The Marginal Value of Cash: Structural Estimates from a Model with Financing and Agency Frictions

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Abstract

How much value does an additional dollar of cash create for a firm? It is generally recognized that the marginal value of cash (MVC) can either exceed or fall below one dollar. Estimates of MVC can guide corporate cash and payout policy, indicate the quality of governance, and make a firm a target for takeover or activism. Yet, the existing methods of estimation lack a rigorous theoretical foundation and often provide implausibly high or low estimates. In this paper, we provide a formulation of MVC and structurally estimate the MVC based on a model which encompasses the important determinants for the choice of cash savings, including financing and agency costs. We find that firms with large cash and capital stocks have higher marginal value of cash. In recent years, firms that pay out more exhibit higher MVC than those that pay out less. Two quasi-natural experiments validate the MVC estimates.

Keywords: marginal value of cash, corporate cash policy, agency problems, financial constraints, costly external finance

JEL Classification: G32, G34, G35

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1 Introduction

In a seminal paper, Blanchard, Lopez-de Silanes, and Shleifer (1994) examined what firms do with cash windfalls, and documented the associated shareholder wealth effects. For a small sample of eleven firms with Tobin's Q well below unity, they found that managers, instead of returning the cash to shareholders, used it in ways more consistent with the pursuit of private benefits. The median shareholder value gain was 30 percent of the windfall amount, indicative of shareholder wealth destruction.

Since the Blanchard et al. (1994) study, financial economists have been interested in the concept of the *marginal value of cash* (henceforth, MVC), as a way to understand whether firms are putting corporate cash to good use. More cash is clearly valuable; however, exactly how much an additional dollar of cash is worth is supposed to depend on what firms do with it. For example, financially constrained firms might be able to increase their investment in positive net present value projects with more cash, so an additional dollar of cash is likely to add more to shareholder value for such firms. In poorly governed firms, managers are likely to appropriate some of the value via the pursuit of private benefits (as in the case of a majority of the firms in Blanchard et al. (1994)), and the MVC would be low.

Empirical estimates of the MVC often imply very large deviations from unity. One of the first papers to estimate MVC, Faulkender and Wang (2006) estimate an MVC of 0.94 for their sample; however, subsample estimates range from 0.45 to 1.15.[1] Subsequent studies have used estimates of the MVC to assess the real importance of various (unobserved) frictions and the resulting inefficiencies (or misallocation of resources).[2] These studies also often show large deviations, ranging from as high as 1.77, implying that an additional dollar of

[1]The subsample estimates in Faulkender and Wang (2006) and some of the studies mentioned below are our own estimates, based on regressions reported in these papers. Since the regressions often involve interaction terms of change in cash and other variables, following Dittmar and Mahrt-Smith (2007), we evaluate the MVC at the sample mean values of these other control variables to generate these subsample estimates. Details are available on request.

[2]See for example Dittmar and Mahrt-Smith (2007), Masulis, Wang, and Xie (2009), Frésard and Salva (2010), Chen, Harford, and Lin (2015).

cash creates as much as 77 cents of additional value for the average firm, to as low as 0.78, implying a value loss of 22 cents per additional dollar.

How plausible are these estimates? Consider the case of estimates of MVC in excess of unity. For a firm that is already raising some external financing, the main reason why the MVC could exceed 1 is that an additional dollar of cash allows it to save the deadweight financing cost associated with the last dollar of external financing. However, this implies that the *upper bound* of MVC is one plus the deadweight cost of raising an additional dollar of external finance. For the average firm, this deadweight cost cannot be 70 percent, as some of the MVC estimates would suggest. In fact, structural estimations of models typically imply the deadweight costs of issuance to be around 4%, i.e., 4 cents to a dollar, which would suggest an upper bound MVC of 1.04 for firms that raise some external financing.[3] For firms that do not raise external financing but pay out cash, either in the form of dividends or repurchases, arguably, the MVC is even lower — equal to the value of a dollar in the hand of the investor (otherwise, the value-maximizing firm would retain that dollar instead of paying it out). Agency problems would reduce the MVC, and structural estimations can give the extent of value loss associated with the average firm due to managerial agency problems.

In this paper, following Nikolov and Whited (2014), we construct a model of firm's investment and cash holdings decisions. The model assumes that managers derive private benefits from diverting a fraction of current cash holdings and cash flows. However, their compensation is tied to firm value and a bonus related to current profit. In this setting, for each realization of a productivity shock, managers choose the stock of capital and cash holdings to maximize their discounted payoff. We first estimate the model parameters via the simulated method of moments (henceforth, SMM) and generate the firm's marginal value of cash as a function of the state variables (capital, cash holdings, and the productivity shock). Second, we extract the triplet of state variables for each firm-year observation in the real

[3] Nikolov and Whited (2014) estimate the cost of external financing to be between 4.3% and 6.5%, but consider the former estimate to be more reasonable.

data. Third, we compute the MVC for each firm-year observation in the real data, based on the model-implied MVC function. Our sample average MVC estimate, gross of loss due to managerial agency problems, is 1.0184, with a standard deviation of 0.012. Net of loss due to managerial agency problems, MVC is 1.005, with a standard deviation of 0.023.

Most of the existing literature is based on two closely related methodologies for estimating the MVC. Fama and French (1998), and Faulkender and Wang (2006), respectively, regress the market value of the firm scaled by the book value of assets (annual excess stock returns) on excess cash holdings scaled by book value of assets (change in cash holdings scaled by the lagged market value of equity). We discuss the latter methodology more extensively as it has been more widely used in recent studies. We address two questions: (i) How do we conceptualize the MVC?, and (ii) Why do the estimates in the literature differ so much from ours?

In general, MVC can be greater than, equal to, or less than 1, depending on external financing costs and managerial agency problems. The manager's optimization exercise equates her marginal benefit from retaining an additional dollar of cash to her marginal cost of doing so. The former is precisely the manager's share of the increase in the present value of future cash flows due to an additional dollar of cash retained, i.e., $\frac{1}{1+r}\mathbb{E}_t[\frac{\partial V_{t+1}}{dh}]$, plus the increase in the present value of her future private benefits. The marginal cost of retaining a dollar is the manager's foregone share of the best alternative use of a dollar of cash. The latter is either the value of a dollar paid out as dividends, or of not replacing a dollar of costly external financing (if the firm raises external funds in the current period), which includes the deadweight financing cost per dollar raised. From the first order condition, it is straightforward to show that depending on whether or not the firm raises external financing, the MVC is either one, or one plus the deadweight cost of a dollar of external finance, minus the marginal private benefit to the manager per unit of ownership.[4] In what follows, we call

[4]This holds as long as the firm either raises external finance or pays out cash. If it does neither, the first-order condition does not hold with equality and the MVC is not pinned down by the first-order condition.

this the net MVC. Gross MVC is net MVC plus the manager's marginal private benefit per unit of ownership. The gross MVC is thus the marginal value of cash per unit of ownership *to the manager*, and equals the opportunity cost of retaining a dollar. Thus, while the net MVC is the marginal value of a dollar of cash to shareholders, the gross MVC or the MVC to the manager guides managerial decisions.

As regards the second question, we suggest that the widely-used methodology due to Faulkender and Wang (2006) is in fact not estimating the MVC; rather, it is estimating another useful concept — the marginal value of cash *flow*. This is so because the control variables in the most widely-used regression include, other than change in cash, change in net assets excluding cash, net external financing, and dividends. The firm's cash flow is left out. Its inclusion would create a multi-collinearity problem: by virtue of the cash flow identity, cash flow plus net external financing equals change in net assets plus change in cash plus dividends. However, with the other components of the cash flow identity held fixed, there is a one-to-one relationship between cash flow and change in cash holdings — a dollar increase in the former implies a dollar increase in the latter. Therefore, the coefficient of the change in cash holdings is the same as that of cash flow when the change in cash holding is excluded from the set of explanatory variables. We verify this intuition for both our model-generated data and the real data — when we replace change in cash with cash flow, we get coefficients that are identical (for the model-generated data) or very similar in magnitude (for the real data).

The marginal value of cash flow is different from the MVC. Even when it can be considered exogenous, it is different from a "helicopter cash drop" (Blanchard et al. (1994)). One reason for this is that cash flow is associated with a productivity shock and can contain information about future cash flows, due to the persistence of the shock. We verify this intuition in our model-generated data by varying the persistence of the productivity shock and in the actual data. The coefficient of change in cash (alternatively, cash flow) is monotonically increasing in the persistence of the shock. Therefore, we contend that the MVCs typically estimated by standard methodologies reflect value implications that go beyond the effect of a dollar of cash drop. While financial constraints and governance that the literature has focused on may affect the marginal value of a dollar of cash flow, these effects may be co-mingled with those due to shock persistence. On the other hand, the earlier studies that estimate the MVC may have more relevance for a growing literature on how shock persistence affects firm valuation and corporate policy (Décamps, Gryglewicz, Morellec, and Villeneuve (2017); Chang, Dasgupta, Wong, and Yao (2014)).

In our baseline model, since the estimated model parameters are fixed for every firm in our panel of firms, the only driver of variations in the MVC is each firm's history of productivity shocks. Thus, the model endogenously generates relationships between firm-specific variables (such as the market-to-book ratio) and the MVC. We discuss below some of the more important relationships that emerge for both the model-generated data and the real data.

First, we group firms into high-and-low productivity groups based on the productivity shocks and examine how MVC changes for each group with capital stock, with cash fixed at the sample median. We find that firms with larger capital stock have lower gross MVC. This relationship is consistent with the notion that larger firms are supposed to be less financially constrained in the real economy, and hence have lower MVC due to financing cost. In our baseline model, the cost of external financing per dollar is the same for all firms. Thus, the negative relationship is likely driven by the fact that smaller firms, having lower profits net of fixed operating costs, are more reliant on external financing; therefore, the MVC due to financing cost is on average higher for these firms. Since our model is estimated to match the real economy, the computation of the MVC using the real data is based on the same set of parameters, and similar logic applies for the observed relationship in the real data. [5] More interestingly, we find that the *net* MVC is higher in larger firms, and the relationship

[5] It is likely, however, that larger firms in the real economy face lower financing costs *per dollar* than smaller firms, and not simply a lower probability of seeking external financing. Thus, the wedge between the MVCs due to financing cost of large and small firms could be larger than what we estimate.

flips because of the agency components in the MVC: overall, larger firms tend to incur lower loss from managerial bonus and diversion per additional dollar retained than smaller firms. This occurs because, with cash holdings fixed, additional private benefits derive from additional capital investment, but larger firms with larger stock of capital have relatively higher cash flows, and are more likely to distribute additional cash rather than invest it. These relationships are observed both for the model-generated data and the real data.

Second, we find that for firms in each productivity group, those with higher cash holdings (with capital fixed at the sample median) have lower gross MVC in the model. This is expected because these firms have less need for external financing. However, this relationship is the opposite in the real data, where we find that firms with higher cash-to-asset ratio have higher gross MVC, presumably because the firms with higher financing needs accumulate more cash. For both the model and the real data, the loss due to managerial private benefits decreases in cash, as the incremental investment from an additional dollar of cash decreases. The net MVC *increases* in cash for both the model and the real data. This result is important because it suggests that higher cash holding is not necessarily symptomatic of more severe agency problems. Firms with large cash holdings have been targets of hostile takeover threats or, more recently, by activist shareholders pressurizing managers to pay out the cash. Our results suggest that larger cash holdings, even in the presence of agency problems, could be associated with higher MVC. Thus, targeting based only on the level of cash holdings could be counterproductive and destroy investor value if it forces firms to pay out the cash.

Third, for the real data, we find that both gross and net MVC is higher for firms in the highest market-to-book ratio group. Firms with high market-to-book experience positive productivity shocks; as a result, they have higher market valuations and also need external capital to grow. The latter contributes to the higher MVC of these firms. Likewise, we also find the MVCs are higher for firms that invest at a higher rate.

Fourth, we examine the relationship between corporate payouts and MVC. For firms in the real economy, we find that gross and net MVCs are higher for firms that pay out more.[6] One feature of the real data is that firms often pay out and raise external financing at the same time, although this never happens in the model. When we examine the time trend of the difference in the MVCs in the upper and lower terciles of the payout'to-assets ratio in the real data, we find that this is a phenomenon of the last two decades. Moreover, while the difference in gross MVC between the upper and lower terciles is negative for the years prior to 2004, it becomes positive in subsequent years. This is consistent with the observation that firms that are raising significant external financing are also paying out more. The net MVC exhibits a similar pattern. These findings are highly consistent with those in Farre-Mensa, Michaely, and Schmalz (2021). These authors document that 42 percent of firms raise external financing and payout cash in the same period. While debt issuance is the dominant form of external financing, most of the payout is in the form of share repurchases. There is a particularly sharp increase in the gap between payouts and internal funds post 2002, which declines during the financial crisis and recovers after the crisis. Our findings closely mirror this pattern.

Finally, to validate our estimated MVC, we examine how two quasi-natural experiments affect sample MVCs. The first is the Americal Jobs Creation Act (ACJA) of 2004, which temporarily reduced the tax on repatriated foreign cash savings from 35% to 5.25% for U.S. corporations. Xu and Kim (2021) identify a group of firms who repatriated foreign earnings under the AJCA in 2004 and after, and a group of firms who discussed repatriation of foreign earnings under the AJCA in their 10-K but did not repatriate. We expect that the MVC for the first group would be higher than that of the second, both immediately before, and possibly even after, the Act. This is what we find. In our second quasi-natural experiment, we examine the impact of large industry tariff cuts on parameters that capture managerial agency problems, and the MVC. We find that managerial diversion decreases significantly, and MVC is higher, after the major tariff cuts. These findings are consistent with the idea

[6]Payouts comprise dividends as well as share repurchases.

that more intense foreign competition are associated with stronger governance (Dasgupta, Li, and Wang (2018)) and firms are more in need of external financing, which increases the MVC.

We contribute to the empirical literature mentioned above on measuring marginal value of cash and relating its value with corporate policies and governances. We point out the caveats of these existing MVC measures and provide our own based on structural estimation of a model in the spirit of Nikolov and Whited (2014). The most related paper is Halford, McConnell, Sibilkov, and Zaiats (2020), who also cast doubt on the existing methodology for estimating MVC. Their main argument is that the existing methodology generates unreasonably large estimates of MVC in some cases, and for firms that should have similar values of MVC, the estimates are drastically different values. However, they neither identify what goes wrong with the existing methodology nor provide a correct method to compute MVC, both of which are accomplished in our paper.[7]

Our paper is also closely related to the theoretical literature on dynamic models of cash holdings (e.g., Anderson and Carverhill, 2011; Bolton, Chen, and Wang, 2011; Riddick and Whited, 2009, among others) and the structural estimation literature (e.g., Bazdresch, Kahn, and Whited, 2018; Eisfeldt and Muir, 2016; Hennessy and Whited, 2005, 2007; Li, Taylor, and Wang, 2018; Morellec, Nikolov, and Schürhoff, 2012; Taylor, 2013, among others). We add to this literature by providing a methodology to construct endogenous unobserved variables for a specific firm-year observation based on structurally estimated dynamic models and real data.

The rest of the paper is organized as follows. Section 2 establishes a model for the determination of corporate investment and cash holding policies, conceptualizes the MVC, and discusses how to derive the MVC from the solution of the model. Section 3 introduces sample construction and discusses our structural estimation method. Section 4 begins by

[7] Halford et al. (2020) propose several ways to improve upon the existing methodology for estimating MVC. However, as they admit, their remedies exhibit minor improvement and are insufficient to align the estimates with economically reasonable values.

demonstration why existing methods do not estimate the marginal value of cash, presents the MVC estimates based on the structural approach, and discusses how the MVC is related to corporate policy. Section 5 applies our measure of the MVC to examine the impact of two quasi-natural experiments. Finally, Section 6 concludes.

2 Model

We adopt a direct and structural approach to explore implications of the cash saving decision on firm value. For that, we construct and estimate a dynamic model following Nikolov and Whited (2014). In this model, the firm lives infinitely and delegates decision making to a manager. The manager's utility is not perfectly aligned with that of investors, and internal cash stock brings private benefits to the manager. Each period, the manager makes decisions on investment and cash saving to maximize her own utility. External financing is costly, and cash stock alleviates investment distortion due to financial constraints. Therefore, the value of cash encompasses both agency costs related to cash and value enhancement from mitigating financial constraints.[8]

2.1 Production

The firm employs capital k_t to produce output. Its operating profit is given by $\pi_t = e^{z_t} k_t^{\alpha} - c_f - c_l k_t$, where $\alpha \in (0, 1)$ captures both market power and decreasing return to scale, $c_f > 0$ is the fixed operating cost arising from fixed outside opportunity costs for some scarce resources (e.g., managerial labor) used by the firm, $c_l > 0$ is the proportional operating cost, and z_t is a productivity shock. The productivity shock is realized and observed by the manager before investment and cash saving are decided, and it follows an AR(1) stochastic process:

$$z_t = (1 - \rho_z)\bar{z} + \rho_z z_{t-1} + \sigma_z \varepsilon_t, \tag{1}$$

[8]Due to the dynamic feature of the model, the value of cash reflects both the current and future expected agency costs and financial constraints.

where $\bar{z}$ is the unconditional mean of z_t, $\rho_z \in (0,1)$ is the persistence coefficient, $\sigma_z > 0$ is the conditional volatility of z_t, and ε_t is a standard Gaussian shock.

The firm accumulates capital through investment: $k_{t+1} = i_t + (1-\delta)k_t$, where i_t stands for investment, and $\delta \in (0,1)$ is the depreciation rate. Following Abel and Eberly (1994), we assume that adjustment of capital stock is subject to quadratic costs:

$$CA(i_t, k_t) = \frac{a}{2}\left(\frac{i_t}{k_t}\right)^2 k_t, \tag{2}$$

where a is a positive constant.

2.2 Financing

The firm has three financing sources: current cash flows, cash stock, and external funds. At the beginning of the period, the firm has a stock of cash $h_t \geqslant 0$. The cash stock earns a taxable interest income at the risk-free rate, r. If internal resources fall short of meeting the investment demand, the firm can raise funds externally. Let $f \geqslant 0$ denote the amount of external financing.[9] External financing is costly: For every dollar raised externally, the firm pays $\phi_l f$ dollars of flotation costs, where $\phi_l \in (0,1)$. In addition, each time the firm opts for external financing, it must pay a fixed cost $\phi_f > 0$. The total costs of external financing are $\phi_f + \phi_l f$.

2.3 Managerial Incentives

The manager is risk neutral. The manager's employment contract with the firm stipulates her compensation. In this paper, we do not explicitly study the optimality of the managerial employment contract but take it as given. This approach allows us to estimate the effects of managerial contract features without compromising model tractability.

[9] We do not distinguish debt and equity financing because the focus of this paper is on the implications of cash or internal funds on firm value.

The manager's compensation consists of two parts: a profit-sharing component and an equity component. Specifically, the manager receives a fraction ($0 < \xi < 1$) of the firm's operating profit as bonus. In addition, the firm grants a proportion ($0 < \kappa < 1$) of ownership to the manager (e.g., through restricted stocks or stock options). That is, for every dollar of payout, the manager receives κ dollars. The equity component of the managerial contract helps align the manager's incentive with that of investors. The larger the κ, the more the manager acts like an outside investor. Nevertheless, the manager's own utility differs from that of outside investors. In particular, she can divert a fraction ($0 < s < 1$) from the firm's current profit and cash stock.

There are two types of agency problems associated with the manager's decisions. First, both the bonus and the diversion from current operating profits result in the manager preferring a larger firm size, which in turn leads to "empire building". Second, the manager's diversion from cash stock induces the firm to hoard more cash than necessary. Both of these actions destroy firm value.

2.4 Objective Function

We first specify the firm's cash flow, which is affected by the manager's compensation. Before payout or external financing, the firm's cash flows are given by

$$\begin{aligned}\tilde{d}_t = {} & (1-\tau)[1-(\xi+s)]\pi_t + \tau\delta k_t - k_{t+1} + (1-\delta)k_t - CA(i_t, k_t) \\ & - h_{t+1} + [1 + r(1-\tau)](1-s)h_t,\end{aligned} \tag{3}$$

where $\tau \in (0, 1)$ is the corporate income tax rate. The first term indicates that after the firm generates operating profits, the manager shares a fraction (ξ) as bonus and diverts some (s) for personal consumption. The second term is from the tax deductibility of depreciation. The third to fifth terms stand for investment and capital adjustment costs. The last two terms show the change in cash holdings, where the manager can divert a fraction (s) of current cash stock.

The firm adopts straightforward payout and financing polices as follows. The firm pays out $\tilde{d}_t$ if its value is positive, and raises external funds to cover the deficit and pays the costs for external financing if $\tilde{d}_t$ is negative. Therefore, the net cash flows distributed to investors are

$$d_t = \tilde{d}_t - \mathbb{I}_t(\phi_f - \phi_l \tilde{d}_t) = (1 + \phi_l \mathbb{I}_t)\tilde{d}_t - \phi_f \mathbb{I}_t, \tag{4}$$

where $\mathbb{I}_t$ is an indicator function that equals one if the firm raises external funds (i.e., $\tilde{d}_t < 0$) and zero otherwise.

Given the manager's compensation structure and her private benefits from diversion, her instantaneous utility function, per unit of ownership, can be specified as

$$u_t = \frac{\xi + s}{\kappa}(1-\tau)\pi_t + \frac{s}{\kappa}[1 + r(1-\tau)]h_t + d_t. \tag{5}$$

The manager chooses investment and cash saving in each period to maximize the present value of her lifetime utilities per unit of ownership:[10]

$$U_t = \max_{(k_{t+s}, h_{t+s})_{s=1}^{\infty}} \mathbb{E}_t \sum_{s=0}^{\infty} \frac{u_{t+s}}{(1+r)^s}, \tag{6}$$

where, for simplicity, we assume a constant discount factor for both the manager and shareholders following Nikolov and Whited (2014). Based on Eqs. (5) and (6), we can show that the manager's lifetime utility comes from three parts, i.e., firm value, bonus, and diversion:

$$U_t = \underbrace{\mathbb{E}_t \sum_{s=0}^{\infty} \frac{d_{t+s}}{(1+r)^s}}_{\equiv V_t} + \underbrace{\frac{\xi}{\kappa}\mathbb{E}_t \sum_{s=0}^{\infty} \frac{(1-\tau)\pi_{t+s}}{(1+r)^s}}_{\equiv B_t} + \underbrace{\frac{s}{\kappa}\mathbb{E}_t \sum_{s=0}^{\infty} \frac{(1-\tau)\pi_{t+s} + [1 + r(1-\tau)]h_{t+s}}{(1+r)^s}}_{\equiv S_t} \tag{7}$$

where V_t is investor value or firm value, B_t is the present value of the manager's bonus

[10]For convenience, we scale manager's utility by her ownership. Since we assume that manager's ownership κ is an exogenously given constant, maximizing utilities leads to the same optimal investment and cash holdings policies as maximizing utilities per unit of ownership.

payments per unit of ownership, and S_t is the present value of future diversions per unit of ownership. The first component aligns with investor value, but the other two components induce the manager to deviate from optimal decisions on investment and cash saving for the firm.

We rewrite the manager's optimization problem (Eq. (6)) into the equivalent Bellman's equation given below:

$$U(k_t, h_t, z_t) = \max_{k_{t+1}, h_{t+1}} u_t + \frac{1}{1+r}\mathbb{E}_t[U(k_{t+1}, h_{t+1}, z_{t+1})], \tag{8}$$

where $u_t = u(k_t, k_{t+1}, h_t, h_{t+1}, z_t)$ is defined by Eqs. (3), (4), and (5). This model satisfies the conditions for Theorem 9.6 in Stokey and Lucas (1986). Therefore, problem (8) is a contraction mapping, which features a unique solution in the form of $U(k, h, z)$, i.e., the present value of the manager's lifetime utility as a function of the state variables.

2.5 Firm Policies and the Marginal Value of Cash

In this section, we discuss the firm's decisions on investment and cash savings and derive the marginal value of cash. To illustrate the intuition, we first derive the first-order conditions of the Bellman equation (8) for *interior* optimal policies (h_{t+1}, k_{t+1}):

$$\frac{\partial U_t}{\partial h_{t+1}} = \frac{1}{1+r}\mathbb{E}_t\left[\frac{\partial U_{t+1}}{\partial h_{t+1}}\right] - (1+\phi_l \mathbb{I}_{it}) = 0, \tag{9a}$$

$$\frac{\partial U_t}{\partial k_{t+1}} = \frac{1}{1+r}\mathbb{E}_t\left[\frac{\partial U_{t+1}}{\partial k_{t+1}}\right] - (1+\phi_l \mathbb{I}_{it})\left[1 + a\left(\frac{i_t}{k_t}\right)\right] = 0, \tag{9b}$$

where $U_t = U(k_t, h_t, z_t)$ and $U_{t+1} = U(k_{t+1}, h_{t+1}, z_{t+1})$. Eq. (9a) indicates that the optimal cash saving is determined by the equality between the marginal value of cash (i.e., the discounted expected utility from a unit of cash tomorrow) and the marginal cost of a unit of cash saving today. As can be seen from Eqs. (5) and (4), if the firm is not raising any external financing, the marginal opportunity cost per unit of ownership of retaining a dollar (and not paying it out to investors) is one; if it is raising external financing, the marginal cost per unit of ownership of retaining a dollar and not substituting a dollar of external finance is one plus the linear financing cost ϕ_l. Similarly, Eq. (9b) shows that the marginal benefit of a unit of investment is the discounted utility from the increase of a unit of capital stock, which must be equal to the marginal cost of a unit of investment at the optimum, i.e., including the cost of the investment and the associated adjustment cost, and the cost of financing the investment, $1 + \phi_l \mathbb{I}_{it}$.

The decomposition of the managerial utility given in Eq. (7) leads to

$$\underbrace{\frac{1}{1+r}\mathbb{E}_t\left[\frac{\partial V_{t+1}}{\partial h_{t+1}}\right]}_{\lambda_{f,t}} = \frac{1}{(1+r)}\mathbb{E}_t\left[\frac{\partial U_{t+1}}{\partial h_{t+1}}\right] - \frac{1}{(1+r)}\mathbb{E}_t\left[\frac{\partial B_{t+1}}{\partial h_{t+1}}\right] - \frac{1}{(1+r)}\mathbb{E}_t\left[\frac{\partial S_{t+1}}{\partial h_{t+1}}\right]$$

$$= \underbrace{(1 + \phi_l \mathbb{I}_{it})}_{\lambda_{u,t}} - \underbrace{\frac{1}{(1+r)}\mathbb{E}_t\left[\frac{\partial B_{t+1}}{\partial h_{t+1}}\right]}_{\lambda_{b,t}} - \underbrace{\frac{1}{(1+r)}\mathbb{E}_t\left[\frac{\partial S_{t+1}}{\partial h_{t+1}}\right]}_{\lambda_{s,t}}, \tag{10}$$

where λ_u is the marginal value of cash from the perspective of firm i's manager (per unit of ownership), λ_f is the marginal value of cash from the perspective of firm i's outside investors, λ_b and λ_s are deductions in marginal value of cash due to bonus and diversion scaled by managerial ownership κ. For convenience, we define λ_u as the **gross MVC** and λ_f as the **net MVC**. Without agency problems, the net MVC of the firm is exactly equal to the marginal opportunity cost of saving an incremental unit of cash (i.e., $1 + \phi_l \mathbb{I}_t$). However, because of the presence of agency costs, the net MVC can be less than one if the agency costs are large enough. A firm's net MVC indicates the increase in the firm value due to one dollar of cash windfall, while the gross MVC represents the marginal value of cash for the manager per unit of ownership, and is useful in understanding the firm's corporate decisions, which are made by its manager. In other words, the gross MVC is useful in understanding corporate cash policy, while the net MVC tells us about the impact of such a policy on shareholders.

Discussion

- The characterization of the MVC in Eq. (10) is surprisingly simple. If the firm is raising external financing in the current period, the gross MVC equals the marginal cost of external finance. If it is not raising external finance but paying out cash, its MVC is one.

- It is possible, however, that the firm is neither paying out cash nor raising external financing. This would happen if the gross MVC, i.e., $\frac{1}{1+r}\mathbb{E}_t\left[\frac{\partial U_{t+1}}{\partial h_{t+1}}\right]$ is between $1+\phi_l$ and 1. In this case, the manager does not raise additional external finance since it costs more than its marginal value to the manager; nor does the manager pay out any cash because the marginal value of cash exceeds what it is worth if paid out.

- The firm could also choose zero external financing and zero payout because of the fixed costs of issuance. In that case, the gross MVC can be larger than one plus the cost of external finance. If the gross MVC exceeds one plus marginal issuance cost, the manager would benefit from raising external financing and increasing the firm's cash holdings in the absence of fixed costs of issuance. However, it might be prevented from raising external financing due to the fixed costs of issuance. The firm would also not pay any dividends because the MVC exceeds one.

- The MVC is only affected by the firm's current external financing requirement, which takes into consideration its external financing needs and issuance costs in the future. This is because if the MVC diverged from unity because of such anticipated future needs, the firm would allocate more to increase cash holdings. It will continue to do so as long as the MVC remained above unity. However, it may not have enough cash to satisfy all its future financing needs. In that case, it will raise external financing now, and the MVC will equal one plus the cost of external finance.

- The analysis also shows that the cost of external financing provides an upper bound for the net MVC (subject to the caveat discussed above that due to the fixed costs of issuance, the firm may neither raise external finance nor pay out cash, and MVC can exceed 1 plus marginal issuance cost). This is intuitive: since a firm can always issue securities to raise financing, an additional dollar of cash cannot be worth more than the additional cost of security issuance. The lower bound can be below one, due to the presence of agency costs.

- In reality, a firm may end up not being able to raise external financing due to information asymmetry. This occurs if there is a divergence in the cost of finance that the firm is willing to pay and that which the investors require. The MVC of the manager is *not* infinity, but rather the external financing cost the manager is willing to pay. The latter is the marginal utility from capital scaled by one plus the marginal capital adjustment cost, ie., $\frac{\frac{1}{1+r}\mathbb{E}_t\left[\frac{\partial U_{t+1}}{\partial k_{t+1}}\right]}{\left[1+a\left(\frac{i_t}{k_t}\right)\right]}$.

2.6 Signaling Benefits and Taxes on Payouts

In our model, firms never raise external financing and pay out cash at the same time; however, in reality, many firms do (we discuss this extensively in section 4.2.4). One reason for this is that there are potential signaling benefits. If the signaling benefit of the first dollar of cash paid out is worth more than the external financing cost, and the benefit is decreasing in the amount paid out, a firm would pay out cash until the marginal benefit of a dollar paid out equals the marginal benefit from reducing external financing by 1$. In this case, the MCV is again given by $(1 + \phi_l)$.

For firms that do not raise external financing but pay out cash, the marginal benefit of paying out a dollar of cash, though below $1 + \phi_l$, could still exceed 1$ due to signaling benefits. Since our model assumes that the opportunity cost of retaining a dollar for a firm that does not raise external finance is 1$, we could be underestimating MVC for such firms.

On the other hand, shareholders pay dividend and capital gains taxes on payouts, which would lower the marginal benefit to shareholders and MVC for such firms. In Appendix E, we extend the baseline model to include a non-zero payout tax rate τ_d and examine how payout tax affects the value of MVC. We show that the decomposition of $\lambda_{f,t}$ in equation (10) still holds in the presence of dividend tax, however, $\lambda_{u,t}$ is instead given by

$$\lambda_{u,t} = 1 - \tau_d \mathbb{J}_t + \phi_l \mathbb{I}_t \, ,$$

where $\mathbb{J}_t = 1$ if the firm makes positive payouts (i.e., $\tilde{d}_t > 0$) and zero otherwise. Payout taxes affect the value of MVC directly by lowering MVC from 1 to $1 - \tau_d$ when firm makes positive payouts, and indirectly by altering firm's investment and financing decisions. However, the upper bound for the net MVC would still be the cost of external financing, while the lower bound becomes one minus payout tax rate instead of one as in the baseline model. In our sample, 52.4% (77.46%) of firm-year observations have positive dividend (dividend plus repurchases) payouts. Assume that payout tax rate is on average 20%,[11] it implies 15% reduction on the estimated average value of net MVC. Therefore, dividend tax alone is unlikely to explain the large loss in MVC as seen in some of the estimates in the literature and makes the estimated MVC even less likely to be much higher than one.

Since it is challenging to separately identify the payout tax costs and signaling benefits of payouts and the net magnitude is likely small, we essentially assume that they cancel each other out.[12] Even though we fail to determine exactly what the sample MVC might be in view of the above limitations, it is important to note that this does not affect our major goals in this paper. First, our conclusion that the cost of external financing provides an upper bound on MVC estimates, which is likely to be much lower than those often documented by

[11] Capital gain on most assets held for longer than a year is taxed at 0%, 10%, or 20%, and is taxed at the marginal tax rates for the ordinary income, which ranges between 10% to 39.6% in our sample, for assets held less than a year. Before the passage of the Jobs and Growth Tax Relief Reconciliation Act of 2003 (JGTRRA), dividends are taxed at the marginal tax rates for the ordinary income. After 2003, qualified dividend income was taxed at the same rates as long-term capital gains, while ordinary dividend continues to be taxed as ordinary income. Historical U.S. individual income tax rates & brackets can be found at `https://taxfoundation.org/historical-income-tax-rates-brackets/`.

[12] As we discuss in section 4.2.4, payouts may also be induced by (possibly misguided) shareholder activism. The benefits of such payouts for managers are even more difficult to ascertain.

existing methodology, remains. Second, as regards the lower bound on MVC estimates, we are able to quantify the losses due to managerial agency problems. Third, our model still correctly identifies subsamples with higher versus lower MVCs, based on firm characteristics, which has been the focus of most of the empirical research related to the marginal value of cash.

2.7 MVC Measure Based on Structural Estimation

In the model, the aforementioned components of the marginal values of cash defined in equation (10), i.e., λ_u, λ_f, λ_s, and λ_b, are functions of three state variables: capital (k), cash holdings (h), and productivity shock (z). These MVCs for each firm-year observation in the data can be easily computed via the following steps.

(i) Structurally estimate the model parameters, $\Theta \in \mathcal{R}^N$, where N is the number of model parameters.

(ii) Given the estimated model parameters, $\hat{\Theta}$, numerically solve the manager's lifetime utility as a function of the state variables, $U(k, h, z; \hat{\Theta})$, on a given set of grid points in the (k, h, z)-space based on a recursive method using the Bellman's equation (8). The present value of the manager's bonus, $B(k, h, z; \hat{\Theta})$, and the present value of the manager's diversions, $S(k, h, z; \hat{\Theta})$, can be simultaneously solved in this process.

(iii) For a specific firm-year observation with the triplet of state variables (k_{it}, h_{it}, z_{it}) and the external financing action $\mathbb{I}_{it}$, the gross MVC λ_u is set to $1 + \phi_l$ if firm i raises external financing in year t, set to 1 if firm i does not raise external financing, and set to the value of the expected derivative $\frac{1}{1+r}\mathbb{E}_t\left[\frac{\partial U_{t+1}}{\partial k_{t+1}}\right]$ at the point (k_{it}, h_{it}, z_{it}) if firm i neither pays out nor raises external financing. For the last scenario under which firm's optimal cash holdings are from a corner solution and the first order condition does not hold, the expectation and the derivative are computed numerically.

(iv) Compute λ_b and λ_s as the expected derivatives of B and S with respect to cash (h) numerically and compute λ_f according to the equation (10).

This structural approach has a few advantages in estimating and examining the MVC. First, the MVC can be estimated for every possible combination of the state variables (i.e., k_{it}, h_{it}, and z_{it}), which allows us to examine how it varies with the state variables. Second, as the decomposition in Eq. (10) shows, we can study the respective contribution of various components (financial costs and agency costs, etc.) to the MVC. Third, and more importantly, we show in Section 4.1 that the traditional regression approach cannot generate accurate MVC measures due to (i) the nonlinearity of the relationship between firm value and firm characteristics and (ii) endogeneity. Lastly, our MVC measure is firm-year specific, while the traditional regression approach only generates an average value of MVC for a given sample.

Our approach also has its limitations. Although our MVC measure varies with firm's specific state variables, i.e., k_{it}, h_{it}, and z_{it}, the estimated parameters are the same for all firms in the sample. A consequence of this caveat is that the model-predicted payout and financing decisions of firm i in year t based on the three state variables can be different from its actual behavior. This is why our preferred procedure for estimating λ_u is based on the firm's actual financing and payout behavior and structural estimates of the model.[13] However, our method of constructing MVC can be extended easily to incorporate heterogeneity in model parameters across firms with subsample estimations. We provide such an example in Section 5.

[13]Note that we could simply set λ_u to the value of $\frac{1}{1+r}\mathbb{E}_t\left[\frac{\partial U_{t+1}}{\partial k_{t+1}}\right]$ regardless of firm's actual payout and financing status because the first order condition (9a) implies that we should get the same values for λ_u in theory for these interior solutions.

3 Data and Estimation

Our data covers the universe of the ExecuComp firms. This sample restriction is due to the requirement of information about managerial ownership and compensation. Following the literature, we exclude all regulated and financial firms (i.e., firms with SIC 4900-4999 and 6000-6999). We retrieve financial information from the Compustat database and managerial compensation data from the ExecuComp database. To be included in our sample, the main variables (see Appendix A for their detailed definitions) for an observation must have non-missing values for at least two consecutive years. Our final sample has 14,283 observations for 2,028 firms between the years 1993 and 2017. Summary statistics of the main variables used in the estimation are presented in Table 1, which are comparable to those in the literature, particularly with Nikolov and Whited (2014).

As explained in the previous section, our MVC measure depends on the model parameters. The model has fifteen parameters in total: the unconditional mean, standard deviation, and autocorrelation of the productivity shock ($\bar{z}$, σ_z and ρ_z), the curvature of the production function (α), the fixed and proportional operating costs (c_f and c_l), the quadratic adjustment cost parameter for investment (a), the fixed and proportional financing costs (ϕ_f and ϕ_l), the depreciation rate (δ), the managerial ownership (κ), the profit-sharing (bonus) parameter (ξ), the diversion parameter (s), the corporate income tax rate (τ), and the discount rate (r). We estimate seven parameters, $\{c_f, c_l, a, \phi_f, \phi_l, \xi, s\}$, and calibrate the other eight parameters separately.

We calibrate the discount rate as the risk-free rate (i.e., annualized average three-month T-bill rate minus average inflation rate) in our sample period, which is equal to 0.012.[14] The depreciation rate is set to be 0.126, its average value in our sample. We follow Nikolov and Whited (2014) to set the corporate income tax rate as 20%. The managerial ownership is

[14]The literature (Nikolov and Whited, 2014, among others) commonly uses the real risk-free rate as the discount rate. Discount rate is simply a scaling factor in this type of models because it is the same for all firms and the same for managers and investors.

calibrated to match the average share ownership and options held by the top five highest paid executives in the firm in our sample, which is equal to 0.051. As for the parameters related to production and the productivity shock, $\{\alpha, \bar{z}, \sigma_z, \rho_z\}$, we first estimate the panel of shocks for the firm-year observations in our sample and then calibrate the parameters based on the AR(1) stochastic process given in Eq. (1). The detailed procedure for the calibration of the parameters of the productivity shock process is given in Appendix B.

We estimate the remaining seven model parameters using the simulated method of moments (SMM), which selects one set of parameters to minimize the distance between the moments simulated from the model and the data counterparts. To generate the simulated moments, the model must be solved repeatedly when SMM navigates over the parameter space. The model does not have an analytical solution, so we solve it numerically. Appendix C provides detailed description for the numerical method used to solve the model.

As a method of structural estimation, SMM's identification requires picking enough number of moments that are sensitive to the model parameters to be estimated. To understand the identification of the model parameters, we conduct comparative statics of the model, shown in Figure 1. In each panel of this figure, we solve and simulate the model ten times. Each time, we change the parameter in question (on the horizontal axis), while the other parameters are fixed at their values in the baseline estimation reported in Table 2. The values of the moments in question are the averages of 100 simulated panels with 5,000 firms and 30 periods. Basically, the comparative statics demonstrate the sensitivity of the moments with respect to the model parameters.

The mean and variance of the investment-to-assets ratio (i/k) help identify the investment adjustment cost parameter (a). As the first two panels of Figure 1 show, a higher a lowers both the level and volatility of investment. The mean and variance of the ratio of cash to assets ($h/(k+h)$) and profitability ($e/(k+h)$, where $e = [1-(\xi+s)]\pi$) are informative about the operating cost parameters (c_f and c_l). As the third to sixth panels of Figure 1 show, while the fixed cost (c_f) motivates higher cash hoarding and depresses profitability, the proportional operating cost (c_l) tends to enlarge the volatility of both the cash-to-asset ratio and profitability.

We include the mean and variance of the external financing-to-assets ratio ($(\phi_f + \phi_l f)/(k + h)$) and the payout-to-assets ($(1 - \mathbb{I})d/(k + h)$), which are informative about the financing cost parameters (ϕ_f and ϕ_l). For example, the fixed financing cost increases both the level and volatility of external financing, as shown in the seventh and eighth panels of Figure 1.[15] In contrast, the proportional financing cost (ϕ_l) lowers both the level and volatility of payout (see the ninth and tenth panels of Figure 1).

The final set of moments pertains to the agency parameters—bonus (ξ) and diversion (s). We include the mean of the market-to-book ratio ($V/(k + h)$) to identify diversion because the higher the diversion, the lower the firm value, as shown in the eleventh panel of Figure 1. Indeed, the M/B ratio relates to other parameters too, such as production and financing costs. However, these other parameters can be closely identified through the moments discussed above, leaving the level of M/B to identify the degree of diversion. We do not include the variance of M/B as a moment because it is well known to depend on many heterogeneous factors, making it hard to match. We include the ratio of managerial bonus to assets ($\xi\pi/(k + h)$) for identification of the bonus parameter. Clearly, they are directly related (see the last panel of Figure 1).

Appendix D describes the details of the SMM estimation, and the results are presented in Table 2. Panel A of Table 2 shows that all parameter estimates, except that of the fixed financing cost (ϕ_f), are statistically different from zero. As indicated in Eq. (10), three parameters are crucial for the determination of the net MVC: the proportional financing cost (ϕ_l), the bonus coefficient (ξ), and the diversion coefficient (s). While the financing cost increases the net MVC, the agency coefficients lowers it. Our estimation shows that on average, the firm incurs a proportional financing cost of 2.6 cents when it raises one

[15] The fixed financing cost (ϕ_f) causes the firm to raise external financing less frequently but increases the magnitude of financing when it indeed raises finance.

dollar externally. The estimate of the diversion coefficient is relatively small in magnitude.[16] However, they play important roles in the determination of cash stock as well as the MVC. For example, a one standard deviation increase in the diversion coefficient (s) is associated with a two percentage decrease in the M/B ratio, as shown in Figure 1.

The data moments as well as their counterparts simulated from the model are reported in Panel C of Table 2. The SMM estimation works reasonably well, as it closely matches most of these moments except the variances of investment and external financing. It is common for firm characteristics simulated in structurally estimated models to have lower variations than their counterparts observed in the actual data. More importantly, the moments we choose to match are able to identify the estimated parameters except for the fixed financing cost parameter ϕ_f, evidenced by the small standard error of each parameter. In fact, all estimated parameter values except for ϕ_f are different from zero at the significance level of 1%.

Before we study the marginal value of cash, which is the focus of the paper, we explore how the investment and cash holdings vary with the state variables in the model at the baseline estimated parameter values. Figure 2 plots the model-implied optimal investment-to-capital ratio (i/k) against the beginning-of-period capital (k), with the beginning-of-period cash holdings (h) fixed at the sample median, and against cash holdings (h), with the level of capital fixed at the sample median. The optimal end-of-period cash-to-assets ratio ($h'/(k+h)$), is plotted against the current capital (k) and cash holdings (h), respectively, in a similar fashion. Optimal i/k and $h'/(k+h)$ at high and low productivity levels are plotted in red dotted lines and blue solid lines, respectively.

First, as we expect, the investment rate increases with productivity and decreases with current capital level due to the assumed decreasing-return-to-scale production function. When the productivity level is high, the investment rate does not change with the level

[16]The estimates suggest that on average, the manager diverts 0.78 basis points from one dollar of cash flow or cash stock and is awarded by about one cent for each dollar of operating profit generated. These estimates are similar to those estimated by Nikolov and Whited (2014).

of cash holdings given the current capital level, because internal funds are sufficient. In contrast, when the productivity level is low and internal funds are not enough to support the desired level of investment, the investment rate increases with the level of cash holdings. Second, with the current cash holdings fixed, the optimal cash-to-assets ratio $(h'/(k+h))$ decreases with productivity and capital. Firms with higher productivity and capital have higher internal funds and optimally choose to hold less cash. Lastly, with capital held fixed, the optimal cash-to-assets ratio $(h'/(k+h))$ initially increases with the current cash holdings, and less productive firms hold more cash than the more productive ones as they do not generate as much cash flow. When current cash holdings are large enough, firms are no longer constrained, and the optimal cash holdings stay at the unconstrained optimal level. Consequently, the optimal cash-to-assets ratio decreases, and there is an overall hump-shaped relationship with current cash holdings.

4 Results

In this section, we discuss the caveats of the existing measure of MVC and propose our own measure. We study the relationship of our measure of MVC with various firm characteristics, compute the marginal value of cash for each firm-year observation based on our measure, and explore the properties of the sample MVCs.

4.1 Common Methodologies for Estimating MVC

One of the most commonly used methods for estimating MVC in the literature is proposed by Faulkender and Wang (2006) and is the regression coefficient on changes in cash holdings in the following regression (adapted to our setting):

$$r_{it} - R_{it}^{B} \quad = \quad \gamma_0 + \gamma_1 \frac{\Delta h_{it+1}}{P_{it-1}} + \gamma_2 \frac{i_{it}}{P_{it-1}} + \gamma_3 \frac{d_{it}}{P_{it-1}} + \gamma_4 \frac{\Delta D_{it}}{P_{it-1}} + \gamma_5 \frac{h_{it}}{P_{it-1}}$$

$$+\gamma_6 \frac{h_{it}}{P_{it-1}} \times \frac{\Delta h_{it+1}}{P_{it-1}} + \varepsilon_{it} \tag{11}$$

where $P_{it-1} \equiv V_{it-1} - d_{it-1}$ is the market equity (i.e., stock price times number of shares outstanding) at the end of period $t-1$; d_{it} is the net cash flow to investors, which equals dividend payout D_{it} if $d_{it} \geq 0$ and equals negative of equity financing if $d_{it} < 0$; r_{it} is the stock return of firm i for period t, defined as V_{it}/P_{it-1}, R^B_{it} is the return on one of the 25 Size/BM portfolios to which stock i belongs at t; h_{it+1} is the cash stock at the end of period t, and i_{it} is the investment made in period t.[17] Other control variables used in Faulkender and Wang (2006), including interest expense, market leverage, and R&D, are absent in the simulated data. Next, we use simulated data to illustrate that regression (11) is misspecified, and what is the economic meaning of γ_1.

4.1.1 The dependent variable in (11)

The correct dependent variable in regression (11) should be the capital gain during period t, defined as P_{it}/P_{it-1}, instead of the realized return, V_{it}/P_{it-1}, which includes both capital gain and dividend yield. The empirical measure of MVC in regression (11) is analogous to a partial derivative of V_{it} with respect to h_{it+1}. Assuming that cash holding h_{it+1} is optimally chosen, the first order condition implies that

$$\frac{\partial V_{it}}{\partial h_{it+1}} = -\frac{\partial B_{it}}{\partial h_{it+1}} - \frac{\partial S_{it}}{\partial h_{it+1}} = -(1+r)(\lambda_b + \lambda_s)\,, \tag{12}$$

which equals zero in the absence of agency costs. In fact, our model framework implies

$$\frac{\partial P_{it}}{\partial h_{it+1}} = \frac{1}{1+r}\mathbb{E}_t\left[\frac{\partial V_{t+1}}{\partial h_{t+1}}\right] = \lambda_f\,,$$

[17] We label the cash stock at the end of period t as h_{it+1} to be consistent with the convention used in the model.

where $P_{it} \equiv V_{it} - d_{it}$. Therefore, if a linear regression is used to measure MVC, the correct dependent variable, scaled by lagged market value, should be the realized capital gain during period t, not the realized return. A dollar saved for the future raises current market value, but lowers dividend payments — the net effect on *firm value* or returns inclusive of dividend yield is zero (or negative, when agency costs are present).

The fact that the dividend yield, d_{it}/P_{it-1}, is one of the control variables alleviates this problem but cannot completely solve it. Since the dependent variable is firm i's return adjusted using the return on one of the 25 Size/BM portfolios to which stock i belongs at t, the average dividend yield of benchmark portfolio also has to be included in the set of control variables. Table A.2 in the Appendix shows that the regression coefficients are larger when we replace the adjusted return with adjusted capital gain of firm i as the dependent variable.

4.1.2 The economic meaning of γ_1

If regression (11) cannot generate the true value of MVC in the data, what does the value of γ_1 represent? Notice that the value of γ_1 remains the same if we replace the regressor $\Delta h_{it}/P_{it-1}$ of regression (11) by E_{it}/P_{it-1}, which is the earnings in period t and corresponds to the earnings before interest and extraordinary items in Faulkender and Wang (2006). This is due to the cash flow identity $E_{it} = d_{it} + \Delta h_{it+1} + i_{it}$. The r.h.s. of this identity is the use of funds while the l.h.s. is the amount of cash flows firm i generates in period t.[18] Thus, with other items of the identity held fixed, there is a one-to-one correspondence between change in cash holdings and earnings or cash flows. We argue below that the coefficient γ_1 captures the increase in firm value per unit of increase in cash *flow*, not cash *holdings*.

We demonstrate this by using 100 simulated panels, each with 5,000 firms and 30 years, based on the model solution under the parameterization reported in Table 2. Regression (11)

[18] Faulkender and Wang (2006) use changes in earnings as one of the control variables. To illustrate the equivalence between using changes in cash holdings and using earnings as a regressor in regression (11) due to the cash flow identity, we control for lagged earnings instead.

is estimated for each simulated panel and the coefficients are averaged across the simulations. We present the results in Table 3, where the first column conducts the FW regression (11) and the second column replaces the change of cash stock in regression (11) with earnings. As expected, the two coefficients are identical.

We then verify this intuition using the actual data. The results are presented in Table 4, and the details about the data construction and definitions are provided in Appendix F. in Column 1 of Table 4 replicates the baseline regression of Faulkender and Wang (2006) (i.e., Column I of their Table II) using our sample. In Column 2 of Table 4, we replace the change in net assets with the implied investment inferred from the cash flow identity, where the other variables in the identity are constructed using the data items from the balance sheet.[19] We also replace net financing with that constructed using the balance sheet data. These substitutions are needed because the FW regressors do not exactly match the items in the cash flow identity, although they are economically similar.[20] Column 2 shows that with such substitutions, the coefficient of $\Delta Cash_t$ is very close to that from the FW regression (i.e., Column 1). In Columns 3 and 4, we do the substitutions alternately for the change in net assets and net financing, and the results are similar. These findings provide support for the use of the variables from the cash flow identity in the framework of the FW regression.

The key result is in column (5), where we show the difficulty of identification in the FW approach due to the cash flow identity. We repeat the regression in Column 2 except that change in cash stock is replaced with cash flow. The regression coefficient of cash flow is very close to that of $\Delta Cash_t$ in Column 2.[21] Therefore, it is problematic to interpret the coefficient of $\Delta Cash_t$ in the FW regression as the MVC. Moreover, this problem cannot be

[19] Alternatively, we can construct the variables in the cash flow identity using the data items from the statement of cash flow. In Appendix F, we show that this alternative specification gives rise to similar results.

[20] In particular, change in net assets basically attempts to control for the effect of investment but Faulkender and Wang (2006) do not use investment directly.

[21] There are two reasons for the slight difference: First, due to noises and errors, the cash flow identity does not hold 100% in the actual data. Second, the FW regression controls for the change in dividend, which imposes a constraint that essentially requires the contemporaneous dividend payout and the lagged dividend payout to have the same coefficient in the regression.

solved by including cash flow as a control variable because of multicollinearity.

In sum, γ_1 in the FW regression (11) should be better interpreted as the increase in firm value per unit of increase in cash *flow*, controlling for other firm characteristics, rather than the MVC. The reason is that cash flow (an indicator of productivity) proxies a state variable, while change in cash holdings is a choice variable. If we assume that the level of cash holdings is chosen to maximize firm value, then as shown in Eq. (12), changes in cash holdings should lead to zero changes in firm value because of the first order condition of value maximization.[22]

Based on our interpretation, γ_1 will increase with the persistence of the cash flow shock because changes in firm value reflect the expected changes in all future cash flows, not just the current one. Higher persistence means that the shock will lead to larger changes in future cash flows. In contrast, the MVC has no obvious directional dependence on the persistence of the shock. In particular, the MVC is likely to decrease with cash flow persistence if the shock is positive because of relaxed financial constraint but increase if the shock is negative.

We first use the simulated data from our model to confirm this conjecture. Specifically, we estimate γ_1 using the simulated data under three parameterizations: $\rho = 0.676$ (baseline), $\rho = 0.3$, and $\rho = 0.0$, respectively, while the rest of parameters are at their baseline values. Since we can compute the true MVC for the simulated data, we also compare the average MVC with γ_1.

For the results, we refer back to Table 3. We simulate 100 panels, each with 5,000 firms and 30 years, under the aforementioned three specifications. Several observations emerge. First, the value of γ_1 increases with the persistence of the productivity shocks. Under the baseline estimation of $\rho_z = 0.676$, γ_1 is 3.094 and it decreases to 1.300 and 0.939 as ρ_z becomes 0.3 and zero, respectively. Note that zero persistence means that the shock only

[22]In presence of agency costs, managers do not choose the level of cash stock to maximize firm value, but their own utility. Under this scenario, a change in cash stock leads to zero changes in the manager's utility at the optimal level of cash stock, but a nonzero change in firm value, which equals the negative of the increase in manager's wealth from bonus and diversion per $1 increase in cash stock.

affects the current cash flow and \$1 increase in cash flow should lead to \$1 increase in firm value less marginal agency costs, consistent with $\gamma_1 = 0.939$. Second, the value of γ_1 does not equal the true average MVC to outside investors in the sample, i.e., λ_f. In fact, the average λ_f is less than one in all three specifications due to agency costs, while γ_1 is greater than one in columns (1) and (3). Last but not least, there is no clear relationship between the persistence of the productivity shock and the MVC to investors, consistent with our conjecture. Note that regressions coefficients in Table 3 are highly significant and the R-squared is close to one because firms are homogenous in the simulated data and the firm characteristics included in the regression can explain almost all the variations of firm value in the model.

Second, we test the positive relation between γ_1 and cash flow persistence using the actual data and the results are presented in Table 5. We estimate the persistence of productivity shock (i.e., ρ) at the firm level in a rolling window of 10 years, following the method similar to that described in Appendix B. We add to the baseline regression of Faulkender and Wang (2006) a dummy variable $I_{\{High\ \rho\}}$ that equals one if ρ is greater than the sample median and zero otherwise and the interaction term between change in cash holdings ($\Delta Cash$) and this dummy variable. Column (2) of Table 5 indicates that the market values of high-ρ firms are significantly more sensitive to change in cash holdings than those of low-ρ firms, with the difference being 0.102 (s.e.=0.0403). The same result is found when net financing is constructed using the balance sheet data, as shown in Column (4).

In sum, the evidence in Tables 3 and 5 confirms our argument that the coefficient on changes in cash holdings in regression (11) measures the increase in firm value per \$1 increases in cash flow, instead of the marginal value of cash. Next, we propose our measure of MVC based on the approach of structural estimation.

4.2 MVC Based on Structural Estimation

In this subsection, we study how MVCs are related to state variables in the model, impute the MVC for each firm-year observation in the sample given the observed values of its corresponding state variables, and explore the properties of the sample MVCs.

4.2.1 Comparative statics: MVC and firm characteristics

Before we impute the empirical MVC for each firm-year observation, we first discuss the relationship between the MVCs and the state variables based on the model solution. In Panel A of Figure 3, we plot the gross MVC (λ_u), the deductions in MVC due to bonus (λ_b) and due to diversion (λ_s), and the net MVC (λ_f) against capital (k) for firms with low and high levels of productivity, with cash holdings fixed at the sample median. Similar plots of these MVCs against cash holdings (h), with capital level fixed at the sample median, are provided in Panel B.

A few features of these relationships are worth discussing. First, all else being equal, firms with higher productivity, higher capital level, and higher cash holdings incur lower costs of external financing and thus have lower λ_u, which measures the marginal value of cash in the absence of agency costs. These firms have ample internal funds, either from existing cash holdings or from operating cash flow, and are less likely to raise external financing. Consequently, cash is less valuable to them and MVC is lower.

Second, losses in marginal value of cash due to bonus (λ_b) and due to diversion (λ_s) initially increase and then decrease with capital, given the level of cash holdings. Based on the definition, we can write:

$$\lambda_b = \frac{\xi}{\kappa}\frac{\partial}{\partial h_{t+1}}\mathbb{E}_t\left[\sum_{s=0}^{\infty}\frac{\pi_{t+1+s}}{(1+r)^{1+s}}\right], \text{ and } \lambda_s = \frac{s\lambda_b}{\xi} + \frac{s}{\kappa}\frac{\partial}{\partial h_{t+1}}\mathbb{E}_t\left[\sum_{s=0}^{\infty}\frac{h_{t+1+s}}{(1+r)^{s}}\right].$$

Due to bonus and diversion, a part of the firm's operating profits, given by $\pi_t = e^{z_t}k_t^{\alpha} - c_f - c_l k_t$, goes to the manager, which reduces the marginal value of cash to shareholders, λ_f. λ_b

and λ_s measure the manager's marginal private benefits from bonus and diversion. Both λ_b and λ_s are larger if one additional dollar of cash leads to higher investment, which leads to higher future profits and thus higher marginal private benefits for the manager. When the current capital stock is extremely low, the firm's internal funds are scarce and it has to raise external financing to cover operating and investment costs. Given the fixed and linear costs structure of external financing, an additional dollar of cash is used to lower the amount of external financing and does not increase the level of investment, resulting in low λ_b and λ_s.

As capital increases and internal funds are more likely to be sufficient, the likelihood of raising external financing goes down, evidenced by the negative relationship between λ_u and capital. The capital stock enters a range in which the MVC exceeds one, but either no external finance is raised because the smaller financing gap does not justify incurring the fixed costs of issuance, or because the MVC is lower than one plus the per unit deadweight cost of finance. In this range, additional cash results in additional investment, so the λ_b and λ_s are high. Because the likelihood of falling into this region gets larger as capital and productivity increase, λ_b and λ_s initially increase with productivity. As capital increases further, more firms have enough internal funds to invest, and the MVC falls to 1. An additional dollar of cash is less likely to be invested, and λ_b and λ_s fall. λ_b and λ_s start to decrease with productivity because higher productivity means higher internal funds and lower likelihood that investment is constrained.

Since the net MVC (λ_f) is λ_u minus marginal losses due to agency costs, the relationship between λ_f and capital is an inverted hump shape. λ_f no longer monotonically decreases with firm size, measured by k, due to agency costs. A larger firm can have a higher MVC than a smaller firm. In addition, λ_f can be higher for more profitable (productive) firms when firm size is large enough due to lower agency losses.

Third, λ_b and λ_s decrease with cash holdings (h) and productivity, given the level of capital. The reason is that higher cash holdings and higher productivity lower the likelihood that investment is constrained by internal funds, and one additional dollar of cash is thus less likely to increase manager's marginal private benefits. As a result, λ_f increases with cash holdings and productivity due to agency costs. Note that the literature generally argues that agency costs are higher for firms with larger amounts of cash holdings due to the free cash flow problem (Jensen, 1986). In contrast, our model shows that at our estimated parameter values, λ_b and λ_s decrease and λ_f increases with cash holdings.[23] Therefore, private benefits due to diversion alone will not incentivize the manager to hoard cash.

To summarize, the gross MVC (λ_u) decreases in (a) productivity (high versus low subgroups) (b) capital and (c) cash holding, with the other two held fixed, consistent with our intuition. However, due to lower marginal agency costs, the net MVC or MVC to shareholders λ_f increases in cash holdings and productivity. Moreover, when firm size is sufficiently large, λ_f could increase with firm size (productivity), with cash holding and productivity (firm size) held fixed, again because marginal agency costs decrease. The above comparative statics analysis explores the relationship between MVCs and one of firm characteristics while holding others fixed. However, firm characteristics are correlated in the data due to endogeneity. Next, we impute the MVCs for each firm-year observation in our sample based on the estimated model and explore the properties of the sample MVCs.

4.2.2 Properties of the sample MVCs

For a parameterized model, we can impute the MVC for any given triplet of state variables. Among the triplet, we observe capital and cash holdings of each firm in every fiscal year. Moreover, we can impute the firm-year productivity shock based on sales under the assumption of a Cobb-Douglass production function. Therefore, we construct the firm-year MVC in three steps: (1) estimate the model parameters to match the moments of the data sample; (2) construct the mapping between the MVC and the three state variables under the

[23] One might argue that the manager has incentive to hoard cash instead of paying it out because she can divert s fraction of the cash holdings next period as private benefits. Consequently, λ_s could increase with cash holdings. However, the manager in our model will never do so because the estimated s is too small to compensate for the tax loss on interest earned, i.e., $s/\kappa < \tau r$.

estimated parameters; (3) for every firm-year observation, impute the MVC corresponding to its triplet of state variables based on the mapping in Step (2).

Following the aforementioned three steps, we construct the firm-year MVCs for the sample between 1991 and 2017. Their distributions are plotted as histograms presented in Figure 4. First, gross MVC (λ_u) mostly has a value of either one or one plus the cost of per dollar external financing, which is 2.6 cents in our baseline estimation. λ_u reflects the firm's cost of financing in our model, which is one when the firm does not raise external funds, is $1 + \phi_l$ when it pays out, or is any number larger than one when firm neither pays out nor raises external financing. This last scenario occurs 48 times out of the 14,283 firm-year observations in our sample. Their distribution can barely be seen from Figure 4 due to the small sample size and is shown separately in Figure A.1 in the Appendix. The average λ_u of these 48 observations is 1.0367, which is larger than the average of the full sample, 1.0184. Second, the average deductions in marginal value of cash due to diversion and bonus are 0.0085 and 0.0048, which are relatively small compared to the cost of per dollar external financing. However, the distributions of λ_b and λ_s have long right tails, indicating that agency conflicts are severe for some firms. Lastly, the distribution of the net MVC (λ_f) is bimodal because of the binary nature of λ_u.

Next, we explore the relationship between the firm's characteristics and its imputed MVC in the sample. At the end of each fiscal year t, we sort firms based on their size (k, measured by PP&E), cash-to-assets ratio, investment-to-capital (i/k) ratio, market-to-book (MTB) ratio, and net payout-to-assets ratio into three groups (Low, Medium, and High) based on the 33rd and 67th percentiles of the respective distributions, and compute the year t average gross MVC (λ_u), deductions from MVC due to bonus (λ_b) and diversion (λ_s), and the net MVC (λ_f) within each group. Table 6 presents the MVCs of each subgroup (for ease of comparison and presentation, the numbers are in percentages).

Several patterns emerge. First, consistent with the comparative statics analysis of section (4.2.1), λ_u decreases with firm size while λ_b and λ_s exhibit a hump-shaped relationship, and

λ_f exhibits an inverted hump-shaped one, with firm size. This result highlights the importance of agency costs in the relationship between MVC and firm size. Second, consistent with the comparative statics analysis, firms that hold more cash indeed have smaller λ_s and λ_b. However, opposite to the comparative statics analysis, firms with higher cash holdings incur larger costs of external financing and have higher λ_u. This result highlights the endogenous feature of the cash holdings choice. Firms that have higher financing costs and those that foresee higher investment needs in the future will optimally choose to hold more cash. For the same reason, λ_u is higher for those firms. With higher financing costs and lower agency costs, firms with higher cash holdings have higher marginal value of cash λ_f.

Third, consistent with our intuition, λ_u and λ_f monotonically increase with investment-to-capital, market-to-book, and external financing-to-assets ratios. Firms with higher growth potentials, proxied by the investment-to-capital and market-to-book ratios, have higher needs for capital and thus have higher MVC. Financing is more costly and thus cash is more valuable for firms that raise more external financing. Although agency problems do create a wedge between λ_u and λ_f, financial constraint plays a more important role in shaping the relationship between MVCs and firm's investment-to-capital, market-to-book, and external financing-to-assets ratios than agency problems do in the real data.

Lastly, firms with higher payout-to-assets ratio incur higher financing costs and thus have higher λ_u. They also have lower marginal agency costs of cash and have lower λ_s and λ_b, and consequently, have higher λ_f. Later we show that this result is driven by the phenomenon that a significant portion of firms who pay out also raise external funds at the same time. This result contradicts our model's implication that value maximizing cash/payout policy cannot be associated with firms simultaneously raising external financing and paying out cash. However, if this were to happen (perhaps because there are some unmodelled benefits from payouts or because firms are pressured into paying out cash even when MVC is high), the marginal value of cash is still determined by the marginal cost of external finance and our MVC measure is still valid.

4.2.3 Dynamic relationship between MVCs and firm characteristics

In this subsection, we explore how firm characteristics and MVC change over time. Specifically, at the end of each year, we sort firms into three groups (Low, Medium, and High) based on the 33rd and 67th percentiles of the sample distribution of one of the five firm characteristics: capital stock, cash-to-assets ratio, investment-to-capital ratio, market-to-book ratio, and external financing-to-assets ratio. We then track the dynamics of eleven group characteristics of the Low and High groups for the $[-3, 3]$ window surrounding the group formation year: average net and gross MVCs (λ_f and λ_u), and the deductions in MVC due to bonus (λ_b) and due to diversion (λ_s), total factor productivity (TFP), marginal productivity of capital (MPK), capital (PP&E), cash-to-assets ratio, investment-to-capital ratio, external financing-to-assets ratio, and payout-to-assets ratio. Figures 5 to 9 present the 7-year dynamics of these eleven characteristics for groups sorted on the five firm characteristics.[24]

MVC & Size — Figure 5 demonstrates the evolution of firm characteristics in the low and high capital-stock groups over a 7-year period surrounding the group formation year. Although firms with larger capital stock experience higher productivity shocks (TFP), their marginal productivity (MPK) is lower because the stock of capital is high. As a result, larger firms invest at a lower rate, raise less external financing, and payout more. Consistent with their low investment and financing demand, larger firms tend to have lower cost for external financing, as inferred from their lower gross MVC (λ_u). Moreover, our results also show that firms with high stock capital tend to have lower marginal agency costs, indicated by lower λ_b and λ_s. Consequently, the net MVC (λ_f) is higher for larger firms despite their lower financing cost. This result echoes the finding reported in Table 6 and can be explained by our comparative statics analysis in Section 4.2.1.

MVC & Cash holdings — Figure 6 examines how firm characteristics in the low and

[24]For each event, only firms that are present during the entire 7-year period centering around the event year are included in the sample. Therefore, the sample used in Figures 5 to 9 is different from the full sample used in Table 6, resulting in slightly different firm characteristics reported in these figures and in Table 6. However, the general patterns are the same.

high cash-to-assets-ratio groups evolve over a 7-year period centering at the group formation year. It shows that the high-cash firms start to accumulate cash at a higher rate at least five years prior to the group formation and the accumulation slows down after their cash-to-assets ratio reaches peak in the event year. These high-cash firms tend to be much smaller than the low-cash group and have consistently higher MPK. As a result, they also invest at a higher rate throughout the 7-year period. External financing contributes largely to the increase in cash holdings, which also drops significantly when cash accumulation slows down after the event year. Because of higher investment needs, cash is more valuable (for both managers and outside investors) of high-cash firms, i.e., gross and net MVC are both higher. In addition, losses in the marginal value of cash due to bonus and diversion (prior to event year) are lower because additional cash substitutes for costly external financing. After the event year, as external financing decreases and investment falls, high cash firms also pay out more.

MVC & Investment — Figure 7 examines how firm characteristics in the low and high investment-to-capital-ratio groups evolve over time. The high-i/k group has higher i/k ratio, TFP level, and MPK during the entire 7-year period than the low-i/k group. All the aforementioned three characteristics of the high-i/k group reach a peak in the event year. The high-i/k firms tend to be smaller but grow rapidly. They raise more external financing, accumulate cash at a faster rate, and pay out less. Not surprisingly, cash is more valuable to these firms. This result is consistent with our comparative statics analysis in Figure 3 and the summary statistics of sample MVCs in Table 6.

MVC & MTB — Figure 8 shows the evolution of firm characteristics in the low and high market-to-book-ratio groups. Consistent with our intuition, high-MTB firms have higher productivity, MPK, and investment rate. Thus they hold more cash and raise more external financing, given their larger need for capital. As a result, the marginal values of cash for firm and manager are higher for high-MTB firms (λ_b and λ_s are lower because additional cash goes to replace costly external financing).

MVC & External financing — Figure 9 shows how firm characteristics in the low and high external financing-to-assets-ratio groups evolve over time. Consistent with our intuition, high external financing firms have higher productivity, MPK, and investment and thus are more in need of funds. Given the need of funds, they also hold more cash. Consequently, cash is more important to these firms and their λ_u and λ_f are higher. Interestingly and counter-intuitively, firms that raise more external financing also pay out more, which is consistent with the finding in Table 6 that high payout firms have high marginal value of cash. We investigate firm's payout behavior in details in Section 4.2.4.

Overall, size, cash stock, investment rate, MTB, and external financing-to-assets ratio are persistent firm characteristics. The differences in these sorting variables and, more importantly, in the marginal values of cash between the corresponding High and Low groups stay quite stable throughout the 7-year period.

4.2.4 MVC and payout

Table 6 shows that high payout firms have higher marginal value of cash, and Figure 9 indicates that a significant portion of high payout firms raise external financing. In our model, firms would never pay out and raise external financing at the same time. There are two possible reasons why they might do so in reality. First, firms might be pursuing value-maximizing payout and financing policies, but there could be benefits from payouts that are not included in our model–for example, signaling the soundness of a firm's financial condition. Second, firms' payout and financing policies are not value maximizing and firms pay out cash in response to external pressure, even when they need to raise external financing. In this section, we explore this phenomenon in more detail.

Each year for the period between 1993 and 2017, we sort firms into three groups (Low, Medium, and High) based on the 33rd and 67th percentiles of the sample distribution of payout-to-assets ratio at each fiscal year-end and compute the average gross MVC (λ_u), reductions in MVC due to bonus (λ_b) and diversion (λ_s), net MVC (λ_f), capital (PP&E),

cash-to-assets, investment-to-capital (i/k), external financing-to-assets (EF-to-assets), and payout-to-assets (PO-to-assets) within each group. Figure 10 plots the time-series differences in these firm characteristics between the High and Low groups in blue lines and the 95% confidence interval in dotted lines.

Figure 10 indicates that there were significant changes to the behavior of high payout firms relative to the low payout firms around year 2000. Before 2000, high payout firms raised less external financing, invested less, and held less cash compared to low payout firms. Moreover, these differences were in general significant at the 5% significance level. However, these differences became close to zero and insignificant after 2000. Lastly and most importantly, high payout firms indeed incurred lower external financing costs before 2000, evidenced by their lower λ_u, compared to low payout firms, although the difference is insignificant. However, after 2000, high payout firms have significantly higher λ_u reflecting that they incurred higher external financing costs. Throughout the sample period, differences in λ_s and λ_b are small and insignificant between high and low payout firms. As a result, the difference in λ_f exhibits the same time trend as the difference in λ_u. In general, the comparisons of high vs. low payout firms before 2000 are consistent with our intuition, i.e., high payout firms raise less external financing, have less investment opportunities, and cash is less valuable. However, the post-2000 picture seemingly goes against intuition.

The implication that, post-2000, the high payout firms raise external financing more often than the low payout firms, echoes the findings of a recent paper (Farre-Mensa et al., 2021).[25] These authors find that over 40% of firms that pay out cash also raise external financing in the same year, and this trend has increased sharply since 2003. Most of this payout is discretionary payout via share repurchases, and is not explained by aversion to dividend cuts that might trigger concerns about the firm's financial soundness.

[25]This implication may not be apparent from the fact that external financing scaled by assets is similar for the two groups post-2000. However, this is explained by the fact that the high payout firms are larger than the low payout firms throughout the period — as shown in the figure. The larger denominator of the external financing ratio masks the fact that the high payout firms become more reliant on external financing.

What explains this phenomenon? Information asymmetry-related signaling benefits of payouts should be less relevant for larger firms, and as the figure shows, the high payout firms are larger than the low payout firms throughout the sample period. Moreover, if firms' payout and financing policies are value maximizing and there are signaling benefits of payouts, it is not clear why the phenomenon of paying out cash while at the same time raising costly external financing becomes more important after 2000— if anything, with the share of professional investors increasing in the U.S. markets over time, the opposite should be expected. Based on the evidence, we conjecture that a plausible reason for the change of payout behavior in the last two decades is pressure from activist shareholder to pay out cash.

In recent years, shareholder activists, especially hedge fund activists who emerged after 2000s and became increasingly important, have played an important role in corporate governance. They actively intervene in target firms' operations, policy making, and corporate governance practices. Presumably, their interventions aim to unlock firm value in underperforming firms that can be associated with various management and governance problems. A large cash stock often makes a company a target of hedge fund activism campaigns. Facing the threat of shareholder activists, managers might voluntarily pay out more to avoid becoming a target to protect their control of the firm.[26]

Hedge fund activists' demand to distribute "excess" cash echoes the concern about managerial misuse or abuse of corporate resources due to the "free cash flow problem" (Jensen, 1986). The underlying assumption is that firms with high cash holdings are more likely to misuse the cash. Forcing firms to payout will reduce agency costs and increase firm value. However, as we show in Table 6 and Figure 6, agency costs are lower and cash is more valuable for high-cash firms because they optimally choose to hold more cash when they face higher financing costs and foresee higher financing needs in the future. If firms are forced to

[26]See, for example, "As Activism Rises, U.S. Firms Spend More on Buybacks than Factories" (The Wall Street Journal, May 26, 2015).

pay out more or voluntarily do so to avoid becoming a target of shareholder activists, many firms will choose to pay out and raise external financing at the same time. Consequently, these high payout firms bear high financing costs and have high marginal value of cash as shown in 10. Our results thus question the rationale of shareholder activists' agenda of targeting firms with high cash holdings.

5 Applications

In this section, we use two natural experiments to validate our measure of marginal value of cash and our estimation. In the first experiment, we classify firms affected by the American Jobs Creation Act (AJCA) of 2004 into two groups based on whether they did or did not repatriate foreign earnings. Groups that repatriated foreign earnings are considered to have greater need for cash. We examine whether the MVC estimates for these groups are consistent with their "revealed" need for cash. In the second experiment, we estimate two subsamples ("before" and "after") for the same set of firms in industries that were subject to major tariff cuts, to see whether our estimation can detect differences in agency costs and MVC following exogenous changes in industry competition.

5.1 MVC and the decision to repatriate foreign earnings under the AJCA

The American Jobs Creation Act (AJCA) of 2004 provided a temporary tax break for firms by lowering the repatriation tax rate from 35% to 5.25% for multinational U.S. firms that had earnings held by foreign subsidiaries. Xu and Kim (2021) identify a group of firms who repatriated foreign earnings under the AJCA in 2004 and after, and a group of firms who discussed repatriation of foreign earnings under the AJCA in their 10-K but did not repatriate. Firms in both groups are required to have positive foreign earnings during the previous 3 years before 2004. We expect that the first group of firms would have a higher marginal value of cash than the second group during 2004-2007, the period during which firms' forward-looking marginal values of cash could affect the decision of repatriation.[27] We also examine the 2001-2004 period, immediately before the Act, and expect similar results.

We impute the MVCs of these two groups of firms and the results are reported in Table 7.[28] Consistent with our intuition, for the 2004-2007 period, the average gross MVC (i.e., the MVC for managers, who make corporate decisions), is significantly higher for firms who repatriated foreign earnings under the AJCA than that for firms who could but did not, with the t-value of the difference being 2.28. The net MVC is also significantly higher. For the 2001-2004 period, the gross MVC for the group that repatriated is higher, but not statistically significant. However, the net MVC for that group is again significantly higher.

Figure 11 plots the average gross MVC (λ_u), deductions in MVC due to bonus (λ_b) and diversion (λ_s), and net MVC (λ_f) for each year of the seven year period between 2001 to 2007. It shows that firms who repatriated foreign earnings consistently have higher gross and net marginal values of cash for manager and for firm than firms who did not during the period around the AJCA, especially after 2004. In sum, all the above evidence shows that our imputed MVCs correctly reflect the value of cash to firms' managers who make corporate decisions.

5.2 Subsample estimation: groups before and after tariff cuts

Dasgupta et al. (2018) examine the effects of competition shocks induced by major industry-level tariff cuts, and find that tariff cuts are followed by forced turnovers in poorly governed firms. Tightening of disciplinary mechanisms should result in lower diversion. Therefore, we expect the parameter s and the estimated λ_s to be lower following industry tariff cuts

[27] The MVCs after the Act are likely to reflect managerial anticipations of the marginal value of cash. However, to the extent repatriations happen and reduce the need for cash, looking at the 2004-2007 period biases against finding the expected results.

[28] We thank Qiping Xu and Taehyun Kim for providing us the data.

in the affected industries. Moreover, we expect that the marginal value of cash to become higher after tariff cuts because firms often respond to those shocks by increasing R&D and advertising expenses to improve the competitiveness of their products, all of which increase the need for external financing and make cash more valuable.[29]

We combine our sample with the data from Dasgupta et al. (2018) to identify the treated firms as follows. An event year for a 4-digit (SIC) industry is defined as the year during which at least one major tariff cut happens for the given industry.[30] An event window includes three years before and three years after the event year. If there are multiple major tariff cuts within less than three years in the same industry, we merge those events into one event and make the first event year as the event year for these serial events, and extend the post-event period to three years after the second event.

We conduct separate estimations for two groups of firms: firms in the subsample before the event time (170 observations), and firms in the subsample after the event time (388 observations).[31] Given the small number of observations, we estimate the diversion parameter s and the bonus parameter ξ only. For the rest of the parameters, managerial ownership uses the subsample average and the others take the values from the full sample estimation. Table 8 reports the estimated parameter values for these two subgroups and statistics of the imputed marginal values.

Several observations emerge. First, estimated diversion parameter s and bonus parameter ξ in all two subgroups are positive and highly significant. Second, there is a large drop in the magnitude of diversion parameter s after tariff cuts, from 0.0623 ‰ to 0.0400 ‰, and

[29]The implications regarding the bonus parameter ξ are somewhat ambiguous. If managers are being over-compensated via bonus payments, we would expect the bonus parameter to decrease after tariff cuts. However, bonus payments can also be part of incentive pay. Dasgupta et al. (2018) find that for retained managers in good governance firms, incentive pay increases following tariff cuts.

[30]Following Frésard (2010) and Dasgupta et al. (2018), we identify a specific industry-year to experience a major tariff cut if the tariff rate of this industry is reduced by more than three times of the median tariff cut in the industry over the sample period. We exclude tariff cuts that are recovered by equivalently large increases in tariff rates within the subsequent three years.

[31]The same set of firms are included in the before- and after-tariff-cuts subgroups. The number of observations are different because the number of years in the before- and after-event periods are different.

the different is highly significant with a t-value of -4.81. In terms of the loss in MVC due to diversion, λ_s decreases significantly from 0.0035 to 0.0027 with the t-value of the change being 2.86. These results indicate significant reduction in agency costs due to managerial diversion after tariff cuts. Third, the change in the bonus parameter ξ is very small, being -0.02% with $t = -0.18$, after tariff shocks. Fourth, the average gross MVC increases significantly after tariff cuts, with the t-value of the change being 2.30. This result is consistent with our intuition that responses to more intense competition generally make cash more valuable. Interestingly, however, the net MVC does not increase – even with the bonus parameter ξ slightly going down, the marginal value from an additional dollar of cash going to the manager in the form of bonus increases and the net MVC falls slightly (though not significantly). The overall results from this subsample analysis confirm that our parameter estimates and the imputed marginal values of cash are largely consistent with the economic mechanisms that they intend to capture.

6 Conclusion

Companies can accumulate cash for both "good" reasons and "not-so-good" reasons. Managers, and not shareholders directly, make decisions on cash policies and so self-serving managers can build up cash to pursue private benefits. On the other hand, precautionary cash savings can be valuable for shareholders. A lack of clarity on this issue has often made companies targets of hostile takeover attempts, of shareholder activism, and may have distorted corporate policy.

The marginal value of cash, i.e., the additional value that the last dollar of cash created for shareholders, should be a good indicator of whether cash is being put to good use. It is precisely this concept that has stimulated a great deal of research on estimating the marginal value of cash – in particular, the extent to which it deviates from the benchmark of $1 based on the quality of corporate governance, or financial constraints. One troubling feature of the methods used to generate these estimates is that they are not well-grounded in theory. They also often generate very large deviations from the $1 benchmark.

In this paper, we first show why existing methods fail to correctly estimate the marginal value of cash. Next, based on a model due to Nikolov and Whited (Nikolov and Whited (2014)), which allows managerial agency problems to affect corporate policy, we formalize the concept of the marginal value of cash or MVC. We structurally estimate the model parameters which allows us to estimate the MVC in the real data. Our estimates of MVC imply much smaller deviations from the $1 benchmark but are nonetheless highly informative in terms of how the MVC is related to corporate policy outcomes such as the stock of cash holdings or capital (i.e., firm size), variables related to the firm's environment such as growth opportunities, and regulation. Some of the novel findings are that (i) larger and more profitable firms could have higher MVCs because they suffer lower losses in MVC due to bonus payments to managers and diversion, (ii) firms with higher cash-to-assets, growth opportunities, and investment ratios have higher MVCs, because these firms have higher financing needs, and (iii) high payout firms have high MVCs on average, especially after 2000, because these firms also have high financing needs and simultaneously raise external financing.

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Table 1: Summary Statistics

The table reports summary statistics for the main variables used in the estimation. The sample covers the firm-year observations in the Compustat and ExecuComp databases between the years 1993 and 2017 with non-missing values of the variables reported in this table. Detailed variable definitions are given in Appendix A.

Variable	N	Mean	Std. Dev.	25%	Median	75%
Investment and Financial Characteristics						
Cash	14,283	0.166	0.176	0.031	0.101	0.243
Investment	14,283	0.133	0.130	0.060	0.099	0.163
Cash Flow	14,283	0.154	0.117	0.097	0.151	0.214
Market-to-Book	14,283	2.077	1.430	1.231	1.653	2.418
External Financing	14,283	0.050	0.169	−0.003	0.010	0.050
Distribution	14,283	0.040	0.055	0.001	0.017	0.055
Depreciation	14,283	0.129	0.120	0.068	0.095	0.145
Book Assets (in billions)	14,283	3.486	8.245	0.361	0.908	2.536
Managerial Compensation						
Bonus (in bps)	14,283	0.099	0.174	0.000	0.022	0.123
Ownership	14,283	0.037	0.066	0.003	0.009	0.034
Ownership + Options	14,283	0.051	0.069	0.011	0.025	0.058
Ownership + Options II	14,283	0.060	0.071	0.016	0.036	0.073

Table 2: Model Parameter Estimates

This table presents the estimated model parameters in Panel A and the calibrated ones in Panel B. c_f and c_l are the fixed and proportional operational costs; a is the investment adjustment costs; ϕ_f and ϕ_l are the fixed and proportional financing costs; ξ is the bonus parameter; s is the diversion coefficient; r is the discount rate; τ is the corporate income tax rate; δ is the depreciation rate; κ is the managerial ownership; α is the curvature of the production function; $\bar{z}$ is the unconditional mean of the productivity shock; σ is the conditional volatility of the productivity shock; ρ is the serial correlation of the productivity shock. The standard deviations of the parameter estimates are reported in the parentheses. Panel C reports the model-implied averages and variances of cash-to-assets ratio ($h/(k+h)$), investment-to-capital ratio (i/k), profits-to-assets ratio ($e(k+h)$), external financing-to-assets ratio ($(\phi_f+\phi_l f)/(k+h)$), and payout-to-assets ratio ($(1-\mathbb{I})d/(k+h)$), and also reports the averages of Tobin's q ($(V-d)/(k+h)$) and manager's bonus-to-assets ratio ($\xi\pi/(k+h)$). All moments are averaged across 100 simulations.

Panel A: Estimated parameters

	c_f	c_l	a	ϕ_f	ϕ_l	s (‰)	ξ (%)
	4.016	0.010	1.750	1.016	0.026	0.078	0.935
	(0.332)	(0.001)	(0.020)	(2.271)	(0.002)	(0.006)	(0.020)

Panel B: Calibrated parameters

	r	τ	δ	κ	α	$\bar{z}$	σ_z	ρ_z
	0.012	0.200	0.129	0.051	0.697	2.762	0.338	0.676

Panel C: Data and model moments

Moments	Data	Model
$\overline{h/(k+h)}$	0.166	0.180
$\mathrm{var}(h/(k+h))$	0.006	0.008
$\overline{i/k}$	0.133	0.131
$\mathrm{var}(i/k)$	0.010	0.002
$\overline{e/(k+h)}$	0.154	0.150
$\mathrm{var}(e/(k+h))$	0.005	0.004
$\overline{(V-d)/(k+h)}$	2.077	2.172
$\overline{(\phi_f+\phi_l f)/(k+h)}$	0.087	0.081
$\mathrm{var}((\phi_f+\phi_l f)/(k+h))$	0.024	0.003
$\overline{(1-\mathbb{I})d/(k+h)}$	0.051	0.031
$\mathrm{var}((1-\mathbb{I})d/(k+h))$	0.002	0.001
$\overline{\xi\pi/(k+h)}\times 100$	0.099	0.140

Table 3: Faulkender and Wang (2006) Regression and True MVCs

This table presents the results of regressing the excess stock return $r_{it} - R^B_{it}$ on firm characteristics based on the simulated data from three model specifications: the baseline, baseline with the persistence of productivity shock changed to 0.3, and baseline with the persistence of productivity shock changed to 0.0. The average mean and standard deviation (in parentheses) of the true MVC for firm (λ_f) across the simulated samples are reported at the bottom. All variables are deflated by the lagged market equity P_{it-1}. h_{it+1} is the cash stock at the end of period t, d_{it} is the net cash flow to shareholders, which equals dividend payout D_{it} if $d_{it} \geq 0$ and equals negative of external financing if $d_{it} < 0$, r_{it} is the return of firm i for period t, defined as $\frac{V_{it}}{P_{it-1}}$, R^B_{it} is the return on one of the 25 Size/BM portfolios to which stock i belongs at t, i_{it} is the investment made in period t, E_{it-1} is earnings generated by firm i in $t-1$, which corresponds to the earnings before interest and extraordinary items in Faulkender and Wang (2006). Both regression coefficients and their standard errors (in parentheses) are averages across 100 simulations, each with 5,000 firms and 30 years.

	Baseline ($\rho_z = 0.676$)		$\rho_z = 0.3$		$\rho_z = 0.0$	
	(1)	(2)	(1)	(2)	(1)	(2)
Δh_{t+1}	3.094		1.300		0.939	
	(0.005)		(0.002)		(0.002)	
E_t		3.094		1.300		0.939
		(0.005)		(0.002)		(0.002)
i_t	3.187	0.093	1.627	0.327	1.067	0.128
	(0.002)	(0.005)	(0.004)	(0.006)	(0.004)	(0.005)
d_t	2.974	−0.120	1.545	0.245	0.995	0.056
	(0.003)	(0.004)	(0.001)	(0.003)	(0.001)	(0.002)
ΔD_t	−0.326	−0.326	−0.246	−0.246	−0.012	−0.012
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
h_t	0.051	0.051	0.045	0.045	0.058	0.058
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
$h_t * \Delta h_{t+1}$	−0.003	−0.003	0.001	0.001	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
E_{t-1}	−2.297	−2.297	−0.456	−0.456	0.003	0.003
	(0.002)	(0.002)	(0.001)	(0.001)	(0.000)	(0.000)
intercept	−0.057	−0.057	−0.078	−0.078	−0.083	−0.083
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Adj. R^2	0.982	0.982	0.993	0.993	0.995	0.995
λ_f	0.962		0.970		0.963	
	(0.014)		(0.008)		(0.008)	

Table 4: Nonidentification of Faulkender and Wang (2006) Regression

This table demonstrates nonidentification of the Faulkender and Wang (2006) regression approach. The dependent variable is the excess stock return. All independent variables are scaled by the lagged market capitalization and are self-explained except that Inv stands for investment, $Net\ Fin$ stands for net financing, and Div means dividend payout. In Column 1, we repeat the baseline regression of Faulkender and Wang (2006). In Column 2, we replace changes in net assets with investment computed from the cash flow identity and net financing with that constructed from the balance sheet data items, labeled as $\widetilde{Net\ Fin}_t$. Columns 3 and 4 alternately replace changes in net assets with the implied investment and net financing with that constructed from the balance sheet data items. Column 5 repeats Column 2 except that changes in cash holdings are replaced with cash flow. Details on data construction can be found in Appendix F. Standard errors are clustered at the firm level and reported in parentheses. The superscripts *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
$\Delta Cash_t$	1.005***	0.967***	0.862***	1.098***	
	(0.019)	(0.019)	(0.019)	(0.020)	
$Cash\ Flow_t$					0.955***
					(0.018)
$\Delta Earnings_t$	0.543***	0.576***	0.622***	0.495***	0.578***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
$\Delta Net\ Assets_t$	0.289***			0.397***	
	(0.007)			(0.009)	
$Inv_t\ (Implied)$		0.410***	0.119***		−0.559***
		(0.010)	(0.006)		(0.019)
$Net\ Fin_t$	−0.118***		0.277***		
	(0.012)		(0.013)		
$\widetilde{Net\ Fin}_t$		0.640***		−0.260***	−0.331***
		(0.015)		(0.011)	(0.022)
$\Delta R\&D_t$	1.245***	1.576***	1.908***	1.146***	1.593***
	(0.106)	(0.107)	(0.107)	(0.106)	(0.107)
$\Delta Interest_t$	−1.886***	−0.993***	−0.629***	−1.461***	−0.989***
	(0.091)	(0.090)	(0.091)	(0.091)	(0.090)
ΔDiv_t	3.176***	4.493***	5.139***	2.977***	4.143***
	(0.217)	(0.215)	(0.213)	(0.214)	(0.214)
$Cash_{t-1}$	0.252***	0.201***	0.200***	0.247***	0.199***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
$Leverage_t$	−0.357***	−0.490***	−0.455***	−0.363***	−0.504***
	(0.006)	(0.006)	(0.007)	(0.006)	(0.007)
Constant	0.014***	0.016***	0.029***	0.016***	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	116,946	116,946	116,946	116,946	116,946
Adj. R^2	0.168	0.164	0.149	0.174	0.166

Table 5: Faulkender and Wang (2006) Regression and Persistence of Productivity Shock

This table shows how the Faulkender and Wang (2006) regression depends on the persistence of productivity shock. We estimate the persistence of productivity shock (i.e., ρ) at the firm level in a rolling window of 10 years, following the method similar to that described in Appendix B. In Column 1, we replicate the baseline regression of Faulkender and Wang (2006). In Column 2, we repeat Column 1 and include a dummy variable $I_{\{High\ \rho\}}$ that equals one if ρ is greater than the sample median and zero otherwise and the interaction term between change in cash holdings ($\Delta Cash$) and this dummy variable. In Column 3, we substitute change in net assets and net finance of the Faulkender and Wang (2006) regression by capital expenditure and net finance, respectively, constructed from the balance sheet data items, as in Table 4. Column 4 is the same as Column 3 except that we include the dummy variable $I_{\{High\ \rho\}}$ and its interaction term with change in cash. Other control variables are the same as Table 4 and are omitted from the table presentation. Standard errors are clustered at the firm level and reported in parentheses. The superscripts *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
$\Delta Cash$	1.005***	0.826***	0.967***	0.785***
	(0.019)	(0.033)	(0.019)	(0.033)
$\Delta Cash \times I_{\{High\ \rho\}}$		0.102**		0.102**
		(0.043)		(0.043)
$I_{\{High\ \rho\}}$		−0.010***		−0.009***
		(0.003)		(0.003)
Other controls		omitted		
Observations	116,946	65,066	116,946	65,066
R-squared	0.168	0.167	0.164	0.164

Table 6: Firm Characteristics and MVCs in The Sample

This table presents the relation between firm's characteristics and the MVCs. In each year t, we sort firms on the levels of their size (k), cash-to-assets ratio, investment-to-capital ratio (i/k), market-to-book ratio (MTB), external financing-to-assets ratio (EF), and payout-to-assets ratio (PO) into three groups (Low, Medium, and High) based on the 33rd and 67th percentiles and compute the year t average gross MVC (λ_u), deductions in MVC due to bonus (λ_b) and due to diversion (λ_s), and net MVC (λ_f) within each group. The means and standard deviations (in parentheses) of the MVCs for the three groups sorted based on a specific characteristic are presented in the block under the name of the corresponding sorting variable. All numbers are in percentage.

	$\lambda_u - 1$ (%)	λ_b (%)	λ_s (%)	$\lambda_f - 1$ (%)	$\lambda_u - 1$ (%)	λ_b (%)	λ_s (%)	$\lambda_f - 1$ (%)
	Capital (PP&E)				Cash-to-Assets			
Low	2.04	0.45	0.37	1.22	1.65	1.00	0.51	0.14
	(1.10)	(0.75)	(0.31)	(1.52)	(1.28)	(1.68)	(0.56)	(2.56)
Medium	1.76	2.03	0.90	−1.16	1.73	0.92	0.49	0.33
	(1.24)	(1.86)	(0.57)	(2.71)	(1.25)	(1.55)	(0.51)	(2.36)
High	1.71	0.05	0.17	1.49	2.14	0.64	0.46	1.04
	(1.26)	(0.48)	(0.15)	(1.39)	(1.03)	(1.10)	(0.39)	(1.84)
	i/k				MTB			
Low	1.48	0.93	0.50	0.05	1.50	0.95	0.50	0.06
	(1.31)	(1.57)	(0.52)	(2.46)	(1.30)	(1.61)	(0.52)	(2.47)
Medium	1.87	0.82	0.47	0.58	1.83	0.86	0.50	0.47
	(1.20)	(1.46)	(0.49)	(2.27)	(1.21)	(1.45)	(0.50)	(2.26)
High	2.17	0.81	0.48	0.88	2.18	0.75	0.46	0.97
	(1.00)	(1.37)	(0.46)	(2.10)	(0.99)	(1.34)	(0.46)	(2.09)
	EF				PO			
Low	0.30	0.95	0.50	−1.14	1.68	0.91	0.49	0.28
	(0.84)	(1.57)	(0.52)	(2.21)	(1.27)	(1.53)	(0.51)	(2.34)
Medium	2.56	0.84	0.49	1.24	1.67	0.96	0.52	0.19
	(0.42)	(1.43)	(0.48)	(1.91)	(1.27)	(1.57)	(0.52)	(2.41)
High	2.63	0.78	0.46	1.40	2.03	0.72	0.44	0.86
	(0.00)	(1.41)	(0.48)	(1.85)	(1.11)	(1.37)	(0.47)	(2.16)

Table 7: Decision to Repatriate Foreign Earnings under the AJCA

This table presents the means and standard deviations of the gross MVC (λ_u), deductions in MVC due to bonus (λ_b) and due to diversion (λ_s), and net MVC (λ_f) for two groups of firms during 2001 to 2004 and during 2004 to 2007: firms who repatriated foreign earnings under the American Jobs Creation Act (AJCA) in 2004 and after, denoted as group 'Rep Yes', and firms who discussed repatriation of foreign earnings under the AJCA in its 10-K but did not repatriate, denoted as group 'Considered Rep'. Firms in both groups are required to have positive foreign earnings during the previous 3 years before 2004. The last two columns of the table report the average differences in MVCs and the corresponding t-stats between group 'Rep Yes' and group 'Considered Rep'.

	Rep Yes		Considered Rep		Differences	
	mean	std. dev.	mean	std. dev.	mean	t-stat
			Before the AJCA: 2001-2004			
λ_u	1.0183	0.0122	1.0173	0.0125	0.0010	0.91
λ_s	0.0047	0.0049	0.0055	0.0052	-0.0009	-1.93
λ_b	0.0081	0.0144	0.0105	0.0163	-0.0025	-1.81
λ_f	1.0055	0.0229	1.0013	0.0259	0.0043	1.98
			After the AJCA: 2004-2007			
λ_u	1.0205	0.0109	1.0183	0.0121	0.0022	2.28
λ_s	0.0047	0.0049	0.0056	0.0053	-0.0008	-1.98
λ_b	0.0080	0.0144	0.0091	0.0139	-0.0011	-0.93
λ_f	1.0079	0.0220	1.0037	0.0223	0.0041	2.23

Table 8: Subsample estimates: with and without tariff cuts

We identify two groups of observations for each major tariff cut during 1993 to 2005: firm-year observations during a three-year period without any tariff cuts before the event are classified as "Before tariff cuts", and firm-year observations during a three-year period after the event are classified as "After tariff cuts". This table presents estimated diversion parameter s and bonus parameter ξ for two groups of observations.The means and standard deviations of the managerial ownership, the gross MVC (λ_u), deductions in MVC due to bonus (λ_b) and due to diversion (λ_s), and net MVC (λ_f) are also reported. The MVCs of these firm-year observations are imputed based on the estimated parameter values. The last two columns of the table report the differences in the parameter estimates, ownership, MVCs and the corresponding t-stats between these two groups.

Panel A: Parameter estimates

	Before tariff cuts		After tariff cuts		After − Before	
	mean	s.e.	mean	s.e.	mean	t-stat
s (‰)	0.0623	0.0043	0.0400	0.0018	-0.0223	-4.81
ξ (%)	1.9498	0.0983	1.9298	0.0504	-0.0200	-0.18
# of Obs	170		388			

Panel B: Sample statistics

	Before tariff cuts		After tariff cuts		After − Before	
	mean	std. dev.	mean	std. dev.	mean	t-stat
Ownership (%)	5.5234	7.2343	5.3054	6.9365	-0.2179	-0.33
λ_u	1.0186	0.0120	1.0210	0.0106	0.0025	2.30
λ_b	0.0188	0.0309	0.0240	0.0306	0.0052	1.84
λ_s	0.0035	0.0033	0.0027	0.0022	-0.0008	-2.86
λ_f	0.9963	0.0361	0.9943	0.0345	-0.0020	-0.60

Figure 1: Comparative Statics

This figure shows comparative statics of the model. In each panel, we solve and simulate the model ten times. Each simulated sample has 5,000 firms and 30 periods. One simulation corresponds to a different value of the parameter on the horizontal axis with the other parameters fixed at their baseline values reported in Table 2. In each simulation, we compute the average value of the moment in question in the simulated sample.

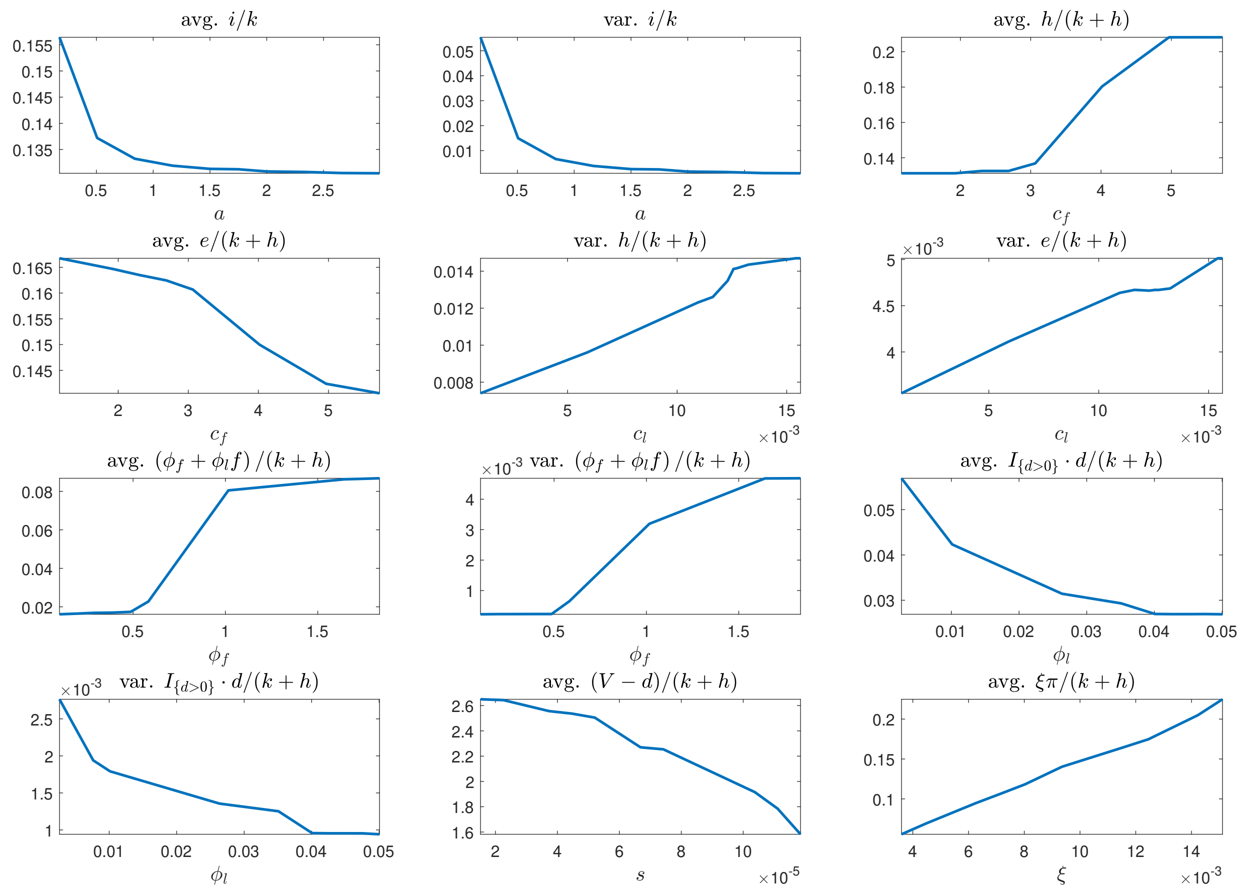


Figure 2: Optimal Investment and Cash holdings

This figure plots the model-implied optimal investment-to-capital ratio (i/k), and optimal cash-to-assets ($h'/(h+k)$) against the current capital (k) and cash holdings (h), holdings all else equal. Optimal i/k and h'/a at high and low productivity levels (around $2\sigma_z$ higher or lower than the mean) are plotted in red dotted lines and blue solid lines, respectively. The model is solved using parameter values from the baseline estimation.

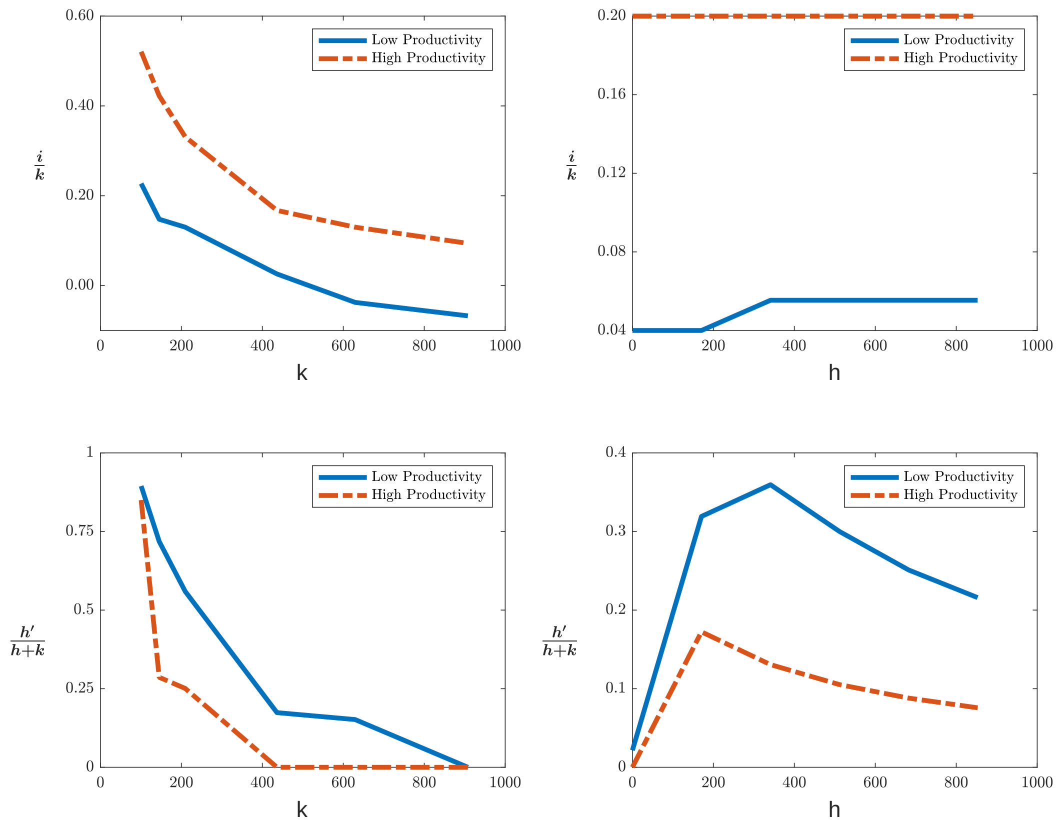
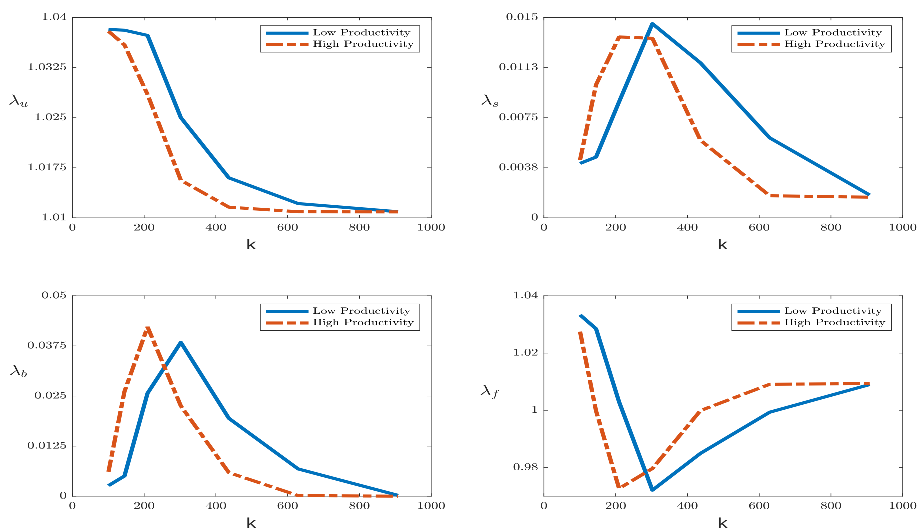
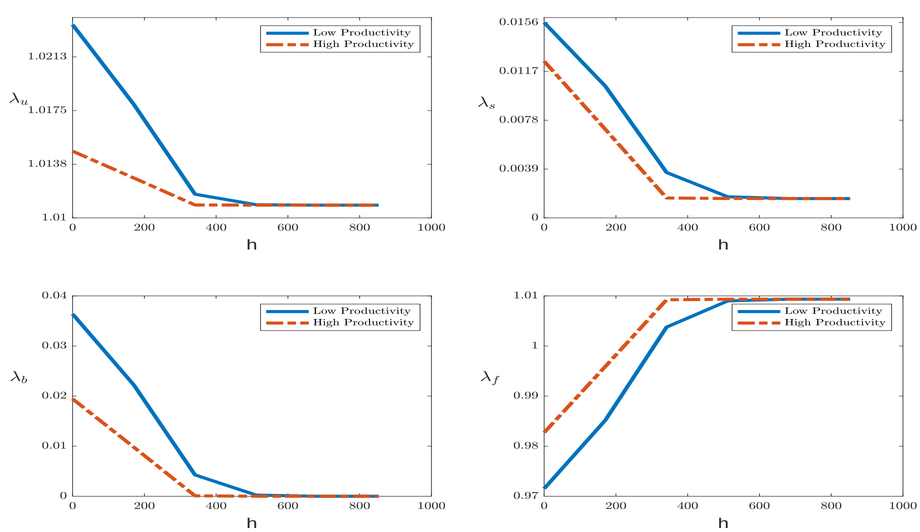


Figure 3: Marginal Values of Cash

This figure plots the gross MVC (λ_u), deductions in MVC due to bonus (λ_b) and due to diversion (λ_s), and net MVC (λ_f) against capital (k) in Panel A and against cash holdings (h) in Panel B. The marginal values at high and low levels of productivity (around $2\sigma_z$ higher or lower than the mean) are plotted in red dotted lines and blue solid lines, respectively. The level of cash holdings in Panel A and the level of capital in Panel B are set at the corresponding median values in the data. The model is solved under the estimated parameters reported in Table 2.



Panel A: MVC vs. Capital (k)



Panel B: MVC vs. Cash holdings (h)

Figure 4: Histogram of Marginal Values of Cash

The figure presents the histograms of the gross MVC (λ_u), deductions in MVC due to bonus (λ_b) and due to diversion (λ_s), and net MVC (λ_f), which are computed based on the estimated model for 14,283 firm-year observations in our sample between 1993 and 2017. Variables are winsorized at 1th and 99th percentiles. The means and standard deviations of the marginal values of cash are also reported in the corresponding plots.

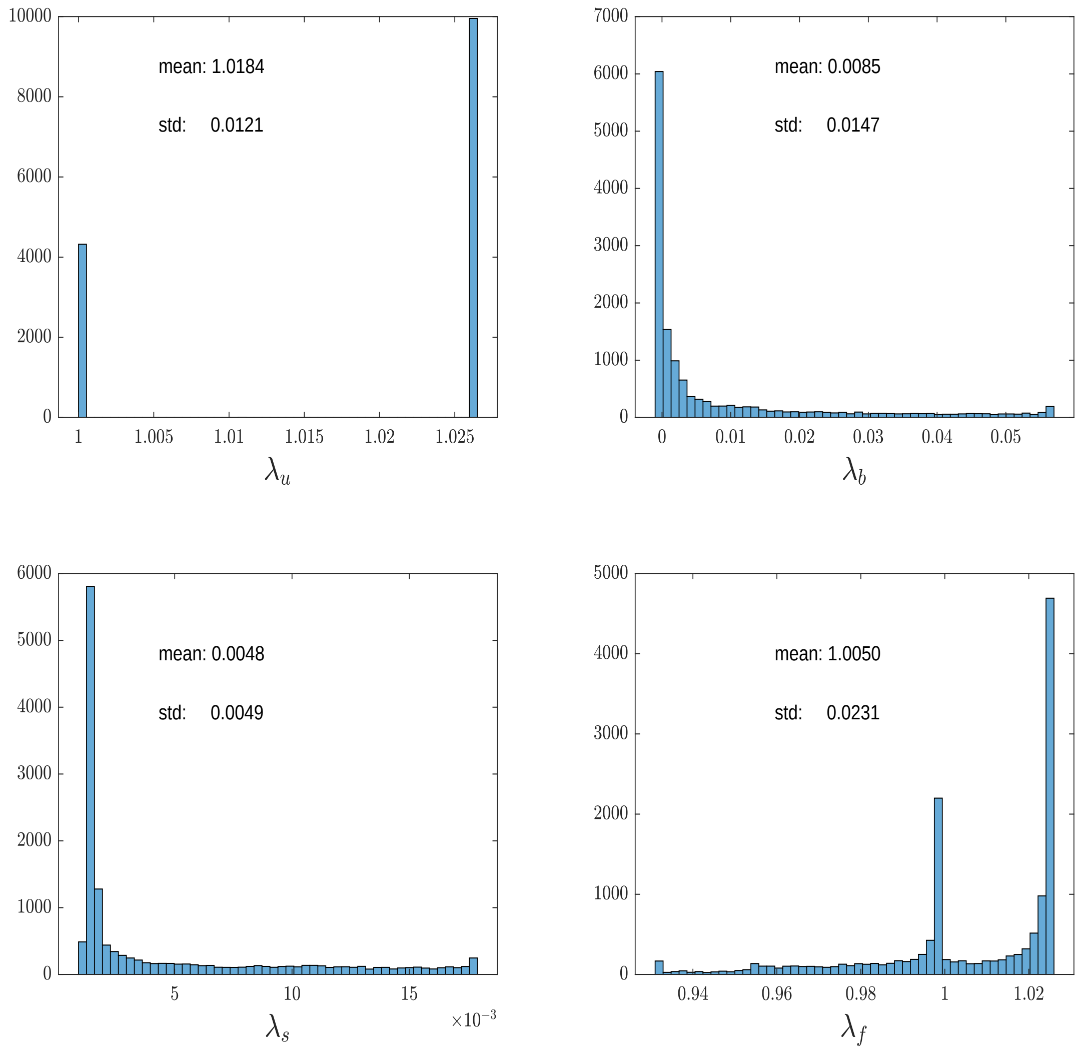


Figure 5: MVC vs. Size

Firms are put into three groups (Low, Medium, and High) based on the 33rd and 67th percentiles of the sample distribution of capital (PP&E) at time 0. The average total factor productivity (TFP), marginal productivity of capital (MPK), capital (PP&E), cash-to-assets, investment-to-capital (i/k), external financing-to-assets (EF-to-assets), payout-to-assets (PO-to-assets), gross MVC (λ_u), deductions in MVC due to bonus (λ_b) and due to diversion (λ_s), and net MVC (λ_f) in the Low and High groups during prior and post 3-year period of group formation are plotted in red and blue lines, respectively.

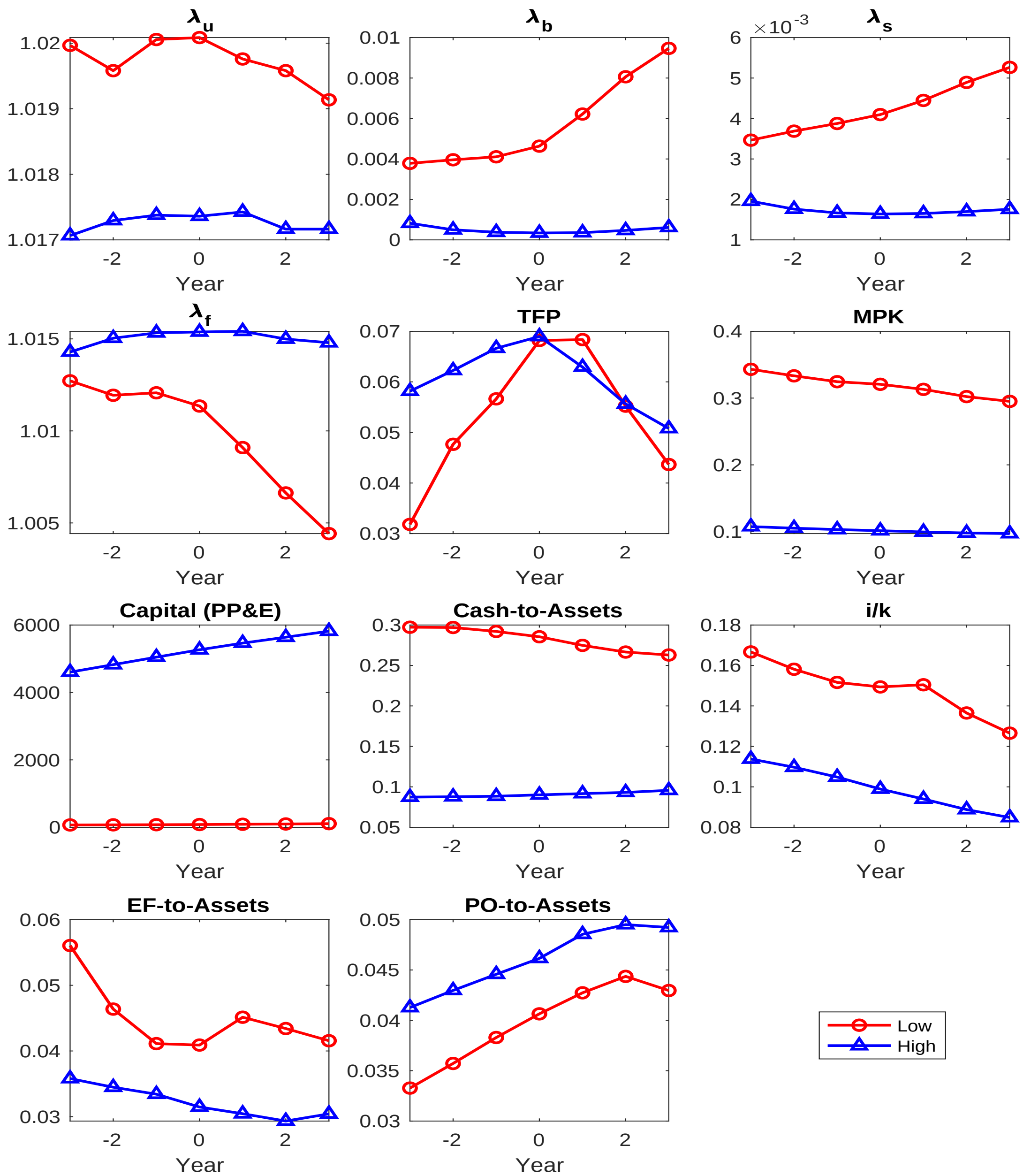


Figure 6: MVC vs. Cash holdings

Firms are put into three groups (Low, Medium, and High) based on the 33rd and 67th percentiles of the sample distribution of cash-to-assets ratios at time 0. The average total factor productivity (TFP), marginal productivity of capital (MPK), capital (PP&E), cash-to-assets, investment-to-capital (i/k), external financing-to-assets (EF-to-assets), payout-to-assets (PO-to-assets), gross MVC (λ_u), deductions in MVC due to bonus (λ_b) and due to diversion (λ_s), and net MVC (λ_f) of the firms in the Low and High groups during prior and post 3-year periods of group formation are plotted in red and blue lines, respectively.

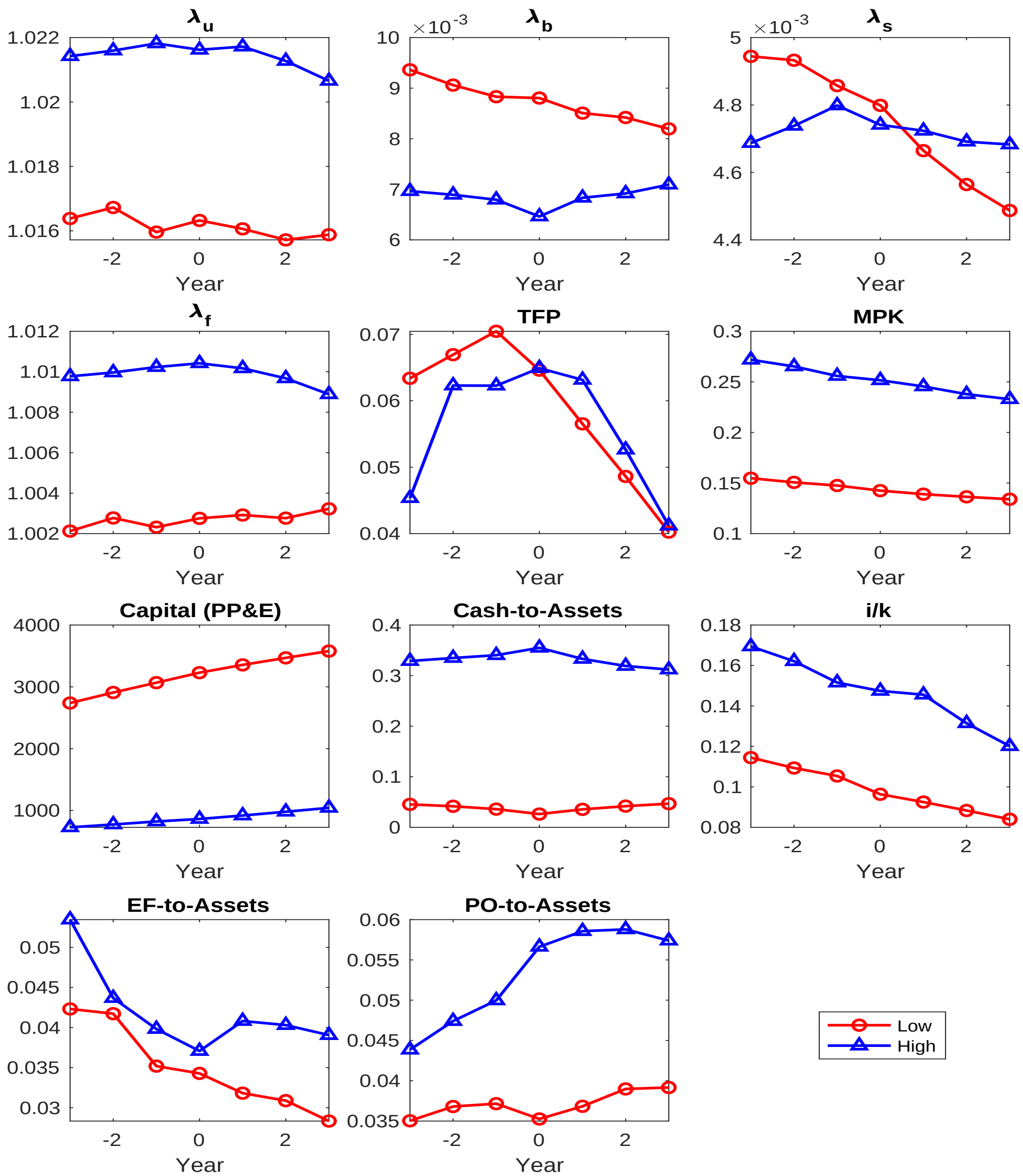


Figure 7: MVC vs. Investment

Firms are put into three groups (Low, Medium, and High) based on the 33rd and 67th percentiles of the sample distribution of investment-to-capital (i/k) ratios at time 0. The average total factor productivity (TFP), marginal productivity of capital (MPK), capital (PP&E), cash-to-assets, investment-to-capital (i/k), external financing-to-assets (EF-to-assets), payout-to-assets (PO-to-assets), gross MVC (λ_u), deductions in MVC due to bonus (λ_b) and due to diversion (λ_s), and net MVC (λ_f) of the firms in the Low and High groups during prior and post 3-year periods of group formation are plotted in red and blue lines, respectively.

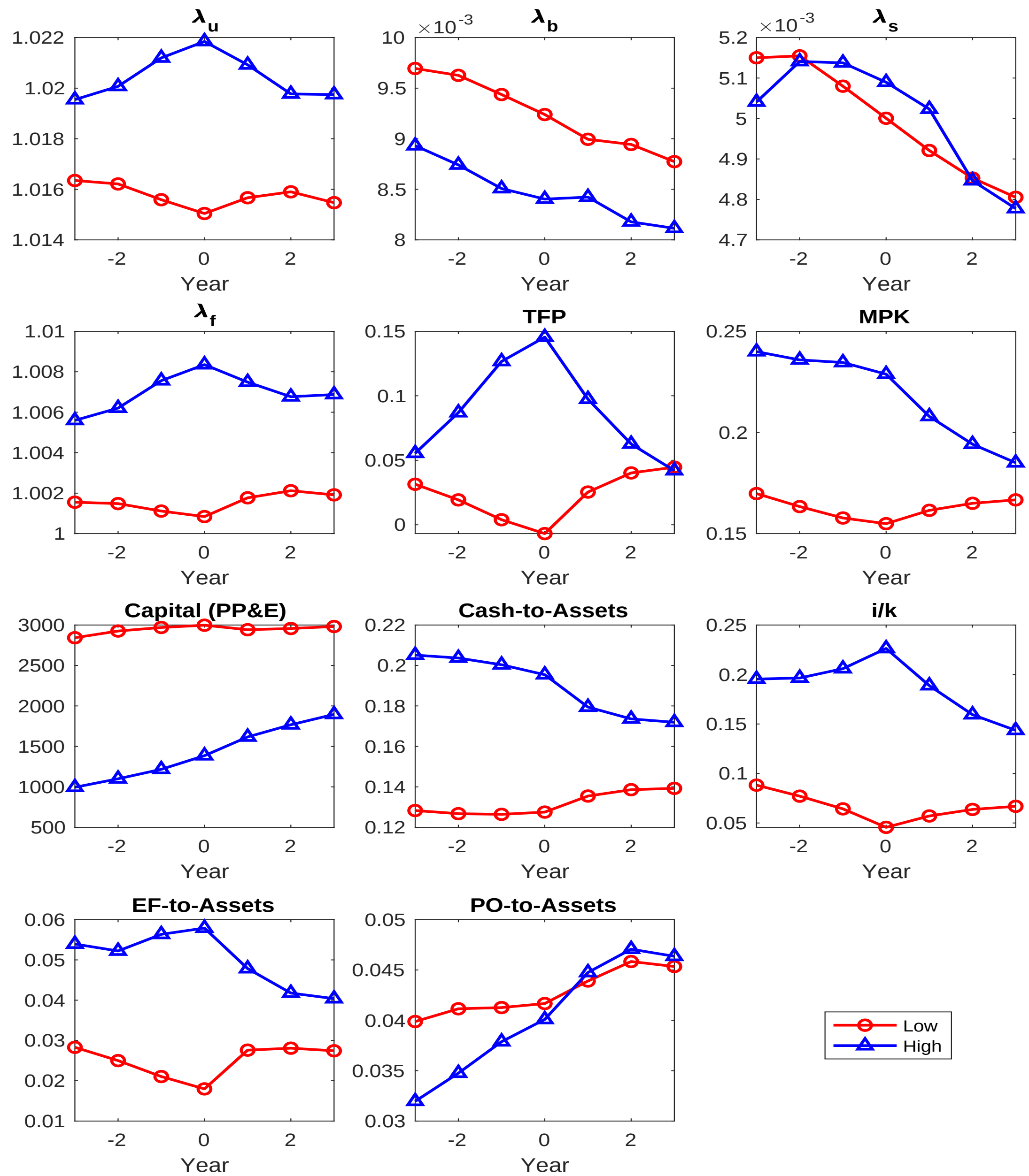


Figure 8: MVC vs. MTB

Firms are put into three groups (Low, Medium, and High) based on the 33rd and 67th percentiles of the sample distribution of market-to-book ratios at time 0. The average total factor productivity (TFP), marginal productivity of capital (MPK), capital (PP&E), cash-to-assets, investment-to-capital (i/k), external financing-to-assets (EF-to-assets), payout-to-assets (PO-to-assets), gross MVC (λ_u), deductions in MVC due to bonus (λ_b) and due to diversion (λ_s), and net MVC (λ_f) of the firms in the Low and High groups during prior and post 3-year periods of group formation are plotted in red and blue lines, respectively.

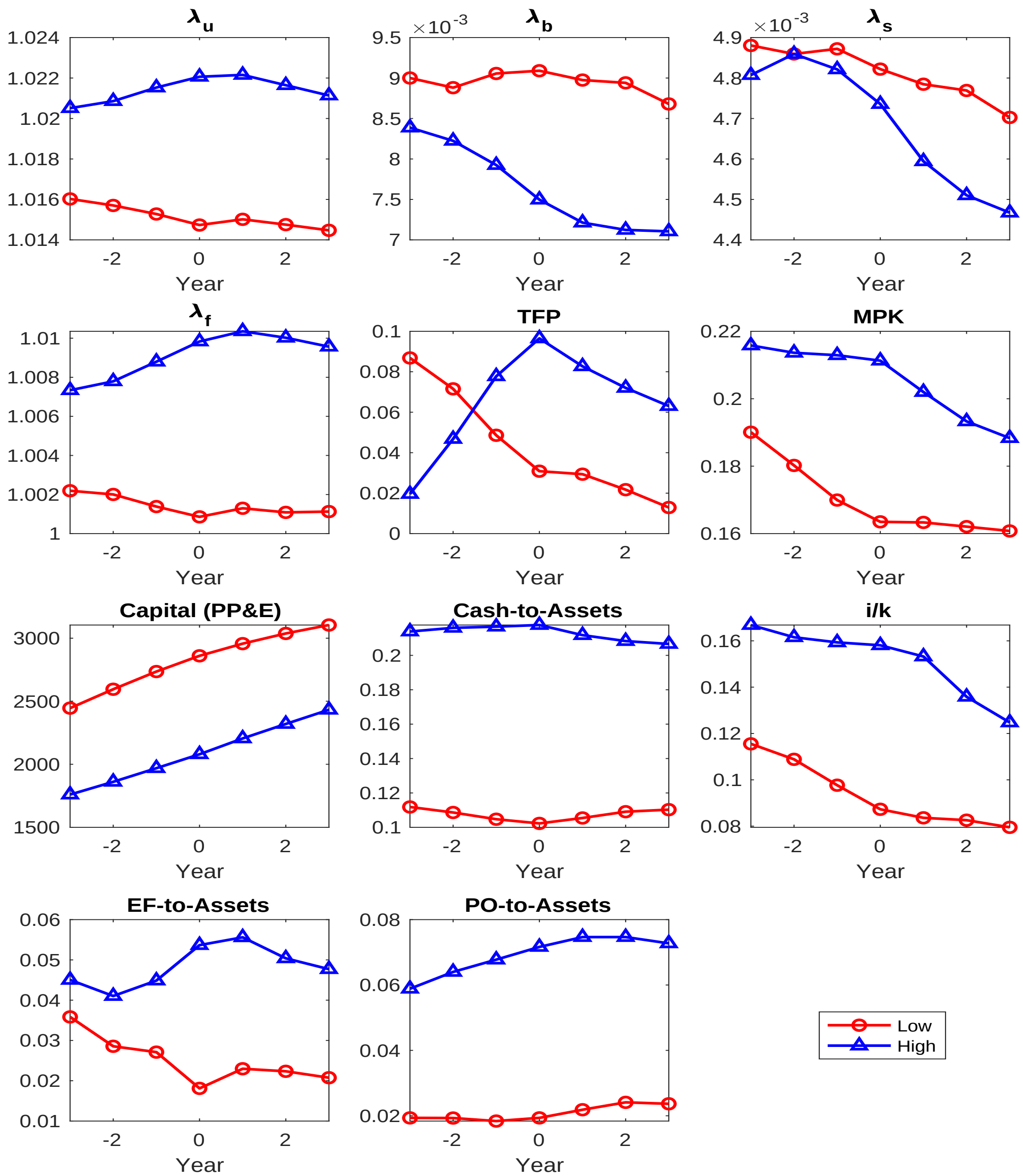


Figure 9: MVC vs. External Financing

Firms are put into three groups (Low, Medium, and High) based on the 33rd and 67th percentiles of the sample distribution of external financing-to-assets ratios (EF) at time 0. The average total factor productivity (TFP), marginal productivity of capital (MPK), capital (PP&E), cash-to-assets, investment-to-capital (i/k), external financing-to-assets (EF-to-assets), payout-to-assets (PO-to-assets), gross MVC (λ_u), deductions in MVC due to bonus (λ_b) and due to diversion (λ_s), and net MVC (λ_f) of the firms in the Low and High groups during prior and post 3-year periods of group formation are plotted in red and blue lines, respectively.

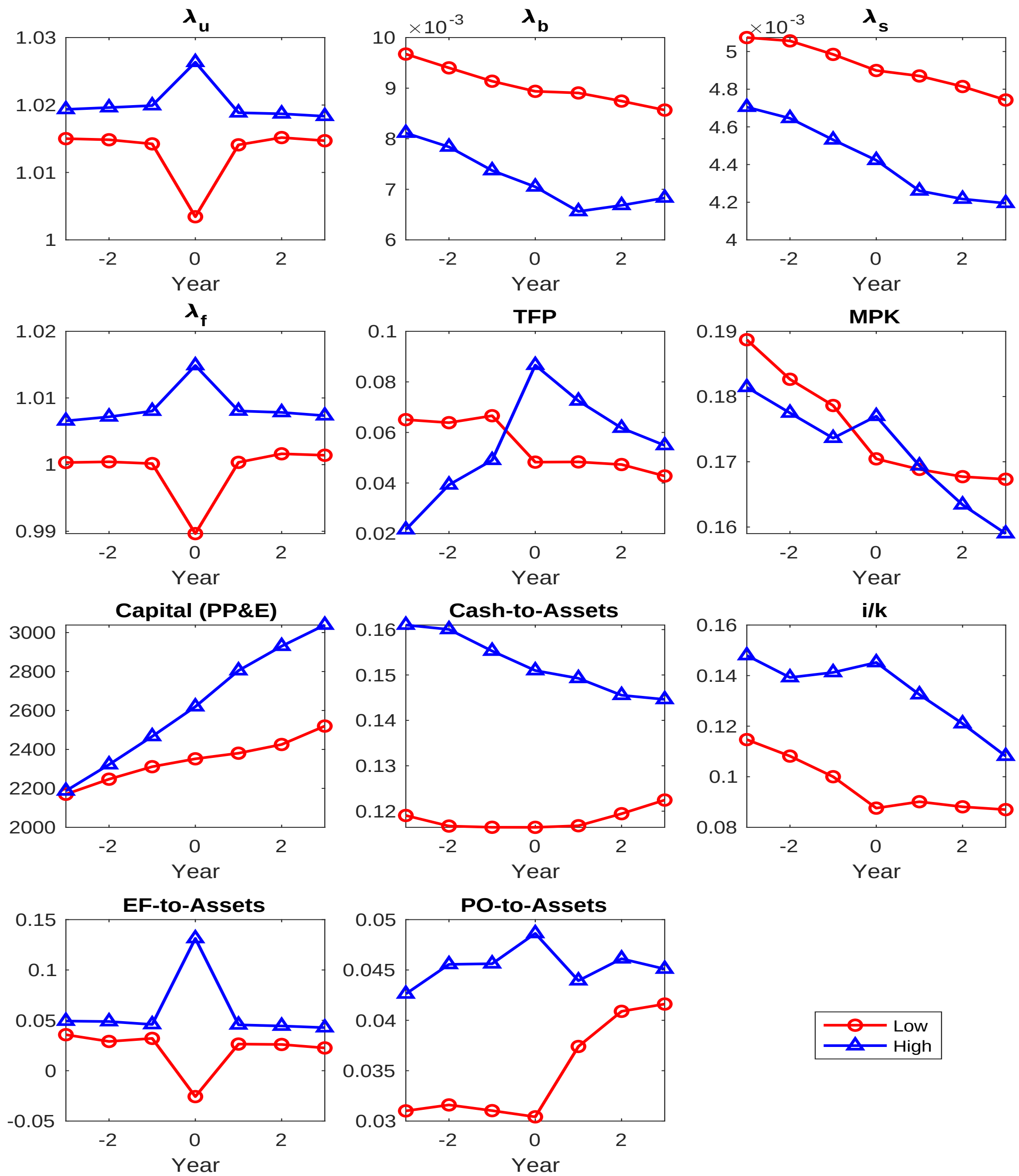


Figure 10: Payout Trend

We sort firms into three groups (Low, Medium, and High) based on the 33rd and 67th percentiles of the sample distribution of payout-to-assets ratio at each fiscal year-end and compute the average gross MVC (λ_u), deductions in MVC due to bonus (λ_b) and due to diversion (λ_s), net MVC (λ_f), capital (PP&E), cash-to-assets, investment-to-capital (i/k), external financing-to-assets (EF-to-assets), and payout-to-assets (PO-to-assets) within each group. This figure plots the differences in these firm characteristics between the High and Low payout groups, e.g., $\Delta\lambda_u \equiv \lambda_u^{\text{High}} - \lambda_u^{\text{Low}}$, in blue solid lines and the 95% confidence interval in dotted lines for period 1993-2017.

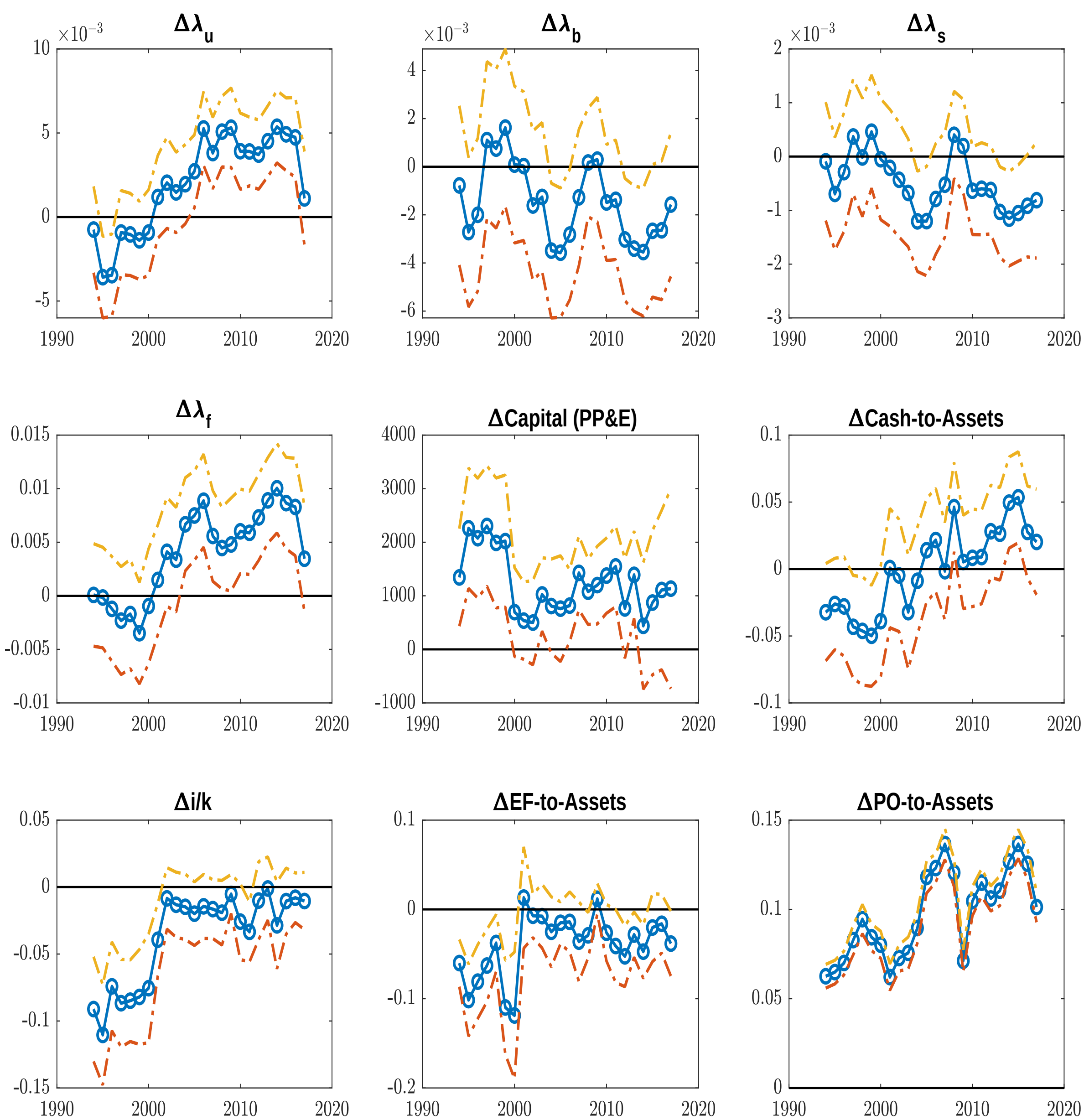
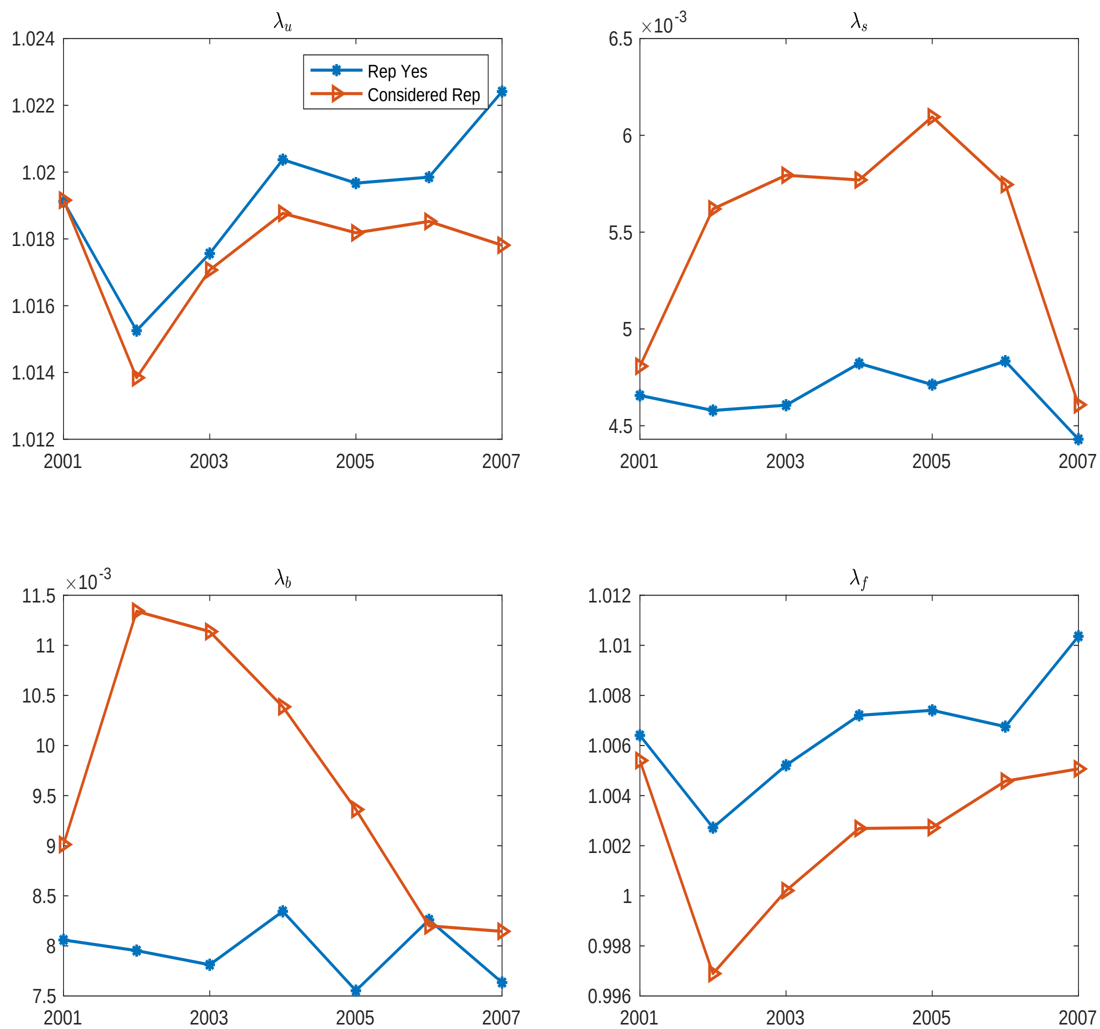


Figure 11: Decision to Repatriate Foreign Earnings under the AJCA

This figure plots the average gross MVC (λ_u), deductions in MVC due to bonus (λ_b) and due to diversion (λ_s), and net MVC (λ_f) for two groups of firms between 2001 to 2007: firms who repatriated foreign earnings under the American Jobs Creation Act (AJCA) in 2004 and after, denoted as group "Rep Yes", and firms who discussed repatriation of foreign earnings under the AJCA in its 10-K but did not repatriate, denoted as group "Considered Rep". Firms in both groups are required to have positive foreign earnings during the previous 3 years before 2004.



Appendix

A Variable Definitions

All continuous variables are winsorized at the 1st and 99th percentiles. All dollar values are in millions and are adjusted by the Consumer Price Index to the year 2001 dollars. The variables are constructed based on the definitions below following Nikolov and Whited (2014).

Table A.1: : Definitions of Important Variables Used in the Analysis

Variable	Source	Detailed Explanation
A: Investment and Financial Characteristics		
Cash	Compustat	Cash and short-term investments (CHE_{t-1})/Assets - Total (AT_{t-1})
Investment	Compustat	(Capital Expenditures (CAPX_t) − Sale of Property (SPPE_t))/Property, Plant and Equipment - Total (Gross) (PPEGT_{t-1})
Cash Flow	Compustat	Earnings Before Interest (EBITDA_t)/Assets - Total (AT_{t-1})
Market-to-Book (MTB)	Compustat	(Common Shares Outstanding (CSHO_{t-1})×Price Close - Annual Fiscal Year (PRCC_F_{t-1}) + Book Debt (BD_{t-1}))/Assets - Total (AT_{t-1}), where Book Debt (BD) = Assets - Total (AT) − Book Equity (BE), and Book Equity (BE) = Stockholders Equity - Total (SEQ) + Deferred Taxes and Investment Tax Credit (TXDITC) − Preferred/Preference Stock (Capital) - Total (PSTK). If PSTK is missing, then substitute it with Preferred Stock - Redemption Value (PSTKRV); and if PSTKRV is missing, then substitute it with Preferred Stock - Liquidating Value (PSTKL).
External Financing	Compustat	(Long-Term Debt - Issuance (DLTIS_t) − Long-Term Debt - Reduction (DLTR_t) + Sale of Common and Preferred Stock (SSTK_t))/Assets - Total (AT_{t-1})
Distribution	Compustat	(Dividends Common/Ordinary (DVC_t) + Dividends - Preferred/Preference (DVP_t) + Purchase of Common and Preferred Stock (PRSTKC_t))/Assets - Total (AT_{t-1})
B: Managerial Compensation (of the five highest paid executives)		
Managerial Bonus	ExecuComp, Compustat	Bonus (BONUS_t)/Assets - Total (AT_{t-1})
Managerial Ownership	ExecuComp	Shares Owned - Options Excluded ($\text{SHROWN\_EXCL\_OPTS}_t$)/Common Shares Outstanding (CSHO_t)
Ownership + Options	ExecuComp	(Shares Owned - Options Excluded ($\text{SHROWN\_EXCL\_OPTS}_t$) + Unexercised Exercisable Options ($\text{OPT\_UNEX\_EXER\_NUM}_t$))/Common Shares Outstanding (CSHO_t)
Ownership + Options II	ExecuComp	(Shares Owned - Options Excluded ($\text{SHROWN\_EXCL\_OPTS}_t$) + Unexercised Exercisable Options ($\text{OPT\_UNEX\_EXER\_NUM}_t$) + Unexercised Unexercisable Options ($\text{OPT\_UNEX\_UNEXER\_NUM}_t$))/Common Shares Outstanding (CSHO_t)

B Parameter Calibration for Production and Productivity Shock

Following the theoretical model, the logarithm of the firm's production is $\log y_{it} = z_{it} + \alpha \log k_{it}$, where $z_{it} = a_0 + a_i + \rho_z z_{i,t-1} + u_{it}$, a_i is introduced to absorb the firm-specific heterogeneity, and $u_{it} \sim \mathcal{N}(0, \sigma_z^2)$. We assume that $p\lim \sum_i a_i/N = 0$, where N is the number of firms. With this assumption, it is easy to show that the unconditional mean of the productivity shock (i.e., $\bar{z}$) is equal to $a_0/(1-\rho_z)$. We then adopt the following steps to calibrate the parameters of production and the productivity shock, $\{\alpha, \bar{z}, \sigma_z, \rho_z\}$:

i. Approximate production (y_{it}) using sales. Then, regress the logarithm of sales on the logarithm of the stock of physical capital at the beginning of the year. We include the firm fixed effects to remove the firm heterogeneity. α is calibrated as the coefficient of capital stock from this regression.

ii. Estimate z_{it} as the difference between $\log y_{it}$ and $\hat{\alpha} \log k_{it}$. Then, regress the estimated z_{it} on $z_{i,t-1}$ with the firm fixed effects. The coefficient of $z_{i,t-1}$ gives us the calibration of ρ_z, and the intercept coefficient of this regression gives us the calibration of a_0. $\bar{z}$ can be calibrated using either the sample mean of z_{it} or the relation $\bar{z} = a_0/(1-\rho_z)$.

iii. Estimate u_{it} using the residual from the regression in the previous step and calibrate σ_z as its standard deviation.

Following the above method, we calibrate $\alpha = 0.697$, $\rho_z = 0.676$, $a_0 = 0.899$, and $\sigma_z = 0.338$. We also show that the sample mean of z_{it} is 2.762, which is approximately equal to $0.899/(1-0.676)$, with a slight difference due to the rounding and sampling errors.

C Model Solution

We numerically solve the model on a discrete grid of the state variables, k, h, and z. With the calibrated values of $\bar{z}$, σ_z, and ρ_z, we transform the continuous AR(1) stochastic process of the productivity shock given in Eq. (1) into a discrete Markov chain on a grid of 11 points over the support four standard deviations ($4\sigma_z$) below and above $\bar{z}$ using the method of Tauchen (1986). We let the grid of the capital stock have twenty-five points between 0.01 and its largest value in our sample. To properly capture the curvature of the model solution around the steady state, we carefully calibrate the grid points of the capital stock using a recursive method such that the value of its middle point equals the mean value of the capital stock in the sample. In this way, the distance between two consecutive points on the grid of the capital stock increases exponentially. We let the grid of the cash stock have twenty-five points evenly spanned over the support between zero and 10% of the largest capital stock in the sample. In our empirical exercise, the optimal choice of c never hits the upper bound of this grid. To increase precision of the model solution, we allow the policies (i.e., the capital stock and cash stock in the next period, k' and h') to have a finer grid, with ten points equally spaced between two consecutive grid points of the corresponding state variable.

The model is solved using the value-function-iteration method based on the Bellman's equation (8). For the policies between the grid points of the state variables, we compute the value function via interpolation. To speed up the computation, we also adopt the Howard's improvement algorithm during the iteration of the value function. This procedure yields the functional form of not only the manager's lifetime utility, $U(k, h, z)$, and the policy function, $(k', h') = p(k, h, z)$, but also that of the shareholder value $V(k, h, z)$, the present value of the manager's bonuses, $S(k, h, z)$, and the present value of the manager's diversion, $B(k, h, z)$. These latter value functions are computed using a similar iterative method given the manager's optimal policy function.

D Details on SMM Estimation

For each set of model parameters, after solving the model numerically, we simulate $L = 100$ pseudo panels each with $N^S = 5,000$ firms for $T^S = 126$ periods. We then compute the model implied moments as $m^l(\Theta)$ for each simulated panel data. Let m be the data moments. Then SMM searches for the parameter values that minimize the distance between the model implied moments and the data moments:

$$\hat{\Theta} = \underset{\Theta}{\operatorname{argmin}} \left(m - \frac{1}{L} \sum_{l=1}^{L} m^l(\Theta) \right)' W \left(m - \frac{1}{L} \sum_{l=1}^{L} m^l(\Theta) \right), \tag{A.1}$$

where W is a positive definite weighting matrix.

Our model pertains to a representative firm, and the simulated panel data is homogeneous. However, the sample contains the heterogeneity that is not captured by the model, which drives a significant part of the variances of the variables we study. Therefore, when we construct the data moments, we undertake the within-firm transformation of the variables before calculating their variances.

We use the inverse of the covariance matrix of the data moments as the weighting matrix, which minimizes the overall model error variance. The covariance matrix of the data moments is estimated using a seemingly unrelated regression (SUR) approach, in which each data moment is estimated as a coefficient from a regression equation. To remove the impact of data heterogeneity, we demean all variables at the firm level before running the regressions.

The covariance matrix for the model parameters is given by

$$\left(1 + \frac{1}{L}\right) \left(G(\Theta)'\hat{W}G(\Theta)\right)^{-1} G(\Theta)'\hat{W}\hat{\Omega}\hat{W}G(\Theta) \left(G(\Theta)'\hat{W}G(\Theta)\right)^{-1}, \tag{A.2}$$

where L is the number of simulations, $G(\Theta)$ is the Jacobian of $m - 1/L \sum_l m^l(\Theta)$, and Ω is the clustered covariance matrix of the data moments. Ω enters the computation of the covariance matrix for the parameters because of the temporal dependence in the data. We estimate it using the SUR approach for the *actual* data moments (i.e., only demean the variables at the firm level when calculating the variances) with the standard errors clustered at the firm level.

E Model with payout tax

In this appendix, we extend the baseline model and assume that investors are subject to a non-zero payout tax rate τ_d. In this case, the net cash flow to investors is given by

$$d_t = (1 - \tau_d \mathbb{J}_t + \phi_l \mathbb{I}_t)\, \tilde{d}_t - \phi_f \mathbb{I}_t, \tag{A.3}$$

where $\mathbb{J}_t = 1$ if the firm makes positive payouts (i.e., $\tilde{d}_t > 0$) and zero otherwise. Thus, $d_t = (1-\tau_d)\tilde{d}_t$ if $\tilde{d}_t > 0$, $d_t = \tilde{d}_t$ if $\tilde{d} = 0$, and $d_t = \tilde{d}_t - (\phi_f - \phi_l \tilde{d}_t)$ if $\tilde{d}_t < 0$. And the manager's instantaneous utility function is

$$u_t = \frac{\xi + s}{\kappa}(1-\tau)\pi_t + \frac{s}{\kappa}[1 + r(1-\tau)]h_t + d_t, \tag{A.4}$$

where d_t is defined in equation (A.3). Note that payout tax affects the manager's instantaneous utility only through its effect on firm's payout d_t. Similarly as in the baseline model, we can write the manager's lifetime utilities per unit of ownership as:

$$U_t = \max_{(k_{t+s}, h_{t+s})_{s=1}^{\infty}} \mathbb{E}_t \sum_{s=0}^{\infty} \frac{u_{t+s}}{(1+r)^s}, \tag{A.5}$$

and decompose it into three parts, firm value, bonus, and diversion:

$$U_t = \underbrace{\mathbb{E}_t \sum_{s=0}^{\infty} \frac{d_{t+s}}{(1+r)^s}}_{\equiv V_t} + \underbrace{\frac{\xi}{\kappa}\mathbb{E}_t \sum_{s=0}^{\infty} \frac{(1-\tau)\pi_{t+s}}{(1+r)^s}}_{\equiv B_t} + \underbrace{\frac{s}{\kappa}\mathbb{E}_t \sum_{s=0}^{\infty} \frac{(1-\tau)\pi_{t+s} + [1 + r(1-\tau)]h_{t+s}}{(1+r)^s}}_{\equiv S_t} \tag{A.6}$$

The first-order conditions of the Bellman equation (8) for *interior* optimal policies (h_{t+1}, k_{t+1}) from the manager's perspective are:[A.1]

$$\frac{\partial U_t}{\partial h_{t+1}} = \frac{1}{1+r}\mathbb{E}_t\left[\frac{\partial U_{t+1}}{\partial h_{t+1}}\right] - (1 - \tau_d \mathbb{J}_t + \phi_l \mathbb{I}_t) = 0, \tag{A.7a}$$

[A.1] Due to the existence of fixed costs of external financing, $\tilde{d}_t = 0$ could be an interior solution.

$$\frac{\partial U_t}{\partial k_{t+1}} = \frac{1}{1+r}\mathbb{E}_t\left[\frac{\partial U_{t+1}}{\partial k_{t+1}}\right] - (1 - \tau_d \mathbb{J}_t + \phi_l \mathbb{I}_t)\left[1 + a\left(\frac{i_t}{k_t}\right)\right] = 0, \tag{A.7b}$$

where $U_t = U(k_t, h_t, z_t)$ and $U_{t+1} = U(k_{t+1}, h_{t+1}, z_{t+1})$. The decomposition of the managerial utility given in Eq. (A.6) leads to

$$\begin{aligned}
\underbrace{\frac{1}{1+r}\mathbb{E}_t\left[\frac{\partial V_{t+1}}{\partial h_{t+1}}\right]}_{\lambda_{f,t}} &= \frac{1}{(1+r)}\mathbb{E}_t\left[\frac{\partial U_{t+1}}{\partial h_{t+1}}\right] - \frac{1}{(1+r)}\mathbb{E}_t\left[\frac{\partial B_{t+1}}{\partial h_{t+1}}\right] - \frac{1}{(1+r)}\mathbb{E}_t\left[\frac{\partial S_{t+1}}{\partial h_{t+1}}\right] \\
&= \underbrace{(1 - \tau_d \mathbb{J}_t + \phi_l \mathbb{I}_t)}_{\lambda_{u,t}} - \underbrace{\frac{1}{(1+r)}\mathbb{E}_t\left[\frac{\partial B_{t+1}}{\partial h_{t+1}}\right]}_{\lambda_{b,t}} - \underbrace{\frac{1}{(1+r)}\mathbb{E}_t\left[\frac{\partial S_{t+1}}{\partial h_{t+1}}\right]}_{\lambda_{s,t}}.
\end{aligned} \tag{A.8}$$

Notice that the difference between the baseline model and the model with non-zero payout tax rate resides on the gross MVC $\lambda_{u,t}$. In the baseline, $\lambda_{u,t} = 1 + \phi_l$ if firm raised external financing and equals one if firm pays out. In the model with payout tax, $\lambda_{u,t} = 1 + \phi_l$ if firm raised external financing and equals $1 - \tau_d$ if firm pays out.[A.2]

[A.2] If firm neither pays out nor raise external financing, the value of $\lambda_{u,t}$ (and $\lambda_{f,t}$) cannot be obtained through the first order conditions, which are only valid for interior solutions, and has to be computed based on the derivatives of manager's life-time utility U (and firm value V).

F FW Regression and Nonidentification

The sample is constructed following Faulkender and Wang (2006). We collect the data from the Compustat and CRSP databases over the period between 1971 and 2017, excluding all financial and utility firms (SIC codes 4900-4999 and 6000-6999). All variables are adjusted to real values in the year 2001 dollars using the Consumer Price Index. The dependent variable is the excess stock return over the 12-month period corresponding to the firm's fiscal year, where the 25 benchmark portfolios are formed based on the size and BE/ME breakpoints from Kenneth French's website.[A.3]

The baseline regression of Faulkender and Wang (2006) includes the following independent variables: Change in cash stock ($\Delta Cash_t$), change in earnings before interest and extraordinary items ($\Delta Earnings_t$), change in net assets ($\Delta Net\ Assets_t$), net financing ($Net\ Fin_t$), change in R&D expenditures ($\Delta R\&D_t$), change in interest expense ($\Delta Interest_t$), change in dividend payout (ΔDiv_t), lagged cash stock ($Cash_{t-1}$), and leverage ratio ($Leverage_t$). All independent variables are scaled by the lagged market capitalization of the firm's equity.

To show that the FW approach is subject to non-identification, we construct the variables in the cash flow identity:

$$Inv_t + \Delta Cash_t + Div_t - Net\ Fin_t = Cash\ Flow_t. \tag{A.9}$$

We first construct the cash flow identity variables using data items from the balance sheet (BS) except for investment (Inv_t), which is inferred using the identity (A.9):

- $\Delta Cash_t$: change in cash and cash equivalents (CHE)
- Div_t: total dividends, i.e., common stock dividends (DVC) + preferred stock dividends (DVP)

[A.3] We thank Kenneth French for making the data available.

- $Net\ Fin_t$: net financing, i.e., net issuance of equity + net issuance of debt. Net issuance of equity equals change in book equity minus change in retained earnings (RE), where book equity is total assets (AT) minus total liabilities (LT) minus preferred stock (PSTKL) plus deferred taxes (TXDITC) plus convertible debt (DCVT). When missing, preferred stock (PSTKL) is replaced by redemption value of preferred stock (pstkrv). Net issuance of debt equals change in long-term debt (DLTT) plus change in short-term debt (DLC).

- Cash flow equals income before extraordinary items (IB) plus depreciation and amortization (DP) minus working capital accruals, where working capital accruals is constructed as change in current assets (ACT) minus change in cash and cash equivalents (CHE) minus change in current liabilities (LCT) plus change in short-term debt (DLC) plus change in tax payable (TXP).

All variables are deflated by the lagged market value of equity.

Alternatively, we can construct the variables in the cash flow identity using data items from the statement of cash flow. U.S. firms are required to issue Statement of Cash Flow (SCF) since July 15th, 1988. Prior to that, firms report their cash flows in three different types of formats ($scf = 1,\ 2,$ and 3). We follow the method of Chang et al. (2014) to construct the variables in the statement of cash flow using all the types of format available. Construction details using the Compustat items are provided below:

- Investment: CAPX + IVCH + AQC + FUSEO − SPPE − SIV for firms with $scf = 1,\ 2,$ and 3; CAPX + IVCH + AQC − SPPE − SIV − IVSTCH − IVACO for firms with $scf = 7$.

- Change in cash stock (CHECH)

- Dividends: DVC + DVP

- Net financing: net equity issuance + net debt issuance. Net equity issuance = SSTK − PRSTKC. Net debt issuance = DLTIS − DLTR − DLCCH for firms with $scf = 1$; DLTIS − DLTR + DLCCH for firms with $scf = 2,\ 3,\ \text{and } 7$

- Cash flow: IBC + XIDOC + DPC + TXDC + ESUBC + SPPIV + FOPO + FSRCO − working capital accruals for firms with $scf = 1, 2,\ \text{and } 3$; IBC + XIDOC + DPC + TXDC + ESUBC + SPPIV + FOPO + EXRE − working capital accruals for firms with $scf = 7$, where working capital accruals equal WCAPC for firms with $scf = 1$, −WCAPC for firms with $scf = 2$ and 3, and −RECCH − INVCH − APALCH − TXACH − AOLOCH − FIAO for firms with $scf = 7$

Likewise, all variables are scaled by the lagged market value of equity.

Similar to the discussion in Section 3, we can show that the FW regression approach is subject to non-identification due to the cash flow identity using the variables constructed with data items from the statement of cash flow. The results are presented in Table A.3. In column 1, we replicate the baseline regression of Faulkender and Wang (2006). Column 2 substitute the change in cash stock with that from SCF, the change in net assets with investment from SCF, and net financing with that from SCF. Column 3 replaces the change in cash stock with that from SCF, while keeping the change in net assets and net financing untouched. Columns 4 and 5 keeps the change in cash stock but alternately replace the change in net assets with investment from SCF and net financing with that from SCF. In all these alternative specifications, the regression coefficients of the change in cash stock are close to that in the baseline FW regression, which suggests that using the variables from the cash flow identity will not materially change the results. Finally, column 6 repeats the regression in column 2 except that the change in cash stock is replaced by cash flow. The regression coefficient of cash flow in column 6 is very close to that of the change in cash stock in column 2. Therefore, this finding, again, confirms our critique about the non-identification problem of the FW approach.

Table A.2: Faulkender and Wang (2006) Regression: Capital Gain as Dependent Variable

This table presents the results of regressing the excess capital gain $\tilde{r}_{it} - \tilde{R}^B_{it}$ on firm characteristics based on the simulated data from three model specifications: the baseline, baseline with the persistence of productivity shock changed to 0.3, and baseline with the persistence of productivity shock changed to 0.0. The average mean and standard deviation (in parentheses) of the true MVC for firm (λ_f) across the simulated samples are reported at the bottom. All variables are deflated by the lagged market equity P_{it-1}. h_{it+1} is the cash stock at the end of period t, d_{it} is the net cash flow to shareholders, which equals dividend payout D_{it} if $d_{it} \geq 0$ and equals negative of external financing if $d_{it} < 0$, $\tilde{r}_{it}$ is the capital gain of firm i for period t, defined as $\frac{P_{it}}{P_{it-1}}$, $\tilde{R}^B_{it}$ is the capital gain on one of the 25 Size/BM portfolios to which stock i belongs at t, i_{it} is the investment made in period t, E_{it-1} is earnings generated by firm i in $t-1$, which corresponds to the earnings before interest and extraordinary items in Faulkender and Wang (2006). Both regression coefficients and their standard errors (in parentheses) are averages across 100 simulations, each with 5,000 firms and 30 years.

	Baseline ($\rho_z = 0.67$)		$\rho_z = 0.3$		$\rho_z = 0.0$	
	(1)	(2)	(1)	(2)	(1)	(2)
Δh_{t+1}	3.436		1.371		0.947	
	(0.005)		(0.002)		(0.001)	
E_t		3.436		1.371		0.947
		(0.005)		(0.002)		(0.001)
i_t	3.057	−0.379	1.561	0.190	1.067	0.119
	(0.002)	(0.005)	(0.004)	(0.006)	(0.003)	(0.004)
d_t	2.291	−1.145	0.480	−0.890	−0.009	−0.956
	(0.004)	(0.004)	(0.001)	(0.003)	(0.001)	(0.002)
ΔD_t	−0.308	−0.308	−0.173	−0.173	0.002	0.002
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
h_t	0.137	0.137	0.156	0.156	0.137	0.137
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
$h_t * \Delta h_{t+1}$	−0.003	−0.003	0.001	0.001	−0.000	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
E_{t-1}	−1.900	−1.900	−0.365	−0.365	0.008	0.008
	(0.002)	(0.002)	(0.001)	(0.001)	(0.000)	(0.000)
intercept	−0.075	−0.075	−0.082	−0.082	−0.083	−0.083
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Adj. R^2	0.967	0.967	0.986	0.986	0.993	0.993
λ_f	0.962		0.970		0.963	
	(0.014)		(0.008)		(0.008)	

Table A.3: Non-Identification of the FW Regression—Based on Statement of Cash Flow (SCF) Variables

This table demonstrates the non-identification of the Faulkender and Wang (2006) approach using the variables constructed from SCF data items. The dependent variable is the excess stock return. All independent variables are constructed in the same way as in Table 4 except for those followed by (SCF) whose construction is discussed in Appendix F. In column 1, we repeat the baseline regression of Faulkender and Wang (2006). In column 2, we replace the change in cash stock with that constructed from SCF data, the change in net assets with investment from SCF, and net financing with that from SCF. Column 3 only replaces change in cash stock with that from SCF. Columns 4 and 5 alternately replace the change in net assets with investment from SCF and net financing with that SCF. Column 6 repeats column 2 except that the change in cash stock is replaced with cash flow computed from data items in SCF. Standard errors are clustered at the firm level and reported in parentheses. The superscripts *, **, and *** indicate the statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta Cash_t$	1.005***			0.873***	1.020***	
	(0.019)			(0.018)	(0.019)	
$\Delta Cash_t$ (SCF)		1.113***	1.013***			
		(0.024)	(0.023)			
$Cash\ Flow_t$ (SCF)						1.082***
						(0.022)
$\Delta Earnings_t$	0.543***	0.611***	0.586***	0.605***	0.535***	0.616***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
$\Delta Net\ Assets_t$	0.289***		0.247***		0.303***	
	(0.007)		(0.006)		(0.007)	
Inv_t (SCF)		0.718***		0.642***		−0.391***
		(0.013)		(0.012)		(0.023)
$Net\ Fin_t$	−0.118***		−0.037***	−0.192***		
	(0.012)		(0.012)	(0.013)		
$Net\ Fin_t$ (SCF)		−0.201***			−0.151***	0.899***
		(0.013)			(0.012)	(0.024)
$\Delta R\&D_t$	1.245***	1.523***	1.454***	1.481***	1.224***	1.543***
	(0.106)	(0.106)	(0.107)	(0.107)	(0.106)	(0.106)
$\Delta Interest_t$	−1.886***	−1.233***	−1.982***	−1.134***	−1.823***	−1.241***
	(0.091)	(0.087)	(0.090)	(0.087)	(0.090)	(0.087)
ΔDiv_t	3.176***	4.045***	3.595***	3.961***	3.142***	3.714***
	(0.217)	(0.212)	(0.217)	(0.212)	(0.217)	(0.210)
$Cash_{t-1}$	0.252***	0.119***	0.173***	0.177***	0.253***	0.118***
	(0.010)	(0.009)	(0.009)	(0.010)	(0.010)	(0.009)
$Leverage_t$	−0.357***	−0.617***	−0.371***	−0.596***	−0.351***	−0.628***
	(0.006)	(0.007)	(0.006)	(0.007)	(0.006)	(0.007)
Constant	0.014***	0.013***	0.025***	0.011***	0.013***	0.005*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Observations	116,946	116,946	116,946	116,946	116,946	116,946
Adj. R^2	0.168	0.179	0.153	0.180	0.168	0.181

Figure A.1: Histogram of Gross Marginal Value of Cash for Firms with Zero External Financing and Zero Payouts

This figure presents the histogram of gross marginal values of cash for firms who neither raise external financing nor pay out. There are only 48 observations in our sample.