Managerial Hedging and Incentive Compensation in Stock Market Economies[1]

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Abstract

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Incentive compensation exposes managers to the risk of their firms. Managers can hedge their aggregate risk exposure by trading in financial markets, but cannot hedge their firm-specific exposure. This gives them an incentive to pass up firm-specific projects in favor of standard projects that contain greater aggregate risk, giving rise to excessive aggregate risk in stock markets compared to the first-best allocation. In turn, this reduces the ability of investors to use stock markets to share risks amongst each other. The optimal incentive compensation designed to address such diversification externality is characterized in a capital asset pricing model (CAPM) economy. The extent to which managers can hedge their risks in financial markets affects in important ways the effectiveness of the optimal design in controlling diversification externality.

Keywords: Incentive Compensation, Hedging, Aggregate Risk, Idiosyncratic Risk, Financial Innovation, Capital Asset Pricing Model (CAPM)

J.E.L. Classification Code: G31, G32, G10, D52, D62, J33

1 Introduction

Incentive compensation schemes are provided to managers with the objective of aligning their interests with those of shareholders of their firms. Such schemes, by definition, need to restrict managers from trading in their own firm. Recent empirical evidence suggests however that executives can use financial markets, for example by trading in a market index, to privately alter their exposure to the risk of their firms. Garvey and Milbourn (2002) show that the average executive faces little relative performance evaluation and thus appears to be able to remove the influence of market-wide factors in his compensation. Jin (2002) documents that the market-wide component of incentive compensation does not affect the pay-for-performance sensitivity of CEO compensation. Bettis, Bizjak, and Lemmon (1999) examine the use of zero-cost collars and equity swaps by corporate insiders and find that executives significantly alter their effective ownership of the firm using these instruments. This evidence suggests that general transactions by managers in the stock market are not commonly restricted, partly because such restrictions would be hardly enforceable.

What are the implications of such private managerial hedging for capital budgeting? We show that if risk-averse managers can hedge aggregate risk exposure of their portfolio better than firm-specific exposure, they have an incentive to reduce their entrepreneurial activity. For example, they may pass up innovative projects with firm-specific risk in favor of standard projects that have greater aggregate risk. If all managers in the economy engage in such risk substitution, then the cash flows of firms become more correlated with each other. Lack of entrepreneurial activity by managers thus produces excessive aggregate risk in the stock markets. In turn, this reduces the ability of shareholders and investors to employ the stock market for risk-sharing purposes. This effect, which we call the *diversification externality* of incentive compensation, has not been directly studied in the theoretical or in the empirical literature of corporate finance.

We fully characterize the optimal incentive compensation designed to mitigate such diversification externality. We also discuss the implications of allowing for moral hazard problems other than diversification externality, such as the more traditional seeking of private benefits by managers. Finally, we demonstrate that the extent to which managers can hedge their exposures plays a crucial role in determining how effective the optimal compensation might be in limiting diversification externality.

We develop our results by introducing managers and entrepreneurs in an incomplete-markets, general-equilibrium Capital Asset Pricing Model (CAPM) economy. The choice of this setting is driven by three considerations. First, the incomplete-markets, general-equilibrium setup helps us properly address the issue of efficient risk sharing in stock markets. Clearly, welfare effects through risk sharing cannot be studied in a purely partial-equilibrium setting. Second, the endogenous determination of equilibrium stock prices, in particular as given by the CAPM pricing rule, plays a crucial role in the design of the optimal incentive contract. The stock prices in our model are determined under a rational expectation of ex-post managerial actions and, in turn, discipline ex-ante managerial actions. Finally, the CAPM setting enables us to cast the managerial choice between aggregate risk and firm-specific risk in terms of a choice of betas, the covariances of cash flows with traded risk factors. These are most tractable to model and analyze in CAPM economies.

We examine firms owned by entrepreneurs as well as firms owned by shareholders but run by managers. We consider a capital budgeting problem where the firm can produce a given expected cash flow with a given total risk through the use of several alternative technologies: standard technologies have greater betas with respect to the aggregate risk factor and thus have greater aggregate risk; innovative technologies have lower betas with respect to the aggregate risk factor and thus have greater firm-specific risk. The moral hazard in our setting arises from a misalignment between the objective of entrepreneurs and managers, relative to that of investors and shareholders, regarding the choice of technology to produce the cash flows of firms.

Throughout the paper, we focus on incentive compensation in the form of equity ownership. It is analytically difficult in our setup to incorporate other forms of explicit incentive compensation, such as executive stock options, and other forms of implicit exposures that managers may be subject to, such as the firm-specificity of their human capital. We allow managers to trade in markets for aggregate risks, but not in markets for firm-specific risks. Later, we relax this assumption. We assume that managerial trades in the capital markets cannot be contracted upon.

We turn first to a brief description of our positive results. In our benchmark economy, there is no moral hazard: there is no conflict of interest between managers and shareholders, or entrepreneurs and investors, regarding the choice of technology. This would be the case, for instance, if managers and entrepreneurs could pre-commit to their technology choice. Since there is no moral hazard, managers and entrepreneurs simply hold the market share of their own firm as in the traditional CAPM economy.

Typical corporations are, however, affected by moral hazard. In general, managers and entrepreneurs cannot pre-commit their technology choices. Their incentives may thus not be aligned with those of shareholders and investors. Since managers and entrepreneurs are risk-averse and can hedge only the aggregate risk component of their incentive compensation, they have an incentive to increase the beta of their firms' cash flows with respect to aggregate risks. Simply, by doing so they can reduce their exposure to unhedgeable firm-specific risks. Since increasing aggregate risk beta, for a given total risk, reduces firm value in the stock markets, such behavior is essentially a moral hazard that affects the firms' management. We refer to this moral hazard as diversification externality since it leads to greater aggregate risk in the stock markets.

Crucially, the only instrument shareholders and investors have to limit such moral hazard is also incentive compensation. The optimal design of incentive compensation thus trades off the possibly conflicting objectives of aligning the objectives of management with investors and of alleviating the diversification externality. We characterize precisely the optimal incentive compensation and the induced risk composition of firm cash flows. We do so assuming that the only moral hazard in the firm arises due to the diversification externality.

In particular, we show that if the firm's technology is intrinsically more loaded on the aggregate risk factors of the economy (for example, in pro-cyclical industries), then the optimal incentive compensation scheme provides the managers and the entrepreneurs a relatively lower equity holding of their firms. The intuition for this result is as follows. Incentive compensation is employed as a pre-commitment device to alleviate the ex-post moral hazard of diversification externality. In the case described above, the diversification externality is particularly severe. Hence, it is optimal to choose a smaller incentive compensation ex ante. In fact, depending upon the size of the intrinsic loadings of the firm on aggregate risk factors, it may be optimal to choose an equity holding for managers and entrepreneurs that is lower than even the market share of the firm, the benchmark holding in the absence of any moral hazard. This could be thought of as being a *negative* incentive compensation design.

This has important empirical implications. In the context of our model, the only moral hazard arises due to the diversification externality. Hence, we predict that firms that require management to hold a larger equity share have a lower component of risk loaded on the common stock market factors. This is an equilibrium effect: a consequence of the fact that incentive compensation and firms' risk composition are both *endogenous* in our model. But in practice the incentive compensation schemes are provided to also address agency problems other than the diversification externality, for instance, to address the managerial ability to extract private benefits from their project choices. Since these additional agency problems vary greatly across firms, so too do the observed levels of incentive compensation.

Our results imply that an *exogenous* increase in the managerial equity ownership of a firm should give rise to activity aimed at loading the firm's risk on aggregate traded risks: 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. In Section 3.2, we discuss in detail the implications of this result for existing empirical work that relates incentive compensation to R^2, the extent of firm-level stock returns explained by market returns. We also relate our results to the empirical work that compares across countries the average R^2's, the average extent of systematic risk in stock returns of firms, and the extent of diversity in aggregate economic activity.

We next discuss our normative results concerning the efficiency of the stock market economies in dealing with the diversification externality. We show that in equilibrium entrepreneurs and managers do in fact choose greater aggregate risk in their firms' cash flows compared to that under the first-best. However, the equilibrium incentive contracts induce a level of aggregate risk in firms that is constrained (second-best) efficient.[1] This is because prices in our model do not simply guarantee market clearing. They also efficiently align the objectives of entrepreneurs and stockholders with those of the (constrained) social planner. Managers and entrepreneurs, while price-takers, nevertheless face a price schedule for the firm they manage: they recognize that increasing the aggregate risk of the firm reduces the equilibrium value of its shares. Motivated by the capital gains from reducing the aggregate risk of cash flows, in equilibrium managers and entrepreneurs choose firm loadings on aggregate risk factors that are constrained efficient.

Finally, we consider financial innovations that enable greater managerial hedging. In our CAPM economy, financial innovations that allow investors to better diversify their endowment risks have positive effects on aggregate welfare. This is not necessarily so for innovations which allow entrepreneurs and managers to hedge firm-specific and sector-specific risks of their firms, since such innovations might have a negative effect on their incentives. Nevertheless, financial markets have incentives to issue such innovations as entrepreneurs and managers will in fact demand them ex post.[2] We show that innovations that accentuate diversification externality tend to be the ones allowing entrepreneurs and managers to completely undo their incentive contracts. Such innovations preclude the role of incentive contracts in pre-committing a risk composition of firms. The incentives to reduce aggregate risk of firm's cash flows are thus weakened, resulting in a negative welfare effect.

A discussion of the related literature follows. Section 2 presents the CAPM economy with a representative firm. Section 3 develops the positive analysis, focusing on the choice of incentive compensation and risk composition of firm cash flows. Empirical evidence supporting our main results is also discussed therein. Section 4 addresses the normative questions concerning the efficiency of equilibrium choices. Section 5 considers extensions of the basic model. Section 6 discusses the implications of financial innovations. Section 7 concludes. Appendices 1–3 contain the model assumptions and the closed-form expressions for the competitive equilibrium, the definition of welfare criterion, and the proofs of propositions, respectively.

[1] Under the first-best, the social planner can contract upon the technology choice and designs the optimal incentive compensation. By contrast, under the constrained efficient case, the social planner designs the optimal compensation scheme, taking the moral hazard of diversification externality as given.

[2] The findings of Bettis, Bizjak, and Lemmon (1999) cited earlier provide direct evidence for managerial demand for such financial innovations. Ofek and Yermack (2000) also document the managerial propensity to actively rebalance their portfolios once a certain ownership level has been reached.

1.1 Related Literature

The substitution of firm-specific risk by aggregate risk that we study is similar in spirit to the effect of managerial risk-aversion on the reduction of firm-specific risk first studied by Amihud and Lev (1981). Amihud and Lev considered diversification by firms, for example through mergers, as a way of reducing the firm-specific risk. Such diversification can be value-reducing, since it can be achieved by investors on their own. In more recent work, Garvey and Milbourn (2002) and Jin (2002) consider models wherein managers can hedge systematic risk of their exposure to the firm. In these models, managerial effort increases expected cash flow but does not affect cash flow risk. Hence, incentive compensation is affected by the managerial ability to hedge but it does not affect the risk composition of firm's cash flows.

By contrast, we abstract from the incentives of entrepreneurs and managers to diversify their firm's cash flows by reducing *only* the firm-specific variance of cash flows. We concentrate exclusively 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. Such substitution of firm-specific risk by aggregate risk is assumed not to affect the total risk of cash flows. In this sense, our choice of capital budgeting problem is complementary to that studied in the existing literature.

The equilibrium economy employed in our analysis 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 of our attempt to embed the agency-theoretic 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. We study the following two issues within the CAPM setup: (i) the optimal equity ownership structure of firms, and (ii) the incentives of entrepreneurs and managers to affect the correlation of their firms' stock returns with the returns of assets they can trade in financial markets.

Few general equilibrium analyses of the ownership structure of firms have been developed. Allen and Gale (1988, 1991, 1994) developed a theoretical analysis of the capital structure of firms in general equilibrium. However, they did not study economies with moral hazard, which are characterized by a misalignment of entrepreneurial and managerial objectives with those of the stock market investors. Magill and Quinzii (1998) studied the diversification effect in terms of risk reduction in a general equilibrium model and also addressed the issue of efficiency. They did not, however, allow entrepreneurs to affect the correlation of their firms' returns with other firms or with financial markets.[3]

Rampini (2000) analyzed the effect of productivity shocks on the amount of entrepreneurial activity. In his model too, an important role is played by the risk borne by entrepreneurs arising through their partial ownership of project cash flows for incentive reasons. However, the choice of the risk composition of project cash flows induced by such ownership is not considered. Holtz-Eakin, Rosen, and Willen (2001) developed 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. Their partial-equilibrium setting, however, did not address the managerial diversification externality which is of central interest to this paper.

Hilt (2002a) linked the lack of diversity in aggregate economic activity to risk-reducing incentives induced in the entrepreneurs by incentive compensation. Hilt (2002b) built a similar model to explain the (lack of) entrepreneurship in the American whaling industry during mid–1850s. These papers, however, are not concerned with the equilibrium compensation responses that play a crucial role in our analysis.[4] Meulbroek (2000a, 2000b) examined the private cost of incentive compensation to risk-averse managers. Her analysis differs from that in our paper by our explicit inclusion of the incentive-related benefits of compensation as well as the costs of such compensation to managers.

Finally, Leland and Pyle (1977) and Kihlstrom and Matthews (1990) built signalling models where incentive compensation signals information about firms' quality, which accrues asymmetrically to managers but not to the investors. 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) considered dynamic trading by a "large" shareholder. The equilibrium trading by this shareholder is determined simultaneously with the value of the company's shares that in turn depend upon the shareholder's incentives post-trading. We employ a similar notion of rational-expectations equilibrium.

[3]Also, in contrast to our analysis and from the standard assumptions in corporate finance, Magill and Quinzii (1988) allowed entrepreneurial actions to affect the support of their firm's return. Interestingly, this implies that entrepreneurs can indirectly write ex-post contracts with payoffs that are contingent on their action, and thus first-best efficiency is obtained.

[4]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.

2 The Model

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 economies where entrepreneurs and managers can choose the risk composition of the cash flows that their firms produce. Restricted participation is introduced in order to restrict the trading of these entrepreneurs and managers in their own firms. We present the simplest version of the model by relegating all the technical details to Appendix 1 where the general version is presented. The generality of the setup is required only for the extensions of the simplest case considered in Section 5.

2.1 The CAPM Economy with a Firm

An economy is populated by H agents, who live for two periods, 0 and 1. The set of agents is denoted as $\mathcal{H} := \{1, \ldots, H\}$. Agent $h \in \mathcal{H}$ 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 over the consumptions at date 0 and date 1, denoted as c_0^h and c_1^h, respectively:

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

where $E[\cdot]$ is the expectation taken over the probability space that spans the sources of uncertainty in the economy, and $A > 0$ is the absolute risk aversion coefficient assumed same for all agents for simplicity.

The first agent in the economy ($h = 1$) is the representative entrepreneur. The remaining agents, $h = 2, \ldots, H$, represent the stock market investors. We do not distinguish between entrepreneurs and managers in this section, and generally refer to them as entrepreneurs for sake of brevity. Corresponding to the entrepreneur is a firm denoted as $f = 1$. The entrepreneur owns the firm which has a technology that produces a random cash flow at time 1 denoted as y_1^f. The economy is perfectly competitive with the firm being interpreted as a "sector" composed of a measure 1 of identical firms.

The entrepreneur is assumed to have a private endowment at time 0, y_0^h, but no private endowment at time 1 other than through his ownership of the firm. To be precise, the entrepreneur is assumed to start out as the sole owner of firm's technology. 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. The entrepreneur can sell a part of his firm's ownership in the stock market, giving rise to positive net supplies of risky assets as we describe below. The entrepreneur also has choice over the technology of his firm, and in turn, over the cash flows that his firm produces.

Financial markets consist of (i) the bond market, where the bonds have a constant payoff; (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) an economy-wide factor traded in financial markets that captures a market-wide index. In order to obtain the CAPM economy under these assumptions, we assume that all endowments and financial assets are normally distributed. Furthermore, we need to orthogonalize the financial asset structure.

Suppose that the economy's risks are spanned by $N \geq 2$ factors, assumed to be orthogonal, and denoted as x_n, $n = 1, ..., N$. In Appendix 1, we provide a precise formulation of such 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 $J = 2$ factors are traded and denote this set of traded factors as $\mathcal{J} = \{1, 2\}$.

The first risk factor is an aggregate risk factor, denoted x_1, which can be considered positively correlated with the aggregate endowment of investors, which is $\sum_{h=2}^{H} y_1^h$. The second risk factor, denoted x_2, is orthogonal to the aggregate risk factor x_1 and also to the aggregate endowment of investors $\sum_{h=2}^{H} y_1^h$. This second factor should thus be interpreted as the "corporate sector-specific" risk in the economy.[5]

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

$$y_1^f - E(y_1^f) := \beta_1^f x_1 + \beta_2^f x_2 \tag{2}$$

with zero covariance between x_1 and x_2. Without loss of generality, we adopt the following normalizations: $E(x_i) = 0$ and $\text{var}(x_i) = 1$ for $i = 1, 2$. The firm's betas, β_1^f and β_2^f, measure the covariance of the firm's earnings, y_1^f, with risk factor 1 and 2, respectively.

Trading in financial and stock markets is 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, denoted

[5] 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 that is required in our model is that *there exists at least one factor that can be traded by the entrepreneurs and that is positively correlated with the aggregate endowment of the economy*, a requirement that is easily met. For example, in Section 5.1 we extend the basic model to allow for multiple sectors and model x_1 as the stock market index.

as asset 0 with payoff $x_0 := 1$, without any restrictions.

2.2 Capital Budgeting

Our choice of capital budgeting problem is partly motivated by the diversification literature starting with Amihud and Lev (1981), partly justified by simplicity and clarity, and partly inspired by our desire to study the implications of capital budgeting for risk sharing in stock markets. We first provide an informal description of the capital budgeting problem, next present the motivation behind studying it, and then state the problem formally.

The entrepreneur can, at a cost, choose the technology he adopts and in turn affect the risk composition of the firm's cash flows. In particular, the firm can use several different technologies to produce a given level of expected cash flow for a given level of total risk of cash flow. For instance, there may be standard technologies that contain greater aggregate risk, and innovative technologies that contain greater firm-specific risk. The choice of technology by the entrepreneur determines the proportions of aggregate and firm-specific components in the firm's total cash flow risk. This choice is affected by the entrepreneur's incentive compensation, a point that is central to our analysis.

There are many corporate activities that 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. The CEO can either invest the company's funds in R&D activities directed towards the invention of a new drug, or invest these funds in increasing the extent of marketing for existing drugs that already proliferate in the market. The risk from R&D activities is more firm-specific since it depends upon the success of the research activities. The risk from existing business lines is, however, more aggregate in nature: it depends upon the global demand for these drugs which also affects the profits of other pharmaceutical companies. 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.[6]

[6]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, documented the lack of experimentation with new hybrid seeds by Indian farmers and their unflinching adherance to tried-and-tested agricultural practices. He attributed this to the lack of markets in India for insurance against agricultural losses and bad weather, which led to Indian farmers holding significant undiversifiable exposure to the risk of failure of their crops.

In another interesting study, Hilt (2002b) documented 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 showed 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.

More generally, the propensity of entrepreneurs and managers to load a firm's cash flow onto aggregate risk, and away from firm-specific risk, could be considered a form of *herding.* The literature on herding behavior often attributes it to peer-based evaluation of management. See, for example, Scharfstein and Stein (1990) and the references therein. While incentive compensation schemes that contain a relative performance evaluation component are observed only for very young executives or in the mutual fund industry (as documented respectively by Garvey and Milbourn, 2002, and Murphy, 1999), it is often argued that such evaluation is implicit through reputation effects. In this respect, our analysis makes it clear that herding-like behavior can be partially rationalized as a direct consequence of the *observed* incentive compensation schemes and the fact that managers have the ability to hedge aggregate risks in capital markets. Managerial hedging gives rise to herding incentives even if no relative performance evaluation is present in either the explicit or the implicit contractual form of the compensation faced by managers.

Finally, our capital budgeting problem is natural given the fundamental result of the asset-pricing literature that an asset's valuation is affected by the covariance between its return with the aggregate consumption and the market return, and not by its total risk. While changes to levels of firm-specific risk do not affect a well-diversified portfolio in the limit, the changes to levels of aggregate risk affect even a well-diversified portfolio in significant ways. Thus, our choice of capital-budgeting problem has important welfare implications for levels of aggregate risk in the economy.

Formally, the entrepreneurs can affect the correlation of firm cash flow y_1^f with the aggregate risk factor x_1, given that the expected cash flow is $E(y_1^f)$ and that the total variance of cash flow is $\mathrm{var}(y_1^f)$ (denoted as $\overline{V}$ for brevity). They do so by choosing the betas, β_1^f and β_2^f, the respective loadings of the firm's technology on the aggregate risk and the sector-specific risk. These betas also determine their personal starting endowment. The choice is subject to the constraint that $(\beta_1^f)^2 + (\beta_2^f)^2 = \overline{V}$, the total variance of the cash flows. Hence, this choice affects the distribution of the variance of cash flows between the aggregate and the sector-specific risks, but this does not alter the expected value or the variance of cash flows of their firm. It follows that once β_1^f is chosen, β_2^f is determined by the constraint; we denote such β_2^f as $\beta_2^f\left(\beta_1^f\right)$. The choice of β_1^f thus fully captures the choice of technology.

This technology choice is costly to entrepreneurs: 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, summarized by $\bar{\beta}_1^f$. We assume that the cost is increasing and convex in $(\beta_1^f - \bar{\beta}_1^f)^2$, as formally stated in Assumption 4, Appendix 3. This assumption enables us to model the moral hazard in a relatively simple and succinct manner.

2.3 Incentive Compensation

Each entrepreneur sells a fraction $w > 0$ of the firm in the stock market and holds the remaining fraction, $(1 - w)$, of the firm. This remainder constitutes the *incentive compensation* of the entrepreneur. We focus exclusively on incentive compensation that consists of equity ownership of entrepreneurs and managers in their firms. Since the firm's cash flows are loaded on risk factors traded in the economy, the positive supply w arising from the sale of the firm translates into the positive supplies for these risk factors. The positive supply of factor $j = 1, 2$ in the economy is $s_j = w\beta_j^f$, which is the fraction of the firm sold times the loading of the firm's cash flows on factor j. In addition, there is a positive supply of riskless bonds, which is factor 0. The supply of bonds is given by $s_0 = wE(y_1^f)$.

The incentive compensation contractually prevents the entrepreneurs from trading in the firm-specific risk factor. Formally, the entrepreneur can trade the aggregate endowment risk factor, x_1, but not the component of risk contributed by the firm, x_2. This is consistent with the observed restrictions on managerial trading, documented for example by Bettis, Coles, and Lemmon (2000).

2.4 Corporate Governance

We consider different corporate governance structures. A governance structure determines whether the firm is originally held by entrepreneurs, as in *owner-managed firms*, or by shareholders, as in *corporations.* In the case of a corporation, the firm is run by managers; in other words, it is management-controlled. Such distinction is important empirically. For instance, La Porta, Lopez de Silanez, and Shleifer (1999) document that in a sample of 27 developed countries, slightly more than one-third of firms are management-controlled and held by widely dispersed investors, whereas one-third are owner-managed and controlled by a single family. As will be crucial in the analysis to follow, the governance structure also determines whether entrepreneurs and managers can pre-commit to their technology choice or not. That is, the governance structure determines whether there is moral hazard in the economy under investigation.

We describe below these different governance structures. Under each structure, we present the optimal contracting problem between entrepreneurs or managers and investors or stockholders. The solution to the contracting problem determines the equity ownership structure of firms, specifically, how much of the firm is held by entrepreneurs or managers and how much of the firm is held by capital market investors. In turn, the equity ownership structure determines the equilibrium risk loadings of firms on the aggregate risk factor. The exact sequence of events under each structure is contained in Table 1.

Table 1: The Sequence of Events under Different Governance Structures

Governance Sructure	Sequence of Events				
Benchmark	Entrepreneurs choose fraction w to sell. Entrepreneurs choose aggregate risk loading β_1^f.	$\Rightarrow$	All agents including entrepreneurs trade. Markets clear, prices are determined.		
Owner-Managed Firms	Entrepreneurs choose fraction w to sell.	$\Rightarrow$	All agents including entrepreneurs trade. Markets clear, prices are determined.	$\Rightarrow$	Entrepreneurs choose aggregate risk loading β_1^f.
Corporations (Management–Controlled Firms)	Investors choose fraction w to retain. Managers awarded fraction $(1 - w)$.	$\Rightarrow$	All agents including managers trade. Markets clear, prices are determined.	$\Rightarrow$	Managers choose aggregate risk loading β_1^f.

Benchmark Governance. In the benchmark case, the entrepreneur owns the firm ex ante. The entrepreneur first chooses the technology to determine the loadings of the firm's payoff on the aggregagte risk factors. Next, he sells a fraction of the firm on the stock market and also conducts trades that help him hedge the aggregate risk of his exposure to the firm. As the firm is sold after the entrepreneur chooses the technology, no issue of moral hazard arises.[7] Effectively, the entrepreneur's choice of technology, β_1^f, and his choice of what fraction of the firm to sell, w, are simultaneous.

More formally, when choosing β_1^f and w, the entrepreneur anticipates that the proceeds from the sale of the firm will in fact depend upon these choices. The representative entrepreneur, while a price-taker, faces parametric prices for factors, denoted as π_0, π_1, and π_2, for the risk-free asset, the aggregate risk asset, and the corporate sector–specific asset, respectively. In equilibrium, the prices are determined so as to clear the markets for financial assets, as described below in Section 2.5.[8] The anticipated proceeds of the entrepreneur are

[7] For the sake of simplicity, we temporarily abstract from moral hazard problems other than the diversification externality, but revisit the matter in Section 3.1 where we discuss in detail the implication of such alternative moral-hazard problems for our results.

[8] It should be noted that since the entrepreneur takes as given the equilibrium prices for the risk factors, π_j, the supply of these factors in the market, s_j, are also implicitly taken as given. 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 ability to also affect the equilibrium prices of risk factors in the economy.

thus simply the sum of the prices of risk factors multiplied by the respective betas of the firm's cash flows. In particular, for given choices of β_1^f and w, the entrepreneur's proceeds will amount to

$$w\left(E(y_1^f)\pi_0 + \beta_1^f\pi_1 + \beta_2^f\left(\beta_1^f\right)\pi_2\right) \ . \tag{3}$$

After the firm has been sold, trading occurs in all markets and prices for the risk factors are determined at the competitive equilibrium, described below in Section 2.5.

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. In this case, the entrepreneur owns the firm ex ante. First, the entrepreneur sells a fraction of the firm on the stock market and conducts the trades that help to hedge the aggregate risk of exposure to the firm. Next, the owner–manager chooses the firm's technology and determines the loading of the firm's cash flows on the risk factors.

As the firm is sold before the entrepreneur's technology choice has been made, the issue of moral hazard arises in this case. In particular, the proportion of the firm that the entrepreneur holds, $(1-w)$, determines the choice of β_1^f, the aggregate risk loading. Investors in the market rationally anticipate the mapping between the entrepreneur's holding of the firm $(1-w)$ and the choice of β_1^f. Thus, the price at which shares are sold on the market reflect a rational expectation of the technology choice, and thus, this price depends on the proportion $(1-w)$. The entrepreneur also rationally anticipates this mapping between $(1-w)$ and the stock price. Magill and Quinzii (1998) introduce a similar equilibrium concept and refer to the anticipatory behavior of entrepreneurs as "rational conjectures."

Formally, for a given choice of w, the entrepreneur's choice of β_1^f can be derived; let it be denoted $\beta_1^f(w)$. Investors anticipate $\beta_1^f(w)$. Hence, for given prices of risk factors, π_j, the proceeds from the sale of the firm are given by

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

The entrepreneur, while choosing w, anticipates these proceeds as well. This intuitively suggests that entrepreneurs can possibly employ the choice of w as an ex-ante pre-commitment device to commit to the ex-post choice of technology characterized by $\beta_1^f(w)$. As in the benchmark case, prices for the risk factors are determined at the competitive equilibrium after the firm has been sold and all trading has taken place.

Corporations. In this case, ownership of the firm is spread across the capital market investors ex ante. First, stockholders hire a manager for the firm and choose the fraction

$(1-w)$ of the firm's stocks with which to endow the manager. Next, trading takes place in capital markets, including manager's hedging trades. After all trading has occurred, the manager chooses the technology for the firm and determines the loadings of the firm's payoff on the economy's risk factors.

The stock ownership of the manager can be interpreted as incentive compensation. In addition, the manager must be given a time-0 compensation (in terms of units of consumption good) such that the utility from time-0 compensation and time-1 incentive compensation amounts to the manager's reservation utility value of $\overline{W}$. The issue of moral hazard again arises in this case as the manager chooses firm's technology after trading has occurred. In general, the manager owns only a fraction of the firm. Therefore, when the stockholders choose the manager's compensation $(1-w)$, they rationally anticipate the mapping between $(1-w)$ and the manager's choice β_1^f.

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

$$w\left(E(y_1^f)\pi_0 + \beta_1^f(w)\pi_1 + \beta_2^f\left(\beta_1^f(w)\right)\pi_2\right) . \tag{5}$$

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 the incentive compensation determined.

2.5 Competitive Equilibrium of the CAPM Economy

The prices π_0, π_1, and π_2, anticipated by the entrepreneurs and the investors, are determined at the competitive equilibrium of the economy. Each agent h chooses 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 utility as specified in equation (1), subject to the budget constraints and the restricted participation constraints. All markets clear at a competitive equilibrium; in particular, the market for the consumption good as well as the financial and stock markets. Formal definitions as well as closed-form solutions for equilibrium allocations and prices of this CAPM economy are reported in Appendix 1 for the general economy with more than one firm and more than two traded assets. We discuss below the salient features of the competitive equilibrium that we exploit in our analysis.

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

$$\beta_j^h := \frac{\operatorname{cov}\left(y_1^h, x_j\right)}{var\left(x_j\right)} . \tag{6}$$

To an economy is also associated a vector of net supplies of stocks. As derived in Section 2.3, the supply of risky asset j is $s_j = w\beta_j^f$, which is the fraction of the firm sold times the loading of the firm's cash flows on factor j. In addition, there is a positive supply of riskless bonds, which is factor 0. The supply of bonds is given by $s_0 = wE(y_1^f)$.

Given a list of betas and net supplies associated with each factor, the competitive equilibrium for the economy is uniquely determined.[9] 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 can trade factor j. Formally,

$$\frac{\pi_j}{\pi_0} = E\left(x_j\right) - A\left(\beta_j + \frac{1}{H_j} s_j\right), \tag{7}$$

where

$$\beta_j = \operatorname{cov}\left[\left(\sum_{h\in H_j,\ h=1} (1-w)y_1^h + \sum_{h\in H_j,\ h>1} y_1^h\right), x_j\right]. \tag{8}$$

Given this cross-sectional beta pricing relationship, the economy is referred to as an incomplete-markets CAPM economy.

3 Equilibrium Equity Ownership and Risk

The following propositions characterize the solution to the optimal contracting problem between entrepreneurs and investors, or between managers and shareholders, as introduced in the previous section. The solution consists of two pieces: (i) the optimal equity ownership of firms, measured by the fraction w of the firm that is sold to (or retained by) investors; (ii) the loading β_1^f of the firm's cash flows on the aggregate risk factor of the economy. We consider each of the corporate governance structures: owner managed firms, with and without moral hazard, and corporations.

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

[9] 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 the personal endowment. Formally, this is captured in equations (28) and (33) in Appendix 1.

Proposition 1 (Benchmark: No Moral Hazard) *For owner-managed firms with no moral hazard, at equilibrium each entrepreneur chooses to sell a fraction w^* of the firm, where*

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

The equilibrium loading on the aggregate risk factor, denoted $\beta_1^* = \beta_1^f(w^*)$, is lower than the initial value of this loading $\bar{\beta}_1^f$:

$$\beta_1^* < \bar{\beta}_1^f.$$

In the absence of moral hazard, incentive compensation schemes are not called for. In equilibrium, each entrepreneur simply owns the market fraction of the firm. This is the same fraction of the firm that any other agent in the economy holds: $\frac{1}{H}$. The entrepreneur, who is a price taker, nevertheless faces a price schedule for the firm (equation 4) and understands that the firm is priced depending on the composition of its risk with respect to different risk factors in the economy. In particular, the entrepreneur recognizes that increasing the aggregate risk of the firm reduces the equilibrium value of its shares. Motivated by the capital gains from reducing the aggregate risk component, in equilibrium the entrepreneur reduces the loading of the firm on such a factor, choosing $\beta_1^* = \beta_1^f(w^*) < \bar{\beta}_1^f$.

Consider now each of the corporate governance structures with moral hazard. In the case of owner-managed firms, entrepreneurs make technology choices after receiving the proceeds from the sale of their firms to capital market investors. In the case of corporations, managers make technology choices 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.

To be precise, entrepreneurs and managers privately prefer to increase their firms' aggregate risk loading in order to reduce the unhedgeable component of their own wealth. This goal can be achieved, for example, by the substitution of innovative projects by those that are more prosaic and characterized by greater aggregate risk. A diversification externality is thus imposed on the firm's investors, who must bear more of the aggregate risk, and, in turn, less of the idiosyncratic risk. Since idiosyncratic risk can be shared more effectively among investors than aggregate risk, this results in a welfare loss to the investors.

Incentive compensation can be designed by entrepreneurs (in the case of owner-managed firms) and shareholders (in the case of corporations) to limit this diversification externality. Intuitively, since moral hazard is rationally anticipated by all agents, incentive compensation is employed as an ex-ante pre-commitment device to reduce the extent of moral hazard in ex-post technology choices. In fact, the equilibrium incentive compensation is chosen in such a way that entrepreneurs and managers instead have an incentive to decrease the loading of their firms on the aggregate risk factor. This is formalized below in Propositions 2 and

3. We first provide the intuition for how incentive compensation can be designed to induce entrepreneurs and managers to reduce the loading of their firms' cash flow on the aggregate risk.

Consider the benefits and the costs that underly the choice of β_1^f, the aggregate risk loading of a firm's cash flows. The marginal benefit to entrepreneurs and managers from increasing β_1^f arises from the resulting reduction in their firm-specific exposure. This is a pure risk-aversion effect. Entrepreneurs and managers cannot trade the firm-specific component of their firms, but they can, and in equilibrium do, trade the aggregate risk component. Consequently, the risk they bear in equilibrium decreases as their choice of β_1^f rises. Formally, the effect of increasing β_1^f is to reduce the firm-specific exposure $(1-w)^2[\overline{V}-(\beta_1^f)^2]$, at a rate that is increasing in the incentive compensation $(1-w)$.

The marginal cost from increasing β_1^f is somewhat subtle. Entrepreneurs and managers rebalance the aggregate risk exposure of their personal portfolios by trading in the market for the aggregate risk asset: they hedge, and in equilibrium they simply own the market portfolio component of this aggregate risk. In other words, entrepreneurs and managers sell most of the aggregate risk component $(1-w)\beta_1^f$ embedded in their incentive compensation, and retain only the market portfolio component $\frac{1}{H}\beta_1^f$ of such risk. Since bearing aggregate risk is disliked by agents in the economy, entrepreneurs and managers incur a cost for selling this element of risk in the capital markets: aggregate risk is sold at a negative price. Considering that the market portfolio position is taken as given by the competitive entrepreneurs and managers, their cost of hedging increases in their incentive compensation.

The results in Propositions 2 and 3 characterize the optimal design of incentive compensation. The design achieves an optimal trade-off of the benefits and costs to entrepreneurs and managers that result from intensifying the aggregate risk of their firms' cash flows. These propositions also characterize the induced risk composition. Proposition 2 addresses the case of owner-managed firms, while Proposition 3 deals with the case of corporations. Interestingly, all else being equal, these two governance structures lead to identical incentive compensation and risk loadings in equilibrium.

Proposition 2 (Owner-Managed Firms) *In owner-managed firms with moral hazard, at equilibrium each entrepreneur chooses w^{**}, the fraction of the firm to sell, and chooses β_1^{**}, the loading on aggregate risk factor, 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*

- $\beta_1^* < \beta_1^{**} < \bar{\beta}_1^f$, *where w^* is the fraction of the firm sold in the benchmark case of owner-managed firms with no moral hazard (Proposition 1).*

Thus, in owner-managed firms with moral hazard, the equilibrium loading on the aggregate risk factor is always greater than that in the benchmark case.

Proposition 3 (Corporations) *In corporations, stockholders choose to retain the same fraction of the firm that an entrepreneur sells in an owner-managed firm with moral hazard: w^{**}. As a consequence, at equilibrium managers choose the same loading on the aggregate risk factor as entrepreneurs would in an owner-managed firm with moral hazard: β_1^{**} .*

Note that $(1 - w^{**})$ represents the incentive compensation, that is, the equity ownership of the entrepreneur or manager in equilibrium. The optimal choice of this compensation induces entrepreneurs and managers to decrease the aggregate component of the risk of their firms. This is captured in the result above that $\beta_1^{**} < \bar{\beta}_1^f$. Nevertheless, the induced aggregate risk loading is greater than that under the benchmark case with no moral hazard, as captured in the result $\beta_1^* < \beta_1^{**}$. The optimal incentive scheme does not alleviate the moral hazard completely.

How does the optimal incentive compensation $(1-w^{**})$ compare to the benchmark choice $(1 - w^*) = \frac{1}{H}$? Does the optimal incentive scheme subject entrepreneurs and managers to less than the market component share of their firm: is $(1 - w^{**}) < \frac{1}{H}$? Or does it expose them to a "disproportionate" share of their firm: is $(1 - w^{**}) > \frac{1}{H}$? As the proposition states, depending on the initial technology of a firm, $\bar{\beta}_1^f$, the optimal incentive scheme might require the entrepreneur or the manager to hold more or less of the firm than the market share in the firm's equity.

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 in Proposition 2 can now be restated more transparently:

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

The intuition for this characterization is as follows. Consider the first case above, $\bar{\beta}_1^f > K \sum_{h=2}^{H} \bar{\beta}_1^h$, which applies to firms with initial technologies that are relatively more loaded on aggregate risk. In this case, the marginal benefit to entrepreneurs and managers from increasing the aggregate risk loading β_1^f is greater than its marginal cost at the benchmark incentive compensation of $(1 - w^*)$. The risk-aversion effect dominates the effect of the costs of hedging. Thus, in equilibrium, incentive compensation is lowered compared to the benchmark case: $w^{**} > w^*$. This is in fact a *negative* incentive compensation scheme and induces a reduction in the aggregate risk loading: $\beta_1^{**} < \bar{\beta}_1^f$.

The second case above, $\bar{\beta}_1^f < K \sum_{h=2}^{H} \bar{\beta}_1^h$, applies to firms with relatively lower loadings on aggregate risk. In this case, the marginal cost to entrepreneurs and managers from increasing the aggregate risk loading β_1^f is greater than its marginal benefit at the benchmark incentive compensation. The cost of personal hedging for entrepreneurs and managers dominates the risk-aversion effect. Thus, in equilibrium, incentive compensation has to be in fact raised: $w^{**} < w^*$. This achieves the desired reduction in the aggregate risk loading.

The reader should recall that the optimal incentive compensation thus far has been 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 entrepreneurs and investors (or between managers and stockholders). A canonical moral hazard in corporate finance, for example, is the seeking of private benefits by entrepreneurs and managers when they choose projects with different expected cash flows. Such alternative moral hazard problems call for incentive compensation schemes that require entrepreneurs and managers to hold fractions of their firms that are disproportionately higher than the market portfolio components of these firms. In such a general setting, therefore, our results only imply that a reduction in the extent of the incentive scheme might be necessary at times to limit the effects of the diversification externality.

3.1 Alternative Moral Hazard Problems

We argue in this section that the different components of moral hazard interact in interesting ways to determine the optimal incentive contract designs. These components include the managerial incentive to load on aggregate risk factors, along with the managerial quest for private benefits that is often examined in corporate finance. Understanding this interaction sheds light on the extant empirical literature and helps reconcile some apparently contradictory pieces of evidence. To this end, the results of Section 3 need to be slightly restated.

The main conclusion of our analysis has been that firms with initial technologies that are relatively more loaded on the aggregate risks (higher $\bar{\beta}_1^f$) require the management to hold a relatively lower share of their own firm's equity (higher w^{**}). In short, highly pro-cyclical industries (for example, utilities, paper, and manufacturing) that are intrinsically heavily loaded on aggregate risks should have incentive compensation schemes with lower power than are found in other industries. Conversely, this implies that firms with compensation schemes that require management to hold a larger equity share should have a lower component of risk loaded on the aggregate risk factors and common stock market factors. This is an equilibrium effect and a consequence of the *endogeneity* of incentive compensation and the firm's risk composition in our model.

This endogenous relationship is subject to the qualification that the extent of moral hazard problems other than the diversification externality be maintained constant across firms. What happens if we allow for a cross-sectional variation in the alternative moral hazard problems? This induces a variation across firms in their choice of incentive compensation that is not related to the diversification externality, hence *exogenous* to our model. This question is relevant since in practice, incentive compensation also serves to address these alternative agency problems. We next demonstrate 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 risk factors. Specifically, firms with high-powered incentive compensation schemes designed to alleviate agency problems, other than the diversification externality, should suffer more of the diversification externality problem.

Proposition 4 *Assume that the cost structure for the entrepreneur's or manager's technology choice is quadratic, specifically* $C(\beta_1^f - \bar{\beta}_1^f)^2$ *for some constant* $C > 0$. *Then, an exogenous increase in the incentive compensation* $(1-w)$, *leads to an increase in the aggregate risk loading* $\beta_1^f(w)$, *if and only if the initial aggregate risk loading,* $\bar{\beta}_1^f$, *is sufficiently high:*

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

Furthermore, as incentive compensation $(1-w)$ *increases,* $K(w)$ *decreases.*

If we think of firms as being distributed on a continuum of initial values $\bar{\beta}_1^f$, then as $(1-w)$ increases more of these firms experience an increase in $\beta_1^f(w)$, their aggregate risk loading, due to the lack of entrepreneurial or innovative activity by managers. Since we can write $(1-w) = (1-w^{**}) + \epsilon$, we interpret the effect of varying $(1-w)$ as simply the effect of varying ϵ, the exogenous component of incentive compensation.

We next discuss the empirical relevance of these results.

3.2 Empirical Evidence

Lack of entrepreneurial activity by managers is often quantified in empirical literature as higher R^2 in a regression of firm-level stock returns on market returns. A higher R^2 can result from a substitution of firm-specific risk with aggregate risk, as we consider, and also from a reduction of firm-specific risk with no effect on aggregate risk. Since the empirical literature has not distinguished between these two forms of managerial activity, we use R^2 as a (imperfect) proxy for what we call as the lack of entrepreneurial activity.[10] Our results above are consistent with the results obtained in the empirical literature that relates R^2 to the extent of managerial equity ownership.

Amihud and Lev (1981) document a significant negative relationship between R^2 from equity accounting returns and the equity ownership of officers and directors. They also find that management-controlled firms, that is, 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. Denis, Denis, and Sarin (1997) identify a similar negative relationship by regressing various measures of diversification on the equity ownership (OWN) of officers and directors. This is consistent with our basic result that incentive compensation endogenously designed to address the diversification externality induces a reduction in firm loadings on traded risk factors, and in turn, in R^2.

Importantly however, Denis, Denis, and Sarin (1997) find that this negative relationship holds at low to moderate levels of OWN, but at very high levels of OWN, there is in fact a positive relationship between diversification and OWN. Very high levels of equity ownership by managers arise primarily to address severity of agency problems, such as the seeking of private benefits. We view such ownership as primarily exogenous to the diversification externality problem. This exogenous component should indeed lead to an increase in managerial activity to load the firm's cash flows on aggregate risk. More generally, our results suggest that a cleaner empirical test of this relationship should disentangle the component of OWN that is endogenous to diversification (R^2) from the component that is exogenous. The endogenous relationship between R^2 and OWN should be negative, whereas the exogenous relationship should be positive.[11] The importance of recognizing this endogeneity of incentive compensation in empirical tests has also been indicated by Himmelberg, Hubbard, and Palia (1999) and Palia (2001) in relating managerial compensation to firm performance measures, such as Tobin's q.

Aggarwal and Samwick (2002) build and test models where diversification can arise either due to managerial aversion to firm-specific risk or due to their desire to earn private benefits. They find that diversification is positively related to the extent of managerial compensation.

[10] Amihud, Kamin, and Ronen (1983) however do present some direct evidence of risk reduction in earnings due to managerial incentives.

[11] May (1995) finds that a firm's diversification is positively correlated with the ratio of the manager's value of share ownership to total wealth. This measure of managerial equity ownership is different than the one employed theoretically in our paper and empirically in the work of Amihud and Lev (1981), Denis, Denis, and Sarin (1995).

They conclude that managers diversify in response to changes in private benefits rather than to reduce their exposure to risk. Our results suggest that their finding is potentially also consistent with a model where managers are averse to firm-specific risk. Introducing an alternative agency problem, such as the seeking of private benefits, leads to a component of incentive compensation that is exogenous to the risk-aversion moral hazard. If such alternative agency problem is severe, and by implication, the exogenous component of incentive compensation is large, then our model predicts a positive relationship between diversification and incentive compensation (Proposition 4). This result does not arise in the models considered by Aggarwal and Samwick since they do not consider the interaction of the two moral hazard problems: they consider the moral hazard problems only one at a time.

Morck, Yeung, and Yu (2000)'s empirical analysis of the risk composition of individual stock market returns in developed and less developed economies in part addressed the endogeneity problem. From their study of stock returns in over 40 countries, they documented that the average R^2's in market model regressions of stocks in less developed economies ("poor countries") are greater than those in developed economies ("rich countries"). That is, stocks in less developed economies have greater co-movement than do stocks in developed economies. For example, they find that, while in the U.S. about 50% of all stocks move in the same direction over a given period, this percentage is much greater both statistically and economically in countries such as India and China. How does this evidence relate to our results on incentive compensation and aggregate risk loadings of firms?

Two salient characteristics of many less developed economies are the weak legal enforcement of contracts and the especially poor protection of property rights. Such an environment limits exogenously the feasibility of incentive compensation schemes. Consequently, entrepreneurs virtually own most of the equity of their firms. By contrast, the levels of equity ownership in developed countries are much lower, due to a greater protection of property rights. Such cross-sectional variation in equity ownership is thus essentially exogenous to the diversification externality. Our results suggest that diversification externality should be more severe in less developed economies, thus resulting in a greater R^2.

This is consistent with the finding of Morck, Yeung, and Yu that in developed economies there is a greater proportion of idiosyncratic risk in individual stock returns than in less developed economies. The disproportionate exposure of to firm-specific risk in less developed countries induces the owner–managers to load their firms' cash flows more on common traded stock factors. This in turn leads to individual stock returns being more strongly correlated in these economies. From a purely econometric standpoint, the variation in legal enforcement and protection of property rights across countries acts as an instrument that corrects for the endogeneity of incentive compensation in such empirical analysis. Hilt (2002a) also examined 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 greater entrepreneurial activity proxied by a more diverse range of industries.[12]

Finally, it is worth stressing and discussing another implication of our analysis. Entrepreneurs and managers with relatively high-powered incentive compensation rebalance their aggregate risk holdings, and, in the process, sell most of the aggregate risk contained in their incentive compensation. Given that they are not excluded from trading in the market indices, it seems natural that they would employ short positions in the market indices as a way of reducing their unhedgeable risk. Unfortunately, data on entrepreneurs' and managers' private trades in market indices and their overall portfolio compositions are not easily available. In the absence of such data for market trades, it is difficult to test this implication directly. Indirect evidence is, however, supportive of our analysis.

Jin (2002) found that the pay-for-performance sensitivity of the CEO's compensation is unaffected by the aggregate or the systematic component of firm risk, but is affected by its firm-specific component. This is consistent with CEOs being able to privately manage the market exposures of their overall portfolios. Garvey and Milbourn (2002) showed that, on average, the executives are able to remove the influence of market-wide factors in their compensation and hence face little relative performance evaluation. Garvey and Milbourn found, however, that relatively younger executives do face relative performance evaluation, probably reflecting their inability to fully hedge the aggregate risk of their portfolios.

Other pieces of indirect evidence concern (i) the finding of Ofek and Yermack (2000) that insiders tend to often sell their existing shares when provided with additional incentive compensation, and (ii) the study by Bettis, Bizjak, and Lemmon (1999) that examined the use of zero-cost collars and equity swaps by corporate insiders to "reverse engineer" their portfolio exposures. Both these findings point to an aversion amongst managers to bearing the risk of their firm's cash flows and to their ability to significantly alter their effective exposure to these cash flows.[13]

[12] One might argue that managers in less developed economies cannot hedge by trading in market indices: simply, trading in market indices does not exist or did not exist till very recently in most of these economies. Note, however, that managers are also hedged "implicitly" through relative performance evaluation. Such evaluation also induces a preference amongst managers for standard technologies, a form of herding, and in turn leads to a diversification externality and a greater R^2 in stock return regressions.

[13] Another important aspect of hedging by managers concerns the timing of such hedging to exploit the private information they have about their firms. Supporting such a private information motive, Bettis, Bizjak, and Lemmon (1999) found that abnormal returns to firms following insider hedging activities are more negative than those associated with ordinary insider sales. Such timing decisions by managers are not inconsistent with our analysis. Our paper examines a complementary rationale for such hedging, one that is based on managerial risk-aversion, and considers its implications for capital budgeting.

With this discussion, we turn to the welfare properties of the optimal incentive compensation design derived in Section 3.

4 Welfare Properties

In this section, we address the following questions pertaining to our analysis. Do entrepreneurs in our owner-managed firms hold too much or too little of their firms? Do stockholders of our corporations choose incentive compensations of managers efficiently from a social or a normative standpoint? Is there efficiency in the induced equilibrium loading of the firms' cash flows on the aggregate risk factor? 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. Furthermore, it is relatively straightforward since the economy has the capital asset pricing model (CAPM) structure.[14]

Not surprisingly, the presence of moral hazard implies that in equilibrium managers and entrepreneurs engage inefficiently in diversification by excessively loading their firms on aggregate risk factors compared to the first-best. First best is, however, too strict a welfare criterion in economies with moral hazard. 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. In Appendix 2 we provide a precise definition of this welfare measure μ. Intuitively, the welfare of an economy is greater if agents in some base case economy (say autarky, where only the risk free bond trades) need to be compensated with a greater consumption at time 0 in order to

[14]For simplicity, we concentrate our analysis in this section on the factor structure introduced in Section 2.2, equation (2). In fact, the analysis extends more generally, as the reader can easily verify, based on the proofs of Appendix 3.

attain the same sum of agents' utilities as in the economy at hand.[15]

4.1 Efficiency of Incentive Compensation and Risk Loadings

The fraction w of the firm held by capital market investors and the loading β_1^f of the firm's cash flows on the aggregate risk factor 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 our general economy is in a technical appendix available from the authors upon request.

Proposition 5 (First-Best) *The equilibrium fraction of the firm held by capital market investors, w^*, and aggregate risk loading, β_1^*, in the benchmark governance structure with owner-managed firms and no moral hazard is first-best efficient.*

Consider next the corporate governance structures where a moral hazard problem does arise. These include the case of owner-managed firms in which entrepreneurs choose the ownership structure before the choice of risk loading, as well as the case of corporations in which stockholders choose the managers' compensation. For such economies with moral hazard, first-best efficiency is too strong a welfare requirement.

The fraction of the firm held by capital market investors and the loading of the firm's cash flows on the aggregate risk factor are *constrained (second-best) efficient* if they maximize the aggregate welfare index μ by the choice of w, anticipating the entrepreneur's (respectively the manager's) choice of β_1^f conditionally on w, and take into account the effects of w and β_1^f on competitive equilibrium prices. The formal definition of constrained efficiency for our general economy is in a technical appendix available from the authors upon request.

Proposition 6 (Constrained Efficiency) *The equilibrium fraction of the firm held by capital market investors, w^{**}, and aggregate risk loading, β_1^{**}, for owner-managed firms with moral hazard and for corporations is constrained efficient.*

[15] Using the closed-form competitive equilibrium solution, given in Appendix 1, it can be shown that this notion of 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, and Acharya and Bisin, 2000). Therefore, an economy is more efficient the lower its equilibrium price of the risk-free asset, in which case the higher is the risk-free return. This is because the risk-free rate increases when precautionary savings in the economy decrease. This in turn occurs when most risk that agents are exposed to is hedged away using the financial markets.

We conclude that the role of the price mechanism in our economy is not simply to guarantee market clearing. The price mechanism 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 on the induced aggregate risk loading also resides in the price mechanism. Managers and entrepreneurs, while price-takers, nevertheless face a price schedule for the firms 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 the capital gains from reducing the aggregate risk component, in equilibrium managers and entrepreneurs choose the loading of the firm on such factors in an efficient manner.

5 Extensions

In this section, we extend the analysis to consider different possible factor structures of the economy under study. Indeed, these extensions exploit more fully the generality of the CAPM economy we introduced in Section 2. 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. Furthermore, 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 a firm as a representative firm, that is, essentially as a sector, and thus often refer to firms as sectors.

5.1 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 in terms of the basic factor structure of the economy are as follows:

$$y_1^f - E(y_1^f) \; := \; \beta_1^f x_1 + \beta_2^f x_2 \tag{9}$$
$$y_1^g - E(y_1^g) \; := \; \beta_1^g x_1 + \beta_3^g x_3 \tag{10}$$

We assume that entrepreneurs cannot trade the share of their own firms contained in their incentive contracts. 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 cash flows that is common across the two sectors and that is possibly correlated with the aggregate endowment risk. Consequently, the stock market cash flows, and by implication the stock market returns, are excessively correlated across sectors, in addition to being correlated with the aggregate portfolio.

More formally, entrepreneurs in sector f (respectively sector g) would want to trade the stock of sector g (respectively sector f) only as a way to hedge a part of the endowment risk. 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 the endowment risk. They trade in the stock market index x_1 only.

Thus, in the presence of moral hazard, the equilibrium incentive compensation $(1 - w^{**})$ and the equilibrium loading β_1^{**} are chosen exactly as Section 3.[16] Intuitively, the incentives of entrepreneurs in sector f (respectively sector g) to load their firms 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.

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

5.2 Purely Idiosyncratic Risk in the Stock Market

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

$$y_1^{f,s} - E(y_1^f) := \beta_1^f x_1 + \beta_2^f \left(x_2 + x_2^s\right), \quad s \in (0, 1) \tag{11}$$

[16]For ease of comparison of the results, we assume here and in the following extensions that the cost function for endowment changes is exactly the same as in Section 3.

The factor x_2^s represents firm s's purely 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 $\text{var}(x_2^s) = \sigma$.

Suppose that entrepreneurs cannot trade the shares of their own firms. 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 of his firm, x_2, as well as the purely idiosyncratic risk component, x_2^s.

Consequently, entrepreneurs have incentives to inefficiently load their firms' risk away from the unhedgeable component $(x_2 + x_2^s)$ and onto the hedgeable component x_1. Each unhedgeable unit of the firm carries a variance of $(1+\sigma)$. The same unit, when sold to agents in the economy, carries an effective variance of 1, as investors can diversify away x_2^s across the continuum of firms. Thus, the equilibrium fraction of their firms that entrepreneurs hold decreases in σ. In turn, this incentive contract implements an equilibrium loading of each firm on the common stock market component x_1, which is increasing in σ. In particular, this loading 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: such risk is purely idiosyncratic and could be diversified away at no cost. This inefficiency arises from two features: (i) from the necessity of providing the entrepreneur with an incentive contract in order to align the entrepreneurs' and the investors' objectives, and (ii) from the restriction that x_2 and x_2^s cannot be independently or jointly traded by entrepreneurs. Under these restrictions on trading, equilibria are nonetheless constrained efficient, as in Section 4.1.

5.3 Non-Traded Risks

Nex, we extend the analysis to consider a sector with a component of risk that 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:

$$y_1^f - E(y_1^f) := \beta_1^f x_1 + \beta_2^f \left(x_2 + x_2^{nt} \right) \tag{12}$$

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

Suppose the firm is not traded in the stock market: it is a private business. Suppose the entrepreneur, agent h', cannot trade even x_2, the sector index in the market. He can only trade x_1. This is in fact the simplest way to introduce an agency problem between the owner and the entrepreneur. 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 constraint, where agent h' cannot trade the factors x_2 and x_2^{nt} in the market, and agent h cannot trade the factor x_2^{nt} in the market.

In this case, the diversification externality takes the form of loading firms' risk onto the common stock market 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 would in the benchmark environment without moral hazard. This results from the restriction on the entrepreneur form trading in the sector index x_2, whereas the owner faces no similar constraint, thus generating in the entrepreneur a greater propensity to increase the market loading of the firm's cash flows.

6 The Effect of Financial Innovations

Financial markets were treated as exogenous in our analysis thus far: securities' payoffs were exogenous as were the portfolio restrictions we imposed on entrepreneurs and managers. Naturally, though, the effects of the managerial incentives to increase aggregate risk loading of their firms depend in important ways on the financial markets available in the economy, particularly on those available to entrepreneurs and managers. In fact, entrepreneurs and managers load their firms' returns on precisely those aggregate risk factors that they can trade to hedge their risk exposure. What then is the effect of introducing financial innovations that allow greater hedging of such risk exposure?

In general, such financial innovations might have positive welfare effects in our incomplete-markets economy. Consider the empirical investigation of the time series of different components of firm-level volatility undertaken by Campbell, Lettau, Malkiel, and Xu (2001). They found 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 convincingly identify 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 result, at least in part, from the increased propensity of entrepreneurs and managers to better hedge their risk exposures due to the introduction of financial innovations. We conjecture that this has led them to reduce wasteful activity aimed at reducing their firm-specific risk. Campbell, Lettau, Malkiel, and Xu (2001) also documented a decline in the correlation between individual stocks. This is consistent with the reduced incentives of managers to substitute firm-specific risks with hedgeable economy-wide risks.[17]

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 5.1. Furthermore, consider an innovation that 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 do all the other agents in the economy. As a consequence, x_2^s has no effect on the economy whatsoever, and, in particular, entrepreneurs do not shy away from undertaking this risk. Thus, in equilibrium entrepreneurs hold a fraction w^{**} of the firm. In turn, the loading on the common stock market component is β_1^{**}. We conclude that this innovation in fact has a positive welfare effect on the economy.

Intriguingly, however, the development of financial markets might also exacerbate the diversification externality. Financial innovations in our economy that allow investors to trade a larger number of factors always have positive effects on the aggregate welfare (see, Acharya and Bisin, 2000). However, this is not necessarily so for innovations that allow entrepreneurs and managers to hedge the risk of the firm or sector. Recall that in the presence of moral hazard, incentive compensation is designed optimally to pre-commit to the induced risk composition of the firm's cash flows. If financial innovations allow entrepreneurs and managers to essentially undo this pre-commitment role of incentive compensation, then they can in fact weaken their incentives to reduce the aggregate risk of firm's cash flows.

Consider again the case of entrepreneurs or managers of firm f (respectively firm g) in Section 5.1. What happens if we allow such entrepreneurs to trade factor x_2 (respectively factor x_3)? In this case, incentive contracts have no bite whatsoever. There is no mechanism by which the entrepreneur can commit to reduce the loading of the firm's return on the stock market. Specifically, there is no commitment to holding a smaller fraction of the firm in the portfolio so as to reduce the loading of the firm's risk on x_1. Similarly,corporations

[17]Bettis, Bizjak, and Lemmon (1999) also documented that the purchases of zero-cost collars and equity swaps by corporate insiders are followed by an increase in the volatility of stock returns for their firms. While they did not isolate the systematic and the idiosyncratic components of volatility, their evidence is consistent with a reduction in the diversifying activities of managers upon better hedging of their risk exposures.

cannot use incentive contracts to align managers' objectives with those of their investors. The entrepreneurs' or managers' portfolio can be rebalanced after the firm is sold on the market, and the managers' incentive contracts can be "undone" in financial markets.

Consequently, in equilibrium the fraction of their firms that entrepreneurs or managers hold coincides with the market share of the firm that is simply the first-best fraction w^*. Crucially, however, the loading on x_1 is not reduced at all and coincides with the initial loading $\bar{\beta}_1^f$. The result represents a lack of *any* entrepreneurial activity. Thus, we conclude that aggregate welfare is reduced as a consequence of the financial innovation that allows the entrepreneurs and managers to better hedge the risks in their portfolios.

Even though such financial innovations generally have negative welfare effects for the economy as a whole, financial markets markets tend to introduce such financial instruments: entrepreneurs and managers will in fact demand them. As previously discussed, investment banks have created a sizable market to manufacture derivative products for CEOs and senior executives, with the purpose of managing their labor income risk.

In summary, innovations that have a negative effect on incentives and welfare tend to be those that allow the entrepreneurs and managers to hedge their sector-specific risk. By contrast, innovations that enable the entrepreneurs and managers to diversify only the firm-specific or purely idiosyncratic risks in general tend to have a positive effect on their incentives and welfare. In models that feature investments in firm-specific risks that improve expected cash flows, it should be noted that innovations to allow hedging of only the firm-specific risk can also have a negative effect on these other incentives and welfare.

7 Conclusions

In this paper, we examined the capital budgeting implications of the managerial ability to hedge the aggregate risk components of their exposures. In particular, we focused on the incentives of managers to reduce the firm-specific risk and increase the aggregate risk of their firms' cash flows, for example, by passing up entrepreneurial activity in favor of more prosaic projects. Such risk-substitution was shown to increase aggregate risk in stock markets and to reduce the ability of investors to share risks via stock markets. We characterized the optimal incentive compensation designed to counteract this diversification externality and studied its welfare properties.

To our knowledge, this paper is the first attempt to integrate the analysis of a firm's governance structure and incentive compensation schemes into a general equilibrium model of the stock market. Our objective behind this analysis has been to identify managerial incentives as an endogenous determinant of the 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 empirical specifications for both cross-sectional and time-series studies of firm-level or economy-wide performance and volatility should include managerial incentives as explanatory variables. For instance, the integration of corporate finance considerations could help explain the amplitude of the observed fluctuations in aggregate stock volatility and their correlation with the business cycle: the fluctuations have proved difficult to justify simply by means of other firm-specific characteristics such as financial leverage; see Schwert (1989).

Also, integrating the effect of incentive compensation in the capital asset pricing model (CAPM) could could contribute to our understanding of asset pricing anomalies in cross-sectional beta regressions (see Cochrane, 2000, for a survey of this literature). For example, such integration may provide a theoretical justification for the introduction of 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 arises in the arena of corporate mergers and acquisitions. Indeed, these corporate activities are important means through which managers can implement their diversifying incentives and the resulting risk compositions of firms' cash flows. We posit the utility of a model that incorporates such managerial incentives to explain the cross-sectional variation in expected returns, risk composition, and discounts (premia) observed in conglomerates, as documented by Lamont and Polk (2001).

APPENDIX 1: CAPM Economy and Its Competitive Equilibrium

We state first the formal assumptions about the general economy we study with a total of H agents, F firms, N risk factors spanning all risks of the economy, and J traded risk factors (out of the total N factors).

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:*[18]

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

Assumption 2 *The economy has a N-dimensional orthogonal normal factor structure (x_1, $\ldots$, 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 a linear combination of N underlying normal risk factors, and hence is in general correlated with other agents' endowments:

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

The first $F < H$ agents are the entrepreneurs. Entrepreneur h owns the firm $f(= h)$.

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:

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

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

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

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

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

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

$$u^h(c_0^h, c_1^h) := -\frac{1}{A} e^{-Ac_0^h} + E\left[-\frac{1}{A} e^{-Ac_1^h}\right] \tag{13}$$

subject to the budget constraints and the restricted participation constraints:

$$\begin{aligned}
c_0^h &= y_0^h - \pi_0 \theta_0^h - \sum_{j \in \mathcal{J}} \pi_j \theta_j^h, \; h \in \mathcal{H}, \; h > F & (14) \\
c_0^h &= y_0^h + \sum_{0 \le j \le J} \pi_j s_j^h - \pi_0 \theta_0^h - \sum_{j \in \mathcal{J}^h} \pi_j \theta_j^h, \; h \in \mathcal{H}, \; h \le F & (15) \\
c_1^h &= y_1^h + \theta_0^h + \sum_{j \in \mathcal{J}} \theta_j^h x_j, \; h \in \mathcal{H}, \; h > F & (16) \\
c_1^h &= (1 - w^h) y_1^h + \theta_0^h + \sum_{j \in \mathcal{J}} \theta_j^h x_j, \; h \in \mathcal{H}, \; h \le F & (17) \\
\theta_j^h &= 0, \; j \notin \mathcal{J}^h & (18)
\end{aligned}$$

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 (13) subject to (14–18) at prices $\pi := [\pi_0, \pi_j]_{j \in \mathcal{J}}$, and such that consumption and financial markets clear:*

$$\sum_h \left(c_0^h - y_0^h\right) \le 0, \tag{19}$$

$$\sum_h \left(c_1^h - y_1^h\right) \le 0, \text{ with probability } 1 \text{ over } \Omega, \text{ and} \tag{20}$$

$$\sum_h \theta_j^h = s_j, \; j = 0, 1, \ldots, J \tag{21}$$

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 (13)-(18), with the market-clearing conditions (19)-(21), is characterized by prices of assets (π_j), portfolio choices (θ_j^h), and consumption allocations (c_t^h), given below.

$$\pi_0 = exp\left\{A\left(y_0 - Ey_1\right) + \frac{A^2}{2H}\sum_{h\in H}\left[(1-R_h^2)\mathrm{var}(y_1^h) + \sum_{j\in J^h}\left(\beta_j + \frac{1}{H_j}s_j\right)^2\right]\right\} \tag{22}$$

where

$$y_0 = \frac{1}{H}\sum_{h\in\mathcal{H}} y_0^h\,, \quad y_1 = \frac{1}{H}\sum_{h\in\mathcal{H}} y_1^h \tag{23}$$

$$\beta_j = \mathrm{cov}\left[\frac{1}{H_j}\left(\sum_{h\in H_j, h\le F}(1-w^h)y_1^h + \sum_{h\in H_j, h>F} y_1^h\right), x_j\right] \tag{24}$$

$$\frac{\pi_j}{\pi_0} = E\left(x_j\right) - A\left(\beta_j + \frac{1}{H_j}s_j\right) \tag{25}$$

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

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

$$\theta_j^h = \left(\beta_j + \frac{1}{H_j}s_j\right) - \beta_j^h, \;\; j \in \mathcal{J}^h, \quad \text{and } \theta_j^h = 0, \;\; j \in (\mathcal{J}^h)^c \tag{26}$$

$$\theta_0^h = \frac{1}{1+\pi_0}\left(y_0^h - E(y_1^h) - \sum_{j\in\mathcal{J}^h}\pi_j\theta_j^h + \frac{A}{2}\,\mathrm{var}(c_1^h) - \frac{1}{A}\,ln(\pi_0)\right) \tag{27}$$

$$c_1^h = \theta_0^h + \sum_{j\in\mathcal{J}^h}\left(\beta_j + \frac{1}{H_j}s_j\right)x_j + \left(y_1^h - \sum_{j\in\mathcal{J}^h}\beta_j^h x_j\right) \tag{28}$$

$$\mathrm{var}(c_1^h) = \mathrm{var}(y_1^h) - \sum_{j \in \mathcal{J}^h} (\beta_j^h)^2 + \sum_{j \in \mathcal{J}^h} \left(\beta_j + \frac{1}{H_j} s_j\right)^2 \tag{29}$$

$$c_0^h = -\frac{1}{A}\, ln\, \frac{1}{\pi_0} + E(y_1^h) + \theta_0^h - \frac{A}{2}\, \mathrm{var}(c_1^h) \tag{30}$$

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

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

$$\theta_j^h = \left(\beta_j + \frac{1}{H_j} s_j\right) - (1 - w^h)\beta_j^h, \;\; j \in \mathcal{J}^h, \quad \text{and } \theta_j^h = 0, \;\; j \in (\mathcal{J}^h)^c \tag{31}$$

$$\theta_0^h = \frac{1}{1 + \pi_0} \left(y_0^h + \sum_{0 \leq j \leq J} \pi_j s_j^h - (1 - w^h) E(y_1^h) - \sum_{j \in \mathcal{J}^h} \pi_j \theta_j^h + \frac{A}{2}\, \mathrm{var}(c_1^h) - \frac{1}{A}\, ln(\pi_0) \right) \tag{32}$$

$$c_1^h = \theta_0^h + \sum_{j \in \mathcal{J}^h} \left(\beta_j + \frac{1}{H_j} s_j\right) x_j + (1 - w^h) \cdot \left(y_1^h - \sum_{j \in \mathcal{J}^h} \beta_j^h x_j \right) \tag{33}$$

$$\mathrm{var}(c_1^h) = (1 - w^h)^2 \mathrm{var}(y_1^h) - \sum_{j \in \mathcal{J}^h} (1 - w^h)^2 (\beta_j^h)^2 + \sum_{j \in \mathcal{J}^h} \left(\beta_j + \frac{1}{H_j} s_j\right)^2 \tag{34}$$

$$c_0^h = -\frac{1}{A}\, ln\, \frac{1}{\pi_0} + (1 - w^h) E(y_1^h) + \theta_0^h - \frac{A}{2}\, \mathrm{var}(c_1^h) \tag{35}$$

$$s_0^h = w^h E(y_1^h), \quad s_j^h = w^h \beta_j^h \tag{36}$$

This 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 $[c_0, c_1]$ defined as:

$$U([c_0, c_1]) := \sum_{h \in \mathcal{H}} \left(-\frac{1}{A} e^{-Ac_0^h} + E\left[-\frac{1}{A} e^{-Ac_1^h} \right] \right). \tag{37}$$

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

$$U([c_0^a, c_1^a]) := U([c_0 - \mu, c_1]) \tag{38}$$

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

$$U^h([c_0^a, c_1^a]) := U^h([c_0 - \mu^h, c_1]), \text{ where} \tag{39}$$

$$U^h([c_0, c_1]) := -\frac{1}{A} e^{-Ac_0^h} + E\left[-\frac{1}{A} e^{-Ac_1^h} \right] . \tag{40}$$

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

$$\mu^h - \mu^{h\prime} = c_0^h - c_0^{h\prime} - \frac{1}{A}\, ln\, \frac{1 + \pi_0}{1 + \pi_0'} \tag{41}$$

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

$$\mu - \mu' = -\frac{H}{A}\, ln\, \frac{1 + \pi_0}{1 + \pi_0'} \tag{42}$$

APPENDIX 3: Proofs of Propositions

Assumption 4 *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 ownership structure w, and next, we consider the choice of optimal w taking into account the technology 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 technology choice β_1^f. Note that we have not substituted $f = 1$ in β_1^f in order to signify that this is the technology choice of firm. The entrepreneur's welfare is measured by the compensating individual transfer, μ^1, given by equation (41):

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

In addition, the entrepreneur suffers a non-pecuniary cost as specified in Assumption 4. 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

$$\begin{aligned}
\frac{\partial \mu^1}{\partial \beta_1^f} &= \frac{\partial c_0^1}{\partial \beta_1^f} \\
&= \frac{\partial}{\partial \beta_1^f}\left[\theta_0^1 - \frac{A}{2}\cdot \mathrm{var}(c_1^1)\right] \\
&= \frac{\partial}{\partial \beta_1^f}\left[\frac{\pi_1}{1+\pi_0}\left(s_1^1 + (1-w)\beta_1^f - (\beta_1 + \frac{1}{H_1}s_1)\right) + \frac{\pi_2}{1+\pi_0}\, s_2^1 - \frac{A\pi_0}{2(1+\pi_0)}\cdot \mathrm{var}(c_1^1)\right] \\
&= \frac{\pi_1}{1+\pi_0} - \frac{\pi_2}{1+\pi_0}\cdot w\,\frac{\beta_1^f}{\beta_2^f} + \frac{A\,\pi_0}{1+\pi_0}\,(1-w)^2\beta_1^f \qquad (43)\\
&= \frac{A\,\pi_0}{1+\pi_0}\left[\left((1-w)^2 + \frac{w^2}{H-1} - \frac{1}{H}\right)\beta_1^f - \frac{1}{H}\sum_{h=2}^{H}\bar{\beta}_1^h\right]. \qquad (44)
\end{aligned}$$

where we have used the facts that

$$s_1^1 = w\beta_1^f,\ s_2^1 = w\beta_2^f,\ (\beta_1^f)^2 + (\beta_2^f)^2 = \overline{V},\ \mathcal{J}^1 = \{1\},\ H_1 = H,\ H_2 = H-1, \tag{45}$$

the expression for $\text{var}(c_h^1)$ is employed from equation (34), and to obtain equation (44) from equation (43), we have substituted for the equilibrium prices and aggregate supplies:

$$\begin{aligned}
\beta_1 &= \frac{1}{H}\left[\sum_{h=2}^{H}\bar{\beta}_1^h + (1-w)\beta_1^f\right], \quad s_j = w\beta_j^f \text{ for } j=1,2, \quad \pi_1 = -A\,\pi_0\left(\beta_1 + \frac{1}{H}s_1\right), \\
\pi_2 &= -A\,\pi_0\left(\beta_2 + \frac{1}{H-1}s_2\right) = -\frac{A\,\pi_0}{H-1}\, s_2 \text{ since } \beta_2 = 0 \text{ (by construction).}
\end{aligned} \tag{46}$$

It follows from equation (44) 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 ownership structure w by the entrepreneur. Denoting the costs associated to the technology choice as simply $c(\cdot)$, we can write

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

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

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

where

$$\begin{aligned}
\theta_0^1 - \frac{A}{2}\cdot\text{var}(c_1^1) &= \frac{1}{1+\pi_0}\left[y_0^1 - (1-w)E(y_1^f) + \pi_0 w E(y_1^f) + \sum_{j=1}^{2}\pi_j w\beta_j^f - \pi_1\theta_1^1\right] \\
&- \frac{A}{2}\cdot\frac{\pi_0}{1+\pi_0}\,\text{var}(c_1^1) - \frac{1}{A(1+\pi_0)}\,ln(\pi_0).
\end{aligned} \tag{47}$$

Simplifying using the conditions in equations (45)–(46) above, we obtain

$$\begin{aligned}\frac{\partial[\mu^1 - c(\cdot)]}{\partial w} &= -E(y_1^f) + \frac{1}{1+\pi_0}\left[(1+\pi_0)E(y_1^f) + \pi_2\beta_2^f\right] + \frac{A\,\pi_0}{1+\pi_0}(1-w)(\beta_2^f)^2 \\ &= \frac{1}{1+\pi_0}\left[\pi_2\beta_2^f + A\pi_0(1-w)(\beta_2^f)^2\right] \\ &= \frac{A\,\pi_0}{1+\pi_0}\,(\beta_2^f)^2\,\left(1 - w - \frac{w}{H-1}\right). \end{aligned} \tag{48}$$

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

$$\begin{aligned}\frac{d^2[\mu^1 - c(\cdot)]}{dw^2} &= \frac{d}{dw}\left(\frac{\partial[\mu^1 - c(\cdot)]}{\partial w}\right) \\ &= \frac{\partial^2\mu^1}{\partial w^2} + \frac{\partial^2\mu^1}{\partial\beta_2^f\partial w}\cdot\frac{d\beta_2^f}{dw} \\ &= \frac{\partial^2\mu^1}{\partial w^2} \;=\; -\,\frac{H}{H-1}\cdot\frac{A\,\pi_0}{1+\pi_0}(\beta_2^f)^2 \;<\; 0, \end{aligned} \tag{49}$$

since

$$\begin{aligned}\frac{\partial^2\mu^1}{\partial\beta_2^f\partial w} &= \frac{\partial}{\partial\beta_2^f}\left[\frac{A\,\pi_0}{1+\pi_0}\,(\beta_2^f)^2\,\left(1 - w - \frac{w}{H-1}\right)\right] \\ &= \frac{2\,A\,\pi_0}{1+\pi_0}\,\beta_2^f\,\left(1 - w - \frac{w}{H-1}\right) \;=\; 0 \text{ at } w^* = 1 - \frac{1}{H}\,. \end{aligned} \tag{50}$$

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

Since the proof of Proposition 5 (first–best) relies on some of the steps in the above proof, we present it next.

Proof of Proposition 5. In the first best, the ownership 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 ownership structure w. The expression for compensating aggregate transfer $\mu = \sum_{h=1}^{H}\ \mu^h$ is given in equation (42). The cost structure for the technology choice stated in Assumption 4 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 (22), 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:

$$\frac{\partial \mu}{\partial \beta_1^f} = -\frac{H}{A(1+\pi_0)} \cdot \frac{\partial \pi_0}{\partial \beta_1^f}, \text{ where} \tag{51}$$

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

Equations (51) and (52) 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 (44) implying that for a given ownership structure w, the first best technology 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 ownership 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 technology choice. Thus,

$$\frac{\partial \mu}{\partial w} = -\frac{H}{A(1+\pi_0)} \cdot \frac{\partial \pi_0}{\partial w}, \text{ where} \tag{53}$$

$$\begin{aligned}
\frac{\partial \pi_0}{\partial w} &= \pi_0 \cdot \frac{\partial}{\partial w}\left[\frac{A^2}{2H}\left((1-w)^2 \mathrm{var}(y_1^f) - (1-w)^2(\beta_1^f)^2 + \sum_{H\in\mathcal{H}}\sum_{j\in\mathcal{J}^h}\left(\beta_j + \frac{1}{H_j}s_j\right)^2\right)\right] \\
&= \pi_0 \cdot \frac{A^2}{2H} \cdot \frac{\partial}{\partial w}\left[(1-w)^2(\beta_2^f)^2 + \frac{1}{H}\left(\sum_{h=2}^{H}\bar{\beta}_1^h + \beta_1^f\right)^2 + \frac{w^2}{H-1}\cdot(\beta_2^f)^2\right] \\
&= \pi_0 \cdot \frac{A^2}{2H} \cdot \left[-2(1-w)(\beta_2^f)^2 + \frac{2w}{H-1}(\beta_2^f)^2\right] \\
&= \pi_0 \cdot \frac{A^2}{H}(\beta_2^f)^2\left(1 - w - \frac{w}{H-1}\right). \qquad (54)
\end{aligned}$$

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 (48). It follows now that in the absence of moral hazard, the entrepreneur's ownership structure choice w^*, and by implication also his technology choice β_1^*, is first-best efficient. $\diamondsuit$

Since it is easier from an expositional standpoint to present the proofs of Proposition 2, 3 and 6 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 6.

Sequence of Steps: First, we characterize the technology choice β_1^{**} and the ownership 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 6). 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 technology 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 (32) in the rational expectations equilibrium, the relevant holding from the entrepreneur's standpoint at the time of technology choice is

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

where Π^1 is a lump sum constant representing the already collected proceeds from firm's sale. Note that in equilibrium, investors anticipate the technology 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 (41) except for the difference that at the time of technology 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:

$$
\begin{aligned}
\frac{\partial \hat{\mu}^1}{\partial \beta_1^f} &= \frac{\partial \hat{c}_0^1}{\partial \beta_1^f} = \frac{\partial}{\partial \beta_1^f}\left[\hat{\theta}_0^1 - \frac{A}{2}\cdot \mathrm{var}(c_1^1)\right] \\
&= \frac{\partial}{\partial \beta_1^f}\left[\frac{\pi_1}{1+\pi_0}\left((1-w)\beta_1^f - (\beta_1 + \frac{1}{H_1}s_1)\right) - \frac{A}{2}\cdot\frac{\pi_0}{1+\pi_0}\cdot \mathrm{var}(c_1^1)\right] \\
&= \frac{\partial}{\partial \beta_1^f}\left[\frac{\pi_1}{1+\pi_0}(1-w)\beta_1^f - \frac{A}{2}\cdot\frac{\pi_0}{1+\pi_0}\cdot(1-w)^2\left(\mathrm{var}(y_1^f) - (\beta_1^f)^2\right)\right] \\
&= \frac{\pi_1}{1+\pi_0}(1-w) + \frac{A\,\pi_0}{1+\pi_0}\,(1-w)^2\beta_1^f \qquad (55)\\
&= \frac{A\,\pi_0}{1+\pi_0}(1-w)\left[\left(1-w-\frac{1}{H}\right)\beta_1^f - \frac{1}{H}\sum_{h=2}^{H}\bar{\beta}_1^h\right]. \qquad (56)
\end{aligned}
$$

where equation (56) is obtained from equation (55) 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 technology 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 ownership 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 technology choice and taking all prices as given. Hence, the optimal ownership 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

$$\frac{\partial[\mu^1 - c(\cdot)]}{\partial w} \ = \ \frac{A\,\pi_0}{1+\pi_0}\,(\beta_2^f)^2\left(1 - w - \frac{w}{H-1}\right) \ = \ 0 \text{ at } w = w^* = 1 - \frac{1}{H}, \tag{57}$$

as in the no moral hazard case (see equation 48 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 technology 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 $\frac{\partial[\mu^1 - c(\cdot)]}{\partial\beta_1^f}$.

$$\frac{\partial[\mu^1 - c(\cdot)]}{\partial\beta_1^f} \ = \ \frac{\partial[\hat{\mu}^1 - c(\cdot)]}{\partial\beta_1^f} - \frac{\partial(\hat{\mu}^1 - \mu^1)}{\partial\beta_1^f} \ = \ -\frac{\partial(\hat{\mu}^1 - \mu^1)}{\partial\beta_1^f} \tag{58}$$

where

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

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

$$= \frac{A\,\pi_0\,w}{H(1+\pi_0)}\left[\sum_{h=2}^{H}\bar{\beta}_1^h + \left(1-\frac{w}{w^*}\right)\beta_1^f\right] \qquad (59)$$

where we have employed the equilibrium conditions (45)–(46). 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 technology 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 (56), we get

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

$$= \frac{A\,\pi_0}{1+\pi_0}\left[-2(1-w)\beta_1^f + \frac{1}{H}\left(\sum_{h=2}^{H}\bar{\beta}_1^h + \beta_1^f\right)\right]. \qquad (60)$$

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, ownership 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, ownership 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 ownership structure above (Proposition 6).

From the proof of the first-best efficiency of no moral hazard case (Proposition 5), we know that $\forall w$:

$$\frac{\partial[\mu - c(\cdot)]}{\partial \beta_1^f} = \frac{\partial[\mu^1 - c(\cdot)]}{\partial \beta_1^f}, \text{ and} \tag{61}$$

$$\frac{\partial[\mu - c(\cdot)]}{\partial w} = \frac{\partial[\mu^1 - c(\cdot)]}{\partial w}. \tag{62}$$

It follows that $\forall w$:

$$\frac{d[\mu - c(\cdot)]}{dw} = \frac{\partial[\mu - c(\cdot)]}{\partial \beta_1^f} \cdot \frac{d\beta_1^f(w)}{dw} + \frac{\partial[\mu - c(\cdot)]}{\partial w} = \frac{d[\mu^1 - c(\cdot)]}{dw} \tag{63}$$

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

The proof that the ownership structure choice is w^{**} (and, hence is constrained efficient) under the corporation structure follows readily. The welfare of investors $\{h = 2, \ldots, H\}$ 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 ownership 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 $w = w^{**}$,

$$\frac{d[\mu - c(\cdot)]}{dw} = \frac{\partial[\mu - c(\cdot)]}{\partial \beta_1^f} \cdot \frac{d\beta_1^f}{dw} + \frac{\partial[\mu - c(\cdot)]}{\partial w} = 0 \tag{64}$$

$$\Rightarrow \frac{\partial[\mu - c(\cdot)]}{\partial \beta_1^f} = -\frac{\left(\frac{\partial[\mu - c(\cdot)]}{\partial w}\right)}{\left(\frac{d\beta_1^f}{dw}\right)}. \tag{65}$$

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 ownership 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 (65), 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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