Agency Conflicts and Cash: Estimates from a Structural Model

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Abstract

We estimate a dynamic model of firm investment and cash accumulation to ascertain whether agency problems affect corporate cash holding decisions. We model four specific mechanisms that misalign managerial and shareholder incentives: managerial bonuses based on current profits, limited managerial ownership of the firm, a managerial preference for firm size, and managerial perquisite consumption. Interestingly, we find nonmonotonic relations between features of cash policy and both perquisites and size preference. Our estimates indicate that agency issues related to perquisites are more important for explaining corporate cash holding than issues related to empire building. We also find that firms with lower blockholder and institutional ownership have higher managerial perquisite consumption. These agency problems result in a 22% increase in cash and a loss to equity holders of approximately 6%.

1. Introduction

We seek to understand how manager-shareholder conflicts distort corporate cash holding decisions, as well as to ascertain whether these distortions in turn affect shareholder value. This question is economically interesting in light of the buildup of high levels of corporate cash that preceded the recent financial crisis and recession. This question is also challenging because cash accumulation is a dynamic decision: managers' accumulation of liquid assets today only makes sense if the managers intend to spend them in the future. These dynamics complicate the standard intuition that managers tend to waste large cash flows, because cash flows are not cash stocks. One must therefore also study the incentives to accumulate cash stocks in the first place. Further complicating this question is the issue that different types of agency problems might have different effects on cash accumulation.

To address these questions, we develop and estimate a dynamic model of firm investment and cash accumulation. In the model the firm manager owns only a small fraction of the firm's equity and receives private benefits from increasing firm size and from diverting firm resources. Although the combination of limited ownership and private benefits misaligns the manager's interests with those of the shareholders, an implicit cost of firing the manager allows him to get away with behavior detrimental to shareholder value. In this setting, not only can we estimate the magnitude of the effect of agency problems on corporate cash decisions, but we can use these estimates to understand the channels through which these agency problems operate. Briefly, we find that cash holding decisions by managers are more affected by the private benefits they obtain from resource diversion (perquisite consumption, self-dealing, transfer pricing, or outright stealing) than from empire building. We also find that these value destroying activities lead to a 6% drop in shareholder value.

Our model is based on a standard neoclassical model of investment. This setting is ideal for studying cash accumulation because of the basic trade-off that determines optimal cash balances. In general, firms hold cash because they have unanticipated funding needs associated with investment opportunities or profit shortfalls and because other sources of finance are more expensive. This trade-off implies that it is impossible to understand cash holding without understanding the interaction between cash holding and investment. Our infinite horizon model centers around this basic trade-off. It features a manager who makes decisions about both investment and financing this investment, via current profits, externally raised funds, or accumulated cash balances.

The manager has a compensation package that consists of an equity share, as well as a cash bonus that is related to current profits. The equity share aligns the manager's interests with those of shareholders, but the bonus moves him away from the objective of maximizing stockholder value by causing him to put excessive weight on the objective of maximizing current profits. More important, the manager has a taste for empire building, which distorts optimal firm investment decisions, and therefore the closely intertwined decision to hold cash. Intuitively, as this desire grows, he increases firm size and tends to use external funds rather than cash to finance this growth. Finally, the manager has a limited ability to divert both profits and liquid assets from their optimal uses within the firm. This managerial self-dealing has a strong positive effect on cash accumulation, relative to capital, because in the model the manager can only divert liquid assets—not capital.

Our estimation results provide four central insights. First, standard neoclassical models of the type in Riddick and Whited (2009) do not provide enough incentive for firms to hold cash. Because managerial empire building motives can either raise or lower firms' cash balances, they do little to help understand cash holding. On the other hand because resource diversion opportunities lead to higher cash balances, modeling these opportunities helps reconcile the model with the data. Second, we are able to quantify the effects of the agency issues we model. Although on average agency results in 22% increase in cash balances and a 6% loss in shareholder value, these effects vary widely, especially across groups of firms sorted by the extent of independent blockholder ownership. Third, we find substantial heterogeneity in both managers' preference for firm size and in their ability to divert resources. We find that for governance measures based on institutional ownership, our model estimates produce intuitive results. Ceteris paribus, poor governance results in more perquisite consumption, more cash, and greater loss of shareholder value. In contrast, measures of governance based on antitakeover provisions provide the opposite results. Because of the problems, discussed below, with interpreting governance indices, and because of the evidence in Bhagat, Bolton and Romano (2008) that governance indices are uninformative about corporate performance, we view this result at least as much as casting doubt on the indices rather than on our model. Fourth, looking at the cross sectional heterogeneity in our sample of firms reveals that governance is but one of many important factors that affect cash holding, and most of these other factors, such as the serial correlation of productivity shocks, or the degree of returns to scale, are inherently unobservable. Using a structural model allows us to see not only whether, but also how all of these different forces affect cash.

The role of agency conflicts in shaping the incentives for firms to accumulate and use liquid assets has been of interest in corporate finance at least since Jensen's (1986) observation that managers' decisions about the use of internal funds is central to the conflict between managers and shareholders. Although numerous empirical researchers have studied the effects of agency conflicts on cash holding, this topic remains of interest because no single prominent conclusion has emerged from these exercises. For example, Mikkelson and Partch (2003) find no difference in the governance structures of firms that hold different amounts of cash. Opler, Pinkowitz, Stulz, and Williamson (1999) find that cash accumulation has almost no impact on investment, and Bates, Kahle, and Stulz (2009) find that governance has played almost no role in the recent buildup of corporate cash. In contrast, Harford (1999) and Harford, Mansi, and Maxwell (2008) find that firms with more antitakeover provisions hold less cash and tend to do value-destroying acquisitions, and Dittmar and Mahrt-Smith (2007) find a significant detrimental impact of governance on the value of cash.

Two reasons have likely led to the lack of a coherent overall picture from these empirical results. The first is simply that corporate governance is hard to observe and measure. For example, many of the governance characteristics contained in the Gompers, Iishi, and Metrick (2003) index or the Bebchuk, Cohen, and Ferrell (2009) index capture features of governance that impede the market for corporate control. However, as noted in Coates (2000), every firm has a latent poison pill that can be adopted at short notice without shareholder consent. As such, even firms that appear to have adopted few antitakeover provisions can have a great deal of leeway with which to deter possible bidders and thereby to leave managers entrenched. This problem can be magnified if poorly governed firms, realizing that they are being monitored and that they can always adopt a poison pill, have an incentive to mimic their well-governed counterparts by limiting antitakeover provisions.

Even characteristics such as the presence or absence of a large blockholder need not be indicators of governance quality. For example, a large blockholder can be passive if this block constitutes a tiny fraction of its entire portfolio, and a diffusely held corporation can have good internal governance as in Acharya, Myers, and Rajan (2009). All of these arguments imply considerable noise in the available proxies for governance. It is therefore not surprising that the empirical literature has found conflicting results from examining weak data.

These conflicting empirical results could also be an artifact of endogeneity. At least since Himmelberg, Hubbard, and Palia (1999), researchers have understood and dealt with the problem that governance and firm decisions are jointly determined. For example, Yun (2009) studies the effect of governance on the composition of corporate liquidity by using state-level changes in takeover protection as credible exogenous shocks to corporate governance. The endogeneity issue that has *not* been addressed is the one between all other firm decision variables that end up in governance regressions. Typical cash regressions include variables such as the market-to-book ratio, operating profits, R&D expenses, and capital expenditures. Clearly, all of these variables are jointly determined, and because many are likely to be correlated with governance measures, the coefficients on governance measures can biased enough to change their sign, even if the researcher uses instruments for governance.

To deal with the two problems of endogeneity and measurement, and to try to sort out the conflicting results in the literature, we take an alternate approach to understanding the effect of corporate governance on corporate cash holdings by using structural estimation. Specifically, we estimate the parameters of our model using simulated method of moments (SMM). On an intuitive level, we use observed features of managerial contracts and observed financing and investment choices to obtain estimates of the average managerial preferences for empire building and for perquisite consumption. This strategy replaces the need to find instruments or clever natural experiments with a transparent stand on the features of the managerial decision process that are important for cash holding. More generally, structural estimation recognizes that all variables in the data are endogenous and in fact exploits this endogeneity to achieve identification. It does so by imposing certain model assumptions on the data, and these modeling assumptions are usually easily understood because they are grounded in basic economics. Our estimation also allows us to isolate which types of managerial behaviors affect cash holding and identify the specific economic mechanisms that drive our results. Finally, our estimation replaces noisy measures of governance with a model of specific agency conflicts that is cast in terms of relatively easy-to-observe variables.

Topically our paper contributes to the empirical literature on corporate cash holdings by providing evidence on how agency problems affect cash policy. We thereby start to sort out the conflicting evidence, described above, that this literature has produced. Methodologically, however, our paper belongs to the empirical corporate finance literature that performs structural estimation on dynamic models. For example, Hennessy and Whited (2005, 2007) and DeAngelo, DeAngelo, and Whited (2009) also use SMM on discrete time dynamic models, but they look at different questions such as the low-leverage puzzle, market timing, the cost of external finance, and leverage rebalancing speeds. Similar to our work, Morellec, Nikolov, and Schürhoff (2009) also explore an agency issue using structural estimation, but they examine how managerial resource diversion helps us understand the low leverage puzzle, and they use simulated maximum likelihood rather than SMM. Finally, Taylor (2010) uses structural estimation to explore the agency issues surrounding the firing of CEOs.

Section 2 outlines the model, Section 3 presents several comparative statics exercises. Section 4 describes our data sources and presents summary statistics. Section 5 describes the estimation procedure. Section 6 contains our results and counterfactual exercises, and Section 7 summarizes our findings.

2. The Model

We develop a simple neoclassical model of investment and cash accumulation. First describe the real side of the firm; second, we discuss financing; third, we specify managerial incentives. Finally, we specify the manager's maximization problem and discuss the intuition behind the solution.

We consider an infinitely lived firm in discrete time. At each time period the firm's manager chooses how much to invest in capital goods and how to finance these purchases. In a standard neoclassical model the manager acts to maximize equity value and thus acts completely in the interest of shareholders. We depart from this setting by considering a manager who faces a standard compensation package consisting of an equity stake in the firm, as well as a share of current after-tax cash flows. This latter feature of the model induces a degree of managerial myopia because the manager puts more weight on maximizing current profits than he would if he were maximizing equity value alone. We also assume that the manager has a preference for (aversion to) firm size, in which we allow the data to determine whether on average firms do or do not exhibit tendencies toward empire building. The firm's managers select investment and liquid asset holdings to maximize their utility, which is linear in the equity stake, the bonus, and firm size. Thus, managers are risk neutral.

2.1 Production Technology

The real side of the firm is characterized by a production technology that uses only capital, k. Per period, after tax profits are given by $(1-\tau)\,\varepsilon k^{\theta}$, in which τ is the corporate tax rate, $\theta < 1$, and in which ε is a shock observed by managers each period before making any investment or cash holding decisions. The parameter θ describes a combination of market power and decreasing returns to scale. The shock ε follows an $AR(1)$ in logs,

$$\ln\left(\varepsilon'\right) = \rho \ln\left(\varepsilon\right) + v', \tag{1}$$

in which a prime indicates a variable in the next period and no prime indicates a variable in the current period. The innovation v' has a truncated normal distribution with mean 0 and variance σ_v^2. Because the distribution of the shock v' has finite support, the shock ε does as well. We denote the endpoints of this support as $[\underline{\varepsilon}, \overline{\varepsilon}]$. For convenience, we define the Markov transition function associated with (1) as $q\left(\varepsilon', \varepsilon\right)$.

Investment, I, is defined as

$$I \equiv k' - (1-\delta)k, \tag{2}$$

in which δ is the capital depreciation rate, $0 < \delta < 1$. The firm purchases and sells capital at a price of 1 and incurs capital stock adjustment costs that are given by

$$\Psi\left(I, k\right) = \gamma k \mathbf{1}_{I \neq 0} + \frac{a}{2}\left(\frac{I}{k}\right)^2 k. \tag{3}$$

in which γ and a are positive constants. The functional form of (3) is from Cooper and Haltiwanger (2006), who specifically study capital stock adjustment costs. The first term captures a fixed component: it is independent of the size of investment and the indicator function implies that this cost only kicks in when investment is nonzero. The smooth component is captured by the second term. These aspects of the model are important because the smoothness or lumpiness of optimal investment policy is important for optimal cash accumulation policy.

2.2 Financing

The firm's financing environment is simple. It can fund its investment projects with current profits, cash, or external funds. Because we are interested in cash rather than in the composition of external capital structure, we do not distinguish between external debt and equity financing. We have experimented with an extension of the model in which we include debt and equity separately and find that this feature has no qualitative impact on the results. We therefore opt for our simpler specification. We let c denote the stock of cash and f denote the flow of external financing, which can take only positive values. Cash earns interest at the risk-free rate, r, and interest is taxed. To make the choice set compact, we assume an arbitrary upper bound on liquid assets, $\overline{c}$. This upper bound is imposed without loss of generality because of our taxation assumptions.

External finance is costly. For every dollar of finance raised by the firm, it must pay a fee that is linear in the amount raised: $\phi(f) \equiv \phi f$. This assumption is motivated by the existence of flotation costs for equity and public debt and by origination fees for loans. Estimates of these parameters also capture possible adverse selection costs. As a departure from the specification in Hennessy and Whited (2007), we omit a fixed component because real world firms are likely to use lines of credit or other such low-cost sources of finance for their first dollar of outside financing. We also omit a quadratic component because it has little effect on either the model behavior or the estimation results and because it is never estimated to be significantly different from zero.

2.3 Compensation and Incentives

We next discuss managerial compensation and incentives. The manager's compensation contract consists of a profit share and equity share, and we assume that the contract stays fixed over the life of the firm. Although this assumption implies that we may be missing endogenous variation in contracts, the assumption is necessary for estimation of the model because a full-blown dynamic contracting framework is too intractable to estimate directly. The bonus is specified as a fraction $\alpha \in (0,1)$ of current accounting earnings, which are given by $(1-\tau)\left(\varepsilon k^{\theta}+cr\right)$. In this formulation we exclude cash outflows associated with either investment or cash accumulation activities; otherwise the manager would have an incentive to shut down the capital and accumulation programs. The presence of this parameter induces managerial myopia in that it causes the manager to focus too much on current earnings relative to long-run firm value. The equity share is denoted as a fraction $\beta \in (0,1)$ of firm value. The larger β, the more managerial and shareholder incentives are aligned.

Murphy's (1999) survey of CEO compensation documents that compensation packages typically consist of a fixed wage, profit share, straight equity, and options. Our contract deviates from this scheme in three dimensions. First, we ignore the fixed wage component because this component has little effect on how the manager makes cash holding decisions. Second, the model treats the manager's profit share as linear, whereas Murphy (1999) documents that the typical annual incentive plan consists of zero payment if the performance measure is below a specified threshold, followed by an incentive zone where the payoff is linear in performance. The bonus is then capped at some upper bound. We have experimented with such bonus schemes and have found little effect on cash; so we stick with a simple proportional bonus. Third, in our model the manager's equity compensation consists entirely of common stock, whereas a typical real-world CEO typically receives both common stock and options. Therefore, in the empirical implementation of the model, each option's delta is used to compute an effective equity share. In sum, although our stylized contract departs in some respects from real-world contracts, it is nonetheless a good approximation to actual observed compensation packages. Because our aim is to estimate this model, it is important that the contract be representative of what is actually observed in the data.

Finally, we model two separate agency problems. The first is a managerial preference for (or aversion to) empire building in which the manager derives a psychological flow benefit, λ, per unit of installed capital.[1] In our estimation, we allow λ to take negative values. In this case, one can imagine the manager incurring effort costs from running a larger firm. The second agency problem is managerial desire to divert a fraction, s, of the firm's current cash flow and cash stock

[1]Modeling an agency issue as linear in the capital stock has a precedent in Albuquerque and Wang (2008).

as private benefits. The interpretation of these two agency parameters is complex because they embody not only managerial preferences for firm size and for resource diversion, but also managerial entrenchment; that is, the manager's ability to implement his expansion or resource diversion plans. For example, if it is costly for shareholders to launch a control challenge against a possibly entrenched manager, then λ and s will be, ceteris paribus, higher.

2.4 The Objective Function

Because part of the manager's compensation is equity, before we can specify the manager's objective, we must first write down the cash flows that go to equity holders. We use a standard accounting identity to express distributions to shareholders as

$$d\left(k,k',c,c',\varepsilon\right) \equiv (1-\tau)\left(\varepsilon k^{\theta}-(\alpha+s)\left(\varepsilon k^{\theta}+cr\right)\right)+\delta k\tau-I-\Psi\left(I,k\right)-c'+c\left(1+r\left(1-\tau\right)-s\right)+f\left(1+\phi\right). \tag{4}$$

The first two terms represent after-tax operating profits. These profits are then spent on physical assets, financial assets, or the manager's bonus, with any deficit covered by outside financing. We restrict $d\left(k,k',c,c',\varepsilon\right) \geq 0$. Because outside financing is costly, the firm will never raise outside financing to augment distributions.

Given our specification of the manager's contract and preferences, his one period utility function can be written as

$$u\left(k,c,\varepsilon\right)=(\alpha+s)\left(\varepsilon k^{\theta}+cr\right)+cs+\lambda k+\beta d\left(k,k',c,c',\varepsilon\right). \tag{5}$$

The manager chooses (k',c') each period to maximize the present value of his future utility, discounting at the opportunity cost of funds, r. The Bellman equation for the problem is given by

$$U\left(k,c,\varepsilon\right)=\max_{k',\,c'}\left\{\left[(\alpha+s)\left(\varepsilon k^{\theta}+cr\right)+cs+\lambda k+\beta d\left(k,k',c,c',\varepsilon\right)\right]+\frac{1}{1+r}\int U\left(k',c',\varepsilon'\right)dq(\varepsilon',\varepsilon)\right\}. \tag{6}$$

Although the model has no analytical solution, the model can satisfy the conditions for Theorem 9.6 in Stokey and Lucas (1989), which guarantee a solution for (6) in the form of a unique function

$U(k, c, \varepsilon)$. Loosely, these conditions require that the parameter values ensure concavity in the term in brackets in (6), that the choice variables (k, c) lie in a compact set, and that $r > 0$ so that (6) is a contraction mapping.

This model satisfies those conditions. The parameter estimates we obtain all imply the necessary concavity, and the upper bound $\bar{c}$ ensures compactness of the choice set for c. The choice set for k is more complex, but thinking carefully about this choice set also helps the understanding of how empire building operates in the model. In a simple neoclassical model without taxation or agency conflicts, the upper bound for the capital stock is given by the condition

$$\bar{\varepsilon}\bar{k}^{\theta} - \delta\bar{k} \equiv 0.$$

As in Gomes (2001), this condition specifies the level of capital above which profits are insufficient to replace depreciated capital even in the best state of nature. Therefore, these levels of the capital stock are not economically profitable. This type of logic can be extended to our setting straightforwardly by inspecting (4) and (5) and formulating an analogous condition as:

$$(\alpha + \beta)(1 - \tau)\bar{\varepsilon}\bar{k}^{\theta} - (\lambda + \delta\beta)\bar{k} \equiv 0. \tag{7}$$

Therefore, k lies in the interval $[0, \bar{k}]$ implied by (7). Concavity of εk^{θ} in k and $\lim_{k\to\infty} \partial\left(\varepsilon k^{\theta}\right)/\partial k = 0$ ensure that $\bar{k}$ is well-defined.

Our model, with its estimated parameters, also satisfies the concavity conditions in Theorem 9.8 in Stokey and Lucas (1989) that ensure a unique optimal policy function, $\{k', c'\} = p(k, c, \varepsilon)$. The policy function is essentially a rule that states the best choice of k' and c' in the next period for any (k, c, ε) triple in the current period. The numerical solution for the model is described in the Appendix.

Because we are also interested in shareholder value, we need to define the value of the equity of the firm, $V(k, c, \varepsilon)$. Because it is the expected present value of cash flows given by (4), it can be expressed recursively as

$$V(k, c, \varepsilon) = \max_{k',\, c'}{}^{*} \left\{ d\left(k, k', c, c', \varepsilon\right) + \frac{1}{1+r} \int V\left(k', c', \varepsilon'\right) dq(\varepsilon', \varepsilon) \right\}. \tag{8}$$

The operator $\max^{*}$ is optimal choice of $\{k', c'\}$ given the policy rule that is the solution to the managerial utility maximization problem in (6). This choice is not, in general, the same choice of

$\{k', c'\}$ that would be made if the manager were maximizing the expected present value of cash flows. Put differently, managers do not act completely in the interests of shareholders, and, therefore, for any given (k, c, ε), firm equity value is less than in would be in the absence of misaligned incentives.

Despite the parsimonious specification of this model, because it has no analytical solution, it is impossible to determine the signs of the effects of some model parameters on the choice variables. We therefore turn to comparative statics exercises based on model simulations to understand the effects of our modeled agency issues.

3. Comparative Statics

Our ultimate goal is to estimate this model directly to understand whether and how agency problems affect corporate cash holdings. However, understanding the estimation results and, more importantly, identifying the model parameters requires understanding of the economics behind the model. So before presenting our identification strategy and estimation results, we present several comparative statics results that highlight the primary economic forces at work.

If $\alpha = \lambda = s = 0$, then the problem boils down to a standard neoclassical model of the type in Riddick and Whited (2009). In this basic framework the main financing trade-off is essentially between the tax disadvantage of holding cash versus flexibility benefit of holding cash, which arises from funding needs tied to investment opportunities and from external finance being more costly than internal. These types of trade-offs are present in our model as well, and they interact in interesting ways with the agency conflicts that we have introduced. We now examine both the basic incentives to hold cash and the effects of agency conflicts.

Our experiments involve an examination of three key financing variables—the ratio of cash to assets and the fractions of investment funded externally or with accumulated cash balances. The basic intuition behind all of these experiments revolves around the following. First, firms hold cash because they want to invest and because other financing alternatives are more expensive. Therefore, any force that changes optimal investment behavior also changes optimal cash behavior. In particular, if any force either increases the optimal size of investments or the probability of a particularly large investment, that force also increases the probability of outside funding. The optimal reaction is to hoard cash to avoid having to incur the costs associated with external finance. Any agency driven incentive to hold more or less cash must then be balanced this fundamental trade-off. Therefore, to understand the effects of agency, it is important first to understand the basic economics behind the decision to hold cash.

We first examine in Figure 1 the sensitivity of these financing measures to the five parameters that govern the basic functioning of the model: the cost of external finance, ϕ, the standard deviation of the productivity shock process, σ_v, the serial correlation of the driving process, ρ, the curvature of the profit function, θ, and the quadratic adjustment costs parameter, a. Each panel in the figure depicts the sensitivity of a variable to a parameter. To construct each panel, we parameterize the model according to the set of estimation results in Table 3 that correspond to the model that best fits the data. We solve and simulate the model 20 times, each time corresponding to a different value of the parameter in question. We then plot the average over the 100,000 simulated time periods of the resulting financing variables against the different parameter values. We let each of these parameters take values in a range whose center is roughly the estimate from Table 3: $\phi \in [0, 0.25]$, $\sigma_v \in [0.05, 0.5]$, $\rho \in [0.4, 0.9]$, $\theta \in [0.4, 0.9]$, and $a \in [0, 0.9]$.

We first examine how the cost of external finance, ϕ, affects our three variables of interest. These results are in the top two panels of Figure 1. The first panel shows that the average ratio of cash to assets at first rises with ϕ, but then flattens out and even falls slightly for extremely costly external finance. The initial rise is intuitive: the more costly external finance, the more the firm will hoard cash to avoid having to pay this cost. However, as the cost becomes prohibitive, the manager's investment decisions respond less aggressively to productivity shocks. This more measured behavior can be seen in the simulated data as a lower correlation between the realized productivity shocks and investment, and this moderation results in a lower expected need for external funding and consequently lower cash balances. This rise, flattening, and slight fall in cash balances is mirrored in the second panel in the top row with the proportions of investment funded by cash balances and funded externally. Finally, this flatness is important for interpreting our counterfactual exercises below because it mitigates concerns about the interaction between agency problems and the cost of external finance.

The next two rows of panels present the results the parameters that govern the stochastic shock process. As in the case of the external finance parameter, we see a hump-shaped relation between the standard deviation of the productivity shock process, σ_v and cash holdings. A hump shaped pattern arises when two forces offset each other. First, as σ_v rises, the firm is more likely to see a very good realization of the productivity shock. It will therefore have to tap external finance more often, and it holds higher cash balances to avoid costly external financing. Second, as the firm's environment become more uncertain, the manager perceives less signal in any given shock, and the response of investment to these shocks weakens. As above, this lower responsiveness implies lower optimal cash balances.

In contrast to the effect of σ_v on cash balances, the effect the serial correlation of the shock process, ρ, is monotonic. As ρ increases, the firm invests in larger amounts because a positive productivity shock signals not only that capital is productive today, but also that it will continue to be productive. The firm therefore wants higher cash balances to lower the probability of needing external finance when it makes these large investments. The firm also anticipates needing to fund investment in several consecutive years, which also gives rise to higher optimal cash balances.

The effect of profit function curvature on average cash depicted in fourth row is also monotonic. As θ rises, the production function becomes flatter, and productivity shocks therefore have a larger effect on the optimal capital stock. Therefore, both the variance and average size of desired investments rises. The firm holds more cash because large investments imply a greater likelihood of needing external finance. Finally, the fifth row shows that convex adjustment costs have the opposite effect on cash holding. As a increases, the firm makes smaller investments more often, is therefore less likely to have to tap external finance, and holds less cash.

Figure 2 examines the effects of the parameters that shape the misalignment of incentives: the managerial bonus, α, the fraction of the firm owned by the manager, β, the preference for empire building, λ, and the amount of perquisite consumption tolerated by shareholders, s. We allow α to range from 0 to 0.02, β to range from 0 to 0.2, λ to range from -0.005 to 0.005, and s to range from 0 to 0.005. We allow λ to take on negative values based on the notion that CEOs may want to underinvest because running a larger firm is more demanding. This assumption regarding

CEO preferences is in direct contrast to the empire building assumption ($\lambda > 0$) in which the CEO derives positive net utility from being in charge of a larger firm. The ranges for these parameters are governed by the estimates that we present below.

The first row of panels shows how financing reacts to the manager's bonus, α. Once again we observe a nonmonotonic pattern. Initially, as the manager derives more and more compensation as a fraction of current profits, he tends to finance investment more internally and less externally. This phenomenon is due to a mechanical mechanism in the model whereby interest earned on cash balances adds to the compensation base. For very high level of α, enough of the firm's profits gets funneled into managerial compensation that the firm has fewer resources to invest in assets, either physical or financial, and average cash balances fall. Because the baseline value of α estimated from our data is tiny, however, these effects are minimal.

The more interesting effects are in the second through fourth rows of panels, which illustrate the reactions of financing to the preference for empire building, managerial ownership, and the amount of liquid resource diversion. The first panel in the second row of the figure reveals a hump-shaped relation between empire building and cash balances. First, if the manager has a preference for the quiet life as in Bertrand and Mullainathan (2003) ($\lambda < 0$), he keeps firm size small, invests little, and therefore has need neither for cash balances nor for external funds to finance investment. As this shirking mechanism falls and as it is eventually replaced by a preference for empire building, the need to invest more induces a need for both more cash and more external financing. As seen in the second panel in this row, the effect on external financing is monotonic: the more the manager wants to build an empire, the more he uses external financing. However, a second force acts on cash balances in the opposite direction, thereby rendering the relation between λ and cash nonmonotonic. As the preference for empire building grows, managers perceive physical assets to be more valuable relative to financial assets, this effect counteracts the first mechanism, and the fraction of total assets held as cash declines sharply.

The third row of panels shows a positive monotonic effect of resource diversion on average cash balances. This monotonicity is not obvious. If the manager has leeway to divert both cash flows and stocks, the manager ought to have a greater incentive to accumulate both capital and cash. However, the manager cannot "steal" capital itself, only the flow of profits generated by the capital, so diverting cash has a higher marginal benefit to the manager. resource diversion does not have a monotonic effect on the proportion of investment that is financed with cash. At first, this proportion rises as the manager accumulates more and more cash. However, if the manager's capacity for resource diversion becomes very large, he uses internally generated profits to fund investment because he diverts more cash to his own uses.

The results on managerial ownership are in the fourth row of the figure. If managers own a tiny fraction of the firm, he invests only enough to replace depreciated capital. He therefore has no need to hoard cash to avoid costly external finance; so his only motives for accumulating cash are perquisite consumption and his bonus compensation. As the manager's stake in the firm rises, he makes investment decisions that optimally require occasional outside financing, and he therefore has an incentive to hold more cash. With even higher levels of ownership, however, the personal consumption motive for holding cash diminishes, and average cash balances fall.

It is worth noting that in all of these exercises, we are only changing one parameter at a time. In reality, this sort of situation is unlikely to occur because of the endogeneity of contracting and because of assortive matching between firms and managers. For, example, a fall in the perquisite consumption parameter, s, might be brought about by better governance. At the same time better governance is likely to change compensation packages and to change the types of managers that find working at such firms attractive. In the estimation that follows, we actually exploit this endogeneity to determine which unique set of parameters best allows our model to replicate salient features of the data.

4. Data

This estimation requires merging data from various sources. We collect financial statements from Compustat and managerial compensation data from ExecuComp. For some of our split sample estimations we also use governance data from IRRC (governance and blockholders), and institutional ownership data from Thomson Financial. Following the literature, we remove all regulated (SIC 4900-4999) and financial firms (SIC 6000-6999). Observations with missing values for the SIC code, total assets, the gross capital stock, market value, and cash are also excluded from the final sample. As a result of these selection criteria, we obtain a panel data set with 12,727 observations for 2,022 firms, for the time period between 1992 and 2008 at an annual frequency. Specific definitions of the variables we use can be found in Table 1.

Table 2 provides descriptive statistics for our sample. The first panel contains firm-level accounting variables, and two patterns stand out. First, our sample contains large firms. Median firm assets is 0.95 billion, a number approximately 4.5 times larger than median of all firms in Compustat over the same sample period. The reason for the bias toward large firms is the availability of compensation and governance data.

The next panel contains our two compensation variables: managerial bonuses and managerial ownership. The former, as a fraction of book equity, is quite small, which suggests that this mechanism for encouraging managerial myopia may be small. Our ownership variables show that managers on average own small fractions of the firm. This small fraction leaves a great deal of room for a manager's preference for empire building to affect his decisions.

The next two panels contain variables related to corporate governance. We use these variables to determine whether groups of firms sorted on these variables have different estimates of empire building and consequently different levels of cash holdings.

5. Estimation and Identification

In this section, we explain how we take the model derived in Section 2 to the data. Specifically, we use observed features of managerial contracts and observed financing and investment choices to infer estimates of the average managerial preference for empire building and for diverting resources.

5.1 Estimation

We estimate most of the structural parameters of the model using simulated method of moments. However, we estimate some of the model parameters separately. For example, we estimate the risk-free interest rate, r, to equal 0.0112, which is the average over our sample period of the three-month t-bill rate minus the rate of growth of the consumer price index. Similarly, we estimate the depreciation rate, δ, as the average of depreciation to the gross capital stock, which is 0.113.[2] Our data also allow us to estimate the parameters that describe the manager's contract. We estimate the managerial bonus and ownership for the five highest paid executives. We estimate the managerial bonus, α, as the average bonus scaled by the book value of equity, which is 0.0029. Managerial ownership, β, takes into account a direct component, managerial share ownership, and an indirect component, ownership due to options awards, and is equal to 0.0577. Finally, we set the corporate tax rate equal to 35%.[3]

We then estimate the following 7 parameters using simulated method of moments: the external financing cost parameter, ϕ; the standard deviation and autocorrelation of the shock process, σ_ε and ρ, the curvature of the profit function, θ; the quadratic adjustment cost parameter, a; the empire building parameter, λ; and the resource diversion parameter, s. We omit the fixed adjustment cost parameter, γ, from our estimations because including it usually results in a tiny and imprecise estimate. This result makes sense given the large size of the firms in our sample, most of which have smooth investment.

Simulated method of moments, although computationally cumbersome, is conceptually simple. First, we generate a panel of simulated data using the numerical solution to the model. Specifically, we take a random draw from the distribution of ε' (conditional on ε), and then compute $U(k, c, \varepsilon)$, $p(k, c, \varepsilon)$, $V(k, c, \varepsilon)$, and various functions of $U(\cdot)$, $V(\cdot)$, k, and c. We continue drawing values of ε and use these computations to generate an artificial panel of firms. Next, we calculate interesting moments using both these simulated data and actual data. The objective of SMM is then to pick the model parameters that make the actual and simulated moments as close to each other as possible. Details regarding the estimation are in the appendix.

[2]Using industry-level estimates of economic depreciation have almost no effect on our estimates of value loss from empire building.

[3]This parameter primarily affects the firm's average cash holding, because interest taxation is the main cost of holding cash. It is possible to add a parameter to the model that captures the discrepancy between this statutory rate and the average effective rate in the sample. However, as in DeAngelo, DeAngelo, and Whited (2009), this parameter is difficult to estimate and affects the results little.

5.2 Identification

The success of this procedure relies on model identification. Global identification of a simulated moments estimator obtains when the expected value of the difference between the simulated moments and the data moments equal zero if and only if the structural parameters equal their true values. A sufficient condition for identification is a one-to-one mapping between the structural parameters and a subset of the data moments of the same dimension. Because our model does not yield such a closed-form mapping, we take care to choose moments that are sensitive to variations in the structural parameters such as the curvature of the profit function, θ, or the manager's preference for firm size, λ.

We now describe and rationalize the 11 moments that we match. Because the firm's real and financial decisions are intertwined, all of the model parameters affect all of these moments in some way. We can, nonetheless, categorize the moments roughly as representing the real or financial side of the firm's decision-making problem.

The first two non-financial or "real" moments are the first and second central moments of the rate of investment, defined in the simulation as I/k. As discussed in detail below, the first moment helps identify the empire building parameter. The second moment helps identify both the curvature of the profit function, θ, and the adjustment cost parameter. Higher a produces less volatile investment, and lower θ produces less volatile investment because the frictionless optimal capital stock varies less with the shock, ε. However, this one moment cannot identify two parameters at once, so we also include average operating income, which is not affected by the adjustment cost parameters and which is primarily affected by the curvature of the profit function. This relation can be seen by the definition of simulated operating income as $\varepsilon k^{\theta}/k$: the higher θ, the higher average operating income.

Our next two moments capture the important features of the driving process for ε. Here, we estimate a first-order panel autoregression of operating income on lagged operating income. The two moments that we match from this exercise are the autoregressive coefficient and the shock variance. We also match the serial correlation of investment. This moment is primarily affected by the smooth adjustment cost parameter but also by the serial correlation of the driving process,

ρ. Our next moment is the mean of Tobin's q. Simulated Tobin's q is constructed as $(V)/(k+c)$, and all model parameters affect the mean of q.

The next set of moments pertains to the firm's financing decisions. We include the mean and variance of the ratio of cash to capital c/k. We also include the mean and variance of the ratio of total security issuance to capital, f/k. Because our model does not include a debt/equity decision, we cannot attempt to match moments pertaining to the composition of external finance.

We now discuss the identification of the managerial resource diversion parameter, s. It is important for our estimation that the manager can divert both profits and the stock of cash. If he could only divert profits, then given our data, it would be impossible to distinguish resource diversion from low profitability. If he could only divert the stock of cash, it would be impossible to distinguish resource diversion from a divergence between actual interest earned on cash, and the estimate given by our estimate of the real interest rate and our specification of the corporate tax rate. However, because he can divert both profits and cash and because these two variables are negatively correlated in the model (and in the actual data), identification is possible. Not surprisingly, the moment that is most important for identifying resource diversion is Tobin's q: the more resource diversion, the lower q.

Finally, we need to discuss the identification of the manager's preference for empire building, λ. First, without our data on ownership and compensation, we would have to infer this preference solely from firm decisions. In this case, inspection of the Bellman equation (6) and the definition of distributions (4) shows that both λ and the product of the depreciation rate and ownership $(\delta\beta)$ multiply k in (6). Therefore, the empire building preference parameter, λ, can just as easily describe an extra component of the depreciation rate. However, our data on ownership pins down β, and our separate estimation of the depreciation rate pins down δ. With these two parameters pinned down by extra data, we can then use the average rate of investment to identify λ. Other important moments such as average cash, average profitability, and the variance of investment also vary with λ.

The next issue in SMM is whether to match moments using an identity matrix or using a weighting scheme. Using an identity matrix implicitly puts the most weight on the moment that is the largest in absolute value. Because this implication rarely corresponds to a relevant economic or statistical objective, we match moments using the optimal weight matrix, which is the inverse of the covariance matrix of the moments. Roughly speaking, this scheme puts the most weight on the most precisely estimated moments, which is a sensible statistical objective. Because our moment vector consists of separately estimated first through third moments, as well as regression coefficients, we use the influence-function approach in Erickson and Whited (2000) to calculate the covariance matrix of the moments. Specifically, we stack the influence functions for each of our moments and then form the covariance matrix by taking the inner product of this stack.

One final issue is unobserved heterogeneity in our data from Compustat. Recall that our simulations produce *i.i.d.* firms. Therefore, in order to render our simulated data comparable to our actual data we can either add heterogeneity to the simulations, or remove the heterogeneity from the actual data. We opt for the latter approach, using fixed firm and year effects in the estimation of our regression-based data moments and the estimation of variance and skewness.

6. Results

We first present the results of estimating several variants of our baseline model on our full sample. We then move on to estimating our model on a variety of subsamples defined by proxies for corporate governance. Finally, we examine the recent secular upward trend in corporate cash holdings.

6.1 Full Sample Results

Table 3 presents the estimation results, with the top panel reporting moments calculated from our data, simulated moments, and t-statistics for the difference between the two. We report estimates from four models. In the first, we remove all agency problems, that is, we set $\alpha = 0$, $\beta = 1$, $\lambda = 0$, and $s = 0$. In the second we only constrain the resource diversion parameter to be zero, in the third we constrain the empire building parameter to be zero, and in the fourth we estimate all seven parameters.

All four models do a good job of matching average cash balances. None of the simulated moments are either statistically or economically different from the actual data moments. This result is a prerequisite for answering our questions about governance and cash. If we cannot match average cash, our model is of little use in this endeavor. However, our model does not do as good a job matching the within-firm variance of cash balances. The simulated variances are from two to four times greater than the actual variances, and all of the simulated variances are statistically significantly different from the actual variances. We conjecture that this discrepancy arises because in the real world firms hold cash not only to avoid costly external finance but also to act as a source of working capital. This extra source of cash demand is likely substantially less variable than the precautionary motive that we model.

Most of the rest of the moments are well matched. Three exceptions are the size and variance of the flow of external finance, as well as Tobin's q. The first two are in general poorly matched because they are not as precisely estimated as most of the other moments. The optimal weight matrix therefore does not penalize a mismatch of these two moments, and the estimates of these two moments end up differing from their data counterparts. The results on Tobin's q are of particular interest because this moment is relatively precisely estimated. Our no-agency model overestimates q, while our empire-building model and the model with both agency problems underestimate q. Our resource diversion model produces an estimate of q that is insignificantly different from our data moment. We view these results as being informative not only on the existence of agency issues but on the types of agency issues that are important for cash holding. One plausible interpretation of these results is that the no-agency model cannot fit this moment precisely because value-destroying agency problems are important in producing the actual data. Similarly, the two models that contain an empire building motive likely underestimate q because empire building motives are not as important for corporate cash holdings in the real world as they are in our model. The model with only resource diversion, in contrast, does an excellent job of estimating this moment.

The second panel reports the parameter estimates. With the exception of the external financing parameter in the model with both agency problems, all parameters are precisely estimated. What is of particular interest in this table is how the parameter estimates vary across the different models. For example, although the no-agency model can match average cash holdings, it does so at the cost of possibly unreasonable parameter estimates. The estimate of external financing costs and of the variance of the shock process are both quite large. The former implies that when firms raise external finance, they get to keep only 82 cents of every dollar raised. While this figure is in line with some existing estimates of equity issuance costs (Altincilic and Hansen, 2000), it is much higher than the figure one would get from the average Baa interest rate during our sample period, and it is in general unreasonable given the low frequency of seasoned equity offerings relative to debt financing (DeAngelo, DeAngelo, and Stulz, 2010). Our estimation produces this high number because the no agency model has a hard time producing sufficient cash holding; so it requires a large estimate of the cost of external financing to force the simulated moment equal to the actual moment. Such is also the case with the estimate of the variance of the productivity shock process. This estimate is much larger than the estimates obtained in DeAngelo, DeAngelo, and Whited (2009) or Hennessy and Whited (2005, 2007), which is troublesome given that the production technologies in these three models are all quite similar. Once again, the reason is a high shock variance also produces high cash holdings. Finally, the overall test of the overidentifying restrictions of the model, the J-test, produces a strong rejection.

The empire-building model does not fare much better. The J-test once again produces a sound rejection and the estimate of the shock variance is again quite high. Although cash holding decreases with the empire building parameter, our estimate is at a point near the top of the hump in Figure 2, and it therefore has little impact on cash holding. We discuss the value loss implications of this part of the model below. We can, nonetheless give some intuition for the magnitude of this parameter in terms of investment. Recall that managerial utility from expanding the size of the firm is linear in the capital stock and that from equation (2) the rate of investment is also linear in the capital stock. Therefore, we can interpret λ as a component of the manager's *perceived* depreciation of the capital stock. To do so, note that in the maximization problem (6) the rate of investment is multiplied by the managerial ownership fraction, β, and the managerial utility from empire building is not. Therefore, the manager's perceived component of the rate of capital depreciation is λ/β, which is approximately 0.2%. If in a steady state, capital accumulation is just sufficient to replace depreciated capital, this estimate implies that steady state investment will be approximately 1.8% higher than it would be absent a preference for empire building—a small effect.

The resource diversion model does a substantially better job of reconciling the model with the data. The parameter estimates governing technology are in line with previous studies, and the overidentifying restrictions are not rejected. The amount of resource diversion tolerated by shareholders is estimated to be 0.14% of the sum of profits and the stock of cash. This estimate of resource diversion helps the baseline model match the cash moment, so that the estimation does not force the parameters governing the cost of external finance and uncertainty to take large values.

Interesting, the model that contains both resource diversion and empire building does a slightly poorer job of fitting the data. Although the overidentifying restrictions are not rejected, the estimate of the variance of the shock process is quite large and the estimate of the serial correlation is quite small. These estimates imply that the variance of operating profits in the model is about five times the observed within-firm variance of operating profits.

6.2 Sample Splits

We now examine the role of agency in corporate cash holdings by estimating our model on subsamples that have been sorted on a variety of measures of corporate governance. We first discuss and motivate the different governance measures, and then we present the results from our split-sample estimations. We create each subsample by splitting the entire sample into thirds based on the variable of interest, and then discarding the middle third. This sorting scheme mitigates the possibility that better governed firms end up in the group of worse governed firms. This possibility is likely inasmuch as all of our governance measures are at best rough proxies for the inherently nebulous and difficult-to-measure concept of good governance.

Two of our governance measures are based on ownership. The first is the fraction of stock owned by institutional investors, with a higher value indicating better governance, presumably because institutions are much more likely to take a position as an activist shareholder. For example, Hartzell and Starks (2003) 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 outside blockholders, with a higher value once again indicating better governance. As argued by Shleifer and Vishny (1986), the existence of large independent shareholders makes a takeover or a proxy contest easier. In this case, the cost of a control challenge is smaller, and the market for corporate control puts more discipline on the manager.

Our next two measures are the commonly used governance indexes from Bebchuk, Cohen and Ferrell (2009) and Gompers, Ishii, and Metrick (2003)—the E index and G index, respectively. Both indices count provisions recorded by the Investor Responsibility Research Center (IRRC) that describe shareholder rights. The E index includes only those provisions argued by Bebchuk et al. (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. The G index counts all of the provisions documented by the IRRC. As argued in the introduction, all firms' possession of a latent poison pill can seriously undermine the informativeness of these indices. Nonetheless, we examine them because of their widespread use in the rest of the governance literature.

The results from our split sample estimations are in Table 4 and Figure 3. The former reports our parameter estimates, and the latter plots the actual ratio of cash to assets versus the model-implied ratio of cash to assets for each of our 8 samples. The striking result from this figure is the good job our fairly parsimonious model does of matching the average ratio of cash to assets.

The first two panels of Table 4 present the results from dividing the sample by institutional ownership. The estimates of the empire building and resource diversion parameters conform to intuition. We find less of a preference for excessive firm size in the sample with high institutional ownership and slightly less managerial resource diversion, presumably because of a greater tendency for such firms to experience shareholder activism. Interestingly, as shown in Figure 3, this statistically significant difference in the estimated agency parameters is accompanied by almost identical ratios of cash to assets for the two groups of firms. This result is puzzling because our model predicts that the firms subject to managerial resource diversion have higher cash balances. However, this apparent puzzle can be understood by looking further at the parameter estimates in Table 4. Along almost every dimension, except for the cost of external finance, these two groups of firms are different, and each of these characteristics has a strong influence on cash holding. Although it is difficult to gauge the relative strength of these differences, they obviously combine to produce almost identical cash holdings.

The next two panels contain the results for the high and low blockholder ownership groups. Here, although the empire building parameters is almost identical for the two groups, we find a larger resource diversion parameter in the group with low blockholder ownership. This result is intuitive inasmuch as firms with independent blockholders are likely to be better governed. What is not at first intuitive is the similarity in average cash balances across the two groups because our model predicts that higher resource diversion leads to higher cash balances. Once again, the resolution of this puzzle can be found in the estimates of the other parameters. First, the answer is not in any of the parameters that govern the variability of investment because the two groups have similar investment standard deviations. However, the data on the group with low blockholder ownership produce a substantially larger returns to scale parameter, and the income effect that accompanies the ensuing higher profitability leads to higher optimal cash holding.

The next four panels contain the results for the samples split on the basis of the two governance indices. The results here are the opposite of the predictions from our model. The estimates indicate that firms with fewer antitakeover provisions have much more resource diversion, but not significantly different empire building than firms with more antitakeover provisions. Although counterintuitive, this result may have much to do with the weakness of these particular proxies for governance. From Figure 3 we see that firms classified as poorly governed by both indices tend to hold less cash, which is what less resource diversion would predict. In addition, most of the other model parameters imply that the groups with fewer antitakeover provisions should have lower cash: they tend to have less variable cash flows (lower σ_v) and more sharply decreasing returns to scale (lower θ).

In sum, one of the themes that runs throughout this table is that governance in the form of either resource diversion or empire building is not the only determinant of corporate cash holdings. Because accountants do not record fundamental technological characteristics such as returns to scale, adjustment costs, or serial correlation of an unobservable driving process, it is almost impossible to include all of the appropriate controls when trying to understand the relation between governance and cash via linear regressions. This table, therefore, provides some insight into the difficulty that the literature has had with finding conclusive evidence concerning the relation between governance and cash holdings.

6.3 Secular Increase in Cash

Table 5 reports the results from two estimations of the full model that includes both resource diversion and empire building. In the first we use data from 1992 to 1999, and in the second we use data from 2000 to 2008. Our intent is to try to understand the increase in corporate cash holdings over the last two decades documented by Bates, Kahle, and Stulz (2009). In our sample this increase is evident in the difference between the average cash balances in the early and late parts of our sample period. In the 1990s average cash is approximately 11% of assets, and in the 2000s average cash is nearly 17% of assets. Two other moments change noticeably: the serial correlation of investment rises sharply, and the use of external finance decreases sharply.

To understand these shifts, we examine the lower panel of Table 5, which contains our parameter estimates. Three of these parameters change in a statistically significant and economically meaningful way: the variance of profit shocks, the quadratic cost of adjusting the capital stock, and managerial resource diversion all increase. The increase in the estimated shock variance makes sense in light of the positive relation between the shock variance and average cash balances in our model. This increase is also in accord with the result in Bates, Kahle, and Stulz (2009) that an increase in uncertainty has accompanied the increase in cash over the last several years. In contrast, our result concerning the sharp increase in managerial resource diversion is not in accord with their conclusion that agency issues contributed little to the cash build-up. We conjecture that the tight restrictions our model puts on the data are more powerful in their ability to uncover agency effects than is the use of noisy proxies for governance in linear regressions. Finally, the change in the adjustment cost parameter, a, goes a long way toward explaining the increase in the serial correlation and the decrease in the variance of investment observed in the second decade of our sample. The rise in a also helps explain the fall in the use of external finance: firms with low-variance, predictable investment programs are less likely to have to tap costly external finance than are firms with lumpy or high variance investment policies.

6.4 Counterfactuals

In this section we quantify the extent to which a misalignment of incentives destroys shareholder value, changes average cash holdings, and changes the use of external financing. This exercise is useful because it assists in the interpretation the economic magnitude of the empire building and the resource diversion parameters. It also helps answer the question of just how much governance affects corporate cash holding. We compare two firms: one with parameters estimated from our data, and an otherwise identical firm, except that the manager receives no bonus, derives no utility from firm size, cannot divert resources, and is the sole owner of the firm. To estimate the value loss to shareholders from the misalignment of incentives implied by our estimates, we compute firm value scaled by the capital stock for both types of firms. Then we compare these two ratios and report the fractional drop in value resulting from agency. We compute the changes in cash holding and external financing analogously. The results are in Table 6.

For the full sample we find a six percent drop in value from the agency conflicts that we model. This number can be interpreted as the implicit cost of shareholders' launching a control challenge to current management. Accompanying this value loss is an almost 22% increase in cash holdings. This second number can be interpreted as saying that in the absence of agency problems and *everything else held constant*, the average 14% ratio of cash to assets observed in the data would only be approximately 11.5%. Because firms with agency problems hoard too much cash, they also use 33% more external financing.

We find a great deal of heterogeneity in value loss across our different subsamples of firms. Firms with low blockholder ownership experience an almost 14% drop in equity value from the introduction of agency conflicts, and this drop is substantially more severe than the modest 1% fall for the group of firms with high blockholder ownership. Interestingly, these two widely different drops in value are both accompanied by approximately 50% more cash. What does change markedly across the two groups is the use of external financing. The introduction of agency issues produces and almost 50% increase in the use of external financing for the low-blockholder group, but only a 15% increase for the high-blockholder group. We therefore attribute the greater loss in value to the behavior regarding external financing rather than cash.

Firms with low and high institutional ownership experience agency issues produce almost identical value losses and very similar changes in cash and external financing. This result is in line with the similarity of the parameter estimates across the two groups of firms.

The results for the two governance indices are mixed. Firms with low G indices experience large value loss and a 25% increase in cash when agency conflicts are introduced. Whereas this value loss is much larger than the negligible value loss for the high G index firms, the change in cash and external financing are almost identical across the two groups. Finally, firms with a E high index experience a small 1% value loss but a 50% increases in cash and external financing from agency problems, but the low E index firms actually experience a modest value gain. Once again we interpret these mixed results as stemming from the difficulties involved with measuring governance via these indices.

One obvious concern with all of these exercises is the possibility that goverance and the cost of external finance are intertwined. In particular, common intuition suggests that investors would demand a higher return on invested capital if they suspected that management would not use these funds optimally. The intuition that changing governance should also change the cost of external finance cannot be captured in our model because the cost of external finance is a parameter that does not depend on governance. Therefore, our model might understate the deleterious effects of governance on shareholder value. However, an important feature of our model mitigates this concern. Recall that optimal cash balances respond little to changes in the cost of external finance, ϕ, if ϕ is greater than 7%. Therefore, because all of our estimates of ϕ are much larger than 7%, even if governance does change the cost of external finance, the indirect effect on cash balances ought to be minimal.

7. Summary and Conclusions

We use structural estimation of a dynamic model of firm investment and cash accumulation to ascertain whether agency problems affect corporate cash holding decisions. We model four specific mechanisms that misalign managerial and shareholder incentives: managerial bonuses based on current profits, limited managerial ownership of the firm, managerial private benefits from diverting liquid resources, and a managerial preference for firm size. Interestingly, we find a nonmonotonic relation between size preference and cash holdings. If managers receive disutility from having to run a large firm, they invest little and therefore require little financing, including accumulated cash balances. Managers that receive a great deal of utility from overseeing a large firm also hold low levels of cash because they prefer physical to financial assets. Managerial private benefits from diverting resources lead to greater cash holding because it is easier to divert cash than capital. Our estimates indicate that on average managers do have an ability to divert resources but that their desire to build empires is weak. We find a loss to equity holders of approximately 6% and an increase in cash of approximately 22% from these agency problems.

We also use our model as a laboratory to examine whether groups of firms characterized by different measures of corporate governance produce different estimates of agency problems. Intuitively, we find that managers of firms with low blockholder ownership on average divert more liquid resources than do managers of firms with high blockholder ownership. However, these two groups of firms hold almost identical cash balances. The positive effect of agency on cash holding is offset by other firm characteristics that lead to lower cash balances. On the whole, we find that agency issues are but one of many important determinants of cash holding.

One obvious criticism of our approach is that we specify managerial contracts exogenously in the model rather than deriving them as the result of a dynamic principal-agent problem. On the other hand, we take care to model contracts that are actually used, and we use compensation data to estimate directly parameters that describe these contracts. Further, models that derive contracts endogenously are often couched in terms of unobservables, such as the manager's continuation utility, and they are therefore impossible to estimate. One interesting avenue for future research, therefore, is to attempt to adapt dynamic principal-agent models so that they can be taken directly to the data.

Appendix

This appendix describes the numerical solution to the model and the details of our estimation procedure.

Model solution

To find a numerical solution, we need to specify a finite state space for the three state variables. We let the capital stock lie on the points

$$\left[\overline{k}\,(1-\delta)^{50}\,,\ldots,\overline{k}\,(1-\delta)^{1/2}\,,\overline{k}\right]. \tag{9}$$

We let the productivity shock ε have 12 points of support, transforming (1) into a discrete-state Markov chain on the interval $[-4\sigma_v, 4\sigma_v]$ using the method in Tauchen (1986). We let c have 25 equally spaced points in the interval $[0, k^*]$, in which k^* is the steady state capital stock from a model with neither financing nor agency frictions. The optimal choice of c never hits the upper endpoint, although it is occasionally optimal for the firm to hold no cash.

We solve the model via value function iteration on the Bellman equation (6), which produces the value function $U(k, c, \varepsilon)$ and the policy function $\{k', c'\} = p\,(k, c, \varepsilon)$. We solve for equity value by value function iteration on (8) using the policy function corresponding In the subsequent model simulation, the space for ε is expanded to include 120 points, with interpolation used to find corresponding values of U, k, and c.

Estimation

We now give a brief outline of the estimation procedure, which closely follows Lee and Ingram (1991). Let x_i be an *i.i.d.* data vector, $i = 1, \ldots, n$, and let $y_{ik}\,(b)$ be an *i.i.d.* simulated vector from simulation k, $i = 1, \ldots, n$, and $k = 1, \ldots, K$. Here, n is the length of the simulated sample, and K is the number of times the model is simulated. We pick $n = 53,677$ and $K = 10$, 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, $y_{ik}\,(b)$, depends on a vector of structural parameters, b. In our application $b \equiv (\theta, \rho, \sigma_v, a, \gamma, s, \lambda_1, \lambda_2)$. The goal is to estimate b by matching a set of *simulated moments*, denoted as $h\,(y_{ik}\,(b))$, with the corresponding set of actual *data moments*, denoted as $h\,(x_i)$. The candidates for the moments to be matched include simple summary statistics, OLS regression coefficients, and coefficient estimates from non-linear reduced-form models. Define

$$g_n(b) = n^{-1} \sum_{i=1}^{n} \left[h(x_i) - K^{-1} \sum_{k=1}^{K} h(y_{ik}(b)) \right].$$

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

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

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 K. The asymptotic distribution of b is given by

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

in which

$$\text{avar}(\hat{b}) \equiv \left(1 + \frac{1}{K}\right) \left[\frac{\partial g_n(b)}{\partial b} W \frac{\partial g_n(b)}{\partial b'}\right]^{-1} \left[\frac{\partial g_n(b)}{\partial b} W \Omega W \frac{\partial g_n(b)}{\partial b'}\right] \left[\frac{\partial g_n(b)}{\partial b} W \frac{\partial g_n(b)}{\partial b'}\right]^{-1} \quad (10)$$

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 $h(x_i)$.

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Table 1: Data Definitions.

Table 1 presents definitions and source 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)
Cash Flow	Earnings Before Interest (EBITDA) / Assets - Total (AT)
Equity Issuance	Sale of Common and Preferred Stock (SSTK) / Assets - Total (AT)
Net Debt Issuance	Long-Term Debt Issuance (DLTIS) - Long-Term Debt Reduction (DLTR) / Assets - Total (AT)
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)
Tobin's Q	(Common Shares Outstanding (CSHO) * Price Close - Annual Fiscal year (PRCC_F) + Book Debt (BD) - Current Assets - Total (ACT)) / Property Plant and Equipment - Total (Gross) (PPEGT)
Book Leverage	Book Debt / 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)
Executive Compensation (ExecuComp)	
Managerial compensation variables are computed for the 5 highest paid executives of the firm.	
Managerial Bonus	Bonus (BONUS) / Book Equity
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)	
Eindex	6 anti-takeover provisions index by Bebchuk, Cohen, and Farell (2004)
Gindex	24 anti-takeover provisions index by Gompers, Ishii, and Metrick (2003)
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 and blockholders), and Thompson Financial. The sample covers the period from 1992 to 2008 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	0.146	0.175	0.021	0.071	0.212	12,727
Investment	0.126	0.093	0.065	0.101	0.160	12,727
Cash Flow	0.143	0.096	0.097	0.143	0.196	12,727
Net Debt Issuance	0.013	0.078	-0.014	0.000	0.026	12,727
Equity Issuance	0.025	0.062	0.002	0.007	0.019	12,727
Market-to-Book	2.039	1.304	1.222	1.612	2.364	12,727
Depreciation	0.115	0.173	0.063	0.085	0.125	12,727
Book Assets (in billions)	3.568	7.249	0.386	0.953	2.788	12,727
Managerial Characteristics						
Bonus	0.003	0.012	0.000	0.001	0.003	12,727
Ownership	0.041	0.081	0.003	0.009	0.035	12,727
Ownership + Options	0.058	0.084	0.012	0.027	0.063	12,727
Ownership + Options II	0.069	0.087	0.019	0.040	0.081	12,727
Ownership Structure						
Blockholder Ownership	0.173	0.140	0.066	0.154	0.261	2,061
Institutional Ownership	0.645	0.194	0.523	0.669	0.792	6,706
Anti-Takeover Provisions						
Gindex	7.277	2.629	5.000	7.000	9.000	6,511
Eindex	2.376	1.281	1.000	2.000	3.000	6,511

Table 3: Simulated Moments Estimation.

Calculations are based on a sample of nonfinancial, unregulated firms from the annual 2009 COMPUSTAT industrial files. The sample period is from 1992 to 2008. 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. The first panel reports the simulated and actual moments and the t-statistics for the differences between the corresponding moments. All moments are self-explanatory, except the serial correlation and innovation to income. These moments are the slope coefficient and error variance from a first order autoregression of the ratio of income to assets. The second panel reports the estimated structural parameters, with standard errors in parentheses. ϕ_1 and ϕ_1 are the linear and quadratic costs of external finance. σ_v is the standard deviation of the innovation to $\ln(\varepsilon)$, in which ε is the shock to the revenue function. ρ is the serial correlation of $\ln(\varepsilon)$. θ is the curvature of the revenue function, εk^θ . a is the convex adjustment cost parameter, λ is the empire building parameter, and s is the tunneling parameter. T-statistics for the equality of the simulated moments with the data moments are under the simulated moments in parentheses. Standard errors are in parentheses under the parameter estimates.

A. Moments

	Actual moments	Simulated moments			
		No Agency	Tunneling	Empire Building	Both
Average Cash (c/k)	0.1439	0.1428	0.1435	0.1406	0.1427
		(-0.1465)	(-0.1876)	(-1.6103)	(-0.4305)
Variance of Cash (c/k)	0.0058	0.0217	0.0175	0.0220	0.0100
		(10.1439)	(14.3858)	(22.1551)	(7.2025)
Average Investment (I/k)	0.1249	0.1167	0.1154	0.1167	0.1158
		(-0.3996)	(-0.4672)	(-0.3984)	(-0.4418)
Variance of Investment (I/k)	0.0041	0.0083	0.0055	0.0083	0.0065
		(0.7493)	(0.4241)	(0.8115)	(2.0606)
Serial correlation of investment (I/k)	0.4071	0.5080	0.4058	0.4852	0.2977
		(0.0336)	(-0.0004)	(0.0260)	(-0.0456)
Average profits (εk^θ)	0.1437	0.1292	0.1364	0.1277	0.1323
		(-0.9169)	(-0.5450)	(-1.3075)	(-0.7492)
Serial correlation of profits (εk^θ)	0.6704	0.6637	0.6359	0.6620	0.4411
		(-0.0055)	(-0.0291)	(-0.0080)	(-0.3232)
Error variance of profits (εk^θ)	0.0036	0.0017	0.0007	0.0014	0.0024
		(-0.0955)	(-0.1436)	(-0.1261)	(-0.0859)
Average Tobin's q ($V/(k+c)$)	2.0287	2.2904	2.0992	1.7802	1.8285
		(2.7343)	(0.8137)	(-3.0577)	(-2.3570)
Average external finance (f/k)	0.0371	0.0182	0.0151	0.0192	0.0066
		(-1.3559)	(-3.0314)	(-1.4323)	(-2.9560)
Variance of external finance (f/k)	0.0068	0.0007	0.0003	0.0007	0.0001
		(-1.7476)	(-1.5119)	(-1.5854)	(-1.5395)

B. Parameter estimates

	ϕ	σ_v	ρ	θ	a	s	λ	J-test
No Agency								
	0.1832	0.4454	0.6970	0.8980	0.7098			20.0299
	(0.0200)	(0.0140)	(0.0069)	(0.0048)	(0.0519)			(0.0055)
Empire Building								
	0.1373	0.4141	0.7341	0.7025	0.4640		0.0010	18.5004
	(0.0714)	(0.1116)	(0.0468)	(0.0261)	(0.0217)		(0.0001)	(0.0099)
Tunneling								
	0.1299	0.2811	0.6735	0.8192	0.4066	0.0014		8.9070
	(0.0975)	(0.0280)	(0.0208)	(0.0164)	(0.1254)	(0.0002)		(0.2594)
Both								
	0.1443	0.5028	0.4801	0.8960	0.4510	0.0021	-0.0004	4.6726
	(0.2703)	(0.1175)	(0.0710)	(0.0079)	(0.0937)	(0.0001)	(0.0001)	(0.6998)

Table 4: SAMPLE SPLITS: ESTIMATED STRUCTURAL PARAMETERS.

Calculations are based on a sample of nonfinancial, unregulated firms from the annual 2009 COMPUSTAT industrial files. The sample period is from 1992 to 2008. 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. Table 4 reports the estimated structural parameters, with standard errors in parentheses. ϕ_1 and ϕ_1 are the linear and quadratic costs of external finance. σ_v is the standard deviation of the innovation to $\ln(\varepsilon)$, in which $\varepsilon$is the shock to the revenue function. ρ is the serial correlation of $\ln(\varepsilon)$. θ is the curvature of the revenue function, εk^{θ}. a is the convex adjustment cost parameter, and λ is the empire building parameter. Panel A to J 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.

ϕ_1	σ_v	ρ	θ	a	s	λ	J-test
PANEL A : institutional ownership - high							
0.1262	0.2277	0.8325	0.6330	0.5815	0.0005	0.0009	0.3597
(0.0049)	(0.0132)	(0.0023)	(0.0293)	(0.2164)	(0.0006)	(0.0001)	(0.9856)
PANEL B : institutional ownership - low							
0.1225	0.4090	0.6854	0.7425	0.3701	0.0008	0.0010	0.3966
(0.0029)	(0.0522)	(0.0283)	(0.0389)	(0.1102)	(0.0023)	(0.0003)	(0.9828)
PANEL C : blockholder ownership - high							
0.1142	0.2612	0.8235	0.6569	0.5192	0.0003	0.0008	0.7593
(0.0029)	(0.0145)	(0.0055)	(0.1069)	(0.1630)	(0.0005)	(0.0005)	(0.9438)
PANEL D : blockholder ownership - low							
0.1611	0.2109	0.6474	0.6593	0.1471	0.0020	0.0008	0.7300
(0.0040)	(0.0780)	(0.0567)	(0.0433)	(0.1148)	(0.0001)	(0.0002)	(0.9476)
PANEL E : Gindex - high							
0.1346	0.2061	0.6858	0.6837	0.3434	0.0015	0.0005	0.7555
(0.0249)	(0.0214)	(0.0233)	(0.0307)	(0.0286)	(0.0000)	(0.0001)	(0.9443)
PANEL F : Gindex - low							
0.1377	0.3466	0.5691	0.8741	0.3511	0.0026	-0.0003	0.4006
(0.0148)	(0.0663)	(0.0478)	(0.0601)	(0.0887)	(0.0011)	(0.0005)	(0.9824)
PANEL G : Eindex - high							
0.1224	0.3079	0.6753	0.6692	0.5752	0.0015	0.0006	0.4789
(0.0054)	(0.0357)	(0.0174)	(0.0800)	(0.0380)	(0.0000)	(0.0003)	(0.9755)
PANEL H : Eindex - low							
0.1221	0.3567	0.6157	0.7338	0.3741	0.0027	0.0007	0.3369
(0.0237)	(0.0860)	(0.0353)	(0.0483)	(0.1688)	(0.0002)	(0.0005)	(0.9873)

Table 5: Early versus Late Sample Period Estimations

Calculations are based on a sample of nonfinancial, unregulated firms from the annual 2009 COMPUSTAT industrial files. The sample period is from 1992 to 2008. 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. The first panel reports the simulated and actual moments and the t-statistics for the differences between the corresponding moments. All moments are self-explanatory, except the serial correlation and innovation to income. These moments are the slope coefficient and error variance from a first order autoregression of the ratio of income to assets. The second panel reports the estimated structural parameters, with standard errors in parentheses. ϕ_1 and ϕ_1 are the linear and quadratic costs of external finance. σ_v is the standard deviation of the innovation to $\ln(\varepsilon)$, in which ε is the shock to the revenue function. ρ is the serial correlation of $\ln(\varepsilon)$. θ is the curvature of the revenue function, εk^θ . a is the convex adjustment cost parameter, λ is the empire building parameter, and s is the tunneling parameter. T-statistics for the equality of the simulated moments with the data moments are under the simulated moments in parentheses. Standard errors are in parentheses under the parameter estimates.

A. Moments

	1992–1999		2000–2008	
	Actual Moments	Estimated Moments	Actual Moments	Estimated Moments
Average Cash (c/k)	0.1152	0.1125	0.1636	0.1708
		(-0.0354)		(0.6773)
Variance of Cash (c/k)	0.0052	0.0157	0.0060	0.0198
		(0.0629)		(1.4597)
Average Investment (I/k)	0.1394	0.1036	0.1145	0.1051
		(-2.6803)		(-1.3430)
Variance of Investment (I/k)	0.0044	0.0021	0.0036	0.0052
		(-0.0917)		(0.5699)
Serial correlation of investment (I/k)	0.4277	0.5409	0.5682	0.4705
		(0.0032)		(-0.1489)
Average profits (εk^θ)	0.1524	0.1247	0.1378	0.1228
		(-0.3835)		(-1.0313)
Serial correlation of profits (εk^θ)	0.7889	0.8456	0.7164	0.6071
		(0.0420)		(-0.0926)
Error variance of profits (εk^θ)	0.0033	0.0001	0.0041	0.0015
		(-0.0160)		(-0.2828)
Average Tobin's q ($V/(k+c)$)	2.0693	1.9184	1.9989	1.9236
		(-0.1487)		(-1.1730)
Average external finance (f/k)	0.0450	0.0121	0.0314	0.0117
		(-0.2144)		(-0.6030)
Variance of external finance (f/k)	0.0070	0.0002	0.0064	0.0002
		(-0.2439)		(-0.5227)

B. Parameter estimates

	ϕ	σ_v	ρ	θ	a	s	λ	J-test
1992-1999								
	0.1213	0.3482	0.6217	0.6648	0.4726	0.0000	0.0008	0.8395
	(0.0984)	(0.0759)	(0.0245)	(0.0197)	(0.0114)	(0.0003)	(0.0001)	(0.9331)
2000-2008								
	0.1111	0.4274	0.6739	0.6967	0.6239	0.0015	0.0005	0.3837
	(0.0214)	(0.0177)	(0.0145)	(0.0362)	(0.0655)	(0.0000)	(0.0001)	(0.9838)

Table 6: Value Loss and Changes in Cash Holding

Table 6 reports the value loss and differences in cash balances due to the misalignment of incentives between managers and shareholders. Firm value is scaled by the capital stock and represents average value produced per unit of capital. Value loss is the fractional difference between the value of a perfectly governed firm and the value of a firm described by our estimated parameters. The changes in cash and external financing are defined analogously. All variables are scaled by capital. For a perfectly governed firm we set the managerial bonus $\alpha = 0$, managerial ownership $\beta = 1$, tunneling $s = 0$, and empire building $\lambda = 0$.

	Value Loss	Cash Difference	External Finance Difference
Main sample	-0.0606	0.2191	0.3324
Institutional ownership high	-0.0358	0.1758	0.2353
Institutional ownership low	-0.0504	0.2195	0.3967
Blockholder ownership high	-0.0109	0.5604	0.1579
Blockholder ownership low	-0.1403	0.6207	0.4975
Gindex high	-0.0003	0.2857	0.1940
Gindex low	-0.0913	0.2493	0.1427
Eindex high	-0.0111	0.5000	0.4986
Eindex low	0.0265	0.0506	0.2352

Figure 1: Comparative Statics.

Figure 1 depicts the relation between the cost of external financing, ϕ, the standard deviation of the innovation to $\ln(\varepsilon)$, σ, the serial correlation of $\ln(\varepsilon)$, ρ, the curvature of the revenue function, θ, and the convex adjustment cost a and i) the cash to assets ratio and ii) the fraction of investment funded by cash or external financing.

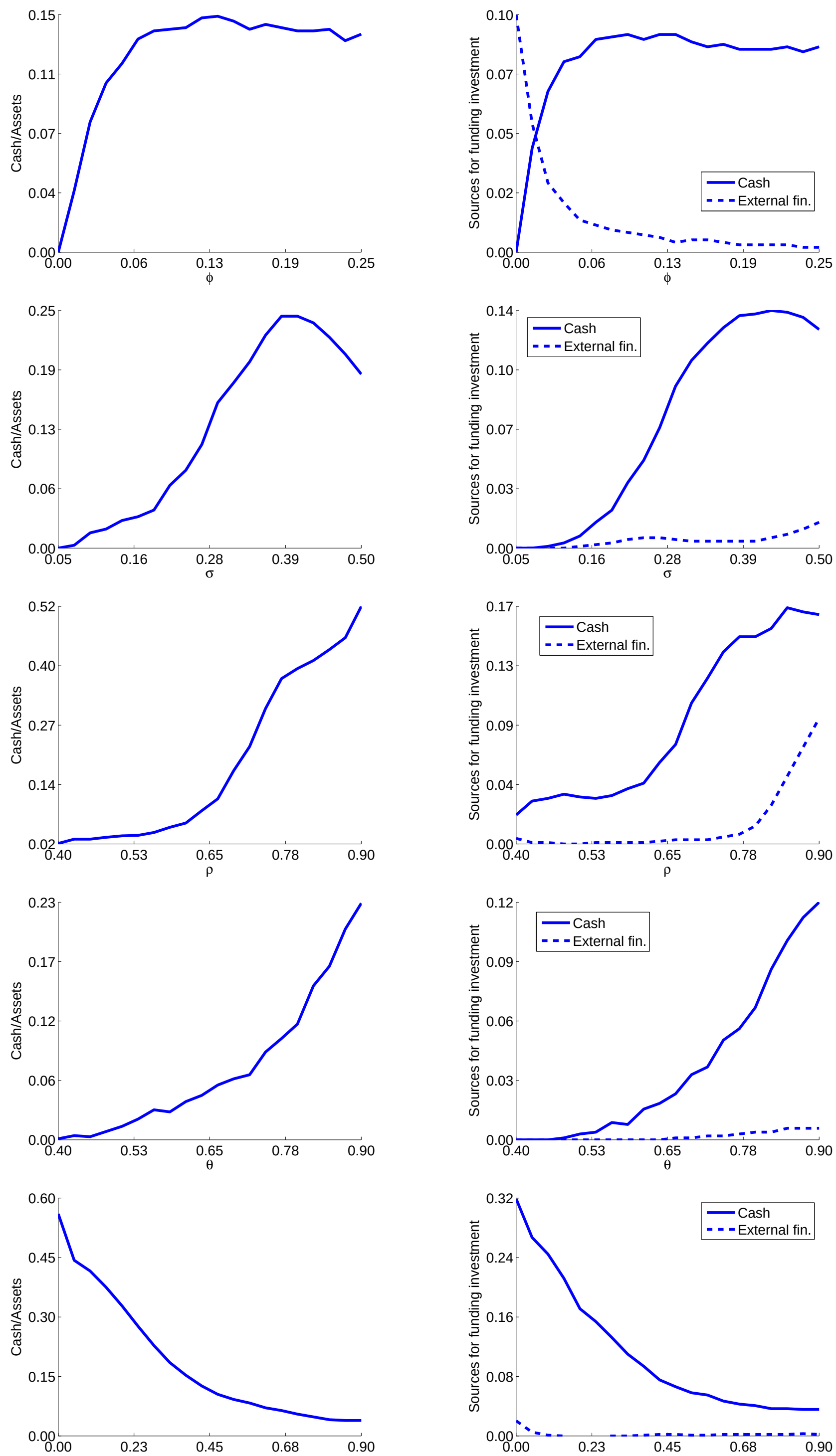

Figure 2: Comparative Statics.

Figure 2 depicts the relation between managerial bonus, α, empire building, λ, managerial ownership, β, and tunneling, s and i) the cash to assets ratio and ii) the fraction of investment funded by cash or external financing.

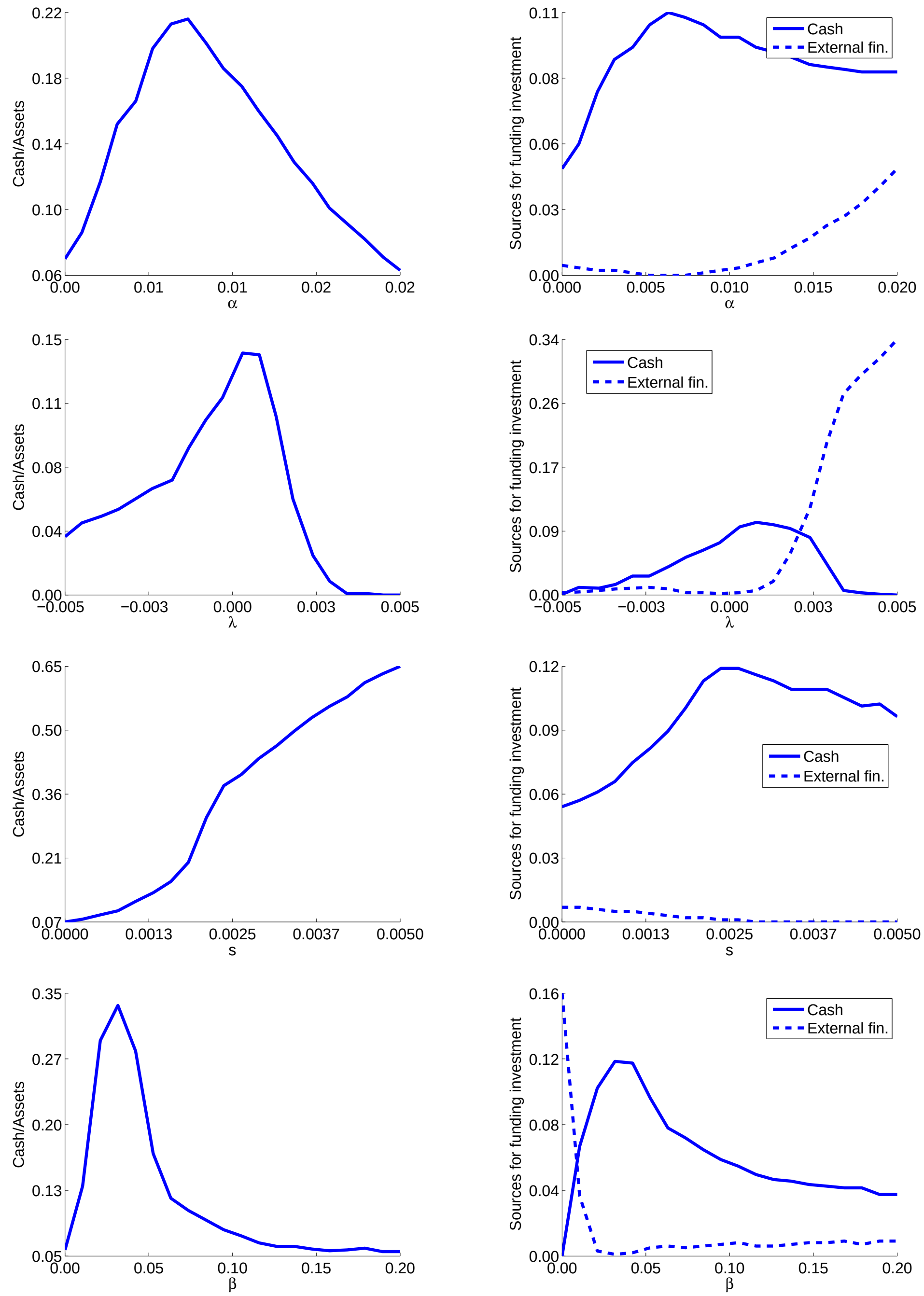

Figure 3: Sample Splits: Estimated and Actual Moments

Figure 3 depicts the relation between the estimated and actual average cash moment for the subsamples. 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 right and left 35% of the distribution, respectively.