dispersion of earnings' forecasts to firm's leverage, but leverage exerts a constraining effect on firm's performance. Although this result is consistent with some previous evidence, it contradict the agency-cost story.

The last part of the empirical analysis further investigates whether the uncovered negative relationship between leverage and Tobin's *Q* is driven by firms' heterogeneity in growth opportunities and agency characteristics. To this purpose, it is estimated a censored normal regression model where the dependent variable is a measure of potential agency costs, proxied by an indicator of low growth opportunities multiplied by balance sheet's free cash flow. The results of the new specification are consistent with agency costs literature indications, since the censored model lends empirical support to the view that the leverage plays a positive effect in reducing the potential non-value-maximizing conduct of managers. At the same time, the negative coefficient of cash flow uncertainty in the first stage leverage equation remains statistically significant.

A notable feature of this empirical investigation is that the leverage-uncertainty relationship uncovered on data extends previous evidence on the role of security analysis as an agency-cost monitoring device, which has been largely unexplored in the literature. This omission is surprising in light of investors' extensive use of analyst earnings forecasts in investment decisions and of the great influence these forecasts (rather than historical measures of growth) have on stock prices. Previous evidence, usually based on variables such as the number of analysts following stocks (e.g. Chang *et al.*, 2006), finds only a generic effect of the presence of security analysts in reducing agency costs associated with the separation of ownership and

control, as conjectured by the original contribution of Jensen and Meckling (1976). The empirical results of this article suggest that the degree of uncertainty surrounding earnings distribution, here expressed by the dispersion of U.K. security analysts' earnings forecasts, is an important factor in the decision to resort to debt by non-financial firms.

Lastly, these findings have some policy implications, as they suggest that interventions favoring financial markets' transparency and information disclosure may have substantial effects on firms' financing choices and then on firm's performance.

Author

Appendix 1

Shareholders maximize the Value of the firm (i.e. the expected discount values of future cash flows):

$$V = \int_0^{F-\theta_1 m-\theta_2} (R_1+E(R_2))g(R_1)dR_1 + \int_{F-\theta_1 m-\theta_2}^{F-\theta_1 m-\theta_2+I^*} (R_1-F+\theta_1 m'+\theta_2)(1+p_G)g(R_1)dR_1 +$$

$$+ \int_{F-\theta_1 m-\theta_2+I^*}^{\infty} (R_1-F+\theta_1 m'+\theta_2-I^*)(1+p_B)+(1+p_G)I^* g(R_1)dR_1 +$$

$$+ \int_{F-\theta_1 m-\theta_2}^{F-\theta_1 m-\theta_2+I^*} (E(R_2)+F-\theta_1 m'-\theta_2)g(R_1)dR_1$$

Rearranging the terms, we get to the following equation:

$$V = \int_0^{F-\theta_1 m-\theta_2} (R_1+E(R_2))g(R_1)dR_1 + \int_{F-\theta_1 m-\theta_2}^{\infty} (E(R_2)+F-\theta_1 m'-\theta_2)g(R_1)dR_1 +$$

$$+ \int_{F-\theta_1 m-\theta_2}^{F-\theta_1 m-\theta_2+I^*} (R_1-F+\theta_1 m'+\theta_2)dR_1 + \int_{F-\theta_1 m-\theta_2+I^*}^{\infty} (R_1-F+\theta_1 m'+\theta_2)g(R_1)dR_1 +$$

$$+ \int_{F-\theta_1 m-\theta_2}^{F-\theta_1 m-\theta_2+I^*} I^* p_G g(R_1)dR_1 + \int_{F-\theta_1 m-\theta_2+I^*}^{\infty} I^* p_G g(R_1)dR_1 +$$

$$+ \int_{F-\theta_1 m-\theta_2}^{F-\theta_1 m-\theta_2+I^*} (R_1-F+\theta_1 m'+\theta_2-I^*)p_G g(R_1)dR_1 +$$

$$+ \int_{F-\theta_1 m-\theta_2+I^*}^{\infty} (R_1-F+\theta_1 m'+\theta_2-I^*)p_B g(R_1)dR_1$$

By further simplification,

$$V(F/m) = E(R_1)+E(R_2)+\int_{F-\theta_1 m-\theta_2}^{\infty} I^* p_G g(R_1)dR_1 +$$

$$+ \int_{F-\theta_1 m-\theta_2}^{F-\theta_1 m-\theta_2+I^*} (F-\theta_1 m'-\theta_2+I^*-R_1)p_G g(R_1)dR_1 +$$

$$+ \int_{F-\theta_1 m-\theta_2}^{\infty} (F-\theta_1 m'-\theta_2+I^*-R_1)p_B g(R_1)dR_1$$

Appendix 2

If we postulate that, given a positive value of debt, V is increasing in F, that is:

$$\int_{F-\theta_1 m-\theta_2}^{I^*} p_G\, g(R_1)dR_1 + I^* p_G\, g(F-\theta_1 m-\theta_2) < -\int_{I^*}^{\infty} p_B\, g(R_1)dR_1$$

then the first derivative of F is positive near $F=\theta_1 m+\theta_2$. It follows that the second derivative is negative for all non negative values of F given $F \geq \theta_1 m+\theta_2$. The second derivative, with respect to F, is:

$$V_{FF} = -p_G g(F-\theta_1 m'-\theta_2+I^*) + p_B g(F-\theta_1 m'-\theta_2+I^*) + p_G g(F-\theta_1 m'-\theta_2)$$

Since $V(F/m)$ is globally strictly concave, it follows that, where $V_F(F^*)=0$, there is a unique global maximum.

Q.E.D.

Appendix 3

From Appendix 1, we know that the Value of the firm is:

$$\begin{aligned} V(F/m) &= E(R_1) + E(R_2) + \int_{F-\theta_1 m-\theta_2}^{\hbar} I^* p_G\, g(R_1)dR_1 + \\ &+ \int_{F-\theta_1 m-\theta_2}^{F-\theta_1 m-\theta_2+I^*} (F-\theta_1 m'-\theta_2+I^*-R_1)\, p_G g(R_1)dR_1 + \\ &+ \int_{F-\theta_1 m-\theta_2}^{\infty} (F-\theta_1 m'-\theta_2+I^*-R_1)\, p_B g(R_1)dR_1 \end{aligned} \qquad (3)$$

The first derivative of this value function $V(F/m)$, with respect to debt choice, F, is:

$$V_F = -\int_{F-\theta_1 m-\theta_2}^{F-\theta_1 m-\theta_2+I^*} p_G\, g(R_1)dR_1 - \int_{F-\theta_1 m-\theta_2+I^*}^{\infty} p_B\, g(R_1)dR_1 \qquad (4)$$

The symmetry of the normal distribution is significant in deriving the first derivative. The update belief about the mean of the cash flow distribution, m', appears in the first derivative, but

only in expression with the posterior of the mean, $(m-m')$. The symmetry of the normal distribution guarantees that a priori these expressions are zero.

From the proof of Proposition 1, a unique interior solution to the manager's maximization problem exists, therefore by the implicit function theorem the comparative static results are as follows:

$$V_{F^*p_G}=-g(F-\theta_1 m-\theta_2+I^*)-g(F-\theta_1 m-\theta_2)\le 0\Rightarrow\frac{dF^*}{dp_G}\le 0$$

being $I^*\ge 0$,

$$V_{F^*p_B}=1-g(F-\theta_1 m-\theta_2+I^*)\le 0\Rightarrow\frac{dF^*}{dp_B}\le 0 \qquad \text{(i)}$$

$$V_{F^*I^*}=-p_G g(F-\theta_1 m-\theta_2+I^*)-p_B g(F-\theta_1 m-\theta_2)\le 0\Rightarrow\frac{dF^*}{dI^*}\le 0 \qquad \text{(ii)}$$

$$V_{F^*m}=\theta_1 p_G g(F-\theta_1 m-\theta_2+I^*)-\theta_1 p_G g(F-\theta_1 m-\theta_2)-\theta_1 p_B g(F-\theta_1 m-\theta_2)\ge 0$$
$$\Rightarrow\frac{dF^*}{dm}\ge 0 \qquad \text{(iii)}$$

being $g(F-\theta_1 m-\theta_2)\le g(F-\theta_1 m-\theta_2+I^*)$

$$V_{F^*\theta_1}=mp_G g(F-\theta_1 m-\theta_2+I^*)-mp_G g(F-\theta_1 m-\theta_2)-mp_B g(F-\theta_1 m-\theta_2)\ge 0$$
$$\Rightarrow\frac{dF^*}{d\theta_1}\ge 0 \qquad \text{(iv)}$$

being $g(F-\theta_1 m-\theta_2)\le g(F-\theta_1 m-\theta_2+I^*)$

$$V_{F^*\theta_2}=p_G g(F-\theta_1 m-\theta_2+I^*)-p_G g(F-\theta_1 m-\theta_2)-p_B g(F-\theta_1 m-\theta_2)\ge 0$$
$$\Rightarrow\frac{dF^*}{d\theta_2}\ge 0 \qquad \text{(v)}$$

being $g(F-\theta_1 m-\theta_2)\le g(F-\theta_1 m-\theta_2+I^*)$

Q.E.D.

Appendix 4

In this case, the realization of cash flow is greater than the estimated mean, or $R_1 > m$. The manager without updating would invest the difference between the realized cash flow and the amount of cash held for future debt payment. Any investment financed beyond I^* is value-decreasing, or:

$$R_1 - I^* - \left(F^* - \theta_1 m' - \theta_2\right) > 0$$

The ability of the manager to update his belief exacerbates the managerial discretion costs. The manager updates following the Bayesian updating rule

$$R_1 - I^* - \left(F^* - \theta_1 m' - \theta_2\right) > R_1 - I^* - \left(F^* - \theta_1 m - \theta_2\right) > 0$$

By simple arithmetic, the additional amount the manager invests is:

$$\theta_1\left(R_1 - m\right)\left(1 - \frac{\sigma^2}{\sigma^2 + \tau^2}\right)$$

Q.E.D.

Appendix 5

In this case, the realization of cash flow is less than the estimated mean, or $R_1 < m$. The manager without updating would invest the difference between the realized cash flow and the amount of cash held for future debt payment. Any investment financed before I^* is value-decreasing, or:

$$R_1 - I^* - \left(F^* - \theta_1 m' - \theta_2\right) < 0$$

The ability of the manager to update his belief exacerbates the managerial discretion costs. The manager updates following the Bayesian updating rule

$$R_1 - I^* - \left(F^* - \theta_1 m' - \theta_2\right) > R_1 - I^* - \left(F^* - \theta_1 m - \theta_2\right) < 0$$

By simple arithmetic, the amount the manager under-invests is:

$$\theta_1\left(m - R_1\right)\left(1 - \frac{\sigma^2}{\sigma^2 + \tau^2}\right)$$

Author

Q.E.D.

Appendix 6

In the case of the Proposition 3 the cost of additional over-investment is:

$$I^{OVER} = \theta_1 \left(R_1 - m \right) \left(1 - \frac{\sigma^2}{\sigma^2 + \tau^2} \right)$$

The first derivative in respect to the variance of the estimated mean of cash flow, τ^2, is:

$$\frac{dI^{OVER}}{d\tau^2} = \theta_1 (R_1 - m) \frac{\sigma^2}{\left(\sigma^2 + \tau^2 \right)^2} \geq 0$$

It is greater than zero. Thus, the additional over-investment is increasing in the precision of the estimate of the mean of the cash flow distribution.

The cost of additional under-investment is:

$$I^{UNDER} = \theta_1 (m - R_1) \left(1 - \frac{\sigma^2}{\sigma^2 + \tau^2} \right)$$

The first derivative in respect to the variance of the estimated mean of cash flow, τ^2, is:

$$\frac{dI^{UNDER}}{d\tau^2} = \theta_1 \left(m - R_1 \right) \frac{\sigma^2}{\left(\sigma^2 + \tau^2 \right)^2} \geq 0$$

As above, it is greater than zero. Thus, the additional under-investment is increasing in the variance of the estimate of the mean of the cash flow distribution.

Q.E.D.

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