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ABSTRACT

Entrepreneurial Incentives in Stock Market Economies*

A Capital Asset Pricing Model of a stock market economy is examined under different corporate governance structures in which the objectives of managers and entrepreneurs in choosing the risk composition of their firms' returns are not aligned with those of shareholders and investors because of moral hazard. It is shown that incentive compensation, by exposing managers and entrepreneurs to unhedgeable firm-specific risk, induces them to change the stochastic properties of firm cash flows. Since they can trade in markets for aggregate risk but not for firm-specific risk, managers and entrepreneurs produce excessive aggregate risk compared to the first-best allocation. This results in a diversification externality for the stock market investors who cannot share the aggregate risks amongst each other as well as they can the firm-specific risks. The optimal incentive compensation designed to address such diversification externality is fully characterized and it is demonstrated that financial markets interact with the stock market in important ways in determining the effectiveness of incentive contracts in controlling the negative welfare effects of diversification externality.

JEL Classification: D52, D62, G10, G31, G32 and J33
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1 Introduction

Entrepreneurship involves the choice of technology. By financing a project, the entrepreneur sells part of the return of the entreprise to investors, e.g., by issuing bonds or stocks. After financing an enterprise, the entrepreneur's objectives while choosing its technology are in general not aligned with those of the investors. Similarly, the manager of a corporation has objectives which are not in general aligned with those of the shareholders. As a consequence, an entrepreneur or a manager might invest in technologies whose mean and risk composition of returns is different from the one that stockholders prefer. This theoretical insight constitutes the basic core of agency theory approach to corporate finance, introduced by the pioneering work of Fama and Miller (1972) and Jensen and Meckling (1976); Gale (2002) surveys the literature.

The theory suggests that incentive compensation schemes, which require managers and entrepreneurs to hold in their portfolios a portion of the firm they manage, contribute to aligning their incentives with those of stockholders (and investors, in general). The effects of the introduction of incentive compensation schemes on firms' performance have been documented empirically, e.g., by means of event studies to identify abnormal market returns after instances of increase in stock-based compensations (e.g., Yermack, 1997).[1] The implications of managerial equity-ownership and incentive compensation schemes for risk reduction, that is, firms' diversification, have also been extensively studied, but with somewhat more inconclusive results. Denis, Denis and Sarin (1997) regress various measures of diversification on equity ownership of officers and directors and document a significant negative relationship. On the other hand, May (1995) finds that a firm's diversification is positively correlated with the managerial share of equity in the firm.[2]

While these studies are concerned with the effect of equity ownership and incentive compensation schemes on performance and diversification, that is on the mean and the variance of firm returns, in this paper we study instead the effect of equity ownership and incentive

[1]Other evidence on the performance effects of incentive compensation schemes has been obtained in the literature by means of regressions of a measure of performance like Tobin's q on managerial stockholdings (e.g., Morck, Schleifer and Vishny, 1988; and McConnell and Servaes, 1990), and by means of case studies of leveraged management buyouts (Kaplan, 1989, 1991); see Murphy (1999) for a survey.

[2]Also, in an early contribution to the litearture, Amihud and Lev (1981) find that management controlled firms (in which all investors including managers have limited equity) engage more in conglomerate type mergers than owner controlled firms (in which some investors have large ownership stakes). They define a merger as conglomerate when the "products of the acquiring and acquired companies ... do not compete with one another," and therefore, they interpret these mergers as a measure of diversification, i.e., of risk reduction activities on the part of management. However, Lamont and Polk (2001) provide evidence that many conglomerates experience an increase in expected stock return, suggesting that these diversifying mergers might have been undertaken precisely to increase risk.

compensation schemes on the composition of the risk structure of a firm, that is on the correlation of a firm's risk with the risk of other firms in the same sector or with the aggregate risk factors in the economy. When managers and entrepreneurs hold part of their wealth as equity of the firm they manage, they have an incentive to choose projects which increase the component of their firm's risk that is correlated with a common traded stock market component (e.g., a stock market index) as long as this reduces their firm-specific risk. This is because, by independently trading in the stock market, managers and entrepreneurs can hedge any common aggregate risk component of their portfolios, but they cannot hedge directly the firm-specific risk component.[3]

Such incentives of managers and entrepreneurs to increase the aggregate risk component of their firm's cash flows have important welfare implications: They reduce the ability of shareholders and investors to employ the stock market for risk-sharing purposes. This effect, which we call the *diversification externality* of managerial and entrepreneurial equity ownership, has not been directly studied in the theoretical nor in the empirical literature in corporate finance.[4] We develop in this paper a theoretical study of this diversification externality by introducing a moral hazard problem where the objectives of entrepreneurs and managers in choosing the extent of aggregate and firm-specific risk of their firms' cash flows (for given levels of total risk) are not fully aligned with the objectives of investors and shareholders. In so doing, we also provide results that can serve as a benchmark for future empirical analysis that attempts to relate the risk composition of corporate cash flows to managerial compensation.

We wish to determine the incentive compensation schemes as the solutions to an optimal contracting problem between managers and stockholders, or, between entrepreneurs and investors. That is, our goal is to determine incentive compensation endogenously in equilibrium along with the managerial and entrepreneurial choices of the risk composition of the firms. These choices, however, depend upon the equilibrium prices of different risks in the economy. Since managers and shareholders, and similarly, entrepreneurs and investors, face different risks in equilibrium, their incentives are not perfectly aligned. A proper evaluation of the resulting different objectives therefore requires a general equilibrium model in

[3]Incentive compensation schemes, by definition, need to be associated with restrictions on the managers' trading of their own firm, and hence, make the firm-specific risk unhedgeable for managers and entrepreneurs. However, general transactions in the stock market are not commonly restricted, in part because such restrictions would be hardly enforceable. Gentry and Hubbard (2000) and Jin (2002) provide empirical evidence to this effect.

[4]Note that the measures of diversification used in the studies by Amihud and Lev (1981), Denis, Denis and Sarin (1997), and May (1995), for instance, cannot distinguish between the diversification due to a reduction in the variance of returns and the diversification effect that we are interested in, i.e., the loading of the firm on common traded market component. Amihud, Kamin and Ronen (1983) however do present some direct evidence of risk reduction in earnings due to managerial incentives.

which the prices of different risks are also determined in equilibrium. To this end, we embed the optimal contracting problem determining the incentive compensation schemes into a general equilibrium Capital Asset Pricing Model (CAPM) economy with moral hazard over the production (technology) choice. Studying entrepreneurial and managerial incentives in a general equilibrium economy has the further advantage that we can properly address the issue of the efficiency of stock market economies in controlling the negative welfare effects of diversification externality, an important aspect of our analysis.

We turn first to a brief description of our positive results. In our benchmark economy, there is no moral hazard, that is, there is no conflict of interest between managers and shareholders, or entrepreneurs and investors regarding production choices. This would be the case, for instance, if managers and entrepreneurs could possibly pre-commit to their production choices, and thus in particular, to a risk composition of cash flows. In this case the diversification externality does not arise. As a result, managers and entrepreneurs simply hold the market share of their own firm in their portfolio.

Typical corporate governance structures however do entail moral hazard. Managers and entrepreneurs cannot in general pre-commit their production choices and often face opportunities to obtain private benefits. In the presence of moral hazard, incentive compensation mechanisms only partly align the objectives of managers and entrepreneurs with those of investors. As a consequence, a diversification externality does arise in general upon the provision of incentive compensation and results in entrepreneurial and managerial activity aimed at increasing the aggregate risk (and thereby reducing the firm-specific risk) of their firm's cash flows. Such diversification externality is essentially another moral hazard affecting the firms' management. Crucially, the only instrument stockholders and investors have to limit such moral hazard is however again incentive compensation. The optimal design of incentive compensation thus takes account of this moral hazard as well, i.e., it trades off the possibly conflicting objectives of aligning the objectives of management with investors and alleviating the diversification externality on the risk composition of firm cash flows.[5]

We characterize precisely the optimal incentive compensation and the induced risk composition of firm cash flows in equilibrium when the moral hazard arises only due to the diversification externality. We show that if the firm's technology is relatively more loaded on the aggregate risk factors of the economy, then the optimal incentive compensation scheme provides the managers and the entrepreneurs a relatively lower equity holding of their firms.

[5] Throughout the paper, we focus on incentive compensation in the form of entrepreneurial and managerial equity ownership. However, we use the general term "incentive compensation" since it is the exposure of entrepreneurs and managers to the firm-specific component of their firms' cash flows which plays a crucial role in our analysis. It is analytically difficult to incorporate other forms of incentive compensation, e.g., the provision of executive stock options, in the CARA-Normal setup of the CAPM economy that we examine.

In this case the moral hazard component due to the diversification externality is particularly severe. In fact, depending upon the size of these loadings, the optimal incentive compensation may result in an equity holding for managers and entrepreneurs that is lower than even the market share of the firm, i.e., lower than the benchmark holding in the absence of any moral hazard.

This characterization has important empirical implications. In the context of our model, maintaining constant the components of moral hazard other than the diversification externality, we predict that firms with relatively more high powered compensation schemes which require management to hold a larger equity share, have a lower component of risk loaded on the common stock market factors (e.g., market indexes). This is an equilibrium effect, a consequence of the *endogeneity* of incentive compensation and firms' risk composition in our model. But in practice the incentive compensation schemes provided to address agency problems other than the diversification externality vary greatly across firms; for instance because the managerial ability and opportunities to extract private benefits from their production choices also vary greatly across firms. Our results imply that an *exogenous* increase in the managerial equity ownership in a firm provided to address such other agency problems should give rise to managerial activity aimed at loading the firm's risk on aggregate traded risk factors. That is, firms with high powered incentive compensation schemes designed to alleviate independent agency problems, other than the diversification externality, should suffer more of the diversification externality problem.[6]

We next discuss our normative results concerning the efficiency of the stock market economies in dealing with the diversification externality. We show that in the equilibrium of our model, entrepreneurs and managers do in fact choose risk compositions of their firms which are excessively loaded on the aggregate endowment risk of the economy and on the common components of the stock market compared to the loadings under the first best Pareto optimum. However, even though the economy's aggregate risks are in equilibrium larger than at the first best Pareto optimum, the equilibrium capital structure of firms induces via incentive contracts levels of aggregate risks in the economy that are constrained (second best) efficient.[7] In other words, the price mechanism in competitive markets does not

[6] In Section 4.2, we discuss in detail the implications of this result for existing empirical work that (i) relates incentive compensation to the risk composition of firm-level stock returns, and (ii) compares across countries the extent of aggregate diversity in economic activity and the extent of systematic risk in stock market returns.

[7] Note that the term "capital structure" in our set-up does not refer to the the combination of equity and debt in a firm's capitalization, contrary to standard usage in the corporate finance literature. There is in fact no corporate debt in our setting. We use the term "capital structure" more generally to correspond to the combination of outside (public) and inside (private, i.e., entrepreneurial or managerial) ownership of the equity of the firm. The design of inside ownership or incentive compensation in our set-up thus corresponds to the design of the firm's "capital structure."

simply operate to guarantee the orderly functioning of markets, that is to guarantee market clearing. It also efficiently aligns the objectives of entrepreneurs and stockholders with those of the (constrained) social planner when designing the incentive compensation schemes for the management. Managers and entrepreneurs, while price-takers, nevertheless face a price schedule for the firm they manage: they understand that the firm is priced depending on the composition of its risk with respect to the different risk factors in the economy. In particular, they recognize that increasing the aggregate risk of the firm reduces the equilibrium value of its shares. Motivated by these capital gains from reducing the aggregate risk component of cash flows, managers and entrepreneurs choose in equilibrium the loadings of the firm on such factors in an efficient manner.

Finally, we study the interaction between the stock market and financial markets. In our CAPM economy, financial innovations which allow agents to better diversify their endowment risks have positive effects on aggregate welfare. However, this is not necessarily so for innovations which allow entrepreneurs and managers to hedge firm-specific and sector-specific risks of their firms. This is because such innovations might have a negative effect on the incentives. Still, financial markets have all the interest to issue such innovations as entrepreneurs and managers will in fact demand them ex-post.[8] In particular, we show that innovations which have a negative effect on incentives tend to be the ones that allow entrepreneurs and managers to hedge sector-specific risk. In contrast, innovations that provide entrepreneurs and managers with an instrument to diversify firm-specific, i.e., purely idiosyncratic risks, tend to improve overall welfare and also tend to have positive effect on their incentives.

A discussion of the related literature concludes these introductory remarks. Section 2 discusses the general equilibrium CAPM economy that we examine. Section 3 presents the properties of the competitive equilibrium. Section 4 develops the positive analysis for one sector CAPM economy focusing on the choice of capital structure (incentive compensation) and firm cash flows (production) for different governance structures. In addition, it considers extensions that allow for (i) multiple sectors, (ii) pure "noise" in firm cash flows, and, (iii) risk factors that are not traded by any agent. Section 5 addresses the normative questions concerning the efficiency of equilibrium choices. Section 6 discusses the implications of financial innovation for the efficiency of capital structure and production choices. Section 7 concludes with some empirical implications and directions for future research. Appendices 1–5 provide formally the model assumptions, the closed-form expressions for the competitive equilibrium, the statement of the production choice faced by entrepreneurs/managers, the definitions of efficiency, and the proofs of propositions, respectively.

[8] Ofek and Yermack (2000) for instance document the managerial propensity to actively rebalance their portfolios once a certain ownership level has been reached.

1.1 Related Literature

The equilibrium economy we study is a version of the standard CAPM model of Sharpe (1964), Lintner (1965), and Mossin (1966) with exponential preferences and normally distributed risk factors. In particular, we follow Willen (1997) who introduced incomplete financial markets and restricted participation in the CAPM economy. We contribute to the study of this class of economies by introducing assets in positive net supply to appropriately capture a stock market economy. However, from a theoretical point of view, the main contribution of this paper consists in our attempt to embed the agency theory approach to corporate finance of Fama and Miller (1972) and Jensen and Meckling (1976) into a general equilibrium model of the price of risk such as CAPM. In particular, we study in a CAPM setup the optimal equity ownership structure of firms and the incentives of entrepreneurs and managers to affect the correlation of their firms' stock returns with the returns of other stocks and with the returns of assets and securities traded in financial markets.

Few general equilibrium analyses of the ownership structure of firms have been developed. Allen and Gale (1988, 1991, 1994) develop a theoretical analysis of the capital structure of firms in general equilibrium. However, they do not study economies with moral hazard which are characterized by a misalignment of entrepreneurial and managerial objectives with those of the stock market investors.[9]

Magill and Quinzii (1998) study the diversification effect in terms of risk reduction in a general equilibrium model and also address the issue of efficiency. They do not however allow entrepreneurs to affect the correlation of their firms' returns with other firms or with financial markets. Also, differently from our analysis and from the standard assumptions in corporate finance, they allow entrepreneurial actions to affect the support of their firm's return. Interestingly, this implies that entrepreneurs can indirectly write ex-post contracts whose payoffs are contingent on their action, and thus, first best efficiency is obtained.

Rampini (2000) analyzes the effect of productivity shocks on the amount of entrepreneurial activity. In his model too, the risk borne by entrepreneurs arising through their partial ownership of project cash flows (for incentive reasons) plays an important role. However, the

[9]Allen and Gale (1994) find that equilibria might not exist, unless constraints to short sales are imposed in the economy. More generally, the competitive markets assumption is not justified in their set-up without such constraints, as a new security in general affects the asset span of the economy, and therefore, affects in a discontinuous manner the hedging and risk sharing opportunities of agents and, in turn, the prices in financial markets. In our CAPM economy, securities and stocks can be represented by loadings on risk factors, and hence, financial innovations and technological decisions of entrepreneurs and managers which affect their firms' cash flows are modelled as changes in such loadings. Provided the number of total factors is not affected by financial innovations, the competitive market assumption is always justified, equilibria exist, and welfare comparisons are appropriate.

model does not consider the choice of the risk composition of project cash flows induced by such ownership. Holtz-Eakin, Rosen and Willen (2001) develop a theoretical model of the choice between wage earning and self-employment in an intertemporal CAPM model where portfolio investments possibly attenuate the uncertainty associated with labor income. The model is however cast in a partial equilibrium setting and does not address the managerial diversification externality which is of central interest to this paper. Hilt (2002a) links the lack of diversity in aggregate economic activity to risk-reducing incentives induced in the entrepreneurs by incentive compensation. Hilt (2002b) builds a similar model to explain the (lack of) entrepreneurship in American whaling industry during mid–1850s. These papers however do not examine the equilibrium compensation responses which play a crucial role in our analysis.[10] Meulbroek (2000a, 2000b) examines the private cost of incentive compensation to risk-averse managers. This analysis differs from that in our paper since we model explicitly the incentive related benefits of compensation as well as its costs to managers.

Finally, Leland and Pyle (1977) and Kihlstrom and Matthews (1990) concentrate on signalling models in which incentive compensations have the objective of signalling information about firms' quality which asymmetrically accrues to managers but not to the general investor. On the contrary, managers in our model do affect their firms' stochastic process for earnings and moral hazard arises because they cannot commit ex-ante to any specific managerial choice. In a somewhat different context, DeMarzo and Urosevic (2000) consider dynamic trading by a "large" shareholder where his trading is simultaneously determined in equilibrium along with the value of the shares which in turn depend upon the shareholder's incentives post-trading.

2 The Economy

We study a class of CAPM economies wih incomplete financial markets, restricted participation and a stock market, represented by assets in positive net supply. In particular, we examine production economies where entrepreneurs and managers can affect the risk composition of the cash flows that their firms produce. We introduce first the structure of the economy and of the equilibrium allocations where we take the production choices as given. We do this in the simplest possible way by relegating all the technical details to Appendix 1. Then, in the next section, we integrate competitive equilibria with production choices, i.e., with the endogenous determination of the risk composition of firm's cash flows by managers

[10] Further, the analysis in Hilt (2002a, 2002b) is restricted to the case where the entrepreneurs can credibly commit to the choice of risks *before* they sell their firms' assets to the stock market. In the parlance of our paper, this case corresponds to there being "no moral hazard," a case that forms a benchmark for the comparison of economies with moral hazard in our analysis.

and entrepreneurs.

An economy is populated by H agents, who live for two periods, 0 and 1. Agent $h \in \mathcal{H} := \{1, \ldots, H\}$ has an endowment y_0^h in period 0, and a random normally distributed endowment y_1^h in period 1, of the unique consumption good.

Agent h's preferences are represented by a Von Neumann-Morgernstern Constant Absolute Risk Aversion utility function:

$$u^h(c_0^h, c_1^h) := -\frac{1}{A}e^{-Ac_0^h} + E\left[-\frac{1}{A}e^{-Ac_1^h}\right] \tag{1}$$

where $A > 0$ is the coefficient of absolute risk aversion assumed to be the same across all agents for simplicity.

The first F agents in $\mathcal{H}$ ($F < H$) are entrepreneurs (we do not distinguish between entrepreneurs and managers in this section, and generally refer to them as entrepreneurs for sake of brevity). Each entrepreneur, say $h \leq F$, owns a firm $f(= h)$ with a technology that produces a random cash flow at time 1 denoted as y_1^f. Entrepreneur h has a private endowment at time 0, y_0^h, but no private endowment at time 1 other than through his ownership of firm. To be precise, entrepreneur h is assumed to start out as the sole owner of firm $f(= h)$'s production. Hence, his time 1 endowment through ownership of the firm corresponds to the random cash flow, y_1^f, produced by the firm's technology. Entrepreneurs can sell a part of their firm's ownership in the stock market giving rise to positive net supplies of risky assets as we describe below. Entrepreneurs also have choice over the technology they adopt, i.e., they can affect the cash flows that their respective firms produce. This production choice is taken as given for now: it is formalized and analyzed later in Section 4.

All agents face financial markets, where a risk-free bond and risky assets are traded, and a stock market, where shares of firms' cash flows are traded.

The bond, asset 0 in our notation, has a deterministic payoff $x_0 = 1$.

The economy's risk is composed of N (orthogonal and normalized) factors, denoted x_n, $n = 1, ..., N$ (see Appendix 1 for a precise formulation of our factor decomposition).

In general, only part of the economy's risk is traded, that is, markets are incomplete. Without loss of generality, we assume that the first $J \leq N$ factors are traded and denote this set of traded factors as $\mathcal{J} = \{1, \ldots, J\}$.

Trading in financial and stock markets is also possibly restricted: only a subset $\mathcal{H}_j$ of agents $\mathcal{H}$ can trade factor $j \in \mathcal{J}$.

Finally, we maintain the assumption that all agents can trade the riskless bond (asset $j = 0$) without restrictions.

3 Competitive Equilibria

Let $\pi_0 \in \Re_+$ denote the price of the risk-free bond, and $\pi_j \in \Re$ the price of the factor j. The problem of each agent h is to choose a consumption allocation, $[c_0^h, c_1^h] \in \Re^2$, and portfolio positions in the risk-free bond and in all tradable assets, $[\theta_0^h, \theta_j^h]_{j\in\mathcal{J}} \in \Re^{J+1}$, to maximize his utility (as specified in equation 1) subject to the budget constraints and the restricted participation constraints. At a competitive equilibrium, the market for the consumption good as well as the financial and stock markets (the markets for all risk factors traded in the economy) clear.[11]

To an economy is associated a vector of 'betas', $\beta := [\beta_j^h],\ h \in \mathcal{H},\ j \in \mathcal{J}$, defined as:

$$\beta_j^h := \frac{cov\left(y_1^h, x_j\right)}{var\left(x_j\right)} \ . \tag{2}$$

Also, to an economy is associated a vector of net supplies of stocks. The net supply of, say, firm f coincides with the fraction w^h of the firm's cash flow that its entrepreneur (denoted as agent $h = f$) trades on the stock market. Net supplies of stocks translate into net supplies of the bond, s_0, as well as of all the risk factors, $s_j, j \in \mathcal{J}$.

Given a list of betas and net supplies associated to each factor, we can solve for a competitive equilibrium for the economy. Betas and net supplies are then determined endogenously based upon the decisions of entrepreneurs regarding their firms' factor loadings and the fraction of their firm they trade on the stock market.

At the competitive equilibrium of this economy, agents' portfolios satisfy a three-fund separation property: each agent holds the bond, the market portfolio, and the unhedgeable component of his endowment.[12]

Also, the standard cross sectional beta pricing relationship holds in this economy: the expected excess return of factor j is proportional to the beta of the factor with respect to the aggregate risk of the economy. However, because of the possible restrictions in market participation, the aggregate risk relevant for the pricing of factor j is the aggregate endowment of the agents who in fact trade factor j.[13]

[11]Formal definitions as well as closed form solutions for equilibrium allocations and prices are reported in Appendix 1.

[12]Formally, this is captured in equations (24) and (29) in Appendix 1.

[13]Formally, this is captured in equations (20) and (21) in Appendix 1. Given this cross sectional beta pricing relationship, the economy is referred to as an incomplete markets CAPM economy.

4 Equity Ownership and Risk

We study now the choice of entrepreneurs who can, at a cost, choose the production technology they adopt and in turn affect the stochastic properties of the cash flows of their firms. The production choice of entrepreneurs in our model consists of determining the risk composition of their firms' cash flows, i.e., the levels of aggregate and firm-specific components of these cash flows for a given level of risk. Our analysis is partly motivated by the literature on diversification discussed in the introduction. In particular, as in Amihud and Lev (1981), we consider the incentives of entrepreneurs and managers deriving from incentive compensation schemes and, more generally, from exposure to their firm's risk. Our interest is in considering the effect of exposure to firm-specific risk that is disproportionate compared to the one contained in the market portfolio. We abstract though from the incentives of entrepreneurs and managers to diversify their firms' cash flows, e.g., by reducing the variance of cash flows. We concentrate exclusively, for simplicity and clarity, on the incentives of entrepreneurs and managers to decrease the unhedgeable component of risk in their portfolios by loading the cash flows of their firm onto risk factors that they can hedge against.

The strongest justification for examining the equilibrium loadings of firm cash flows (and by implication, firm returns) on aggregate factors arises from the asset-pricing literature where a fundamental result is that it is the covariance between an asset's return with the aggregate consumption and market return which affects its valuation and not its total risk. While changes to firm-specific risk do not affect a well-diversified portfolio in the limit, the changes to aggregate risk affect even a well-diversified portfolio in significant ways. Of course, in general and in practice, different components of moral hazard (e.g., the incentive to load on aggregate risk factors that we examine and the seeking of private benefits by managers that is often examined in corporate finance) interact in interesting ways in determining the optimal incentive compensation structure of firms. We will discuss several aspects of such interactions when discussing our results, but we concentrate the formal analysis of the paper on firms' loadings on aggregate risk factors in equilibrium.

There are many corporate activities that in fact entail choosing the extent of aggregate and firm-specific risk of a firm's cash flow. Consider, for example, the following choice faced by the CEO of a pharmaceutical company in deciding the company's overall business strategy. He can either invest the company's funds in R&D activities directed towards the invention of a new drug or he can invest these funds in increasing the extent of marketing for existing drugs that already proliferate the market. The risk from R&D activities is more firm-specific or idiosyncratic in that it depends upon the success of the research activities. The risk from existing business lines is however more aggregate or systematic in that it depends upon the global demand for these drugs which is likely to affect the profits of other pharmaceutical companies as well. Such investment choices affect the extent of aggregate and firm-specific risk in a firm's cash flows and are clearly an integral part of corporate activities.[14]

More generally, the diversification externality we study, that is the loading of a firm's cash flow onto aggregate risk and away from firm specific risk, could be considered as a particular form of *herding*. The literature on herding behavior often attributes it to peer-based evaluation of management (see Scharfstein and Stein, 1990, and the references therein). While incentive compensation schemes containing a relative performance evaluation component are rarely observed other than in the mutual fund industry (see Murphy, 1999), it is often argued that such evaluation is in fact implicit, for example, through reputation effects. In this respect, our analysis makes it clear that herding-like behavior can be rationalized in part as purely a consequence of the *observed* incentive compensation schemes, even if no relative performance evaluation is present in either the explicit or the implicit contractual form of the compensation faced by managers.

We turn next to a formal description of the economy under which we study the equilibrium ownership and risk composition of firms. We restrict ourselves first to an economy in which there is only one representative firm, $h = f = F = 1$ in our notation. This is just for simplicity and allows us to introduce the main results without excessive notation. In Section 4.3, we consider in detail some important extensions.

Financial markets consist of (i) the bond market where the bonds have a constant payoff $x_0 = 1$, (ii) the stock market where the stock of the representative firm or the sector is traded, with a random payoff y_1^f, and (iii) a common economy-wide factor traded in financial markets capturing a market-wide index.

The factor structure of such an economy consists of an aggregate risk factor, x_1, which we can consider as positively correlated with the aggregate endowment of investors, $\sum_{h=2}^{H} y_1^h$, and a second risk factor, x_2, which is orthogonal to x_1 and to the aggregate endowment of investors, and should be interpreted as the 'corporate sector-specific' risk in the economy.[15]

[14]The aversion of entrepreneurs and managers to firm-specific risk and the attendant diversification externality also appear in several contexts other than management compensation. Townsend (1993) for instance documents the lack of experimentation with new hybrid seeds by Indian farmers and their unflinching adherance to tried-and-tested agricultural practices. He attributes this to the lack of insurance markets in India for agricultural losses and bad weather which leads to Indian farmers holding undiversifiable, disproportionate exposure to the risk of failure of the crops they plant.

In another interesting study, Hilt (2002b) documents from a panel study of 723 whaling voyages from 1849-1860 that American sailors chose the standard oceanic areas for whaling year after year. He empirically shows a positive relationship between the extent of standardization in whaling practices by a sailor and the share of the whaling profits that he was awarded in his contract.

[15]An aggregate risk factor such as x_1 could also represent a futures contract on macroeconomic risks. While normative arguments in favor of such contracts have been developed by Athanasoulis and Shiller (2000), a factor *exactly identical* to the one we have constructed is difficult to find in practice. However, all

With respect to this factor structure, the cash flow produced by the firm's technology can be represented in the following form:

$$y_1^f - E(y_1^f) := \beta_1^f x_1 + \beta_2^f x_2, \tag{3}$$

where $E(x_2) = 0$, and $var(x_2) = 1$, and $cov(x_1, x_2) := 0$. The firms betas, β_1^f and β_2^f, measure the covariance of the firm's earnings, y_1^f with factor 1 and 2, respectively.

The choice of entrepreneurs is restricted so that they cannot alter the expected value or the variance of cash flows of their firm, but can only affect their correlation with the market, i.e., the distribution of the variance of cash flows between the aggregate and the sector–specific risks. As we noted earlier, such changes in production can for instance be effected through reducing expenses on R&D and innovative activities, following economy-wide business practices, acquiring other firms in order to increase the aggregate component of firm cash flows, etc.

Formally, each entrepreneur chooses the betas, β_1^f and β_2^f, the loadings of the firm's production and his starting endowment on the aggregate risk and the sector-specific risk respectively, under the constraint that $(\beta_1^f)^2 + (\beta_2^f)^2 = \overline{V}$, where $\overline{V}$ denotes the total variance of the cash flows. It follows that once β_1^f is chosen, β_2^f is determined by the constraint; we denote such β_2^f as $\beta_2^f\left(\beta_1^f\right)$. We describe in the analysis to follow the entrepreneurs' choice of β_1^f, which represents in our analysis their production choice.

The entrepreneurs' production choice is costly: a non-pecuniary costly *effort* must be exerted in order to change the beta of the firm from some initial composition of the cash flow risk, given by $\bar{\beta}_1^f$. Let the cost be increasing and convex in $(\beta_1^f - \bar{\beta}_1^f)^2$. This enables us to model the moral hazard in a relatively simple and succinct manner. The regularity assumptions are stated in Appendix 5.

Each entrepreneur sells a fraction $w > 0$ of his firm in the stock market, and holds the remaining fraction, $1 - w$, of the firm. This remaining fraction constitutes the *incentive compensation* of the entrepreneur.[16] As a result of the firm's sale in the stock market, the positive supply of factor $j = 1, 2$ in the economy is $s_j = w\beta_j^f$. In addition, there is also a positive supply of riskless bonds, i.e., factor $j = 0$, in the economy given by $s_0 = wE(y_1^f)$. The entrepreneur can trade the aggregate endowment risk factor, x_1, but not the component of risk contributed by his firm, x_2. This is consistent with the observed restrictions on

that is required in our model is that *there exists at least one factor that can be traded by the entrepreneurs which is positively correlated with the aggregate endowment of the economy*, a requirement which is easily met. For example, in Section 4.3.1, we extend the basic model to allow for multiple sectors and model x_1 as the stock market index.

[16]We would like to remind the reader at this point that we focus exclusively on incentive compensation which consists of equity ownership of entrepreneurs and managers in their firms. See also Footnote 5.

managerial trading and is also consistent for instance with the evidence of Jin (2002) who demonstrates that CEO incentives to perform are affected by the firm-specific component of their compensation but not by the systematic risk components.

4.1 Corporate Governance

In this section, we introduce the optimal contracting problem between managers and shareholders, or entrepreneurs and investors, which determines the equity ownership structure of firms as well as their equilibrium risk loadings on common aggregate risk components. Again, we present the problem as simply as possible relegating to Appendix 2 and Appendix 3 the formal statements of the objective of entrepreneurs and managers, and of the production choice problem that they face under different governance structures.

The economy is perfectly competitive; the firm is interpreted as a sector composed of a measure 1 of identical firms. Each entrepreneur faces parametric prices for factors and rationally anticipates the effects of his choice of factor loadings on the equilibrium price of the shares of his own firm. However, we consider different corporate governance structures. In particular, we consider both owner managed firms and corporations (or management controlled firms). Such distinction is important empirically; La Porta, Lopez de Silanez and Shleifer (1999) for instance document that, in a sample of 27 developed countries, slightly more than a third of firms are held by widely dispersed investors (that is, management controlled), and a third are controlled by a single family (that is, owner managed).

We first consider a benchmark case in which each entrepreneur owns the firm ex-ante, makes all the relevant management and technological choices (which determine the loadings of the firm's payoff on the economy's risk factors), and then sells the fraction of the firm on the stock market. As the firm is sold after the entrepreneur's relevant choices have been taken, no issue of moral hazard arises in this benchmark case.[17]

More formally, when choosing β_1^f, the loading on the aggregate risk factor, and w, the fraction of the firm that is sold in the stock market, the entrepreneur anticipates that his revenues from the sale of the firm will in fact depend on β_1^f and w and will amount to

$$w\left(E(y_1^f)\pi_0 + \beta_1^f\pi_1 + \beta_2^f\left(\beta_1^f\right)\pi_2\right) \ .$$

On the contrary, the entrepreneur takes as given the equilibrium prices for the risk factors π_j

[17] We abstract for simplicity from moral hazard and agency considerations between managers and stockholders, or entrepreneurs and investors, other than the diversification externality. These would have the effect of augmenting the equity ownership of managers and entrepreneurs at the benchmark without substantially affecting the analysis. In Section 4.2, we do however discuss in detail the implications of such alternative moral hazard problems for our results.

(and therefore, implicitly, also, their supply in the market s_j).[18] After the firm has been sold, trading occurs in all markets and prices for the risk factors are determined at the competitive equilibrium (described formally in Appendix 1).

In contrast to this benchmark case, the most interesting corporate governance structures give rise to moral hazard. We consider them in turn.

Owner Managed Firms. Each entrepreneur owns the firm ex-ante, sells a fraction w of the firm on the stock market, and then makes all the relevant management and technological choices (which determine the loadings of the firm's payoff on the economy's risk factors).

As the firm is sold before the entrepreneur's relevant choices have been taken, the issue of moral hazard arises in this case. Therefore, the proportion of the firm that the entrepreneur holds for himself, $1-w$, will determine his choice of the loadings on the risk factors. Investors in the market rationally anticipate the mapping between the entrepreneur's holding of the firm $1-w$ and the entrepreneur's choice of β_1^f. The price at which shares are sold on the market reflects therefore this information and depends on the proportion of the firm the entrepreneur holds, $1-w$. The entrepreneur in turn rationally anticipates the mapping between $1-w$ and the stock price as well.[19]

Formally, given w the entrepreneur's choice of β_1^f can be derived; let it be denoted $\beta_1^f(w)$. Investors anticipate $\beta_1^f(w)$ and hence the price of the firm will be represented by

$$w\left(E(y_1^f)\pi_0 + \beta_1^f(w)\pi_1 + \beta_2^f\left(\beta_1^f(w)\right)\pi_2\right) \tag{4}$$

for given prices of factors, π_j. The entrepreneur, while choosing w, anticipates that his revenues from the sale of the firm will in fact amount to (4). As in the benchmark case, trading occurs in all markets and prices for the risk factors are determined at the competitive equilibrium after the firm has been sold.

Corporations. Ownership of the firm is spread across the investors ex-ante; stockholders hire a manager for the firm, choose the fraction of the firm's stocks to endow the manager with, $1-w$; the manager then makes all the relevant management and technological choices which determine the loadings of the firm's payoff on the economy's risk factors. The stock ownership of the manager can be interpreted, without loss of generality, as his compensation. In addition, the manager must be given a time-0 compensation (in terms of units of consumption good) such that his reservation utility from time-0 compensation and time-1

[18]Note that throughout the paper, entrepreneurs and managers are treated as being perfectly competitive. In other words, we disregard any strategic considerations that might arise from their being able to affect also the equilibrium prices of risk factors in the economy.

[19]Magill-Quinzii (1998) introduce this equilibrium concept and refer to the anticipatory behavior of entrepreneurs as 'rational conjectures'.

incentive compensation amounts to his reservation utility value of $\overline{W}$. The issue of moral hazard again arises in this case as the manager will in general only own a fraction of the firm when making all the relevant decisions. Therefore, the stockholders, when choosing the manager's compensation, that is $1-w$, rationally anticipate the mapping between $1-w$ and the manager's choice.

Formally, investors anticipate for any given w the manager's choice of β_1^f, $\beta_1^f(w)$. They choose w anticipating that the value of their holding of the firm in equilibrium will have a value of

$$w\left(E(y_1^f)\pi_0 + \beta_1^f(w)\pi_1 + \beta_2^f\left(\beta_1^f(w)\right)\pi_2\right) \ .$$

As in the other cases, trading occurs in all markets and prices for the risk factors are determined at the competitive equilibrium after the manager has been hired and his incentive compensation determined.

4.2 Equilibrium Equity Ownership and Risk

The following propositions characterize the equity ownership structure of firms and the loading of their risk on the common aggregate component as the solution of the optimal contracting problem between managers and shareholders, or entrepreneurs and investors, introduced in the previous section. More specifically we characterize the equilibrium proportion w of each firm controlled by the entrepreneur and the equilibrium loading β_1^f of each firm on the risk factor representing aggregate endowment risk. We consider each of the corporate governance structures: owner-managed firms with and without moral hazard and corporations.

We start with the benchmark case we introduced in the previous section, in which firms are owner-managed, but there is no moral hazard.

Proposition 1 (Benchmark: No Moral Hazard) *For owner managed firms with no moral hazard, at equilibrium, each entrepreneur chooses the capital structure*

$$w^* = 1 - \frac{1}{H} \ ,$$

and decreases the loading of his firm's cash flows on the aggregate endowment factor

$$\beta_1^f(w^*) = \beta_1^* < \bar{\beta}_1^f.$$

In the absence of moral hazard, incentive compensation schemes are not called for and in equilibrium, each entrepreneur owns the market fraction of the firm he manages, that is the same fraction any agent in the economy holds, $\frac{1}{H}$. The entrepreneur, who is a price taker, nevertheless faces a price schedule for his firm: he understands that the firm is priced depending on the composition of its risk with respect to the different risk factors in the economy. In particular, he recognizes that increasing the aggregate risk of the firm reduces the equilibrium value of its shares. Motivated by these capital gains from reducing the aggregate risk component, the entrepreneur reduces in equilibrium the loading of the firm on such factor, choosing $\beta_1^f = \beta_1^* < \bar{\beta}_1^f$.

Consider now each of the corporate governance structures with moral hazard. Entrepreneurs take decisions on their firms' cash flows after receiving the proceeds from the sale of their firms. Managers, on their part, take decisions after receiving incentive compensation. Hence, entrepreneurs and managers do not internalize fully the cost that an increase in their firms' aggregate risk loading imposes on the rest of the economy. Privately, entrepreneurs and managers prefer to increase their firms' aggregate risk loading in order to reduce the unhedgeable component of their own wealth. This however imposes a diversification externality on the investors in the firm since they must bear greater aggregate risk and lower idiosyncratic risk (which can be shared better among investors than aggregate risk). Incentive compensation, i.e., equity ownership in our model, is used by entrepreneurs and managers to limit the diversification effect. In fact, in equilibrium incentive compensation will always be chosen so that managers and entrepreneurs have an incentive to decrease the loading of their firms on the aggregate risk component (see Proposition 1, below).

To provide an intuition about how in fact incentive compensation schemes can have the effect of inducing managers and entrepreneurs to reduce the loading of their firms' cash flow on the aggregate risk, it is useful to analyze in detail the benefits and costs underlying their choice of the risk composition of their firms, β_1^f. The marginal benefit to entrepreneurs and managers from increasing the aggregate risk loading β_1^f arises from the resulting reduction in their firm-specific exposure. This is a pure risk-aversion effect: Managers and entrepreneurs cannot trade the firm specific component of their firms, while they can, and in equilibrium do, trade the aggregate risk component; as a consequence the risk they bear in equilibrium is lower the higher their firms' loadings on aggregate risk. An increase in β_1^f at the margin results in a benefit which amounts to $(1-w)^2 \cdot [\overline{V} - (\beta_1^f)^2]$, and that therefore increases upon an increase in incentive compensation $1-w$. The marginal cost from increasing β_1^f is instead more subtle. Entrepreneurs and managers rebalance the aggregate risk exposure of their personal portfolio by trading in the market for the aggregate risk asset: in equilibrium they simply own the market component of this aggregate risk. In other words, given their initial position in the aggregate risk deriving from their equity ownership, managers and entrepreneurs sell most of the aggregate risk component $(1-w)\beta_1^f$ that is provided to them by incentive compensation, and retain only the market portfolio component of such risk. Since bearing aggregate risk is disliked by agents in the economy, entrepreneurs and managers incur a cost for supplying such risk, that is, aggregate risk is sold at a negative price. Since the market portfolio position is taken as given by entrepeneurs and managers (who are competitive), their cost from trading in the aggregate risk asset increases upon their initial holding of aggregate risk which is increasing in equity ownership $1 - w$.

The results in Proposition 1 and 2 that follow trade off the benefits and costs that entrepreneurs and managers face when deciding the risk composition of their firm's cash flows and their dependence on incentive compensation. These propositions characterize both the equilibrium risk composition and incentive compensation structures. Proposition 1 deals with the case of owner managed firms and Proposition 2 with the case of corporations. Interestingly, all else being equal, the two corporate governance structures lead to identical equilibrium capital structures and risk loadings.

Proposition 2 (Owner Managed Firms) *In owner managed firms with moral hazard, each entrepreneur chooses the capital structure w^{**} and the loading on aggregate risk β_1^{**} such that*

- $w^{**} \begin{cases} > w^* \text{ if } \beta_1^f(w^*) > \sum_{h=2}^H \bar{\beta}_1^h \\ \leq \; w^* \text{ otherwise} \end{cases}$ *; and*
- $\beta_1^* < \beta_1^{**} < \bar{\beta}_1^f$.

Thus, in owner managed firms with moral hazard, the equilibrium loading on the aggregate endowment factor is always greater than that in the benchmark case of owner managed firms with no moral hazard.

Proposition 3 (Corporations) *In corporations, stockholders choose the same managers' compensation an entrepreneur would choose for himself: w^{**}. As a consequence, managers choose the same loading on the aggregate endowment factor as entrepreneurs would: β_1^{**} .*

At equilibrium, $1-w^{**}$ represents the incentive compensation, i.e., equity ownership of the entrepreneur or the manager. Incentive compensation provides incentives to entrepreneurs and managers to decrease the aggregate component of the risk of the firms they manage, β_1^f. Interestingly, to reach this objective, in equilibrium, incentive schemes are such that they require entrepreneurs and managers to hold a disproportionate share of their firm, i.e., $1 - w^{**} > \frac{1}{H}$, for those firms for which increasing equity holdings at the margin above the market share $\frac{1}{H}$ has the desired incentive effect of inducing a reduction in the firm's loading on the aggregate factor. However, depending upon the initial technology of a firm, $\bar{\beta}_1^f$, the incentive scheme might sometimes require the entrepreneur or the manager to hold less than the market share in the firm's equity.

To properly interpret this result, the reader should recall that we are restricting our formal analysis to incentive compensation schemes designed to address only the moral hazard arising from the misalignment of objectives over the risk composition of the firm's cash flows. In general, we should of course consider other moral hazard components in the relationship between managers and stockholders, or entrepreneurs and investors, e.g., the seeking of private benefits by managers and entrepreneurs. These alternative moral hazard components call for incentive compensation schemes that require managers and entrepreneurs to hold disproportionate fractions of their firms. In this general setting, therefore, our result only implies that a reduction of the power of the incentive scheme might be necessary to limit the effects of the diversification externality.

In order to understand this result better, we assume that the non-pecuniary costs associated with a change in β_1^f are quadratic and equal $C(\beta_1^f - \bar{\beta}_1^f)^2$, $C > 0$ being a constant. The characterization result obtained in Proposition 2 can now be restated more transparently:

$$w^{**} \begin{cases} > w^* \text{ if } \bar{\beta}_1^f > K \cdot \sum_{h=2}^{H} \bar{\beta}_1^h \text{ where } K = \; A\pi_0/(2CH^2(1+\pi_0)) + 1 > 0, \\ \leq \; w^* \text{ otherwise.} \end{cases}$$

The intuition for this characterization is as follows. For firms with initial technologies that are relatively more loaded on aggregate risk, the marginal benefit from increasing the aggregate risk loading β_1^f is greater than its marginal cost at an incentive compensation of $1 - w^*$. In other words, the risk-aversion effect described above dominates so that in equilibrium incentive compensation is lowered compared to the benchmark case ($w^{**} > w^*$) in order to induce a reduction in the aggregate risk loading ($\beta_1^{**} < \bar{\beta}_1^f$). For firms with relatively lower loadings on aggregate risk, the marginal cost is greater at an incentive compensation of $1 - w^*$. That is, the second effect described above through the personal trades of entrepreneurs and managers dominates and equilibrium incentive compensation has to be in fact raised ($w^{**} < w^*$) to achieve a reduction in the aggregate risk loading.

We conclude that, maintaining constant the components of moral hazard other than the diversification externality, firms with initial technologies that are relatively more loaded on the aggregate risks provide incentive compensation schemes with lower power, i.e., they require the management to hold a relatively lower share of their own firm's equity. In particular, industries that are highly pro-cyclical like utilities, paper, manufacturing, etc. are more heavily loaded on aggregate risks by their very nature and should have incentive compensation schemes with lower power than other industries. From a cross-sectional point of view, and again maintaining constant the components of moral hazard other than the diversification externality, the model implies that firms with relatively more high powered compensation schemes which require management to hold a larger equity share, should have a lower component of risk loaded on the common stock market factors. This is an equilibrium effect, a consequence of the *endogeneity* of incentive compensation and firms' risk composition in our model.

What happens however if we consider the cross-sectional variation of a component of moral hazard and incentive compensation that is exogenous, i.e., one that is not related to the diversification externality? This question is relevant of course since in practice incentive compensation is provided also to address agency problems such as the managerial ability to extract large private benefits. Our results imply that an *exogenous* increase in the managerial equity ownership in a firm provided to address such other agency problems should give rise to managerial activity aimed at loading the firm's risk on aggregate traded risk factors (quantified, e.g., by the R^2 in a regression of firm-level stock returns on market returns). That is, firms with high powered incentive compensation schemes designed to alleviate independent agency problems, other than the diversification externality, should suffer more of the diversification externality problem.

We can provide a more precise statement if we assume the cost structure is quadratic, i.e., given by $C(\beta_1^f - \bar{\beta}_1^f)^2$ for some constant $C > 0$. In this case, an exogenous increase in the incentive compensation $1 - w$, that is in the equilibrium equity holdings of managers and entrepreneurs, leads to an increase in the aggregate risk loading $\beta_1^f(w)$ if and only if

$$\bar{\beta}_1^f > K(w) \cdot \sum_{h=2}^{H} \bar{\beta}_1^h \text{ where } K(w) = \; A\pi_0/(2CH^2(1+\pi_0)) + 1/(H(1-w)) > 0.$$

As incentive compensation increases, i.e., as w decreases, $K(w)$ decreases and more firms (if we think of them as being distributed on a continuum of initial values $\bar{\beta}_1^f$) have the property that their aggregate risk loadings $\beta_1^f(w)$ increase.

The endogenous determination of incentive compensation schemes and risk composition could generally explain the lack of consistency across the results obtained in the empirical literature by regressing equity ownership and various measures of mean and variance of returns (see, for example, the studies by Amihud and Lev, 1981, Denis, Denis and Sarin, 1997, May, 1995 and the survey by Murphy, 1999 cited in the introduction).[20] We have in fact just

[20] In particular, Denis, Denis and Sarin (1997) regress various measures of diversification on equity ownership (OWN) of officers and directors and document a significant negative relationship at low to moderate levels of OWN. However, at very high levels of ownership, they in fact find a positive relationship between diversification and OWN. By contrast, May (1995) finds that a firm's diversification is positively correlated with the managerial share of equity in the firm. Also, in an early contribution to the litearture, Amihud and Lev (1981) find that management controlled firms (in which all investors including managers have limited

shown that exogenous variation in the equity ownership of management in general increases the agency problems connected with the diversification externality, while the endogeneity of incentive compensation has the opposite effect of inducing a negative relationship between equity ownership and the severity of the externality.[21]

Morck, Yeung and Yu (2000)'s empirical analysis of the risk composition of individual stock market returns in developed and less developed economies deals in part with the endogeneity problem. They document from their study of stock returns in over 40 countries that the average R^2 in market model regressions of stocks in less developed economies ("poor countries") are greater than that in developed economies ("rich countries"). That is, stocks in less developed economies have greater co-movement than do stocks in developed economies.[22] Legal restrictions and especially the lack of protection of property rights in less developed economies limit exogenously the feasibility of incentive compensation schemes. As a consequence, entrepreneurs essentially own most of the equity of their firm. Consistently with our results, they find that in developed economies there is a greater proportion of idiosyncratic risk in individual stock returns than in less developed economies. The disproportionate exposure to firm-specific risk of entrepreneurs in less developed countries due to the lack of protection of property rights induces them to load their firms' cash flows more on common traded stock factors, and this in turn leads to individual stock returns being more correlated in these economies. From a purely econometric standpoint, the variation in legal restrictions across countries acts as an *instrument* that corrects for the endogeneity of incentive compensation in such empirical analysis.[23]

It is worth stressing and discussing another implication of our analysis: entrepreneurs and managers with relatively high-powered incentive compensation, as they rebalance their aggregate risk holding, *sell* most of the aggregate risk contained in the equity provided to them as incentive compensation. Unfortunately, data on entrepreneurs' and managers' private trades and portfolio composition is not easily available, other than for trades conducted by corporate insiders in their own firms which is available due to the regulatory need that insiders report such trades. In the absence of such data for market trades, it is difficult to test this implication directly. Indirect evidence however is supportive of our analysis. Jin

equity) engage more in conglomerate type mergers than owner controlled firms (in which some investors have large ownership stakes).

[21]The importance of recognizing the endogeneity of incentive compensation in empirical tests relating managerial compensation to firm performance has also been pointed out in a different context by Himmelberg, Hubbard and Palia (1999) and Palia (2001).

[22]Morck, Yeung and Yu (2000) find that while in U.S. about 50% of all stocks move in the same direction, this percentage is much greater, statistically and economically, in countries such as India and China.

[23]Hilt (2002a) also examines this issue theoretically and empirically. His analysis of a sample of 38 countries suggests that countries with strong legal protections of outside investors, which facilitate more diffuse ownership, possess a more diverse range of industries.

(2002) finds that the performance of firms is unaffected by the aggregate or the systematic component of CEO's incentive compensation but is affected by its firm-specific component. This is consistent with CEOs being able to manage privately the market exposures of their overall portfolios. Other pieces of evidence concern (i) the finding of Ofek and Yermack (2000) that insiders do tend to often sell their existing shares when provided with additional incentive compensation, and (ii) the popularly accepted fact that there has been a tremendous growth in the market over the last decade for investment banks to "reverse-engineer" using derivative contracts the compensation contracts of CEOs. Both these findings point to an aversion amongst managers to bearing risk of their firm's cash flows. Given that they are not excluded from trading in the market indices, it seems natural that they would also employ short positions in the market indices as a way of reducing their unhedgeable risk.[24]

4.3 Extensions

In this section, we extend the analysis to consider different possible factor structures of the economy under study.[25] We consider owner managed firms only; the case of corporations is symmetric, as implied by the results in the previous section. We continue to interpret in the following analysis a firm as a representative firm, that is, essentially as a sector, and thus, often refer to firms as sectors.

4.3.1 Multi-Sector Economy

Consider an economy and a stock market with two sectors, f and g. The economy's factor structure is composed of a risk factor, x_1, which we interpret as a common stock market component, and two additional risk factors, x_2 and x_3, which are orthogonal to the common component and should be interpreted as the 'sector-specific' risks in the economy. The cash flows of the two sectors, f and g, in terms of the basic factor structure of the economy, are as follows:

$$y_1^f - E(y_1^f) := \beta_1^f x_1 + \beta_2^f x_2 \tag{5}$$

$$y_1^g - E(y_1^g) := \beta_1^g x_1 + \beta_3^g x_3 \tag{6}$$

[24]Another difficulty with the empirical analysis of entrepreneurs' and managers' private portfolios consists in the fact that their positions in general are affected by a speculative trading component due to private information: managers may hold both market as well as firm-specific or sector-specific risk to an extent that is greater than the market portfolio holding if they have good news about the firm or the sector which are not yet public.

[25]For sake of expositional simplicity, we do not state our results in this section as formal propositions. Formal statements and proofs are available from the authors upon request.

We assume that entrepreneurs cannot trade the share of their own firm contained in the incentive contract. Except for this restriction, we allow entrepreneurs to trade in the stock market. In other words, entrepreneurs in sector f (respectively in sector g) can trade factors x_1 and x_3 (respectively x_1 and x_2).

The results for this multi-sector economy are as follows. Entrepreneurs load their firms' cash flows on x_1, the component of the cash flows which is common across the two sectors (and possibly correlated with the aggregate endowment risk). As a consequence, the stock market cash flows (and by implication, stock market returns) are in equilibrium excessively correlated across sectors in addition to being correlated with the aggregate portfolio.

In the presence of moral hazard, the equilibrium capital structure w^{**} and the equilibrium loading β_1^{**} are chosen exactly as in the previous section.[26] The intuition for this result is straightforward. The incentives of entrepreneurs in sector f (respectively sector g) to load their firm on factor x_1 follow from the fact that they are allowed to hedge against the risk correlated with x_1. These incentives are however independent of what this factor represents: the aggregate endowment of the economy or the common component of the stock market.

Entrepreneurs in sector f (respectively sector g) trade the stock of sector g (respectively sector f) only as a way to hedge the common component of the stock market. That is, in equilibrium, entrepreneurs in sector f (respectively sector g) do not have incentives to trade factor x_3 (respectively factor x_2), which is uncorrelated with their wealth, in order to hedge their endowment risk. They trade in the stock market index x_1 only.

We conclude that individual firms' cash flows and stock market returns are prone to be excessively correlated and that the stock market does in fact contribute additional risk to the aggregate endowment risk of the economy. Again, in general, this is more so for firms and economies in which incentive compensation schemes are most needed in order to address alternative agency problems such as the ability of the managers and the entrepreneurs to easily appropriate the returns of the firms they manage.

4.3.2 Idiosyncratic Risk in the Stock Market

Consider a firm as a continuum of identical firms in measure 1, indexed by $s \in (0,1)$, and facing i.i.d. shocks. Consider sector f (sector g is symmetric). We perturb our basic decomposition of stock market returns as follows:

$$y_1^{f,s} - E(y_1^f) := \beta_1^f x_1 + \beta_2^f \left(x_2 + x_2^s\right), \quad s \in (0,1) \tag{7}$$

[26]For ease of comparison of the results, we assume here and in the discussion which follows that the cost function for endowment changes is exactly the same as in the previous section.

The factor x_2^s represents firm s's idiosyncratic component: it is i.i.d. over s, uncorrelated with x_1, x_2 and x_3, and it satisfies $E(x_2^s) = 0$ and $var(x_2^s) = \sigma$.

Suppose that entrepreneurs cannot trade the shares of their own firms contained in the incentive contracts. Except for this restriction, we allow entrepreneurs to trade in the stock market. In other words, entrepreneurs in sector f can trade factors x_1 and x_3, but cannot trade $(x_2 + x_2^s)$: the entrepreneur in firm s is restricted by the incentive contract to hold the sector specific component, x_2, as well as the idiosyncratic risk component of his firm, x_2^s. As a consequence, entrepreneurs have incentives to inefficiently load part of their firms' risk away from idiosyncratic risk and onto x_1. Each unit of their firm, i.e., $(x_2 + x_2^s)$, that the entrepreneurs are required to hold by the incentive contract carries a variance of $1 + \sigma$. The same unit, sold to agents in the economy carries an "effective" variance of 1, as we assume that investors can diversify away the idiosyncratic component of risk across the continuum of firms. As a consequence, the fraction of their firms that entrepreneurs hold in equilibrium decreases with σ. In turn, the incentive contract implements an equilibrium loading of each firm onto the common stock market component x_1 which is increasing with σ, and hence, is greater than β_1^{**} for any $\sigma > 0$.

The part of the resources entrepreneurs employ to reduce the loading of the firm on x_2^s are wasted from the point of view of the economy as such risk is purely idiosyncratic and could be diversified away at no cost. It is the necessity of providing the entrepreneur with an incentive contract (to align the entrepreneurs' and the investors' objectives), together with the restriction that x_2 and x_2^s cannot be independently traded, that produce the inefficiency.[27]

4.3.3 Non-Traded Risks

We can now extend the analysis to consider a sector with a component of risk which is not traded in the economy (by any investor). For instance, this could be a component of risk that is correlated with aggregate human capital accumulation or with private business income. In fact, both aggregate human capital and private business are empirically important non-traded risk factors in linear cross-sectional CAPM regressions, as documented by Jagannathan and Wang (1996) and Heaton and Lucas (2000), respectively.

Consider a firm f producing private business income y_1^f. The firm is owned by an agent, say agent h, and managed by another agent, say h'. The factor decomposition of the firm's business income is as follows:

$$y_1^f - E(y_1^f) := \beta_1^f x_1 + \beta_2^f \left(x_2 + x_2^{nt} \right) \tag{8}$$

[27]Under these restrictions on trading, equilibria are nonetheless constrained efficient, as shown in the next section.

Factor x_1 represents a common stock market component, a stock market index; factor x_2 represents an (orthogonal) common sector component, also traded in the stock market; and finally factor x_2^{nt} represents an aggregate non traded component correlated with the economy aggregate endowment, which satisfies $E(x_2^{nt}) = 0$ and $cov(x_2^{nt}, x_2) = 0$, $cov(x_2^{nt}, x_1) = 0$.

Suppose the firm is not traded in the stock market, it is a private business. Suppose the entrepreneur, agent h', cannot trade even the sector index in the market, factor x_2. He can only trade x_1.[28] The owner of the firm, agent h, can in fact freely trade in the stock market, but cannot trade x_2^{nt}, the non traded factor. This is captured in our CAPM economy with restricted participation by restricting all agents except agent h' from the market for x_2 and x_2^{nt}, and agent h from the market for x_2^{nt}.

In this case, the diversification externality takes the form of loading firms' risk onto the aggregate factor x_1 and away from the sector specific factor x_2, and especially, away from the non-traded factor x_2^{nt}. The owner naturally shares the entrepreneur's objective to diversify away the firm's loading on the non-traded factor. In general though, the entrepreneur engages in such a diversification activity more than the owner would; that is, more than the entrepreneur himself would in the benchmark environment without moral hazard. This is a result of the fact that the entrepreneur is restricted from trading in the sector index x_2 whereas the owner is not whereby the entrepreneur has greater propensity to increase the market loading of firm's cash flows.

5 Welfare Properties

Are the capital structure, i.e., the mix of the inside equity (incentive compensation) and outside equity, and the loading on the aggregate endowment risk at equilibrium efficient? Do entrepreneurs hold too much or too little of their firm? Do stockholders choose incentive compensations of managers efficiently (from a social or a normative standpoint)? Does the stock market contribute additional risk to the aggregate endowment risk of the economy? Is such additional risk inefficient?

We can answer these questions precisely: welfare analysis is possible in our model since we analyze a general equilibrium economy and it is relatively straightforward since the economy has the CAPM structure.[29]

Not surprisingly, the presence of moral hazard implies that in equilibrium managers and

[28]This is the simplest way to introduce an agency problem between the owner and the entrepreneur.

[29]For simplicity, we concentrate our analysis in this section on the factor structure introduced in Section 4, equation (3). In fact, the analysis extends more generally, as the reader can easily verify, based on the proofs contained in Appendix 5.

entrepreneurs engage inefficiently in diversification, that is, they excessively load their firms on aggregate trading factors. The most interesting question is rather one of constrained efficiency: Could a planner facing the same form of moral hazard which requires incentive compensation schemes at equilibrium regulate the contractual relationships between entrepreneurs and investors, or managers and stockholders, so as to improve the aggregate welfare of the economy? We answer this question next.

We measure the welfare of an economy at equilibrium, μ, as the maximal sum of agents' utilities after lump-sum transfers of consumption goods at time 0 across agents (see Appendix 2 for the precise definition of welfare measure μ).[30]

5.1 Efficiency of Equilibrium Capital Structure and Risk Loadings

The capital structure w and the loading on the aggregate endowment risk factor β_1^f are *first best efficient* if they maximize the aggregate welfare index μ taking into account the effects of w and β_1^f on competitive equilibrium prices. The formal definition of the first-best for the general economy is in Appendix 4.

Proposition 4 (First Best) *The equilibrium capital structure w^* and aggregate risk loading β_1^* in the benchmark corporate governance structure with owner-managed firms and no moral hazard is first best efficient.*

However, when the corporate governance structure is such that a moral hazard problem arises, as in the case of owner-managed firms in which entrepreneurs choose the capital structure before the choice of risk loading and in the case of corporations in which stockholders choose the managers' compensation, first best efficiency is too strong a welfare requirement.

The capital structure w and the loading on the aggregate endowment risk factor β_1^f are *constrained (second best) efficient* if they maximize the aggregate welfare index μ by choice of w, anticipating the entrepreneur's (respectively the manager's) choice of β_1^f conditionally on w, and taking into account the effects of w and β_1^f on competitive equilibrium prices. The formal definition of constrained efficiency for the general economy is in Appendix 4.

[30]Using the closed-form competitive equilibrium solution, given in Appendix 1, it can be shown that the aggregate welfare of an economy can be reduced to the expression

$$\mu = -\frac{H}{A}\, ln\,(1+\pi_0)$$

where π_0 is the price of the risk-free asset (see Willen, 1997). Therefore an economy is more efficient the lower its equilibrium price of the risk-free asset, i.e., the higher the risk-free return. This is because the risk free rate increases when precautionary savings in the economy decrease, i.e., when most risk is hedged by the available financial markets.

Proposition 5 (Constrained Efficiency) *The equilibrium capital structure (respectively management compensation) w^{**} and risk loading β_1^{**} for owner managed firms with moral hazard (respectively for corporations) is constrained efficient.*

We conclude that the price mechanism in our economy does not simply operate to guarantee the orderly functioning of markets, that is to guarantee market clearing, but also efficiently aligns the objectives of entrepreneurs and stockholders with those of the (constrained) social planner when designing the incentive compensation schemes for the management. The intuition for the efficiency result resides in fact all in the price mechanism: Managers and entrepreneurs, while price-takers, nevertheless face a price schedule for the firm they manage. They understand that the firm is priced depending on the composition of its risk with respect to the different risk factors in the economy. In particular, they recognize that increasing the aggregate risk of the firm reduces the equilibrium value of its shares. Motivated by these capital gains from reducing the aggregate risk component, managers and entrepreneurs choose in equilibrium the loading of the firm on such factors in an efficient manner.

6 Interactions between Stock and Financial Markets

Financial markets were treated as exogenous in our analysis thus far: securities' payoffs were exogenous and so were the portfolio restrictions we imposed on entrepreneurs and managers. Naturally though, the effects of the managerial incentives to diversify that we identified, depend in important ways on the financial markets available in the economy and to entrepreneurs and managers in particular. In fact, managers in equilibrium end up loading the returns of the firms they manage on aggregate risk factors that they can use to hedge their risk exposure.

In general, financial innovations might have positive welfare effects. Consider for instance the empirical investigation of the time series of different components of firm-level volatility undertaken by Campbell, Lettau, Malkiel and Xu (2001). They find that for U.S. firms over the 35–year period from 1962 to 1987, the (stock) market as a whole has not become more volatile, but the uncertainty at the level of individual firms has increased substantially. While it is difficult to identify convincingly the determinants of such evidence, our analysis of the firms' corporate governance can suggest one such determinant. The increase in volatility at the level of individual firms could in fact be due to the introduction of financial innovations that enable entrepreneurs and managers to better hedge their risk exposures, and in turn, lead them to reduce the resources previously employed in reducing idiosyncratic risk of their firms. Campbell, Lettau, Malkiel and Xu (2001) also document that the correlations between individual stocks have declined which is also consistent with the reduced incentives to substitute idiosyncratic risks into diversifiable economy-wide risks.

To better illustrate this point in the context of our model, consider the case of entrepreneurs or managers of firm f (respectively firm g) in Section 4.3.1. Further, consider an innovation which allows them to hedge the idiosyncratic component of the firms' return, x_2^s, but not the sector-specific component, x_2. In this case, entrepreneurs (managers) do in equilibrium hedge x_2^s as all the other agents in the economy do. As a consequence, x_2^s has no effect on the economy whatsoever, and in equilibrium, entrepreneurs hold a fraction w^{**} of the firm, and the loading on the common stock market component is β_1^{**}. We conclude that this innovation has in fact a positive welfare effect on the economy.

Intriguingly however, the development of financial markets might also exacerbate the managerial diversification problem we study in this paper. In particular, though financial innovations in our economy that allow investors to trade a larger number of factors have positive effects on aggregate welfare (see, Acharya and Bisin, 2000), it is not necessarily so for innovations which allow entrepreneurs and managers to hedge their firm's (or their sector's) risk. This is because such innovations might have a negative effect on managerial incentives by essentially un-doing the firms' incentive compensation schemes.

Consider again the case of entrepreneurs or managers of firm f (respectively firm g) in Section 4.3.1. What happens if we allow such entrepreneurs to trade factor x_2 (respectively factor x_3)? In this case, incentive contracts have no bite. There is no mechanism by which the entrepreneur can commit to reducing the correlation of his firm return with the stock market, i.e., he cannot commit to holding a smaller fraction of the firm in his portfolio so as to reduce the loading of his firm's risk on x_1. Similarly, corporations cannot align the managers' objectives with those of their investors by way of incentive contracts. The entrepreneurs' portfolio can be rebalanced after the firm is sold on the market and the managers' incentive contracts can be "undone" in financial markets. As a consequence, in equilibrium, the fraction of their firms that entrepreneurs (managers) hold coincides with the market share of the firm which is the first best fraction w^*, but crucially, the loading on x_1 is not reduced at all and coincides with the initial loading $\bar{\beta}_1^f$. Thus, we conclude that, in this case, aggregate welfare is reduced as a consequence of financial innovation which allows the entrepreneurs (managers) to better hedge the risks in their portfolios.

Even though such financial innovations have in general negative welfare effects for the economy as a whole, financial markets have in general all the interest to introduce such financial instruments: entrepreneurs and managers will in fact demand them. There is in fact evidence of a sizeable market created by investment banks to manufacture or reverse-engineer "collars" out of derivative products for CEOs and senior executives to help them manage their labor income risk; Ofek and Yermack (2000) document that once managers reach a certain ownership level, they do actively rebalance their portfolios by various means, possibly also by using such innovative financial instruments.

In summary, innovations which have a negative effect on incentives tend to be those which allow the entrepreneurs and managers to hedge sector-specific risk. By contrast, those innovations which provide the entrepreneurs and managers an instrument to diversify firm-specific or purely idiosyncratic risks in general tend to improve the welfare of entrepreneurs and managers and also have a positive effect on their incentives.

7 Conclusions

This paper is a first attempt at integrating the analysis of firms' corporate structure and incentive compensation schemes into a general equilibrium model of the stock market, with the objective of identifying managerial incentives as a determinant of the endogenous aggregate or economy-wide risk. While we concentrated our analysis on specific agency problems between entrepreneurs and investors, and between managers and stockholders, the model we developed could be of more general use in financial economics.

Our analysis suggests that a useful empirical strategy for both cross-sectional and time-series studies of firm-level and economy-wide performance and volatility might consist of extending the range of explanatory variables to include managerial incentives.

For instance, the integration of corporate structure considerations could help explain the amplitude of the observed fluctuations in aggregate stock volatility and their correlation with the business cycle, which has proved so difficult to justify simply by means of other firm-specific characteristics such as financial leverage; see Schwert (1989).

Also, corporate structure considerations and incentive compensation schemes, when intergrated in the CAPM, could contribute to our understanding of asset pricing anomalies in cross-sectional beta regressions (see Cochrane, 2000, for a survey of this literature), e.g., by providing a theoretical justification for the introduction of corporate structure and managerial incentives in the regressions of firm-level returns on aggregate risk factors.

Finally, a promising application of the endogenous determination of the risk composition of firms and managerial incentives appears to be in the area of corporate mergers and acquisitions. Indeed, these corporate activities are important means through which managers can affect their diversifying incentives and the resulting risk compositions of firm cash flows. Our conjecture is that a model incorporating such managerial incentives might help explain the cross-sectional variation in expected returns and discounts (premia) observed in conglomerates, as documented for example by Lamont and Polk (2001).

APPENDIX 1: Competitive Equilibrium with Positive Net Supply Assets

We state first the formal assumptions about the economy we study.

Assumption 1 *The utility function of agent h is:*

1. *time and state separable:*

$$u^h(c_0, c_1) := u^h(c_0) + u^h(c_1(\omega)),\ \omega \in \Omega,$$

2. *CARA with identical absolute risk aversion, $A > 0$, across agents:*[31]

$$u^h(c) = -\frac{1}{A}e^{-A\,c}$$

Assumption 2 *The economy has a N-dimensional orthogonal normal factor structure (x_1, ..., x_n) which is a multivariate normal with mean 0 and variance-covariance matrix (normalized to) I, the identity matrix.*

In particular, each agent h's endowments in period 1, y_1^h, is generated as linear combinations of N underlying normal risk factors, and hence is in general correlated with other agents' endowments:

$$y_1^h - E(y_1^h) := \sum_{n=1}^{N} \beta_n^h x_n\ ,\ h = F+1, ..., H$$

Each firm's cash flow, y_1^f, is also generated by the N factors. Without loss of generality, we assume that the stock market risk is driven by $C < N$ common orthogonal factors, $(x_1, ..., x_C)$, and, F orthogonal factors, $(x_{C+1}, ..., x_{C+F})$, which correspond to the sectoral risk added by each firm's cash flow:

$$y_1^f - E(y_1^f) := \sum_{c=1}^{C} \beta_c^f x_c + \beta_f^f x_{C+f},\ f = 1, ..., F$$

Financial assets have payoff z_i, $i = 1, ..., I$, which in terms of the factor structure is written as:

$$z_i - E(z_i) := \sum_{c=1}^{C} \beta_c^i x_c + \sum_{i=1}^{I} \beta_j^i x_{C+F+i},\ i = 1, ..., I$$

[31]Only notational complications are added by allowing heterogeneity in absolute risk aversion parameters.

where $(x_{C+F+1}, ..., x_{C+F+I})$ contains the additional risks in the return structure of financial markets.

As discussed in the main text, we use a single index for all factors: $j \in \mathcal{J} := \{1, \ldots, J\}$, where $J := C + F + I$. In general, $J < N$ and $\mathcal{J}^h \subset \mathcal{J}$, for some h, but:

Assumption 3 *All agents h are allowed to trade the risk-free bond.*

The problem of each agent h is to choose a consumption allocation, $[c_0^h, c_1^h] \in \Re^2$, and portfolio positions in the risk-free bond and in all tradable assets, $[\theta_0^h, \theta_j^h]_{j\in\mathcal{J}} \in \Re^{J+1}$, to maximize

$$u^h(c_0^h, c_1^h) := -\frac{1}{A}e^{-Ac_0^h} + E\left[-\frac{1}{A}e^{-Ac_1^h}\right] \tag{9}$$

subject to the budget constraints and the restricted participation constraints:

$$\begin{aligned}
c_0^h &= y_0^h - \pi_0\theta_0^h - \sum_{j\in\mathcal{J}} \pi_j\theta_j^h,\ h \in \mathcal{H},\ h > F && (10)\\
c_0^h &= y_0^h + \sum_{0\le j\le J} \pi_j s_j^h - \pi_0\theta_0^h - \sum_{j\in\mathcal{J}^h} \pi_j\theta_j^h,\ h \in \mathcal{H},\ h \le F && (11)\\
c_1^h &= y_1^h + \theta_0^h + \sum_{j\in\mathcal{J}} \theta_j^h x_j,\ h \in \mathcal{H},\ h > F && (12)\\
c_1^h &= (1 - w^h)y_1^h + \theta_0^h + \sum_{j\in\mathcal{J}} \theta_j^h x_j,\ h \in \mathcal{H},\ h \le F && (13)\\
\theta_j^h &= 0,\ \ j \notin \mathcal{J}^h && (14)
\end{aligned}$$

Note that the budget constraint for entrepreneur h includes the time–0 proceeds from the sale of a fraction w^h of his firm amounting to $\sum_{0\le j\le J} \pi_j s_j^h$, where s_j^h denotes the positive supply of risk factor j provided by the entrepreneur h through the sale of fraction w^h of his firm. These positive supplies are given by $s_0^h = w^h E(y_1^h)$ and $s_j^h = w^h\beta_j^h,\ 1 \le j \le J$.

Definition 1 *A competitive equilibrium is a consumption allocation (c_0^h, c_1^h), for all agents $h \in \mathcal{H}$, which solves the problem of maximizing (9) subject to (10–14) at prices $\pi := [\pi_0, \pi_j]_{j\in\mathcal{J}}$, and such that consumption and financial markets clear:*

$$\sum_h \left(c_0^h - y_0^h\right) \le 0, \tag{15}$$

$$\sum_h \left(c_1^h - y_1^h\right) \le 0,\ \textit{with probability } 1 \textit{ over } \Omega,\ \textit{and} \tag{16}$$

$$\sum_h \theta_j^h = s_j, \; j = 0, 1, \ldots, J \tag{17}$$

where s_j is the net supply of factor j, $s_j := \sum_{1 \le h \le F} s_j^h$.

The competitive equilibrium of the two-period CAPM economy, defined by equations (9)-(14), with the market-clearing conditions (15)-(17), is characterized by prices of assets (π_j), portfolio choices (θ_j^h), and consumption allocations (c_t^h), given below.

$$\pi_0 = exp\left\{ A\left(y_0 - Ey_1\right) + \frac{A^2}{2H} \sum_{h \in H} \left[(1 - R_h^2) var(y_1^h) + \sum_{j \in J^h} \left(\beta_j + \frac{1}{H_j} s_j \right)^2 \right] \right\} \tag{18}$$

where

$$y_0 = \frac{1}{H} \sum_{h \in \mathcal{H}} y_0^h \,, \quad y_1 = \frac{1}{H} \sum_{h \in \mathcal{H}} y_1^h \tag{19}$$

$$\beta_j = cov\left[\frac{1}{H_j} \left(\sum_{h \in H_j, h \le F} (1 - w^h) y_1^h + \sum_{h \in H_j, h > F} y_1^h \right), x_j \right] \tag{20}$$

$$\frac{\pi_j}{\pi_0} = E\left(x_j\right) - A\left(\beta_j + \frac{1}{H_j} s_j \right) \tag{21}$$

and for $h > F$ (non-entrepreneurs),

$$R_h^2 := \frac{\sum_{j \in J^h} \left(\beta_j^h\right)^2}{var(y_1^h)}$$

$$\theta_j^h = \left(\beta_j + \frac{1}{H_j} s_j \right) - \beta_j^h, \;\; j \in \mathcal{J}^h, \quad \text{and } \theta_j^h = 0, \;\; j \in (\mathcal{J}^h)^c \tag{22}$$

$$\theta_0^h = \frac{1}{1 + \pi_0} \left(y_0^h - E(y_1^h) - \sum_{j \in \mathcal{J}^h} \pi_j \theta_j^h + \frac{A}{2}\, var(c_1^h) - \frac{1}{A}\, ln(\pi_0) \right) \tag{23}$$

$$c_1^h = \theta_0^h + \sum_{j \in \mathcal{J}^h} \left(\beta_j + \frac{1}{H_j} s_j \right) x_j + \left(y_1^h - \sum_{j \in \mathcal{J}^h} \beta_j^h x_j \right) \tag{24}$$

$$var(c_1^h) = var(y_1^h) - \sum_{j\in\mathcal{J}^h} (\beta_j^h)^2 + \sum_{j\in\mathcal{J}^h} \left(\beta_j + \frac{1}{H_j} s_j\right)^2 \tag{25}$$

$$c_0^h = -\frac{1}{A}\, ln\, \frac{1}{\pi_0} + E(y_1^h) + \theta_0^h - \frac{A}{2}\, var(c_1^h) \tag{26}$$

and finally, for $h \leq F$ (entrepreneurs),

$$R_h^2 := \frac{\sum_{j\in J^h} (1-w^h)^2 \cdot \left(\beta_j^h\right)^2}{var(y_1^h)}$$

$$\theta_j^h = \left(\beta_j + \frac{1}{H_j} s_j\right) - (1-w^h)\beta_j^h, \;\; j \in \mathcal{J}^h, \quad \text{and } \theta_j^h = 0, \;\; j \in (\mathcal{J}^h)^c \tag{27}$$

$$\theta_0^h = \frac{1}{1+\pi_0}\left(y_0^h + \sum_{0\leq j\leq J} \pi_j s_j^h - (1-w^h)E(y_1^h) - \sum_{j\in\mathcal{J}^h} \pi_j \theta_j^h + \frac{A}{2}\, var(c_1^h) - \frac{1}{A}\, ln(\pi_0)\right) \tag{28}$$

$$c_1^h = \theta_0^h + \sum_{j\in\mathcal{J}^h} \left(\beta_j + \frac{1}{H_j} s_j\right) x_j + (1-w^h) \cdot \left(y_1^h - \sum_{j\in\mathcal{J}^h} \beta_j^h x_j\right) \tag{29}$$

$$var(c_1^h) = (1-w^h)^2 var(y_1^h) - \sum_{j\in\mathcal{J}^h} (1-w^h)^2(\beta_j^h)^2 + \sum_{j\in\mathcal{J}^h} \left(\beta_j + \frac{1}{H_j} s_j\right)^2 \tag{30}$$

$$c_0^h = -\frac{1}{A}\, ln\, \frac{1}{\pi_0} + (1-w^h)E(y_1^h) + \theta_0^h - \frac{A}{2}\, var(c_1^h) \tag{31}$$

$$s_0^h = w^h E(y_1^h), \quad s_j^h = w^h \beta_j^h \tag{32}$$

The equilibrium with positive supply of assets is similar to the one without positive supply (see, Willen, 1997, and, Acharya and Bisin, 2000) but all expressions for the entrepreneurs are modified to reflect the facts that (i) entrepreneur h holds only a fraction $(1 - w^h)$ of his firm, (ii) entrepreneur h collects at time 0 proceeds for the remaining fraction w^h of his firm amounting to $\sum_{0\leq j\leq J} \pi_j s_j^h$, and (iii) aggregate beta β_j in zero supply assets case is replaced by $(\beta_j + \frac{1}{H_j} s_j)$ to reflect the positive supply of assets.

APPENDIX 2: Welfare Properties

Let $[c_0, c_1] := [c_0^h, c_1^h]_{h \in H}$ and let $U([c_0, c_1])$ denote the welfare associated with the consumption allocation $[c_0, c_1]$:

$$U([c_0, c_1]) = \sum_{h \in \mathcal{H}} \left(-\frac{1}{A} e^{-Ac_0^h} + E\left[-\frac{1}{A} e^{-Ac_1^h} \right] \right). \tag{33}$$

Let $[c_0, c_1]$ denote the equilibrium allocation; and let $[c_0^a, c_1^a]$ be the equilibrium allocation for a benchmark economy. The welfare measure μ is the *compensating aggregate transfer* which by definition solves

$$U([c_0^a, c_1^a]) = U([c_0 - \mu, c_1]) \tag{34}$$

The individual compensating transfer, μ^h, can be defined similarly as

$$U^h([c_0^a, c_1^a]) = U^h([c_0 - \mu^h, c_1]), \text{ where} \tag{35}$$

$$U^h([c_0, c_1]) = -\frac{1}{A} e^{-Ac_0^h} + E\left[-\frac{1}{A} e^{-Ac_1^h} \right]. \tag{36}$$

Further, it can be shown that $\mu = \sum_{h \in \mathcal{H}} \mu^h$.

Using the closed-form competitive equilibrium solution stated in Appendix 1, it can be shown that (in particular, see Willen, 1997) the relative individual welfare of agent h across two economies wherein his date–0 consumptions are c_0^h and $c_0^{h\prime}$, respectively, and with respective prices of the risk-free asset as π_0 and π_0', is measured by

$$\mu^h - \mu^{h\prime} = c_0^h - c_0^{h\prime} - \frac{1}{A} \, ln \, \frac{1 + \pi_0}{1 + \pi_0'} \tag{37}$$

Similarly, the relative welfare of two economies with respective prices of the risk-free asset as π_0 and π_0', is measured by

$$\mu - \mu' = -\frac{H}{A} \, ln \, \frac{1 + \pi_0}{1 + \pi_0'} \tag{38}$$

APPENDIX 3: Production Choice

When an entrepreneur (or manager) of firm f undertakes a production choice, he incurs a cost as described below.

Assumption 4 *Each firm's betas on the risk factors, $\boldsymbol{\beta^f}$, which have an initial value of $\bar{\boldsymbol{\beta}}^{\boldsymbol{f}}$ can be changed at a cost $c(\boldsymbol{\beta^f},\bar{\boldsymbol{\beta}}^{\boldsymbol{f}})$.*

Definition 2 *The capital structure w^h (the fraction of the firm that is traded on the stock market) and firm's betas on risk factors $\boldsymbol{\beta^h}$ are the optimal choices of the entrepreneur of an owner–managed firm, $f = h$, with no moral hazard, if they maximize entrepreneur h's equilibrium welfare:*

$$\mu^h - c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}}) = c_0^h - \tfrac{1}{A}\, ln\ (1+\pi_0) - c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}})$$

where c_0^h is as in the competitive equilibrium in Appendix 1 (equation 27-32), for given π_0, π_j, s_j.

Next, we formally define the production choice problem that is faced by the entrepreneur of an owner–managed firm with moral hazard.

Definition 3 *The capital structure w^h (the fraction of the firm that is traded on the stock market) and firm's betas on risk factors $\boldsymbol{\beta^h}$ are the optimal choices of the entrepreneur of an owner–managed firm, $f = h$, with moral hazard if,*

(i) w^h maximizes entrepreneur h's equilibrium welfare:

$$\mu^h - c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}}) = c_0^h - \tfrac{1}{A}\, ln\ (1+\pi_0) - c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}})$$

where c_0^h is as in the competitive equilibrium in Appendix 1 (equation 27-32), for given π_0, π_j, s_j, and

(ii) $\boldsymbol{\beta^h} = \boldsymbol{\beta^h}(w^h)$ where $\boldsymbol{\beta^h}(w)$ maximizes entrepreneur's welfare at capital structure w after the firm has been sold:

$$\mu^h - c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}}) = c_0^h - \tfrac{1}{A}\, ln\ (1+\pi_0) - c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}})$$

where c_0^h is as in Appendix 1 (equation 27-31), for given π_0, π_j, s_j^h.

Finally, we formally define the production choice problem that is faced by the manager of a corporation (with moral hazard).

Definition 4 *The capital structure w^h (the fraction of different firms that are traded on the stock market) and firm's betas on risk factors $\boldsymbol{\beta^h}$ are optimal choices of the corporation, $f = h$, with moral hazard if, given π_0, π_j, s_j,*

(i) w^h maximizes the equilibrium welfare of investors in the corporation:

$$\textstyle\sum_{h'\in\mathcal{H}_h} \mu^{h'} = \sum_{h'\in\mathcal{H}_h} \left[c_0^{h'} - \tfrac{1}{A}\, ln\ (1+\pi_0)\right]$$

where c_0^h *is as given in the competitive equilibrium in Appendix 1 (equation 22-26) and* $\mathcal{H}_h$ *denotes the set of agents (investors) who own ex-ante the firm h, and*

(ii) $\boldsymbol{\beta^h} = \boldsymbol{\beta^h}(w^h)$ *where* $\boldsymbol{\beta^h}(w)$ *maximizes at capital structure w the welfare of the manager after he has received his compensation:*

$\mu^h - c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}}) = c_0^h - \frac{1}{A}\, ln\ (1+\pi_0) - c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}})$

where c_0^h *is given by equations (27), (29-31), and*

$$\theta_0^h \;=\; \frac{1}{1+\pi_0}\left(y_0^h + \Pi^h - (1-w)E(y_1^h) - \sum_{j\in\mathcal{J}^h}\pi_j\theta_j^h + \frac{A}{2}\,var(c_1^h) - \frac{1}{A}\,ln(\pi_0)\right), \quad (39)$$

where Π^h *is a lump sum constant such that the equilibrium welfare of the manager*

$\mu^h - c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}}) = c_0^h - \frac{1}{A}\, ln\ (1+\pi_0) - c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}})$

is equal to his reservation welfare $\overline{W}$.

APPENDIX 4: First Best Efficiency and Constrained Efficiency

Definition 5 *The capital structure* $\boldsymbol{w}$ *(the fraction of different firms that are traded on the stock market) and betas of different firms on risk factors* $\boldsymbol{\beta}$ *are first best efficient for the economy if they maximize*

$\mu - \sum_{h\leq F} c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}}) = -\frac{H}{A}\, ln\ (1+\pi_0) - \sum_{h\leq F} c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}})$

where π_0 *is given by equations (22-32) in the competitive equilibrium of Appendix 1.*

Definition 6 *The capital structure* $\boldsymbol{w}$ *(the fraction of different firms that are traded on the stock market) and betas of different firms on risk factors* $\boldsymbol{\beta}$ *are constrained efficient for the owner-managed firm economy if*

(i) $\boldsymbol{w} = (w^h)_{h\leq F}$ *maximizes aggregate welfare:*

$\mu - \sum_{h\leq F} c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}}) = -\frac{H}{A}\, ln\ (1+\pi_0) - \sum_{h\leq F} c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}})$

where π_0 *is given by equations (22-32) in the competitive equilibrium of Appendix 1, and*

(ii) $\boldsymbol{\beta} = [\boldsymbol{\beta^h}(w^h)]_{h\leq F}$ *where* $\boldsymbol{\beta^h}(w)$ *maximizes entrepreneur h's welfare at capital structure w after the firm* $f = h$ *has been sold:*

$\mu^h - c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}}) = c_0^h - \frac{1}{A}\, ln\ (1+\pi_0) - c(\boldsymbol{\beta^h},\bar{\boldsymbol{\beta}}^{\boldsymbol{h}})$

where c_0^h *is as in Appendix 1 (equation 27-31), for given* π_0, π_j, s_j^h.

Definition 7 *The capital structure* $\boldsymbol{w}$ *(the fraction of different firms that are traded on the stock market) and betas of different firms on risk factors* $\boldsymbol{\beta}$ *are constrained efficient for the corporation economy if*

(i) $\boldsymbol{w} = (w^h)_{h\leq F}$ *maximizes aggregate welfare:*

$\mu - \sum_{h\leq F} c(\boldsymbol{\beta^h},\boldsymbol{\bar{\beta}^h}) = -\frac{H}{A}\, ln\ (1+\pi_0) - \sum_{h\leq F} c(\boldsymbol{\beta^h},\boldsymbol{\bar{\beta}^h})$

where π_0 *is given by equations (22-32) in the competitive equilibrium of Appendix 1, and*

(ii) $\boldsymbol{\beta} = [\boldsymbol{\beta^h}(w^h)]_{h\leq F}$ *where* $\boldsymbol{\beta^h}(w)$ *maximizes at capital structure* w *the welfare of the manager after he has received his compensation:*

$\mu^h - c(\boldsymbol{\beta^h},\boldsymbol{\bar{\beta}^h}) = c_0^h - \frac{1}{A}\, ln\ (1+\pi_0) - c(\boldsymbol{\beta^h},\boldsymbol{\bar{\beta}^h})$

where c_0^h *is given by equations (27), (29-31), and*

$$\theta_0^h = \frac{1}{1+\pi_0}\left(y_0^h + \Pi^h - (1-w)E(y_1^h) - \sum_{j\in\mathcal{J}^h}\pi_j\theta_j^h + \frac{A}{2}\, var(c_1^h) - \frac{1}{A}\, ln(\pi_0)\right), \quad (40)$$

where Π^h *is a lump sum constant such that the equilibrium welfare of the manager*

$\mu^h - c(\boldsymbol{\beta^h},\boldsymbol{\bar{\beta}^h}) = c_0^h - \frac{1}{A}\, ln\ (1+\pi_0) - c(\boldsymbol{\beta^h},\boldsymbol{\bar{\beta}^h})$

is equal to his reservation welfare $\overline{W}$.

APPENDIX 5: Proofs of Propositions

If we restrict attention to the special case of our general setup with a single class of firms and two risk factors as formalized in Section 4, then:

Assumption 5 *Entrepreneur (manager) can choose* β_1^f*, the firm's beta on the aggregate risk which has an initial value of* $\bar{\beta}_1^f$*, subject to a cost* $c\left(\beta_1^f - \bar{\beta}_1^f\right)$*, where* $c\left(\beta_1^f - \bar{\beta}_1^f\right)$ *is smooth, monotonic increasing, strictly convex in* $\left(\beta_1^f - \bar{\beta}_1^f\right)^2$*, and naturally,* $c\,(0) = 0$.

Proof of Proposition 1. We first consider the representative entrepreneur's choice of the firm's cash flows, β_1^f, for a given capital structure w, and next, we consider the choice of optimal w taking into account the production choice.

Let $[\bar{c}_0^1, \bar{c}_1^1]$ denote the equilibrium consumption of the entrepreneur at the initial cash flow composition $\bar{\beta}_1^f$, and $[c_0^1, c_1^1]$ denote the equilibrium consumption of the entrepreneur after his production choice β_1^f. Note that we have not substituted $f = 1$ in β_1^f in order to signify that this is the production choice of firm. The entrepreneur's welfare is measured by the compensating individual transfer, μ^1, given by equation (37):

$$\mu^1 - \bar{\mu}^1 = c_0^1 - \bar{c}_0^1 - \frac{1}{A}\, ln\, \left(\frac{1+\pi_0}{1+\bar{\pi}_0}\right).$$

In addition, the entrepreneur suffers a non-pecuniary cost as specified in Assumption 5. Given the cost structure assumptions, it follows that the entrepreneur increases (decreases) the aggregate risk of firm's cash flows, β_1^f, whenever his individual welfare μ^1 is increasing (decreasing) in β_1^f.

Hence, we compute $\frac{\partial \mu^1}{\partial \beta_1^f}$ below. Note that the entrepreneur trades only in asset 1 (the aggregate risk asset), anticipates the change in his firm's price due to change in its cash flows (loadings on risk factors), but takes as given the prices of all assets and the aggregate supply of risky assets. Hence, using the competitive equilibrium outcomes from Appendix 1, it follows that

$$\begin{aligned}
\frac{\partial \mu^1}{\partial \beta_1^f} &= \frac{\partial c_0^1}{\partial \beta_1^f} \\
&= \frac{\partial}{\partial \beta_1^f}\left[\theta_0^1 - \frac{A}{2}\cdot var(c_1^1)\right] \\
&= \frac{\partial}{\partial \beta_1^f}\left[\frac{\pi_1}{1+\pi_0}\left(s_1^1 + (1-w)\beta_1^f - (\beta_1 + \frac{1}{H_1}s_1)\right) + \frac{\pi_2}{1+\pi_0}\, s_2^1 - \frac{A\pi_0}{2(1+\pi_0)}\cdot var(c_1^1)\right] \\
&= \frac{\pi_1}{1+\pi_0} - \frac{\pi_2}{1+\pi_0}\cdot w\, \frac{\beta_1^f}{\beta_2^f} + \frac{A\,\pi_0}{1+\pi_0}\,(1-w)^2\beta_1^f \qquad (41) \\
&= \frac{A\,\pi_0}{1+\pi_0}\left[\left((1-w)^2 + \frac{w^2}{H-1} - \frac{1}{H}\right)\beta_1^f - \frac{1}{H}\sum_{h=2}^{H}\bar{\beta}_1^h\right]. \qquad (42)
\end{aligned}$$

where we have used the facts that

$$s_1^1 = w\beta_1^f,\ s_2^1 = w\beta_2^f,\ (\beta_1^f)^2 + (\beta_2^f)^2 = \overline{V},\ \mathcal{J}^1 = \{1\},\ H_1 = H,\ H_2 = H-1, \qquad (43)$$

the expression for $var(c_h^1)$ is employed from equation (30), and to obtain equation (42) from equation (41), we have substituted for the equilibrium prices and aggregate supplies:

$$\begin{aligned}
\beta_1 &= \frac{1}{H}\left[\sum_{h=2}^{H}\bar{\beta}_1^h + (1-w)\beta_1^f\right],\quad s_j = w\beta_j^f \text{ for } j = 1,2,\quad \pi_1 = -A\,\pi_0\left(\beta_1 + \frac{1}{H}s_1\right), \\
\pi_2 &= -A\,\pi_0\left(\beta_2 + \frac{1}{H-1}s_2\right) = -\frac{A\,\pi_0}{H-1}\, s_2 \text{ since } \beta_2 = 0 \text{ (by construction)}. \qquad (44)
\end{aligned}$$

It follows from equation (42) that there exists a threshold $\beta_1^*(w) = \frac{1}{[(1-w)^2 + \frac{w^2}{H-1} - \frac{1}{H}]} \cdot \frac{1}{H} \sum_{h=2}^{H} \bar{\beta}_1^h$ such that the entrepreneurs' choice of aggregate risk loading β_1^f satisfies the following:

- if $\bar{\beta}_1^f < \beta_1^*(w)$, then $\beta_1^f < \bar{\beta}_1^f$, and
- if $\bar{\beta}_1^f > \beta_1^*(w)$, then $\beta_1^f > \bar{\beta}_1^f$.

Consider now the choice of the capital structure w by the entrepreneur. Denoting the costs associated to the production choice as simply $c(\cdot)$, we can write

$$\frac{d[\mu^1 - c(\cdot)]}{dw} = \frac{\partial[\mu^1 - c(\cdot)]}{\partial \beta_1^f} \cdot \frac{d\beta_1^f}{dw} + \frac{\partial[\mu^1 - c(\cdot)]}{\partial w} \;=\; \frac{\partial[\mu^1 - c(\cdot)]}{\partial w}$$

since $\frac{\partial[\mu^1 - c(\cdot)]}{\partial \beta_1^f} = 0$ by the first order condition for entrepreneur's production choice. Since the entrepreneur takes prices of all assets and aggregate supplies as given, we obtain that

$$\frac{\partial[\mu^1 - c(\cdot)]}{\partial w} = \frac{\partial c_0^1}{\partial w} \;=\; \frac{\partial}{\partial w}\left[(1-w)E(y_1^f) + \theta_0^1 - \frac{A}{2} \cdot var(c_1^1)\right],$$

where

$$\begin{aligned} \theta_0^1 - \frac{A}{2} \cdot var(c_1^1) \;&=\; \frac{1}{1+\pi_0}\left[y_0^1 - (1-w)E(y_1^f) + \pi_0 w E(y_1^f) + \sum_{j=1}^{2} \pi_j w \beta_j^f - \pi_1 \theta_1^1\right] \\ &- \; \frac{A}{2} \cdot \frac{\pi_0}{1+\pi_0} var(c_1^1) - \frac{1}{A(1+\pi_0)} \, ln(\pi_0). \end{aligned} \tag{45}$$

Simplifying using the conditions in equations (43)–(44) above, we obtain

$$\begin{aligned} \frac{\partial[\mu^1 - c(\cdot)]}{\partial w} \;&=\; -E(y_1^f) + \frac{1}{1+\pi_0}\left[(1+\pi_0)E(y_1^f) + \pi_2 \beta_2^f\right] + \frac{A\,\pi_0}{1+\pi_0}(1-w)(\beta_2^f)^2 \\ &=\; \frac{1}{1+\pi_0}\left[\pi_2 \beta_2^f + A\pi_0(1-w)(\beta_2^f)^2\right] \\ &=\; \frac{A\,\pi_0}{1+\pi_0}\,(\beta_2^f)^2\,\left(1 - w - \frac{w}{H-1}\right). \end{aligned} \tag{46}$$

It follows that $\frac{d[\mu^1 - c(\cdot)]}{dw} = \frac{\partial[\mu^1 - c(\cdot)]}{\partial w} = 0$ at $w^* = 1 - \frac{1}{H}$. It can also be verified that

$$\begin{aligned} \frac{d^2[\mu^1 - c(\cdot)]}{dw^2} \;&=\; \frac{d}{dw}\left(\frac{\partial[\mu^1 - c(\cdot)]}{\partial w}\right) \\ &=\; \frac{\partial^2 \mu^1}{\partial w^2} + \frac{\partial^2 \mu^1}{\partial \beta_2^f \partial w} \cdot \frac{d\beta_2^f}{dw} \\ &=\; \frac{\partial^2 \mu^1}{\partial w^2} \;=\; -\frac{H}{H-1} \cdot \frac{A\,\pi_0}{1+\pi_0}(\beta_2^f)^2 \;<\; 0, \end{aligned} \tag{47}$$

since

$$\frac{\partial^2 \mu^1}{\partial \beta_2^f \partial w} = \frac{\partial}{\partial \beta_2^f}\left[\frac{A\,\pi_0}{1+\pi_0}\,(\beta_2^f)^2\,\left(1-w-\frac{w}{H-1}\right)\right]$$
$$= \frac{2\,A\,\pi_0}{1+\pi_0}\,\beta_2^f\,\left(1-w-\frac{w}{H-1}\right) \;=\; 0 \text{ at } w^* = 1-\frac{1}{H}\,. \tag{48}$$

The entrepreneur's capital structure choice is thus given by $w^* = 1 - \frac{1}{H}$. ♢

Since the proof of Proposition 4 (first–best) relies on some of the steps in the above proof, we present it next.

Proof of Proposition 4. In the first best, the capital structure choice as well as the choice of firm's risk loadings is undertaken by the planner. Consider first the choice of the risk loading β_1^f by the planner for a given capital structure w. The expression for compensating aggregate transfer $\mu = \sum_{h=1}^{H} \mu^h$ is given in equation (38). The cost structure for the production choice stated in Assumption 5 implies that the planner increases (decreases) the aggregate risk of firm's cash flows, β_1^f, whenever aggregate welfare μ is increasing (decreasing) in β_1^f.

From the expression for π_0 in competitive equilibrium characterized in Appendix 1, equation (18), and using the facts that $(\beta_1^f)^2+(\beta_2^f)^2 = \overline{V}$, $\beta_2 = 0$ (by construction), $(\beta_1 + \frac{1}{H_1}s_1) = \frac{1}{H}[\sum_{h=2}^{H}\bar{\beta}_1^h + (1-w)\beta_1^f + w\beta_1^f] = \frac{1}{H}(\sum_{h=2}^{H}\bar{\beta}_1^h + \beta_1^f)$, and $(\beta_2 + \frac{1}{H_2}s_2) = \frac{1}{H_2}s_2 = \frac{w}{H-1}\,\beta_2^f$, we obtain:

$$\frac{\partial \mu}{\partial \beta_1^f} = -\,\frac{H}{A(1+\pi_0)}\cdot\frac{\partial \pi_0}{\partial \beta_1^f}, \text{ where} \tag{49}$$
$$\frac{\partial \pi_0}{\partial \beta_1^f} = \pi_0\cdot\frac{A^2}{2H}\cdot\frac{\partial}{\partial \beta_1^f}\left[(1-w)^2 var(y_1^f) - (1-w)^2(\beta_1^f)^2 + \sum_{H\in\mathcal{H}}\sum_{j\in\mathcal{J}^h}\left(\beta_j + \frac{1}{H_j}s_j\right)^2\right]$$
$$= \pi_0\cdot\frac{A^2}{2H}\cdot\frac{\partial}{\partial \beta_1^f}\left[-(1-w)^2(\beta_1^f)^2 + \frac{1}{H}\left(\sum_{h=2}^{H}\bar{\beta}_1^h + \beta_1^f\right)^2 + \frac{w^2}{H-1}\cdot(\beta_2^f)^2\right]$$
$$= \pi_0\cdot\frac{A^2}{H}\cdot\left[-(1-w)^2\beta_1^f + \frac{1}{H}\left(\sum_{h=2}^{H}\bar{\beta}_1^h + \beta_1^f\right) - \frac{w^2}{H-1}\cdot\beta_1^f\right]. \tag{50}$$

Equations (49) and (50) can be simplified to yield

$$\frac{\partial \mu}{\partial \beta_1^f} = \frac{A\,\pi_0}{1+\pi_0}\left[\left((1-w)^2 + \frac{w^2}{H-1} - \frac{1}{H}\right)\beta_1^f - \frac{1}{H}\sum_{h=2}^{H}\bar{\beta}_1^h\right].$$

This is exactly identical to $\frac{\partial \mu^1}{\partial \beta_1^f}$ in equation (42) implying that for a given capital structure w, the first best production choice β_1^f is the same as that of the entrepreneur in the absence of moral hazard.

Next, consider the planner's choice of capital structure w. Note that

$$\frac{d[\mu - c(\cdot)]}{dw} = \frac{\partial[\mu - c(\cdot)]}{\partial \beta_1^f} \cdot \frac{d\beta_1^f}{dw} + \frac{\partial[\mu - c(\cdot)]}{\partial w} = \frac{\partial \mu}{\partial w}$$

since $\frac{\partial[\mu - c(\cdot)]}{\partial \beta_1^f} = 0$ by the first order condition for production choice. Thus,

$$\frac{\partial \mu}{\partial w} = -\frac{H}{A(1+\pi_0)} \cdot \frac{\partial \pi_0}{\partial w}, \text{ where} \tag{51}$$

$$\begin{aligned}
\frac{\partial \pi_0}{\partial w} &= \pi_0 \cdot \frac{\partial}{\partial w}\left[\frac{A^2}{2H}\left((1-w)^2 var(y_1^f) - (1-w)^2(\beta_1^f)^2 + \sum_{H \in \mathcal{H}} \sum_{j \in \mathcal{J}^h}\left(\beta_j + \frac{1}{H_j} s_j\right)^2\right)\right] \\
&= \pi_0 \cdot \frac{A^2}{2H} \cdot \frac{\partial}{\partial w}\left[(1-w)^2(\beta_2^f)^2 + \frac{1}{H}\left(\sum_{h=2}^{H} \bar{\beta}_1^h + \beta_1^f\right)^2 + \frac{w^2}{H-1} \cdot (\beta_2^f)^2\right] \\
&= \pi_0 \cdot \frac{A^2}{2H} \cdot \left[-2(1-w)(\beta_2^f)^2 + \frac{2w}{H-1}(\beta_2^f)^2\right] \\
&= \pi_0 \cdot \frac{A^2}{H}(\beta_2^f)^2\left(1 - w - \frac{w}{H-1}\right).
\end{aligned} \tag{52}$$

The above equations can be simplified to yield

$$\frac{d[\mu - c(\cdot)]}{dw} = \frac{A\,\pi_0}{1+\pi_0}\,(\beta_2^f)^2\,\left(1 - w - \frac{w}{H-1}\right).$$

This is exactly identical to $\frac{d[\mu^1 - c(\cdot)]}{dw}$ computed for the entrepreneur in the absence of moral hazard in equation (46). It follows now that in the absence of moral hazard, the entrepreneur's capital structure choice w^*, and by implication also his production choice β_1^*, is first-best efficient. ◇

Since it is easier from an expositional standpoint to present the proofs of Proposition 2, 3 and 5 in a somewhat interleaved fashion, we present them together with an overall roadmap of the exact sequence of steps involved.

Proofs of Proposition 2, 3 and 5.

Sequence of Steps: First, we characterize the production choice β_1^{**} and the capital structure choice w^{**} for the case of owner-managed firm with moral hazard and for the case of corporations (Propositions 2, 3). Next, we show the constrained efficiency of these choices (Proposition 5). Finally, we prove the remaining part of Propositions 2, 3 which is that the equilibrium aggregate risk loading in the moral hazard cases exceeds the benchmark aggregate risk loading, i.e., $\beta_1^* < \beta_1^{**}$.

Step 1: Consider first the production choice $\beta_1^f(w)$ of the entrepreneur in the case of owner managed firms with moral hazard. The analysis is similar to that in the proof of Proposition 1 (no moral hazard case) except for the crucial difference that from the entrepreneur's standpoint, firm's proceeds have already been collected. In other words, while entrepreneur's holding of risk free asset θ_0^1 is given by equation (28) in the rational expectations equilibrium, the relevant holding from the entrepreneur's standpoint at the time of production choice is

$$\hat{\theta}_0^1 = \frac{1}{1+\pi_0}\left(y_0^1 + \Pi^1 - (1-w)E(y_1^f) - \sum_{j\in\mathcal{J}^1} \pi_j\theta_j^1 + \frac{A}{2}\, var(c_1^1) - \frac{1}{A}\, ln(\pi_0)\right),$$

where Π^1 is a lump sum constant representing the already collected proceeds from firm's sale. Note that in equilibrium, investors anticipate the production choice of the entrepreneurs so that $\Pi^1 = w\left(E(y_1^f)\pi_0 + \beta_1^f(w)\pi_1 + \beta_2^f\left(\beta_1^f(w)\right)\pi_2\right)$.

The entrepreneur's welfare $\hat{\mu}^1$ is given by equation (37) except for the difference that at the time of production choice, his time-0 consumption is $\hat{c}_0^1$ which is identical to c_0^1 in the competitive equilibrium of Appendix 1 but employs $\hat{\theta}_0^1$ as the holding of risk free asset. Then, under the standard price-taking assumptions, we obtain:

$$\begin{aligned}
\frac{\partial\hat{\mu}^1}{\partial\beta_1^f} &= \frac{\partial\hat{c}_0^1}{\partial\beta_1^f} = \frac{\partial}{\partial\beta_1^f}\left[\hat{\theta}_0^1 - \frac{A}{2}\cdot var(c_1^1)\right] \\
&= \frac{\partial}{\partial\beta_1^f}\left[\frac{\pi_1}{1+\pi_0}\left((1-w)\beta_1^f - (\beta_1 + \frac{1}{H_1}s_1)\right) - \frac{A}{2}\cdot\frac{\pi_0}{1+\pi_0}\cdot var(c_1^1)\right] \\
&= \frac{\partial}{\partial\beta_1^f}\left[\frac{\pi_1}{1+\pi_0}(1-w)\beta_1^f - \frac{A}{2}\cdot\frac{\pi_0}{1+\pi_0}\cdot(1-w)^2\left(var(y_1^f) - (\beta_1^f)^2\right)\right] \\
&= \frac{\pi_1}{1+\pi_0}(1-w) + \frac{A\,\pi_0}{1+\pi_0}\,(1-w)^2\beta_1^f \qquad (53) \\
&= \frac{A\,\pi_0}{1+\pi_0}(1-w)\left[\left(1-w-\frac{1}{H}\right)\beta_1^f - \frac{1}{H}\sum_{h=2}^{H}\bar{\beta}_1^h\right]. \qquad (54)
\end{aligned}$$

where equation (54) is obtained from equation (53) by substituting for the equilibrium prices and aggregate supplies:

$$\beta_1 = \frac{1}{H}\left[\sum_{h=2}^{H}\bar{\beta}_1^h + (1-w)\beta_1^f\right], \quad s_1 = w\cdot\beta_1^f, \text{ and } \pi_1 = -A\,\pi_0\left(\beta_1 + \frac{1}{H}s_1\right).$$

It follows that there exists a threshold $\beta_1^{**}(w) = \frac{1}{(1-w-\frac{1}{H})}\cdot\frac{1}{H}\sum_{h=2}^{H}\bar{\beta}_1^h$ such that

- if $\bar{\beta}_1^f < \beta_1^{**}(w)$, then $\beta_1^f(w) < \bar{\beta}_1^f$, and
- if $\bar{\beta}_1^f > \beta_1^{**}(w)$, then $\beta_1^f(w) > \bar{\beta}_1^f$.

A little thought reveals that the problem of production choice is analogous for the manager of a corporation. In this case, the manager is awarded a fraction $1-w$ of the firm as his incentive contract and next, he takes decisions on firm's endowments. Since the firm is originally held by the stock market investors, they continue to hold the remaining fraction w of the firm. Hence, the initial time–1 endowments for all agents are identical to their endowments in the case of owner managed firms after a fraction w of the firm has been traded (sold) on the stock market. Thus, the analysis for corporations is identical to that above with Π^1 being replaced by the time–0 lump sum compensation awarded to the manager to ensure that, in equilibrium, he obtains his reservation welfare of $\overline{W}$. This lump sum compensation is deducted from time–0 endowments of the firm owners, $h = 2,\ldots,H$. Since the manager treats Π^1 as a constant while undertaking the choice of firm's risk loading, his choice $\beta_1^f(w)$ is identical to that for the owner managed firm with moral hazard.

Next, consider the choice of capital structure w by the entrepreneur of the owner managed firm. Ex-ante, the entrepreneur recognizes that his proceeds from the sale of the firm are given by $\Pi^1 = w\left(E(y_1^f)\pi_0 + \beta_1^f(w)\pi_1 + \beta_2^f\left(\beta_1^f(w)\right)\pi_2\right)$ in equilibrium, and simply maximizes his equilibrium welfare μ^1, taking account of the costs incurred in production choice and taking all prices as given. Hence, the optimal capital structure w satisfies the first order condition

$$\frac{d[\mu^1 - c(\cdot)]}{dw} = \frac{\partial[\mu^1 - c(\cdot)]}{\partial\beta_1^f}\cdot\frac{d\beta_1^f}{dw} + \frac{\partial[\mu^1 - c(\cdot)]}{\partial w}.$$

We examine each of these three terms next.

(I) First, note that

$$\frac{\partial[\mu^1 - c(\cdot)]}{\partial w} = \frac{A\,\pi_0}{1+\pi_0}\,(\beta_2^f)^2\left(1 - w - \frac{w}{H-1}\right) = 0 \text{ at } w = w^* = 1 - \frac{1}{H}, \tag{55}$$

as in the no moral hazard case (see equation 46 in proof of Proposition 1 above).

However, unlike the no moral hazard case, $\frac{\partial[\mu^1 - c(\cdot)]}{\partial \beta_1^f} \neq 0$ (in general) since β_1^f is picked after the proceeds from firm's sale are collected, i.e., the production choice $\beta_1^f(w)$ is given implicitly by the first order condition $\frac{\partial \hat{\mu}^1}{\partial \beta_1^f} = c'(\cdot)$, the RHS being the marginal cost of undertaking endowment change.

(II) Second, we examine $\frac{\partial[\mu^1 - c(\cdot)]}{\partial \beta_1^f}$.

$$\frac{\partial[\mu^1 - c(\cdot)]}{\partial \beta_1^f} = \frac{\partial[\hat{\mu}^1 - c(\cdot)]}{\partial \beta_1^f} - \frac{\partial(\hat{\mu}^1 - \mu^1)}{\partial \beta_1^f} = -\frac{\partial(\hat{\mu}^1 - \mu^1)}{\partial \beta_1^f} \tag{56}$$

where

$$\begin{aligned}
\frac{\partial(\hat{\mu}^1 - \mu^1)}{\partial \beta_1^f} &= \frac{\partial(\hat{\theta}_0^1 - \theta_0^1)}{\partial \beta_1^f} \\
&= \frac{\partial}{\partial \beta_1^f} \frac{1}{1+\pi_0} \left[\Pi^1 - \pi_0 w E(y_1^f) - \sum_{j=1}^{F} \pi_j w \beta_j^f \right] \\
&= \frac{1}{1+\pi_0} \left[\frac{\partial}{\partial \beta_1^f} \left(-\pi_1 w \beta_1^f - \pi_2 w \beta_2^f \right) \right] \\
&= \frac{1}{1+\pi_0} \left[-\pi_1 w - \pi_2 w \left(-\frac{\beta_1^f}{\beta_2^f} \right) \right] \\
&= \frac{A\,\pi_0\, w}{1+\pi_0} \left[\frac{1}{H} \left(\sum_{h=2}^{H} \bar{\beta}_1^h + \beta_1^f \right) - \frac{w}{H-1} \beta_1^f \right] \\
&= \frac{A\,\pi_0\, w}{H(1+\pi_0)} \left[\sum_{h=2}^{H} \bar{\beta}_1^h + \left(1 - \frac{w}{w^*} \right) \beta_1^f \right]
\end{aligned} \tag{57}$$

where we have employed the equilibrium conditions (43)–(44). It follows that at $w = w^*$, $\frac{\partial(\hat{\mu}^1 - \mu^1)}{\partial \beta_1^f} > 0$ since $\sum_{h=2}^{H} \bar{\beta}_1^h > 0$ and hence, $\frac{\partial[\mu^1 - c(\cdot)]}{\partial \beta_1^f} < 0$.

(III) Finally, we examine $\frac{d\beta_1^f}{dw}$. Since $\frac{\partial[\hat{\mu}^1 - c(\cdot)]}{\partial \beta_1^f} = 0$ and $\frac{\partial^2[\hat{\mu}^1 - c(\cdot)]}{\partial {\beta_1^f}^2} < 0$ by the optimality of production choice, it follows that

$$\frac{\partial^2[\hat{\mu}^1 - c(\cdot)]}{\partial {\beta_1^f}^2} \cdot \frac{d\beta_1^f}{dw} + \frac{\partial^2[\hat{\mu}^1 - c(\cdot)]}{\partial w \partial \beta_1^f} = 0$$

$$\Rightarrow \text{ sign}\left(\frac{d\beta_1^f}{dw} \right) = \text{sign}\left(\frac{\partial^2[\hat{\mu}^1 - c(\cdot)]}{\partial w \partial \beta_1^f} \right) .$$

From equation (54), we get

$$\begin{aligned}\frac{\partial^2[\hat{\mu}^1 - c(\cdot)]}{\partial w \partial \beta_1^f} &= \frac{A\,\pi_0}{1+\pi_0} \cdot \frac{\partial}{\partial w}\left[(1-w)^2 \beta_1^f - \frac{(1-w)}{H}\left(\sum_{h=2}^{H} \bar{\beta}_1^h + \beta_1^f\right)\right] \\ &= \frac{A\,\pi_0}{1+\pi_0}\left[-2(1-w)\beta_1^f + \frac{1}{H}\left(\sum_{h=2}^{H} \bar{\beta}_1^h + \beta_1^f\right)\right]. \end{aligned} \tag{58}$$

It follows that at $w = w^* = 1 - \frac{1}{H}$,

$$\frac{\partial^2[\hat{\mu}^1 - c(\cdot)]}{\partial w \partial \beta_1^f} = \frac{A\,\pi_0}{1+\pi_0}\left[-\frac{2}{H}\beta_1^f + \frac{1}{H}\left(\sum_{h=2}^{H} \bar{\beta}_1^h + \beta_1^f\right)\right] = \frac{A\,\pi_0}{H(1+\pi_0)}\left(\sum_{h=2}^{H} \bar{\beta}_1^h - \beta_1^f\right).$$

Thus at $w = w^* = 1 - \frac{1}{H}$,

if $\beta_1^f(w^*) > \sum_{h=2}^{H} \bar{\beta}_1^h$, then $\frac{d\beta_1^f}{dw} < 0$, and if $\beta_1^f(w^*) < \sum_{h=2}^{H} \bar{\beta}_1^h$, then $\frac{d\beta_1^f}{dw} > 0$.

It follows from (I), (II), and (III) above that

- if $\beta_1^f(w^*) > \sum_{h=2}^{H} \bar{\beta}_1^h$, then $\frac{d[\mu^1 - c(\cdot)]}{dw} > 0$ at $w = w^* = 1 - \frac{1}{H}$, and hence, capital structure choice w is greater than the first-best, i.e., $w^{**} > w^*$.
- If $\beta_1^f(w^*) < \sum_{h=2}^{H} \bar{\beta}_1^h$, then $\frac{d[\mu^1 - c(\cdot)]}{dw} < 0$ at $w = w^* = 1 - \frac{1}{H}$, and hence, capital structure choice w is lower than the first-best, i.e., $w^{**} < w^*$.

Further, from the characterization of the cut-off $\beta_1^{**}(w)$, it follows that $\beta_1^f(w^*) < \bar{\beta}_1^f$. Since in either of the two cases above, w^{**} is chosen so as to reduce the aggregate risk loading from its value at w^*, it follows that $\beta_1^{**} = \beta_1^f(w^{**}) < \beta_1^f(w^*) < \bar{\beta}_1^f$.

Step 2: Next, we show the constrained efficiency of the choice of the capital structure above (Proposition 5).

From the proof of the first-best efficiency of no moral hazard case (Proposition 4), we know that $\forall w$:

$$\frac{\partial[\mu - c(\cdot)]}{\partial \beta_1^f} = \frac{\partial[\mu^1 - c(\cdot)]}{\partial \beta_1^f}, \text{ and} \tag{59}$$

$$\frac{\partial[\mu - c(\cdot)]}{\partial w} = \frac{\partial[\mu^1 - c(\cdot)]}{\partial w}. \tag{60}$$

It follows that $\forall w$:

$$\frac{d[\mu - c(\cdot)]}{dw} = \frac{\partial[\mu - c(\cdot)]}{\partial\beta_1^f} \cdot \frac{d\beta_1^f(w)}{dw} + \frac{\partial[\mu - c(\cdot)]}{\partial w} = \frac{d[\mu^1 - c(\cdot)]}{dw} \tag{61}$$

where the planner is constrained and hence employs the same $\frac{d\beta_1^f(w)}{dw}$ as the entrepreneur. The constrained efficiency of capital structure choice w^{**} in the owner managed economy with moral hazard follows.

The proof that the capital structure choice is w^{**} (and, hence is constrained efficient) under the corporation structure follows readily. The welfare of investors $\{h = 2, \dots, H\}$ is given by $\mu - \mu^1$, μ being the aggregate welfare and μ^1 being the welfare of the manager. In equilibrium, $\mu^1 \equiv \overline{W}$, the manager's reservation utility. Hence, optimal capital structure choice of a corporation maximizes $\mu - \overline{W}$, i.e., it maximizes μ, and is constrained efficient.

Step 3: Finally, we prove that the choice of the risk loading under both these governance structures, β_1^{**}, is greater than the benchmark case (first-best), β_1^*.

Since w^{**} is constrained efficient, it follows that at $w = w^{**}$,

$$\frac{d[\mu - c(\cdot)]}{dw} = \frac{\partial[\mu - c(\cdot)]}{\partial\beta_1^f} \cdot \frac{d\beta_1^f}{dw} + \frac{\partial[\mu - c(\cdot)]}{\partial w} = 0 \tag{62}$$

$$\Rightarrow \frac{\partial[\mu - c(\cdot)]}{\partial\beta_1^f} = -\frac{\left(\frac{\partial[\mu - c(\cdot)]}{\partial w}\right)}{\left(\frac{d\beta_1^f}{dw}\right)}. \tag{63}$$

Now, consider first the case where $\beta_1^f(w^*) > \sum_{h=2}^H \bar{\beta}_1^h$. In this case, for the moral hazard economy, $\frac{d\beta_1^f}{dw} < 0$ at $w = w^{**} > w^*$. By optimality of w^* as the first-best capital structure, we have $\frac{\partial[\mu - c(\cdot)]}{\partial w} = 0$ and $\frac{\partial^2[\mu - c(\cdot)]}{\partial w^2} < 0$ at $w = w^*$. This, in turn, implies that $\frac{\partial[\mu - c(\cdot)]}{\partial w} < 0$ at $w = w^{**}$. From equation (63), we conclude that $\frac{\partial[\mu - c(\cdot)]}{\partial\beta_1^f} < 0$ at $w = w^{**}$. In other words, the choice of β_1^f under moral hazard economies is greater than the first-best (at which choice $\frac{\partial[\mu - c(\cdot)]}{\partial\beta_1^f} = 0$). The proof for the second case where $\beta_1^f(w^*) < \sum_{h=2}^H \bar{\beta}_1^h$ follows analogously. $\diamondsuit$

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