Testing Dynamic Agency Theory via Structural Estimation

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Under revision. Comments welcome.

ABSTRACT

We quantify agency conflicts induced by the separation of ownership and control in large public firms by means of structural estimation. We use a simulated method of moments estimator (SMM) to back out the structural parameters of a q-theoretic dynamic agency model of firms from observed financing and investment choices. In the model, an optimal contract resolves the agency conflict between investors and managers, which can be implemented using cash, debt and equity. Our estimates suggest that in order to rationalize observed firm financing and investment policies, the agency conflict between investors and managers needs to be substantial. We provide additional cross-sectional tests based on sample splits according to governance and firm characteristics.

Keywords: Dynamic agency, q-theory, dynamic contracting, managerial compensation, structural estimation

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1 Introduction

Recent theoretical research in corporate finance has the highlighted the role of financial contracting in determining firm policies and dynamics.[1] Financial contracts arise to mitigate incentive conflicts between firms' insiders and outsiders and affect corporations' financial structures, investment policies and valuations. While such effects can be dismissed in a frictionless Modigliani-Miller world, understanding corporate policies empirically requires researchers to deviate from this benchmark. While a more recent literature has started to investigate the effects of financing frictions quantitatively and by means of structural estimation,[2] research on financial contracting has mostly remained qualitative in nature. By and large, quantitative research in corporate finance has concentrated on evaluating the implications of a limited number of very specific departures from MM, namely almost exclusively the presence of taxes and bankruptcy costs.[3] While taxes are undoubtedly an important determinant of firms' financial structures and the ensuing dynamic trade-off models are empirically successful, the theoretical literature on financial contracting has documented how various agency conflicts between firms' investors and insiders can be crucial determinants of firms' financial structures, investment policies and dynamics.[4] An important challenge therefore is to quantitatively assess the implications of such mechanisms. In this paper we aim to take a step into that direction by means of a structural estimation of a dynamic agency model.

We use a simulated method of moments approach to estimate the parameters of a q-theoretic dynamic agency model of firm investment along the lines of DeMarzo, Fishman, He and Wang (2012). In the model, an agency conflict arises because of the separation of ownership and control. Investors hire a manager to run the firm whose unobserved actions affect the performance of the firm. By providing low effort, managers enjoy private benefits at a rate λ per unit of capital. Investors thus aim at designing an optimal contract with managers specifying investment and managerial compensation in such a way as to provide them with incentives to always provide full effort. Such an optimal contract provides incentives by promising higher compensation after favorable observed performance and by the threat of liquidation after bad performance. The threat of liquidation

[1] See e.g. the surveys of Harris and Raviv (1991)and Zingales (2000).

[2] An incomplete list includes Gomes (2001), Moyen (2004), Hennessy and Whited (2005, 2007), Strebulaev (2007).

[3] Two recent exceptions are Morellec, Nikolov and Schurhoff (2010) and Nikolov and Whited (2011), who estimate dynamic models with parameterized agency conflicts between shareholders and managers.

[4] Examples are asymmetric information, moral hazard or limited enforcement of contracts. See Hart (2001) for a survey.

limits the firm's investment, leading to underinvestment. The model thus endogenizes the costs of external financing. Setting the model in continuous time and employing recursive contracting techniques as in DeMarzo and Sannikov (2006), DeMarzo, Fishman, He and Wang (2012) show that this model provides a highly tractable characterization of the optimal contract and its implications for investment.

We take the model to the data by implementing the optimal contract by means of standard securities such as cash, debt and equity. The highly tractable environment allows us to use a simulated method of moments estimator to estimate the structural parameters of the model. This procedure in particular allows us to back out the parameter λ, which is a clean and direct measure of the severity of the agency conflict induced by the separation of ownership and control, from the observed financing and investment decisions of corporations. To that end, our estimator picks parameters that brings the simulated moments from the model on firms' financing, investment and managerial compensation as close as possible to their empirical counterparts.

Our estimates suggest that in order to rationalize observed firm financing and investment policies, the agency conflict between investors and managers, as measured by λ, needs to be substantial. Interpreting λ as he fraction of output that managers can divert for their private benefit, sets this number close to 12%. While it is important to note that the contract ensures that managers do not end up diverting output, giving them the appropriate incentives not to do so, constrains firms' investment and financing choices. Observed choices then suggest that incentive provision must be quite substantial. Intuitively, providing stronger incentives implies a stronger threat of liquidation, which reduces investment as liquidation comes with inefficient capital destruction. Observed investment then sets λ at about 0.12.

We examine further implications of the model by splitting our data sample along various dimensions and estimating the model on subsamples. This allows us to glean how our estimated parameters vary with cross-sectional variation in firm characteristics. We split the sample along corporate governance proxies as well as capital intensity. Our estimates suggest that, in line with economic intuition, firms with better governance exhibit a less severe agency conflict, as implied by their investment and financing choices. Similarly, our estimates indicate that firms with lower capital intensity are more prone to conflicts between investors and managers, which conforms with the notion that young growth firms have less well developed governance structures than large, mature firms.

Our paper is related to several strands of literature in empirical corporate finance on the one hand side, and dynamic contracting on the other. Methodologically, the model is a version of the recent work by DeMarzo, Fishman, He and Wang (2012) integrating long-term contract resolving an agency conflict into a dynamic q-theoretic model of firm investment. We see our contribution in providing an implementation that can be taken to the data, and estimating it using the simulated method of moments. We therefore provide an empirical assessment of this model by testing it and quantifying the mechanism at work. The paper by DeMarzo, Fishman, He and Wang is part of a growing literature that studies the implications of agency conflicts and long-term contracts for firm financing and investment. Prominent examples of this stream of literature include Albuquerque and Hopenhayn (2004), Clementi and Hopenhayn (2006), DeMarzo and Fishman (2007), and Rampini and Viswanathan (2010). Most closely related to our work is Biais, Mariotti, Plantin and Rochet (2006), and DeMarzo and Sannikov (2006), who devise implementations of the optimal contract by means of standard securities in continuous-time setups. None of these papers studies empirical or quantitative implications of the models, or performs structural estimation.

From an empirical point of view, the paper is most closely related to a growing literature on structural estimation of dynamic models of capital structure and investment starting with Hennessy and Whited (2005, 2007). These papers integrate a dynamic trade-off model of capital structure into a neoclassical model of investment, and show that such a setup does a good job at quantitatively explaining many of firms' observed financing and investment choices. We differ from these papers by estimating a model in which capital structure and financing choices emerge within an optimal contract in response to an agency conflict. In this respect, our paper is closer to recent work by Morellec, Nikolov and Schurhoff (2010) as well as Nikolov and Whited (2011), who, in contrast to our optimal dynamic contracting setup, estimate models with exogenous contracts. Earlier work along these lines, includes Gomes (2001).

The paper is structured as follows. The next section describes the agency problem, the optimal contract and its implementation. Section 3 provides a basic quantitative analysis that is helpful to illustrate our identification strategy. Section 4 describes the data and gives some background about the SMM procedure. Section 5 reports the results and the last section concludes.

2 Model

We integrate agency frictions into a standard dynamic neoclassical model of investment with convex adjustment costs along the lines of DeMarzo, Fishman, He and Wang (2011). More specifically, we consider a moral hazard problem induced by the separation of ownership and control. Firms' investors hire an outside manager to run the firm whose unobserved actions affect firm performance. We adopt the notation of DeMarzo, Fishman, He and Wang (2011).

2.1 Technology

For tractability, the model is set in continuous time. Firms employ capital to produce output and invest to accumulate capital. Denoting by K and I the level of the capital stock and the gross investment rate, respectively, a firm's capital stock evolves as

$$dK_t = (I_t - K_t)dt \tag{1}$$

where δ denotes the depreciation rate.

We assume that investment is subject to convex adjustment costs. More specifically, the adjustment cost function $G(I, K)$ is convex in investment I, and homogeneous of degree one in I and K. Thus, we have

$$I + G(I, K) \equiv c(i)K \tag{2}$$

so that the convex function c represents the total cost per unit of capital required for the firm to grow at rate $i = I/K$.

Firms have access to a linear production technology, so that the incremental gross output over the time interval dt can be represented as $K_t dA_t$, where A is the cumulative productivity process and hence dA_t is instantaneous productivity. After accounting for investment and adjustment costs we can thus write the dynamics for the cumulative cash flow process Y_t as

$$dY_t = K_t(dA_t - c(i_t)dt)$$

2.2 Contracting Environment

An agency conflict arises in the model because there is a separation between ownership and control in the firm. Shareholders hire outside managers to run the firm in exchange for wage payments and cannot observe their actions. At the beginning of the employment relationship, investors and managers sign contracts. Managers actions affect the dynamics of productivity in the model and we will subsequently interpret them as effort choice. Specifically, the manager's action $a_t \in [0, 1]$ determines the expected rate of output per unit of capital, so that

$$dA_t = a_t \mu dt + \sigma dW_t$$

where $W = \{W_t; F_t; 0 \leq t < \infty\}$ is a standard Brownian motion and σ is the volatility of the cumulative productivity process A. The manager's action thus affects the drift, but not the volatility of A. While A is observed, neither W_t nor a_t is known to investors, so that low productivity may be due low managerial effort or a bad draw of the Brownian motion.

Contracts with managers can be terminated at any time. In case of termination, investors recover a value lK_t, for some constant $l \geq 0$. We assume that termination is inefficient and entails deadweight losses. Termination can be interpreted as liquidation of the firm, or as firing the manager, in which case deadweight losses can be interpreted as inefficiencies associated with managerial turnover.

When the manager chooses effort a_t, he enjoys private benefits at rate $\lambda(1-a_t)\mu dt$ per unit of the capital stock, where $0 \leq \lambda \leq 1$. Given the linearity of that specification, managers will effectively choose low effort $a_t = 0$, or equivalently, *shirk*, or or will *work*, with $a_t = 1$. Higher private benefits are associated with a more severe agency conflict, which is captured by the parameter λ. Alternatively, the model can be interpreted in terms of cash flow diversion by managers. In that interpretation, $1 - a_t$ can be thought of as the fraction of cash flow the manager diverts for his private benefit, with λ standing for the manager's net consumption per dollar diverted. λ represents the severity of the agency conflict in this interpretation as well.

Investors have unlimited wealth and are risk neutral with discount rate $r > 0$. Managers are also risk-neutral, but discount the future at a rate $\gamma > r$ and hence are impatient relative to investors. This rules out postponing payments to managers forever. Managers have no initial wealth and limited liability, ruling out negative wages.

When formulating the optimal contracting problem between investors and managers, we assume that the firm's capital stock K_t and its cumulative cash flow Y_t are contractible, implying investment I_t and productivity A_t are also contractible. When managers are hired, investors offer them contracts specifying an investment policy I_t, the manager's cumulative compensation U_t, as well as a termination time τ, all of which depend on the history of the manager's performance, summarized by A_t. When a manager is terminated, he receives his reservation value, which is normalized to zero for simplicity. Manager's limited liability implies that the process U_t is non-decreasing. We represent the contract by $\Phi = (I, U, \tau)$.

Given a contract Φ, the manager chooses an effort process $\{a_t \in [0,1] : 0 \leq t < \tau\}$ to maximize the presented discounted value of compensation and the potential private benefits from taking low effort, ie

$$W(\Phi) = \max_{\{a_t \in [0,1]: 0 \leq t < \tau\}} E^a \left[\int_0^\tau e^{-\gamma t} (dU_t + \lambda(1 - a_t)\mu K_t dt) \right] \tag{3}$$

where E^a denotes the expectation operator under the probability measure induced by the action process. As DeMarzo, Fishman, He and Wang (2011) we focus on the case where investors find it optimal to design the contract to always induce high effort $a_t = 1$, and will refer to such contracts as incentive compatible.

The investor's objective is to design an incentive compatible contract that maximizes the expected present value of the payments to them. When designing the contract, they take the initial capital stock K_0 and the initial payoff to the manager W_0 as given. Their optimization problem is thus

$$P(K_0, W_0) = \max_{\Phi} E^a \left[\int_0^\tau e^{rt} dY_t + e^{r\tau} l K_t - \int_0^\tau e^{-rt} dU_t \right] \tag{4}$$

such that Φ is incentive compatible and $W(\Phi) = W_0$. The manager's initial payoff W_0 results from the relative bargaining power of investors and managers when the contract is initiated.

2.3 Solving for the Optimal Contract

In order to illustrate the economic mechanisms at work, we briefly outline the derivation of the optimal contract, but refer to DeMarzo, Fishman, He and Wang (2011) for the details.

For a given incentive compatible contract Φ and a history up to time t, the present value of the manager's future compensation is

$$W_t(\Phi) \equiv E_t\left[\int_0^{\tau} e^{-\gamma(s-t)} dU_t\right] \tag{5}$$

The change of this continuation payoff at time t consists of a wage payment dU_t and a change in the value of future payments dW_t. Given the manager's discount rate γ the incremental compensation must be $\gamma W_t dt$ on average, thus

$$E_t\left[dW_t + dU_t\right] = \gamma W_t dt$$

While this needs to hold on average, incentive compatibility requires that the manager's compensation depends on the firm's performance, and more specifically must be sensitive to its incremental output $K_t dA_t$. Using techniques developed by Sannikov (2008) invoking the martingale representation theorem, it follows that this sensitivity can be characterized as follows,

$$dW_t + dU_t = \gamma W_t dt + \beta_t K_t (dA_t - \mu dt) = \gamma W_t + \beta K_t \sigma dZ_t \tag{6}$$

so that the process β_t determines the sensitivity of the manager's compensation to firm performance. Incentive compatibility requires that β_t is sufficiently high to induce high effort, or in other words, that the manager is sufficiently exposed the firm's realized output. More concretely, suppose the agent deviates by choosing $a_t < 1$, which yields an instantaneous private benefit of $\lambda(1 - a_t)\mu K_t dt$. On the other hand, this deviation triggers an expected reduction in compensation in the magnitude of $\beta_t(1-a_t)\mu K_t dt$. Consequently, inducing high effort implies the incentive compatibility constraint

$$\beta_t \geq \lambda \quad \text{for all} \quad t \tag{7}$$

On the other hand, the sensitivity of the manager's continuation payoff to firm performance implies that after an expended period of bad performance, the manager's continuation payoff is falling. Given limited liability, it cannot fall below zero, so $W_t \geq 0$ for all t. When $W_t = 0$, the contract is terminated. Since this is costly to investors, they want to limit the sensitivity of manager's continuation payoff to firm performance. While incentive provision is necessary, it is inefficient ex post. Optimally, investors impose minimal incentive provision, so that under the optimal contract, the incentive compatibility constraint binds, that is, we have $\beta_t = \lambda$ for all t.

While the relevant state variables at any date t are K_t and W_t, the linearity of the production technology implies that the optimal contracting problem can be equivalently cast in per unit of capital terms. Therefore, the value of the contract is given by $P(K, W) = p(w)K$ reducing the dynamic programming problem to one state variable, namely the scaled continuation payoff $w \equiv W/K$.

A few properties of the scaled value function $p(w)$ are straightforward to establish. First, once the manager's continuation value w falls to zero, the contract must be terminated, implying that

$$p(0) = l \tag{8}$$

Further, investors can always compensate managers with cash right away, rather than deferring their compensation to the future. This implies $p'(w) \geq -1$, as it will cost investors at most one dollar to increase w by a dollar. Because termination is costly ex post for the investors, the optimal contract will try to increase w when it is low, thus deferring compensation rather than paying managers with cash in these situations. However, because managers have a higher discount rate than investors, their compensation cannot be deferred indefinitely, and when w_t is sufficiently high it will be optimal to pay them with cash once $w_t > \bar{w}$, for some $\bar{w}$. Therefore

$$du_t = \max\{w_t - \bar{w}, 0\} \tag{9}$$

where $\bar{w}$ satisfies

$$p'(\bar{w}) = -1. \tag{10}$$

Optimally choosing the payout cutoff implies a 'super contact' condition

$$p''(\bar{w}) = 0. \tag{11}$$

More formally, the evolution of w satisfies

$$dw_t = (\gamma - (i_t - \delta))w_t dt + \lambda\sigma dZ_t + du_t$$

where $du_t = \frac{dU_t}{K_t} = 0$ on $[0, \bar{w}]$ and reflects w_t back to $\bar{w}$. Contracts are thus initialized with some promise w_0 per unit of capital to the manager, which grows at rate γ less the net growth rate $(i_t - \delta)$ of the firm on average. After good firm performance, the promised payoff may reach $\bar{w}$ at which point the manager is compensated with cash, while after bad performance w_t may fall to zero, whence the contract is terminated.

The evolution of w_t implies the following Hamilton-Jacobi-Bellman (HJB) equation that characterizes $p(w)$ on $[0, \bar{w}]$. The investment policy $i(w)$ is given as the solution of the principal's HJB equation for his value function $p(w)$

$$rp(w) = \sup_i (\mu - c(i)) + (i - \delta)p(w) + (\gamma - (i - \delta))wp'(w) + \frac{1}{2}\lambda^2\sigma^2 p''(w) \tag{12}$$

Given a solution for the value function p the investment policy actually admits an analytical solution of the form

$$c'(i(w)) = p(w) - wp'(w) \tag{13}$$

Equations (12) and (13) jointly determine a second-order differential equation which together with the above boundary conditions characterizes $p(w)$ on $[0, \bar{w}]$.

2.4 Qualitative Properties of the Optimal Contract

Incentive provision for managers requires potential termination of the contract after sufficiently bad performance. As termination and managerial turnover involve deadweight losses, investors will more cautiously evaluate investment opportunities with a firm. The presence of the agency friction will thus limit the firm's investment and thus endogenizes the costs of external financing. Intuitively, the lower w, the more likely is inefficient termination and hence the lower investment.

Naturally, suboptimal investment associated with the agency friction is reflected in valuations. Total firm value per unit of capital is given by the sum of the claims of investors and managers on the firm, thus by $p(w) + w$. Accordingly, average or Tobin's q is

$$q_a(w) = \frac{P(K, W) + W}{K} = p(w) + w.$$

Similarly, marginal q, defined as the incremental impact of a unit of capital on firm value, can be calculated as

$$q_m(w) = \frac{\partial(P(K,W)+W)}{\partial K} = P_K(K,W) = p(w) - wp'(w) \tag{14}$$

Figure 1 illustrates $p(w)$ relative to the first best. While in the first best, an additional dollar for the manager necessarily means a dollar less in the pockets of investors, additional features emerge with agency frictions. First, in spite of investors' risk neutrality, the value function is concave. In the presence of agency frictions a mean preserving spread in w is costly as it increases the likelihood of inefficient termination, making investors effectively averse to idiosyncratic risk. Second, the value function need not be monotonic. For sufficiently low w increasing promises to managers also increases the wealth of investors, as it decreases the probability of costly termination. On the other hand, once w is large enough increasing promises to managers reduces investors value function.

These patterns are also reflected in q_m and q_a. Figure 1 shows q in the first best case and with agency frictions and documents that $q^{FB} > q_a(w) > q_m(w)$. The first inequality implies the frictions come with potentially high value losses. The second inequality shows that in the presence of agency frictions, marginal and average q are generally different, in contrast to the standard Hayashi (1982) framework. Average q is above marginal q because, for a given level of W, an increase in K lowers the manager's continuation payoff w, thus brings the contract closer to termination and hence induces a more severe agency problem. Both marginal and average q are increasing in w so that distortions relative to first best decrease as the manager's continuation payoff moves further away from termination after good performance.

Figure 1 illustrates the behavior of investment with agency frictions relative to first best. Investment is determined by the optimality condition

$$c'(i(w)) = q_m(w) = p(w) - wp'(w) \tag{15}$$

With the agency conflict, investment is always below the first best level. The agency conflict thus induces potentially severe underinvestment. Moreover, investment is increasing with w. Since after good performance managers are rewarded with a higher continuation payoff, w is increasing in past profits and persistent, so that investment becomes positively related to past performance and serially correlated. Intuitively, when w is low after a series of bad shocks, the contract is close to termination in which case investors incur deadweight losses proportional to the capital stock, so that they are reluctant to deploy more capital into the firm.

2.5 Implementation of the Optimal Contract

While the previous sections summarized how the optimal contract can be characterized using the manager's continuation payoff w_t and its evolution, we now present a simple implementation of the payments arising in the contract using standard securities along the lines of DeMarzo and Sannikov (2008). This is necessary in order to bring the model to the data via structural estimation, as we will proceed to do in the next section. While such an implementation is not uniquely pinned down by the model, we find our choice to be intuitive and natural.

Intuitively, as the contract is terminated when $w_t = 0$, the continuation payoff captures the distance to termination or, in other words, measures a firm's financial slack. In line with the literature, we interpret financial slack as a firm's cash reserves. When cash reserves are exhausted the firm is liquidated. When the firm generates cash flows it will keep them within the firm as cash reserves rather than paying them out as dividends in order to move away from termination. At some point, the firm will hold a sufficient amount of cash, so that it will start paying dividends. In this way, cash reserves will track the manager's continuation payoff w_t.

We decompose the payments to investors into payouts to standard securities, such as equity and debt. Equity is the claim to dividends paid out once cash reserves are sufficiently high, while we interpret expected free cash flow as coupon payments to debt. Note that in this implementation, coupon payments are time-varying, so that it effectively allows firms' to rebalance their capital structures.

How does this implementation ensure incentive compatibility, that is, how does it guarantee that the manager will always choose high effort? It does so by endowing managers with a fraction λ of firms' equity. This guarantees that managers are only compensated with cash payments once their continuation payoff is sufficiently high, namely when cash reserves are high and the dividend payout boundary is reached, while before that compensation is deferred. Second, giving managers a fraction λ makes sure that deviating to providing low effort and enjoying the associated private benefits is not optimal. The implementation is thus incentive compatible.

For simplicity, we will present the implementation on a per unit of capital basis, which is easily converted back to level by multiplying with K_t. Cash reserves m_t are designed to track w_t. A security is needed to extract expected free cash flows. To start with we will think of them as coupon payments to long term debt. Then the payments du_t are implemented as equity.

Incentive compatibility requires that

$$dw_t = \lambda dm_t$$

as otherwise deviation with low effort would provide attractive private benefits. Accordingly, the firm is terminated when $m_t = 0$. On the other hand, the optimal contract prescribes that the manager is compensated with cash payments when w_t reaches $\bar{w}$, or equivalently, when the firm's cash reserves reach $\bar{m} = \frac{\bar{w}}{\lambda}$. At this point, the firm starts paying out dividends, a fraction λ of which are paid out to the manager. We define coupon payments to debt to be $d(w) = \mu - c(i(w))dt$, corresponding to the firm's expected free cash flow. While this is just one possibility of capturing payments to debt, it captures the notion that firms' debt burden is changing over time. Under this implementation, firm's cash reserves will evolve according to

$$dm_t = \gamma m_t dt + dy_t - d - du_t \tag{16}$$

which is just a restatement of the firm's budget constraint.

Valuation of Securities For our empirical implementation, we will need to compute market values of securities. While these are not available in analytical form, we can easily compute them by numerically solving an ordinary differential equation with suitable boundary conditions. More precisely, if w_t follows

$$dw_t = (\gamma - (i_t - \delta))w_t dt + \lambda\sigma dZ_t + du_t$$

where $du_t = \frac{dU_t}{K_t} = 0$ on $[0, \bar{w}]$ and reflects w_t back to $\bar{w}$, then expectations of the general form

$$G(w_0) = E\left[\int_0^\tau e^{-rt}g(w_t)dt - \kappa\int_0^\tau e^{-rt}du_t + e^{-r\tau}l\right]$$

for some real valued function g and suitable choices of κ, l and so on, are solutions of an ordinary differential equation with boundary conditions reflecting these choices. Specifically, G solves

$$rG(w) = g(w) + (\gamma - (i(w) - \delta))wG'(w) + \frac{1}{2}\lambda^2\sigma^2 G''(w)$$

with boundary conditions $G(0) = l$ and $G'(\bar{w}) = -\kappa$. Given the investment policy $i(w)$ determined as part of the principal's value function, this is straightforward to solve numerically. All market values of securities in the model are of this general form and thus can be computed as solutions to this differential equations.

Figure 1 illustrates the market values of the individual securities as well as total firm value and relates them to managers' continuation payoff. Cash reserves are linearly increasing with w. Given the threat of termination, debt and equity values fall sharply when w falls. On the other hand, the market value of debt is not monotonic. When w increases, the threat of termination falls, which fosters investment and lowers coupon payments.

3 A Basic Quantitative Analysis

Before we describe our formal structural estimation analysis of the dynamic contracting model, we start in this section by giving a first look at the quantitative effects of agency conflicts on firm financing and investment. To that end, we report comparative statics describing the effects of the main model parameters on cash holdings, investment, average q, and leverage. This will also be helpful in order to understand our identification strategy that we will describe below.

3.1 Quantitative Model Predictions

Figures 2 and 3 provide basic comparative statics of the effects of the model parameters on firm financing and investment. Each plot traces the effects of changing one parameter on model implied moments while keeping all other parameters constant. For the remainder of the paper we will specialize convex adjustment costs to quadratic adjustment costs by setting

$$c(i) = i + \frac{1}{2}\theta i^2. \tag{17}$$

We will consider the effects of the intensity of the agency conflict λ, the relative impatience of the agent $\gamma - r$, expected productivity μ, volatility σ and capital adjustment costs θ.

Input parameter values for the base case environment are as follows. The risk-free rate $r = 0.0348$ and the liquidation value is $l = 0.625$. We discuss the calibration of these two parameters in detail in section 4.2. Depreciation $\delta = 0.13$ is annual depreciation. We use quadratic adjustment costs with $\theta = 2.50$. Expected productivity is $\mu = 0.195$ and we set volatility to $\sigma = 0.08$. The manager's discount rate is set as $\gamma = r + 0.0050$. Finally, we choose the agency parameter to be $\lambda = 0.50$.

Figure 2 illustrates the sensitivity of the average cash to asset ratio and investment with respect to the main parameter values. The figure reveals that the cash-to-asset ratio is decreasing in the extent of the agency conflict as captured by λ and, as a matter of fact, quantitatively quite sensitive to it. Intuitively, the more severe the agency conflict, the more sensitive is the manager's compensation to firm performance, and the stronger is the threat of termination. In our implementation, cash or financial slack is given by $m = w/\lambda$. Hence, firms with less severe agency conflicts should have more slack and more cash to avoid liquidation. The cash-to-asset ratio is also decreasing in the manager's relative impatience, as measured by $\gamma - r$. The more impatient the manager is, the stronger is his desire for cash compensation, decreasing the payout boundary $\bar{m}$. This decreases the region over which cash is accumulated. On the other hand, cash is increasing in expected productivity reflecting increased resources. The fact that cash holdings are increasing in volatility reflects the effective risk aversion of investors in the presence of the agency conflict. Higher volatility leads to a higher probability of termination, all else equal, which leads to a higher cash buffer.

The right panel of figure 2 quantifies the sensitivity of investment to changes in parameter inputs. Intuitively, investment is decreasing in the severity of the agency conflict, as a more severe conflict increases the risk of termination associated with deadweight losses. However, quantitatively, the effect is not very strong. Generally speaking, parameter changes affect investment in a similar way as the cash-to-asset ratio, but quantitatively the effects are much weaker. Clearly, higher productivity increases investment, impatience decreases it as the accumulation region shrinks, volatility decreases investment through an effective risk aversion effect, and higher adjustment costs make investment costlier.

Figure 3 quantifies the sensitivity of average q and leverage relative to parameter changes. The left panel focuses on average q. Average q is decreasing in λ. Note that in the model $q_a(w) = p(w) + w$, which is, since $p'(w) \geq -1$, increasing in w. This reflects that increasing w aligns the incentives of investors and managers for low values of w, leading to an increase in $p(w)$. On the other hand, a more severe agency conflict leads to a higher threat of termination under the optimal contract, and lower values of w. The net effect is a fall in average q. A similar intuition underlies the fall of average q in relative impatience. As higher impatience reduces the payout boundary $\bar{w}$, average q falls. Clearly, average q increases in expected productivity and falls with adjustment costs. Higher volatility increases the risk of termination, and hence reduces average q.

The right panel of figure 3 illustrates the quantitative dependence of leverage on model parameters. While leverage is largely insensitive to productivity, relative impatience and capital adjustment costs, it moves quite sharply with λ and σ.

3.2 Identification

Before proceeding with the estimation of the model, it is important to understand how we can identify the model parameters in the data. A sufficient condition for identification is a one-to-one mapping between the structural parameters and a set of data moments of the same dimension. It is however difficult to obtain such a closed-form mapping in any economic model. As a consequence, to achieve identification, we select a set of moments such that every estimated parameter has a differential impact on this set of moments. Heuristically, a moment h is informative about an unknown parameter β if that moment is sensitive to changes in the parameter and the sensitivity differs across parameters. Formally, local identification requires the Jacobian determinant, $det(\partial h/\partial\beta)$, to be nonzero. To aid in the intuition of the identification of the model parameters, Table **??** reports elasticities of the model-implied moments with respect to the parameters, $(\partial h/\partial\beta)/(\beta/h)$, in our base case environment. Inspection of Table **??** reveals that condition $det(\partial h/\partial\beta) \neq 0$ holds and that we can separately identify the parameters of the model.

We further proceed to describing the details of the identification and the choice of moments. We select distributional moments of cash, investment, leverage, and Tobin's q, but also moments that relate to the join distribution of these quantities. Average and variance of cash and leverage and covariance of cash and investment help identify the agency parameter, λ. Average and variance of cash and the covariance of cash and investment help identify the agent discount rate, γ. We note that λ positively affects the variance of cash, while γ exhibits a negative impact. Average investment helps identify the expected productivity μ. The variance of all distributions helps identify the volatility σ. The variance and the serial correlation of cash, investment, Tobin's q, and leverage help identify the capital adjustment cost, θ, and the depreciation, δ. These two parameters are identified based on their differential impact on leverage.

4 Structural Estimation

We now proceed to formally estimate the parameters of the model by means of a simulation-based estimator, namely the simulated method of moments (SMM). To estimate the severity of the agency conflict induced through the separation of ownership and control, we exploit data on managerial compensation from ExecuComp along with firm-level data. We start by describing our data in some more detail, and gather some details of our estimation method in the next section.

4.1 Data

The estimation of the model requires merging data from various standard sources. We collect financial statements data from Compustat, managerial compensation data from ExecuComp, governance data from the Investor Responsibility Research Center (IRRC), and institutional data from Thompson Reuters. Following the literature, we remove all regulated (SIC 4900-4999) and financial firms (6000-6999). Observations with missing SIC code, total assets, gross capital stock, market value, long-term debt, debt in current liabilities, and cash and short-term investments are excluded. We also require that firms have at least two consecutive years of data because we need to lag some of the variables. As a result of these selection criteria, we obtain a panel data set with $12,187$ observations for $1,951$ firms, for the time period between 1992 and 2010, at the annual frequency. Table 1 provides detailed definitions of the variables of interest.

Table 2 reports the descriptive statistics for the sample. The first panel provides financial statements data. We observe that this data is representative of Compustat firms. Our sample exhibits however a bias towards large firms. This is due to the fact that we use the ExecuComp dataset that is defined over the $S\&P1,500$ index. The following three panels contain data on governance indicators that are commonly used in the literature. We use these indicators as criteria to do sample splits. We want to investigate how estimated parameters vary with respect to samples that exhibit different governance characteristics. The last panel reports data on capital intensity. This will help us relate agency frictions to the capital intensity of firms.

4.2 Estimation

We estimate most of the model parameters using simulated method of moments (SMM). However, we estimate some of the model parameters separately. For example, we estimate the risk-free interest rate, r, to equal 0.0348, which is the average over the sample period of the one-year Treasury rate. We follow Berger, Ofek, and Swary (1996) and estimate the liquidation value as

$$L_{it} = (\text{Tangibility}_{it} + \text{Cash}_{it})/\text{Total Assets}_{it}, \tag{18}$$

where $\text{Tangibility}_{it} = 0.715*\text{Receivables}_{it}+0.547*\text{Inventory}_{it}+0.535*\text{Capital}_{it}$. We then estimate 6 parameters using the simulated method of moments: λ the agency parameter; γ the agent's discount rate; μ the expected productivity; σ the volatility of the productivity process; θ the quadratic capital adjustment cost; and δ the capital depreciation rate.

The simulation method of moments, although computationally intensive, is conceptually simple. First, we simulate $S = 10$ artificial panels based on the numerical solution of the model. Every panel contains $20,000$ firms. Each firm is simulated for 50 years. The first 30 years of data are dropped to avoid the effect of initial conditions. Second, we compute interesting moments using both the simulated and the observed data. Finally, the SMM estimator selects the parameters such that the distance between the simulated and the actual data is minimized. We next describe the estimation procedure in some more detail.

One important aspect of the SMM estimation is the choice of weighting matrix. A natural candidate for this choice is the identity matrix. While intuitive, this choice comes with a significant drawback. Indeed, the identity matrix allocates more weight to the moments that are larger in absolute value. This property does not have any valid economic interpretation. As a consequence, we choose to use the optimal weighting matrix that is the inverse of the covariance matrix of the moments. Intuitively, this method allocates more weight on the moments that are measured with greater precision. To compute the covariance matrix of the moments, we follow the influence function approach of Ericson and Whited (2000).

Finally, one last aspect of the estimation relates to unobserved heterogeneity. Indeed, our model generates predictions for a representative firm. However, for the estimation, we use Compustat data, that is a panel data set. To have consistency between the simulated and the observed data, we need to either add heterogeneity to the simulated data or remove heterogeneity from the observed data. We select the second approach. To do so, we use firm and year fixed effects when we estimate variances, covariances, and regression coefficients.

4.2.1 Estimation Procedure

We provide a brief discussion of the estimation procedure, which closely follows Lee and Ingram (1991). Let x_i be an *i.i.d.* data vector, $i = 1, \dots, n$, and let $y_{is}(\beta)$ be an *i.i.d.* simulated vector from simulation s, $i = 1, \dots, n$, and $s = 1, \dots, S$. Here, n is the length of the simulated sample, and S is the number of times the model is simulated. We pick $n = 20,000$ and $S = 10$, following Michealides and Ng (2000), who find that good finite-sample performance of a simulation estimator requires a simulated sample that is approximately ten times as large as the actual data sample.

The simulated data vector, $y_{is}(\beta)$, depends on a vector of structural parameters, β. In our application $\beta \equiv (\lambda, \gamma, \mu, \sigma, \theta, \delta)$. The goal is to estimate β by matching a set of *simulated moments*, denoted as $h(y_{ik}(\beta))$, with the corresponding set of actual *data moments*, denoted as $h(x_i)$. The candidates for the moments to be matched include for example simple summary statistics or OLS regression coefficients. Define

$$g_n(\beta) = n^{-1} \sum_{i=1}^{n} \left[h(x_i) - S^{-1} \sum_{s=1}^{S} h(y_{is}(b)) \right].$$

The simulated moments estimator of β is then defined as the solution to the minimization of

$$\hat{\beta} = \arg\min_{\beta} g_n(\beta)' \hat{W}_n g_n(\beta),$$

in which $\hat{W}_n$ is a positive definite matrix that converges in probability to a deterministic positive definite matrix W. In our application, we use the inverse of the sample covariance matrix of the moments, which we calculate using the influence function approach in Erickson and Whited (2000).

The simulated moments estimator is asymptotically normal for fixed S. The asymptotic distribution of β is given by

$$\sqrt{n}\left(\hat{\beta}-\beta\right) \xrightarrow{d} \mathcal{N}\left(0, \text{avar}(\hat{\beta})\right)$$

in which

$$\text{avar}(\hat{\beta}) \equiv \left(1+\frac{1}{S}\right)\left[\frac{\partial g_n(\beta)}{\partial \beta} W \frac{\partial g_n(\beta)}{\partial \beta'}\right]^{-1}\left[\frac{\partial g_n(\beta)}{\partial \beta} W \Omega W \frac{\partial g_n(\beta)}{\partial \beta'}\right]\left[\frac{\partial g_n(\beta)}{\partial \beta} W \frac{\partial g_n(\beta)}{\partial \beta'}\right]^{-1} \quad (19)$$

in which W is the probability limit of $\hat{W}_n$ as $n \to \infty$, and in which Ω is the probability limit of a consistent estimator of the covariance matrix of $h(x_i)$.

5 Estimation Results

This section presents our results from the SMM estimation of the dynamic agency model. We start by describing results obtained from estimating the model on the full sample. We then estimate the model on several subsamples, split according to governance indices as well as firm characteristics. We then quantify value losses due to agency frictions in the different samples.

5.1 Baseline Parameter Estimates

Table 3 reports the main estimation results on the full sample. Panel A compares the simulated moments with the actual moments, while panel B reports the parameter estimates with standard errors.

Overall, the estimated model provides a reasonable fit to the data. It matches first moments of quantities rather well, as it does serial correlation. On the other hand, volatility is generally too low, and moments involving asset prices are off.

More specifically, the model matches the overall level of cash quite well. This is important, as the comparative statics in the previous section have shown that cash holdings are very sensitive to the severity of the agency conflict parameter λ, and hence reliable estimates require a good fit there. The model also matches investment quite well. This is important as the agency conflict on a first order basis restricts investment.

The model fails to match two important statistics about firm financing and investment, namely market leverage and average q. Model-implied market leverage is almost twice as high as its empirical counterpart. In this sense, the model generates an underleverage puzzle, as documented in many dynamic capital structure models based on a favorable tax treatment of corporate debt, which predict excessive leverage ratios of similar magnitudes. This result is likely due to our model solution abstracting from macroeconomic conditions and assuming that investors are risk neutral. Indeed, recent work (Bhamra, Kuehn and Strebulaev (2010), Chen (2010)) has pointed out the importance of accounting for macroeconomic conditions and risk premia in models of corporate leverage, as corporations likely use debt conservatively as they want to conserve debt capacity for downturns. This channel is missing in the model. A similar argument applies to average q, which includes equity values. Equity values are clearly very sensitive to macroeconomic conditions, and in the presence of time-varying risk premia even more so. In the model, we are abstracting from many elements that may have contributed to the run-ups in stock market valuations that our data sample on average q incorporates, such as the arrival of new technologies and growth options coming in the money. Incorporating such mechanisms into a dynamic agency model would be very interesting.

Volatilities are generally low in the model. While intuitively, this could be easily fixed by a higher value for σ, the estimation procedure generates a fairly conservative value. If σ is reasonably interpreted as idiosyncratic volatility, estimates of it involving stock market data typically yield considerably higher values. The estimation procedure chooses a rather conservative value as investment is sharply decreasing in volatility, as documented in the comparative statics in the previous section. Higher volatility increases the threat of termination, and hence deadweight losses in capital, and hence discourages investment.

Panel B reports the parameter estimates with standard errors. All of the estimated parameters are statistically significant. The most interesting parameter of course is λ, which is estimated to be 0.12. Recall that λ is between zero and one, with a higher value associated with a more severe agency conflict. Indeed, under the cash diversion interpretation of the model, we can think of λ as the fraction of each dollar diverted that managers can use for their own consumption. In this case, $1-\lambda$ is the fraction of a dollar that is lost upon diversion. Our estimate thus suggests that observed financing and investment choices imply that investors need to provide managers with incentives not to divert around 12% of cash flows. This appears quite substantial.

The manager's discount rate is estimated to be $\gamma = 0.045$, which is high in comparison to investors' discount rate $r = 0.0348$. This result is driven by firms' cash holdings. The cash-to-asset ratio is decreasing in relative impatience, and matching the empirical cash-to-asset ratio requires fairly high relative impatience. While, as discussed above, the estimated idiosyncratic volatility $\sigma = 0.08$ is rather low, the technological parameters θ and δ are in line with more direct empirical evidence. The estimate $\theta = 2.219$ is at the upper end, but within the range estimated by Whited (1992), while estimated depreciation $\delta = 0.152$ is well within the range considered in the empirical literature.

5.2 Sample Splits

So far, we have obtained parameter estimates on the full sample. In this case, the SMM parameter estimates correspond to a hypothetical average firm, which subsume all information about cross-sectional heterogeneity. To gauge and measure cross-sectional differences in agency conflicts from the model, we now estimate the model on subsamples. This allows us to glean information about the average firm in the respective subsamples, which is informative about cross-sectional heterogeneity. We split our sample along various corporate governance measures as well as according to capital intensity. We expect both corporate governance and capital intensity to be related to the intensity of agency conflicts. While agency conflicts between ownership and control should be naturally be reflected in firms' corporate governance, higher capital intensity should be associated with more tangible capital, which should be easier to contract on. We create subsamples by splitting the entire sample into thirds based on the relevant variable, and then discard the middle third.

5.2.1 Governance Splits

We start by describing our different governance measures. Following Nikolov and Whited (2011) we use measures based on ownership and two commonly used governance indices. Two of our governance measures are based on ownership. The first is the fraction of stock owned by institutional investors, where a higher value is associated with better governance the idea being that institutions are more likely to be activist shareholders. This interpretation is consistent with the results in Hartzell and Starks (2003) who find that high institutional ownership is negatively related to the level of executive compensation, and positively related to pay-for-performance sensitivity. The second measure is the fraction of stock owned by blockholders, with a higher value is again taken to indicate better governance. This interpretation is based on Shleifer and Vishny (1986), who argue that the existence of large independent shareholders makes a takeover easier. Accordingly, the cost of a control challenge is expected to be smaller, and the market for corporate control puts more discipline on the manager.

The next two measures are commonly used governance indices from Gompers, Ishii, and Metrick (2003) and Bebchuk, Cohen, and Ferrell (2009), the G-index and the E-index, respectively. Both indices count provisions recorded by the Investor Responsibility Research Center (IRRC) that describe shareholder rights. The G-index counts all of the provisions documented by the IRRC. The E-index includes only those provisions argued by Bebchuk, Cohen, and Ferrell (2009) to be the most important for entrenching managers: staggered boards, limits to shareholder bylaw amendments, supermajority requirements for mergers, supermajority requirements for charter amendments, poison pills, and golden parachutes. Using these commonly used indices allows us to link our results to the rest of the governance literature. High G- and E-indices are associated with weak shareholder (or strong managerial) power.

Table 4 reports parameter estimates across subsamples along with standard errors. The upper block of the table presents the results from splitting the sample based on ownership. The results in the case of institutional ownership conform with economic intuition. The estimate of λ for corporations with higher institutional ownership and hence likely better governance is smaller than the corresponding estimate for firms with lower institutional ownership. From the perspective of the model this suggests that such corporations indeed exhibit a less severe agency conflict between shareholders and management, and hence that the fraction of institutional ownership empirically indeed captures aspects of the quality of governance. Interestingly, firms with lower institutional ownership also exhibit higher volatility, suggesting that these are riskier, and higher relative impatience on the side of managers. On the other hand, the estimate also indicates that such firms appear to be more productive. The results in case of blockholder ownership appear less intuitive from the perspective of the model. Specifically, the estimates indicate that the agency conflict induced by the separation of ownership and control is more severe in case of firms with high blockholder ownership, contradicting Shleifer and Vishny's (1986) rationale for using blockownership as a corporate governance index. Of course, this can cast as much doubt on the model as on the usage of the index. Similarly, firms with low blockholder ownership appear to exhibit less volatility, which appears to be counterintuitive from the usage of the index. On the other hand, the sample splits on blockholders are the ones with the smallest sample sizes. This could potentially explain the somewhat counterintuitive results.

The lower block of the table presents the results from splitting the sample based on G- and E-indices. Recall that high values for the indices stand for weak governance, and to the extent that these are good proxies for governance quality, one should expect them to be associated with a severe agency conflict. This is what our estimates suggest. High G-index and high E-index come with higher estimates for λ than low index corporations, as a matter of fact, substantially so. Along this dimension, these indices do conform with the predictions of the model, and economic intuition. On the other hand, corporations with better governance according to the indices appear to exhibit higher volatility.

5.2.2 Capital Intensity Splits

Table **??** presents results from splitting the sample along corporations' capital intensities, reporting both matched moments and parameter estimates. The actual moments reported in panel A show that firms with high capital intensity have lower Tobin's q and higher leverage, they invest less and hold more cash than corporations with low capital intensity. These moments are consistent with the notion that capital intensive firms are profitable 'value' firms with lots of assets in place and collateral, while low capital intensity firms are 'growth' firms with many uncollaterizable growth options. Since more capital intensive firms are more profitable, they hold more cash. The model matches this pattern fairly well, while it fails to reproduce the relative magnitudes of leverage and Tobin's q. This is likely due to the linear production technology adopted in the model that fails to capture differential growth opportunities between capital intensive and less intensive firms. Indeed, the model clearly is inconsistent with many stylized features of the size distribution of firms. Incorporating decreasing returns into the dynamic agency model would be a valuable extension, which would - however- come at the cost of substantial loss of tractability and increased computational flexibility.

Panel B reports parameter estimates across split samples. Consistent with economic intuition, the model predicts low capital intensity firms, that is 'growth' firms, to have a higher private benefits, higher volatility, but also higher productivity. The prediction on higher private benefits, and hence a more severe agency conflict, is driven by the empirical evidence of lower cash holdings, which, as shown in the comparative statics in the previous section, is decreasing in λ.

5.2.3 Agency and Value Losses

Table 5 quantifies values losses and underinvestment relative to first best in various samples. We compute the loss in value as $1 - q_a/a_a^{FB}$ and quantify underinvestment as $1 - i/i^{FB}$. The left panel reports value losses, while underinvestment is reported in the right panel. Value losses can be substantial. Estimated on the full sample, agency frictions imply a loss in average value of almost 3%. This comes with an average underinvestment of 16%. On subsamples sorted along ownership characteristics, firms with better corporate governance incur lower value losses, and underinvest less, in line with the intuition that agency conflicts induced by the separation of ownership and control are less severe. On the other hand, the results are mixed when it comes to the E- and G-indices. While firms with high E-index, and hence, weaker corporate governance, incur substantially higher value losses and underinvest significantly more than corporations with low E-index, the opposite is true in case of the G-index. In this case, however, the quantitative differences are much smaller. On the other hand, these comparisons do not isolate differences in agency conflicts only, but differences along all characteristics, which may explain parts of the discrepancies.

6 Conclusion

We quantify agency conflicts induced by the separation of ownership and control in public firms by means of structural estimation. To that end, we use a simulated method of moments approach to estimate the parameters of a q-theoretic dynamic agency model of firm investment along the lines of DeMarzo, Fishman, He and Wang (2012). In the model, an agency conflict arises because of the separation of ownership and control. Investors hire a manager to run the firm whose unobserved actions affect the performance of the firm. By providing low effort, managers enjoy private benefits at a rate λ per unit of capital. Investors thus aim at designing an optimal contract with managers specifying investment and managerial compensation in such a way as to provide them with incentives to always provide full effort. The parameter λ thus provides a clean and direct measure of the severity of the agency conflict induced by the separation of ownership and control. The model is highly tractable and is therefore amenable to a computationally intensive simulation-based estimator.

We take the model to the data by implementing the optimal contract by means of standard securities such as cash, debt and equity. Our simulated method of moments approach allows us to back out the parameter λ from the observed financing and investment decisions of corporations. To that end, our estimator picks parameters that brings the simulated moments from the model on firms' financing, investment and managerial compensation as close as possible to their empirical counterparts.

Our estimates suggest that in order to rationalize observed firm financing and investment policies, the agency conflict between investors and managers, as measured by λ, needs to be substantial. Interpreting λ as the fraction of output that managers can divert for their private benefit, sets this number close to 12%. We provide further empirical implications of the model about the determinants of agency conflicts based on sample splits according to governance and firm characteristics.

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Table 1: Variable Definitions.

Table 1 presents definitions of variables and sources of data used.

Variable (Data Source)	Variable Definition
Investment and Financial Characteristics (Compustat)	
Cash	Cash and Short-Term Investments (CHE) / Assets - Total (AT)
Investment	Capital Expenditures (CAPX) - Sale of Property (SPPE) / Property Plant and Equipment - Total (Gross) (PPEGT)
Book Equity	Stockholders Equity - Total (SEQ) + Deferred Taxes and Investment Tax Credit (TXDITC) - Preferred/Preference Stock (Capital) - Total (PSTK) if (PSTK) missing then Preferred Stock ? Redemption Value (PSTKRV) if (PSTKRV) missing then Preferred Stock ? Liquidating Value (PSTKL)
Book Debt	Assets - Total (AT) - Book Equity
Market-to-Book	(Common Shares Outstanding (CSHO) * Price Close - Annual Fiscal Year (PRCC_F) + Book Debt (BD)) / Assets - Total (AT)
Market Leverage	Book Debt / (Common Shares Outstanding (CSHO) * Price Close - Annual Fiscal Year (PRCC_F)+ Book Debt (BD)) / Assets - Total (AT)
Depreciation	Depreciation and Amortization (DP) / Property Plant and Equipment - Total (Gross) (PPEGT)
Liquidation cost	See Section XXX
Executive Compensation (ExecuComp)	
Managerial compensation variables are computed for the 5 highest paid executives of the firm.	
Managerial Ownership	Shares Owned - Options Excluded (SHROWN_EXCL_OPTS) / Common Shares Outstanding (CSHO)
Managerial Own. & Options	(Shares Owned - Options Excluded (SHROWN_EXCL_OPTS) + Unexercised Exercisable Options (OPT_UNEX_EXER_NUM)) / Common Shares Outstanding (CSHO)
Managerial Own. & Options II	(Shares Owned - Options Excluded (SHROWN_EXCL_OPTS) + Unexercised Exercisable Options (OPT_UNEX_EXER_NUM) + Unexercised Unexercisable Options (OPT_UNEX_UNEXER_NUM)) / Common Shares Outstanding (CSHO)
Institutional Ownership (Thompson Financial)	
Institutional ownership	Fraction of stock owned by institutional investors
Blockholders (IRRC blockholders)	
Blockholder ownership	Fraction of stock owned by outside blockholders
Anti-Takeover Provisions (IRRC governance)	
Gindex	24 anti-takeover provisions index by Gompers, Ishii, and Metrick (2003)
Eindex	6 anti-takeover provisions index by Bebchuk, Cohen, and Farell (2004)
Capital-Labor Characteristics (NBER)	
Capital Intensity	Total real capital stock / Total payroll
Capital Intensity II	Total real capital stock / Production worker wages
Risk-free rate (FED)	
Risk-free rate	Average T-bill rate

Table 2: Descriptive Statistics.

Table 2 presents descriptive statistics for the main variables used in the estimation. The sample is based on Compustat Annual Industrial Files, ExecuComp, IRRC governance, IRRC blockholders, and Thompson Financial. The sample covers the period from 1992 to 2010 at the annual frequency. Table 1 provides a detailed definition of the variables.

	Mean	S.D.	25%	50%	75%	Obs
Investment and Financial Characteristics						
Cash	0.131	0.160	0.020	0.064	0.184	12,187
Investment	0.119	0.102	0.057	0.092	0.148	12,187
Market-to-Book	1.932	1.257	1.184	1.539	2.191	12,187
Leverage	0.346	0.214	0.177	0.316	0.483	12,187
Depreciation	0.110	0.089	0.064	0.087	0.126	12,187
Liquidation Cost	0.375	0.176	0.260	0.368	0.486	12,065
Book Assets (in billions)	5.608	12.203	0.535	1.397	4.326	12,187
Managerial Characteristics						
Ownership	0.035	0.073	0.003	0.008	0.027	12,187
Ownership + Options	0.050	0.073	0.011	0.024	0.053	12,187
Ownership + Options II	0.060	0.079	0.017	0.035	0.068	12,187
Ownership Structure						
Institutional Ownership	0.662	0.189	0.554	0.688	0.802	5,152
Blockholder Ownership	0.167	0.140	0.060	0.145	0.254	2,020
Anti-Takeover Provisions						
Gindex	7.368	2.619	6.000	7.000	9.000	5,821
Eindex	2.403	1.288	1.000	3.000	3.000	5,821
Capital-Labor Characteristics						
Capital Intensity	3.993	3.463	1.698	2.714	4.674	3,104
Capital Intensity II	8.738	7.210	3.814	6.038	10.728	3,104

Table 3: Simulated Moments Estimation.

Calculations are based on a sample of nonfinancial, unregulated firms from the annual 2011 COMPUSTAT industrial files. The sample period is from 1992 to 2010. The estimation is done with SMM, which chooses structural model parameters by matching the moments from a simulated panel of firms to the corresponding moments from the data. Panel A reports the simulated and actual moments. Panel B reports the estimated structural parameters. λ is the agency parameter. γ is the agent's discount rate. μ is the expected productivity. σ is the volatility of the productivity process. θ is the quadratic capital adjustment cost. Standard errors are in parentheses under the parameter estimates.

Panel A: Moments

	Actual moments	Simulated moments
Average profits	0.1548	0.1695
Variance of profits	0.0042	0.0045
Average investment	0.1138	0.1290
Serial correlation of investment	0.5663	0.8847
Average Tobin's q	1.8255	1.2320
Serial correlation of Tobin's q	0.7550	0.7996
Average distance-to-default	4.8738	5.0665
Serial correlation of distance-to-default	0.4963	0.9157
Covariance of investment and lagged distance-to-default	0.0028	0.0036

Panel B: Parameter Estimates

λ	γ	μ	σ	θ
0.1226	0.0450	0.0429	0.0674	1.7850
(0.0125)	(0.0054)	(0.0024)	(0.0028)	(0.1891)

Table 4: Simulated Moments Estimation: Sample Splits.

Table 4 reports the estimated structural parameters. λ is the agency parameter. γ is the agent's discount rate. μ is the expected productivity. σ is the volatility of the productivity process. θ is the quadratic capital adjustment cost. Standard errors are in parentheses under the parameter estimates. Panel A to H present results from split-sample estimations. The sample is split with respect to high and low i) institutional ownership, ii) blockholder ownership, iii) the Gindex, and iv) the Eindex. High and low refer to the top and bottom 35% of the distribution, respectively.

λ	γ	μ	σ	θ
Panel A : Institutional Ownership - High				
0.1373	0.0521	0.2034	0.0568	4.7493
(0.0323)	(0.0140)	(0.0049)	(0.0068)	(0.4566)
Panel B : Institutional Ownership - Low				
0.1842	0.0421	0.1658	0.0585	1.4919
(0.0690)	(0.0067)	(0.0054)	(0.0061)	(0.4731)
Panel C : Blockholder Ownership - High				
0.1609	0.0453	0.1728	0.0624	2.1761
(0.0730)	(0.0198)	(0.0075)	(0.0083)	(0.7220)
Panel D : Blockholder Ownership - Low				
0.2053	0.0426	0.1665	0.0500	1.7300
(0.0990)	(0.0568)	(0.0088)	(0.0086)	(0.9323)
Panel E : Gindex - High				
0.1812	0.0463	0.1963	0.0575	4.3071
(0.0363)	(0.0150)	(0.0045)	(0.0055)	(0.4435)
Panel F : Gindex - Low				
0.1173	0.0421	0.1696	0.0599	1.8814
(0.0547)	(0.0079)	(0.0076)	(0.0096)	(0.6618)
Panel G : Eindex - High				
0.1881	0.0445	0.1692	0.0550	1.8956
(0.0366)	(0.0169)	(0.0034)	(0.0060)	(0.4892)
Panel H : Eindex - Low				
0.1075	0.0512	0.2018	0.0700	4.6047
(0.0330)	(0.0181)	(0.0071)	(0.0078)	(0.6405)

Table 5: Value Loss and Underinvestment.

Table 5 reports the value loss, measured in terms of Tobin's q, and the underinvestment due to the agency friction. The average Tobin's q and the average investment, based on the SMM parameter estimates, are compared to their first-best counterparts, i.e the scenario where there is no agency conflict.

	Value loss: $(1 - q_a/q_a^{FB})$	Underinvestment: $(1 - i/i^{FB})$
Main Sample	0.0264	0.1331

Figure 1: Investment, Tobin's q, and Market Value of Securities.

Figure 1 depicts the relation between investment, Tobin's q, and the market value of securities, with respect to the continuation value of the agent. The model parameters are set as in the base case scenario.

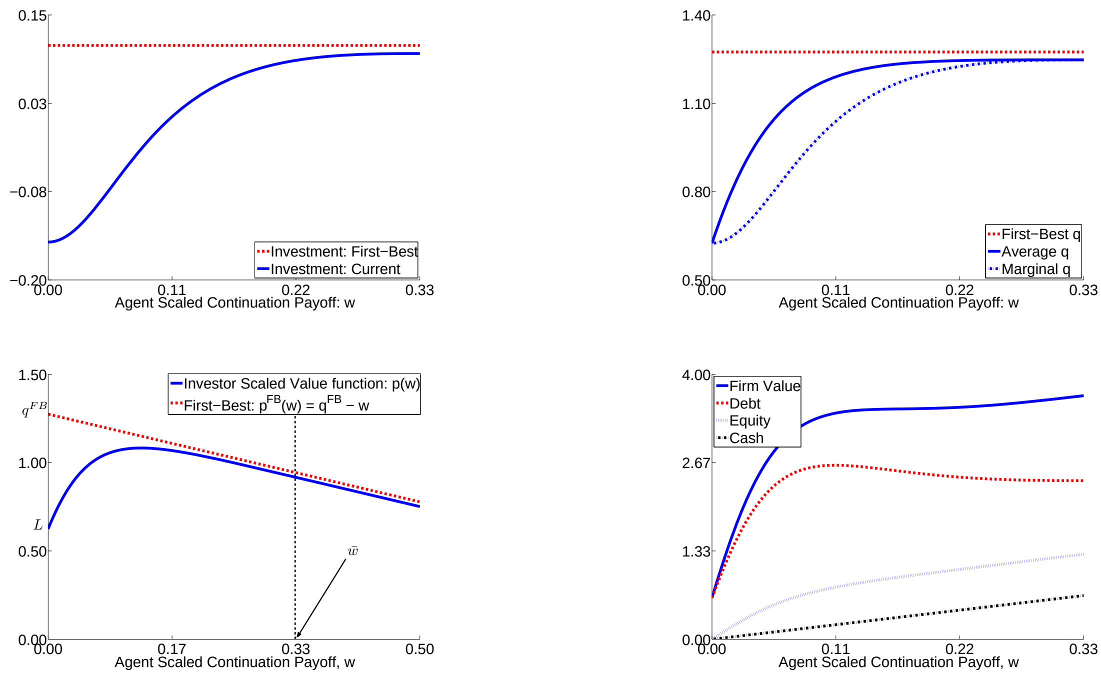

Figure 2: Comparative Statics: Cash and Investment.

Figure 2 depicts the relation between the agency parameter, λ, the agent's discount rate, γ, the expected productivity, μ, the volatility of the productivity process, σ, and the quadratic capital adjustment cost, θ, and i) the cash to assets ratio and ii) investment.

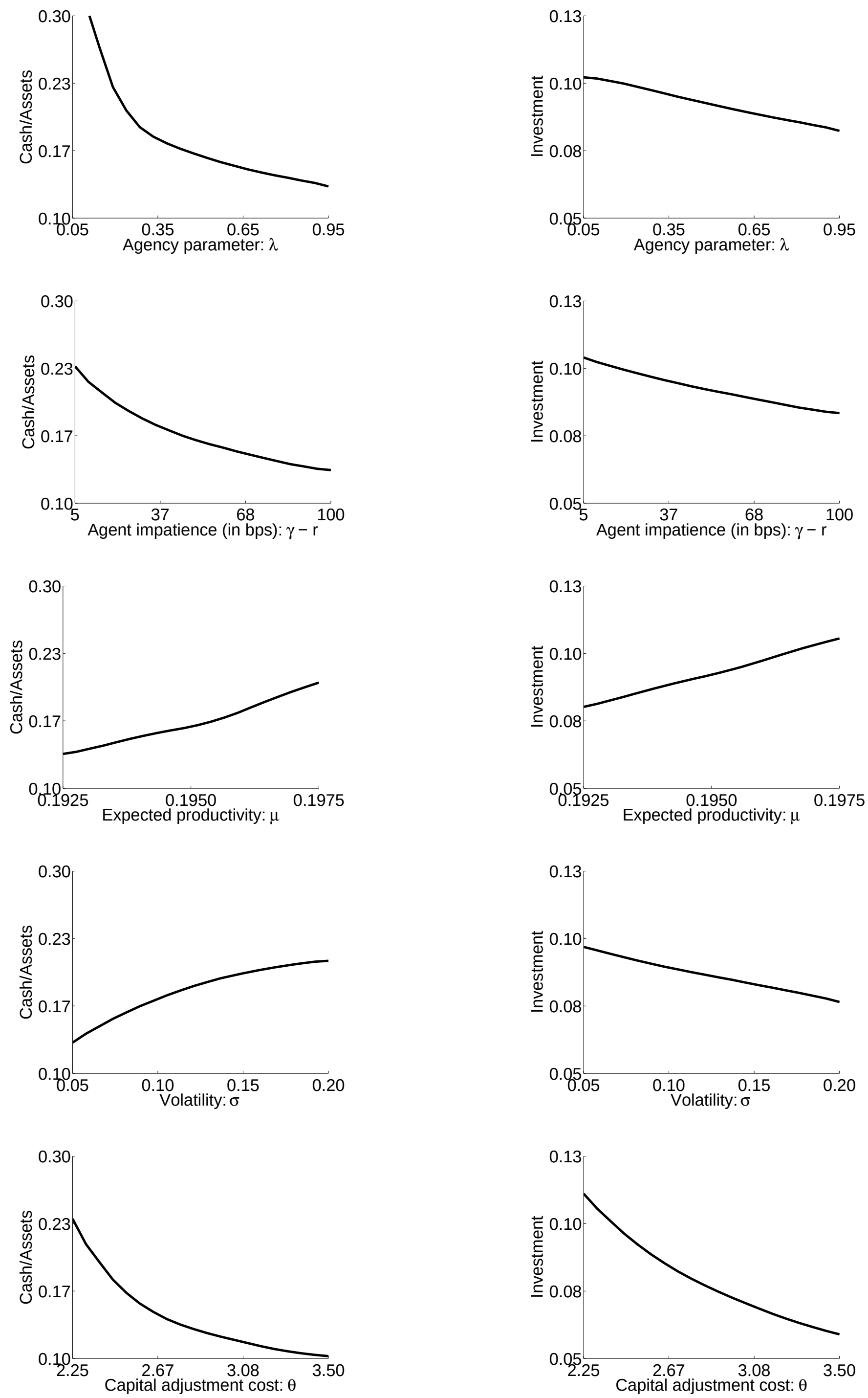

Figure 3: Comparative Statics: Tobin's q and Leverage.

Figure 3 depicts the relation between the agency parameter, λ, the agent's discount rate, γ, the expected productivity, μ, the volatility of the productivity process, σ, and the quadratic capital adjustment cost, θ, and i) Tobin's q and ii) leverage.

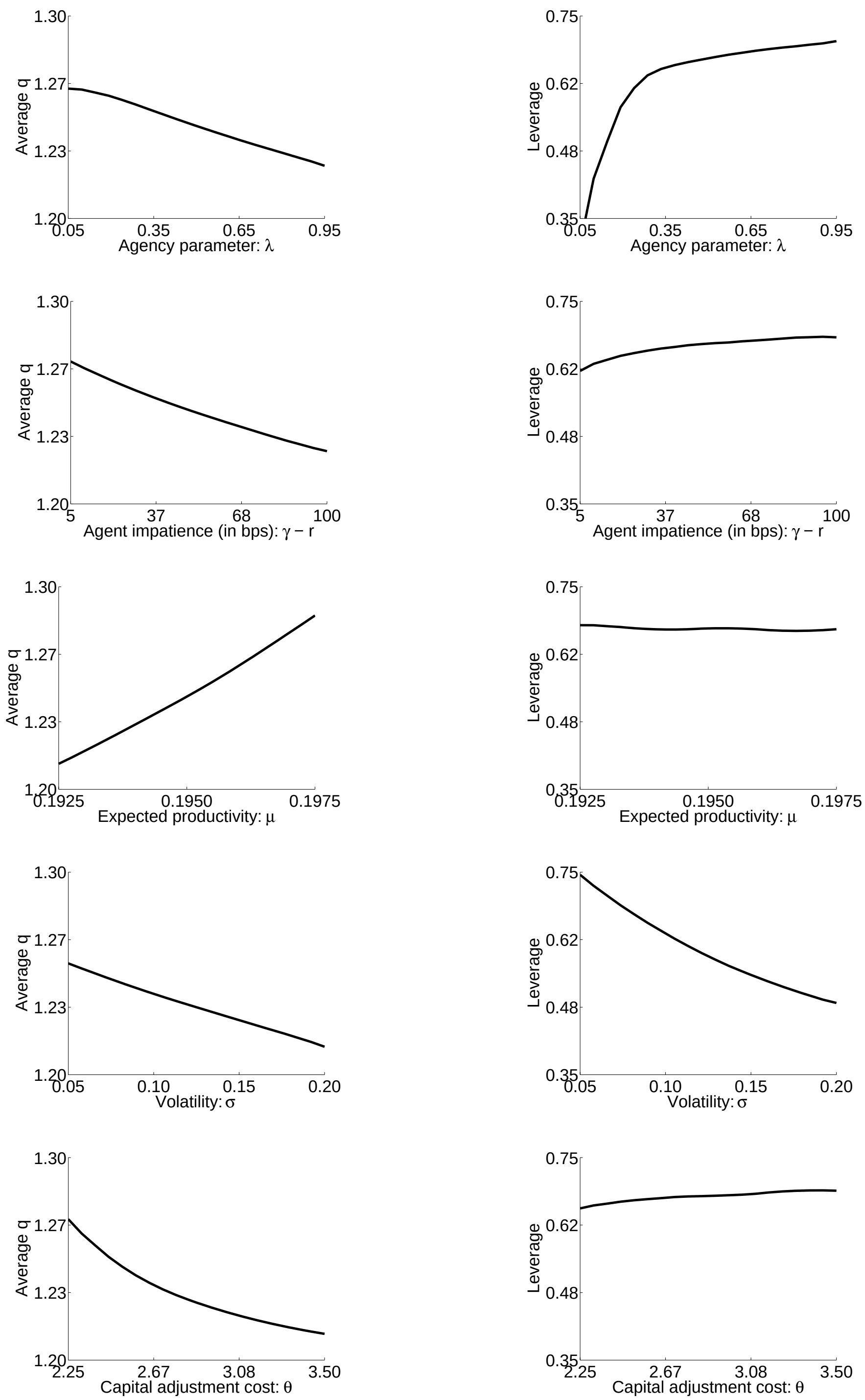

Figure 4: Cumulative Distribution Functions: Cash and Investment.

Figure 4 depicts the relation between the agency parameter, λ, the agent's discount rate, γ, the expected productivity, μ, the volatility of the productivity process, σ, and the quadratic capital adjustment cost, θ, and the cumulative distribution function of i) the cash to assets ratio and ii) investment.

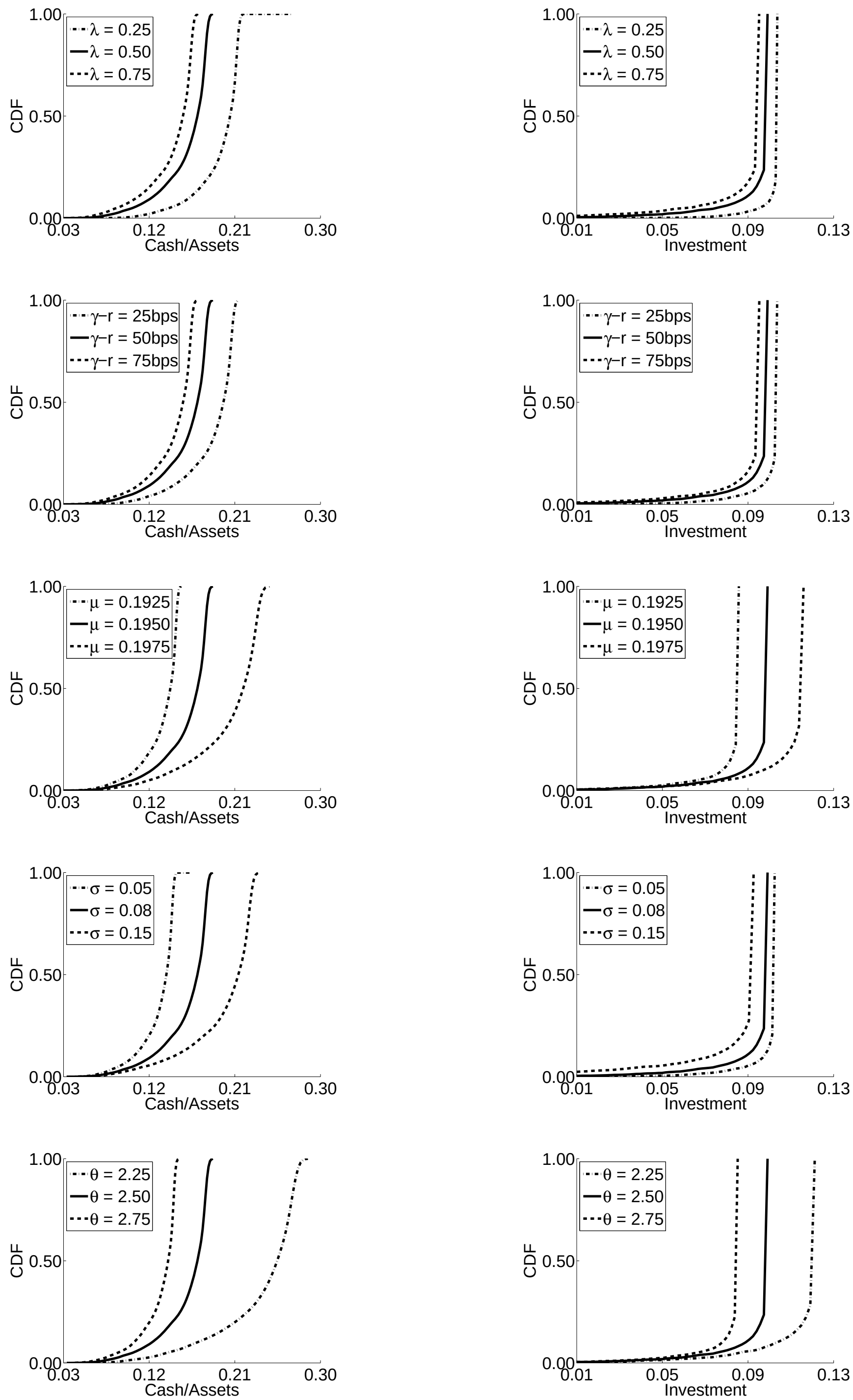

Figure 5: Cumulative Distribution Functions: Tobin's q and Leverage.

Figure 5 depicts the relation between the agency parameter, λ, the agent's discount rate, γ, the expected productivity, μ, the volatility of the productivity process, σ, and the quadratic capital adjustment cost, θ, and the cumulative distribution function of i) Tobin's q and ii) leverage.