



Investment and CEO compensation under limited commitment[☆]

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ABSTRACT

We extend the neoclassical investment model (Hayashi, 1982) to allow for limited commitment on compensation contracts. We consider three types of limited commitment: (i) managers cannot commit to compensation contracts that provide lower continuation utility than their outside options; (ii) shareholders cannot commit to negative net present value (NPV) projects; (iii) both the managers and the shareholders cannot commit. We characterize the optimal contract under general convex adjustment cost functions and provide examples for which closed-form solutions can be obtained. We show that, as in the data, small firms invest more, grow faster, and have a higher Tobin's Q than large firms under the optimal contract. In addition, the pattern of the dependence of chief executive officer (CEO) compensation on past performance implied by our model is also consistent with empirical evidence.

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1. Introduction

This paper develops a tractable continuous-time framework that incorporates limited commitment of financial contracts into the neoclassical investment model. We consider an environment in which a risk-neutral shareholder owns an investment project but does not have access to the production technology and has to delegate investment

decisions to a risk-averse manager. We study three types of limited commitment. First, the manager cannot commit to compensation contracts that provide lower continuation utility than their outside options. We call this limited commitment on the manager side. Second, the shareholder cannot commit to negative net present value (NPV) projects. The second type will be referred to as limited commitment on the shareholder side. In the third case, we consider limited commitment on both the shareholder side and the manager side, or two-sided limited commitment. We show that the optimal contract can be characterized by an ordinary differential equation (ODE), and different types of limited commitment boil down to restrictions on the boundary conditions of the ODE. We provide a regulated Brownian-motion-based characterization of the optimal compensation contract, and we analyze firms' optimal investment policies under all three types of limited commitment.

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Our model is consistent with several stylized facts on firm investment and CEO compensation. First, we show that under limited commitment, small firms invest more, pay fewer dividends, and grow faster than large firms.

Despite the constant returns to scale technology, small firms in our model invest more because managers in small firms are poorly diversified and growing large improves risk sharing. The constant returns to scale technology allows our model to generate a power law in the firm size distribution, and agency frictions are responsible for the dependence of investment and payout on firm size. In our model, wage contracts are a form of operating leverage. Because managers are risk averse and shareholders are risk neutral, optimal risk sharing requires managerial compensation to stay constant whenever the limited commitment constraint does not bind. However, since shareholders cannot commit to negative NPV projects, as the firm value approaches zero, adverse productivity shocks must be accompanied by reductions in managerial compensation so that the firm value stays nonnegative at all times. A binding shareholder-side limited commitment constraint, which is more likely to happen in young and small firms, limits risk sharing and reduces efficiency. As a result, limited commitment on the shareholder side gives rise to an additional marginal benefit of investment in young and small firms: investment and growth alleviate the agency problem and improve risk sharing.

The fact that small firms invest more, pay fewer dividends, and grow faster than larger firms is well documented in the literature. [Evans \(1987\)](#) and [Hall \(1987\)](#) show that small firms grow faster than large firms. Small firms are less likely to pay out dividends, as documented by [Fama and French \(2001\)](#), among others. [Gala and Julio \(2011\)](#) find that firm size is a robust predictor of investment rates even after controlling for many other variables, such as Tobin's Q and firm cash flow.

Some previous models with limited commitment are also consistent with the fact that small firms invest more and grow faster (for example, [Albuquerque and Hopenhayn, 2004](#)). Our model and the [Albuquerque and Hopenhayn \(2004\)](#) model, however, have several main differences. First, they assume risk-neutral managers and consider limited commitment on the manager side only. Our model allows for risk aversion and two-sided limited commitment. Second, their model relies on a decreasing returns to scale technology. Small firms grow faster in their model because capital is more productive; that is, the marginal physical benefit of investment is higher. Our model features constant returns to scale. Small firms grow faster because growth mitigates the agency problem; that is, the marginal agency benefit of investment is higher. Third, because [Albuquerque and Hopenhayn \(2004\)](#) assume a decreasing returns to scale technology and stationary productivity shocks, firms eventually reach their optimal size and no long-run growth occurs. Our model generates long-run growth and is consistent with fat tails in the firm size distribution as in [Luttmer \(2007\)](#). In addition, because of the decreasing returns to scale technology and the identical discount rates of shareholders and managers, firms eventually grow out of the limited commitment constraint in [Albuquerque and Hopenhayn \(2004\)](#). In our model with two-sided limited commitment, the limited commitment constraint binds in the long run.

Second, our model is also consistent with another stylized fact on firm investment and CEO performance. Under the optimal contract with limited commitment, CEO compensation is history-dependent. In particular, limited commitment on the manager (shareholder) side implies that CEO compensation is an increasing function of the historical highest (lowest) level of firm size even after controlling for the current size of the firm.

Our model with one-sided limited commitment implies that compensation depends on the best historical performance of the firm. This implication is similar to that in the classic paper of [Harris and Holmstrom \(1982\)](#). Its empirical support is well documented in labor economics, for example, [Beaudry and DiNardo \(1991\)](#) and [McDonald and Worswick \(1999\)](#). Consistent with previous literature, using the Execucomp database in Compustat, we show that CEO compensation increases with the best historical performance of the firm even after controlling for current performance.

Our calibrated model also features limited commitment on the shareholder side. We show that in this case, CEO compensation depends not only on the historical best performance but also on the historical worst performance of the firm. Consider a firm whose value is driven toward zero by a sequence of negative productivity shocks. Because shareholders cannot commit to negative NPV projects, they optimally reduce CEO compensation to keep the firm value nonnegative. At the same time, optimal risk sharing requires that CEO pay stays constant unless the limited commitment constraint binds. As a result, subsequent positive shocks do not affect CEO compensation. In this case, CEO compensation is determined by the historical worst performance of the firm where the current level of compensation is set.

The above feature distinguishes our model from those with one-sided limited commitment in the previous literature. In [Harris and Holmstrom \(1982\)](#), managerial compensation responds to positive productivity shocks but is downward rigid. In a consumption risk-sharing context, [Krueger and Perri \(2006\)](#) obtain similar results. [Krueger and Perri \(2006\)](#) also show that in the data, consumption responds to both positive and negative productivity shocks. In our model with two-sided limited commitment, managerial pay responds to both positive and negative productivity shocks. We confirm this implication of our model by using Execucomp data. In particular, we show that CEO compensation is positively correlated with not only the best historical performance of the firm, but also the worst historical performance of the firm, even after controlling for the current size of the firm.

Third, limited commitment on the manager side implies that small firms have a higher Tobin's Q than large firms. The negative relationship between Tobin's Q and firm size is well documented in the literature. In our model, investment is efficient and long-run growth is optimal under the first best. Limited commitment lowers the marginal benefit of investment in large and mature firms and encourages investment in young and small firms. As a result, small firms have a higher valuation ratio than large firms.

We characterize the optimal dynamic contract for general convex adjustment cost functions and provide a closed-form solution for a special case. The closed-form solution allows us to derive an explicit expression of the marginal agency cost of investment and relate it to the fundamental

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