Investment Dynamics and Earnings-Return Properties: A Structural Approach

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Abstract:
We propose the standard neoclassical model of investment under uncertainty with short-run adjustment frictions as a benchmark for earnings-return patterns absent accounting influences. We show that our proposed benchmark generates a wide range of earnings-return patterns documented in prior accounting research. Notably, our model generates a concave earnings-return relation, similar to that of Basu [1997], and predicts that the earnings-return concavity increases in the volatility of firms' underlying shock processes and decreases in investment levels. We find strong empirical support for these novel predictions. Overall, our evidence suggests that our proposed benchmark is useful for understanding the joint dynamics of variables of interest to accounting research (e.g., earnings, returns, investment, market-to-book) absent accounting influences, a necessary precondition for inferring the effects of accounting from these dynamics.

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1. Introduction

A substantial body of accounting research investigates the properties of accounting earnings, such as timeliness and conservatism, by studying the contemporaneous relation between earnings and returns.[1] A key challenge to this literature is to discern the effects of accounting-related factors, such as accounting rules and managerial reporting discretion, on earnings-return patterns from the effects of economic fundamentals. To date, we still lack a profound understanding of the economic null of earnings-return patterns—that is, how economic fundamentals jointly determine earnings and returns absent accounting rules and measurement issues. Without such understanding of the economic null, however, the inferences we can draw from empirically observed earnings-return patterns about accounting effects remain limited.

In this paper, we propose a simple model of the firm and investigate its implications for the properties of earnings and returns absent accounting rules and measurement issues, to make progress toward an economic benchmark for earnings-return patterns. In line with extant economics and finance literature, we model the firm as an infinite-horizon dynamic-investment problem under uncertainty with symmetric (convex) capital adjustment costs.[2] In each period, a risk-neutral manager, acting on behalf of shareholders, faces a partially persistent shock to the profitability of capital, the firm's only fixed production factor, and chooses the next period's capital stock (through this period's investment) to maximize the present value of future cash flows.

Absent a closed form solution, we numerically solve the model using dynamic programming techniques. Equipped with the optimal investment behavior (policy function) and firm value (value function) for each possible state, we simulate a time series of earnings, returns, and capital

[1] See Kothari [2001] for a survey of the literature.
[2] See Strebulaev and Whited [2012] for a survey of the literature.

(investments) in response to a symmetric exogenous profitability shock process. The simulated data allows us to investigate the earnings and return patterns generated by our model.

We show that our proposed model generates a wide range of well-documented empirical earnings and return patterns. Compared to previously studied static valuation models (e.g., Ohlson [1995]; Feltham and Ohlson [1995]; Holthausen and Watts [2001]), our model adds two features crucially contributing to its ability to match empirical earnings-return patterns. First, our model features real expansion and adaption options (e.g., Burgstahler and Dichev [1997]; Zhang [2000]). These real options introduce notable nonlinearities in the predicted earnings and return patterns, allowing our model to match empirical patterns, such as the differential persistence of profits and losses (e.g., Hayn [1995]) and the nonlinear shape of earnings-response coefficients (e.g., Freeman and Tse [1992]; Wysocki [1999]). Second, our model features a short-run fixed production factor (due to time-to-build and convex capital adjustment costs) (e.g., Lucas and Prescott [1971]; Hayashi [1982]). This short-run fixed production factor introduces real *dynamics* into investment decisions and the earnings process, allowing our model to match empirical patterns, such as the autocorrelation of investments (e.g., Cooper and Haltiwanger [2006]; Strebulaev and Whited [2012]) and the earnings-return concavity (e.g., Basu [1997]).

Our model's ability to generate a concave earnings-return relation is particularly intriguing given that our model is based on symmetric primitives (e.g., symmetric profitability shocks and adjustment costs). Two channels jointly generate the prominent earnings-return concavity, even in the absence of accounting conservatism. First, current-period earnings respond more strongly to negative than to positive persistent profitability shocks. The intuition behind this is as follows. Suppose a firm experiences a persistent shock to the profitability of its short-run fixed capital stock (e.g., property, plant, and equipment) in the current period. To achieve a more optimal level of capital in the future given the current-period shock, the firm invests in new capital or divests existing capital, depending on the sign of the shock. In changing its capital stock, however, the firm incurs adjustment costs (e.g., costs associated with production disruptions and managerial planning) that reduce its current-period earnings. Thus, adjustment costs exacerbate the earnings-decreasing effects of negative profitability shocks and reduce the earnings-increasing effects of positive profitability shocks.

Second, and more importantly, future-period earnings respond more strongly to positive than to negative persistent profitability shocks. This result follows as capital investments in response to a persistent positive shock in the current period allow firms to take advantage of their increased demand or productivity in the future. Hence, the capital expansion in response to a persistent positive shock increases future earnings (expansion (call) option; e.g., Pindyck [1988]; Wysocki [1999]). By contrast, capital divestments in response to a persistent negative shock in the current period allow firms to minimize the impact of their decreased demand or productivity in the future. Thus, the capital curtailment in response to a persistent negative shock curbs future losses (abandonment/curtailment (put) option; e.g., Hayn [1995]; Lawrence, Sloan, and Sun [2017]).

In sum, current-period earnings respond more strongly to negative than to positive shocks, whereas future-period earnings respond more strongly to positive than to negative shocks. To understand the implications of these differential short- versus long-run earnings effects for the earnings-return relation, note that returns capture both current and future earnings responses to shocks. Hence, returns react less strongly to negative than to positive shocks relative to current-period earnings. Even more so, we find that returns react considerably more strongly to positive than to negative shocks, generating a strongly convex relation between returns and profitability shocks. Thus, plotting earnings (which are a weakly concave function of shocks) as a function of returns (which are a strongly convex function of shocks) yields a concave relation.

Our model highlights two points. First, returns are a convex function of "news," inconsistent with the underlying premise of linearity in Basu [1997]. This convexity is the main channel generating a concave earnings-return relation in our model, suggesting that convex return responses to "news," rather than concave earnings responses to "news," are at the core of the earnings-return asymmetry absent accounting influences. Second, long-run adjustments to short-run fixed input factors are vital for the earnings-return asymmetry in our model. If shocks are purely transitory or adjustment costs are prohibitively high, the earnings-return asymmetry becomes attenuated because current-period shocks have no (differential) future earnings implications; thus, current-period earnings and returns would react similarly to "news," generating a linear earnings-return relation. Further, if all input factors were variable, current period earnings would exhibit an even more convex relation with "news" than returns, generating a convex earnings-return relation.[3]

Overall, our model's ability to match a host of central empirical earnings-return patterns documented in prior accounting research strongly supports its descriptiveness. To further assess its descriptiveness, we explicitly test two novel and model-specific predictions. Specifically, our model predicts that the earnings-return concavity is increasing in the volatility of firms' underlying shock processes (i.e., uncertainty) and decreasing in the level of firms' investments. Using actual (Compustat) data, we find consistent evidence. The empirical earnings-return concavity

[3] In the absence of adjustment frictions, the decision on optimal capital is independent of the amount of capital in place. Thus, the decision problem collapses to a series of static decisions. In such a setting, the earnings-return asymmetry has the opposite sign (e.g., consistent with the case of maximal "decision making impact" in Hemmer and Labro [2016]). Hence, the adjustment friction and associated real dynamics are necessary to generate an earnings-return asymmetry consistent with Basu [1997].

monotonically increases across quintiles of firms' earnings volatility and decreases across quintiles of firms' investment levels.

These empirical findings make three important points. First, the mediating roles of volatility and investment behavior support a close link between an investment-based model of the firm and the concave earnings-return pattern in the data (e.g., Dixit and Pindyck [1994]; Bloom, Bond, and Van Reenen [2007]; Asker, Collard-Wexler, and De Loecker [2014]). Second, the measurement of conservatism via the earnings-return relation is affected by correlated omitted variable concerns related to the volatility of firms' fundamental shock processes, similar to other earnings quality measures (e.g., Hribar and Nichols [2007]; Owens, Wu, and Zimmerman [2017]; Nikolaev [2017]). Finally, earnings and returns, and the earnings-return concavity in particular, are endogenously related to firms' investment behavior, complicating efforts to establish a causal effect of conservatism on firms' investment behavior (e.g., García Lara, García Osma, and Penalva [2016]).

Our study contributes to the accounting literature in two major ways. First, we document the descriptiveness of the neoclassical dynamic-investment model under uncertainty with adjustment frictions for central earnings properties. Although the economics and finance literature has demonstrated its descriptiveness for investment and return patterns (e.g., Berk, Green, and Naik [1999]; Liu, Whited, and Zhang [2009]; Obreja [2013]), the earnings patterns implied by the model have not yet been studied. The dynamics of earnings and their co-movement with variables, such as returns, investment, market-to-book, or cash flow, however, are of fundamental interest to the accounting literature (e.g., Lev [1989]; Kothari [2001]; Gerakos [2012]; Nikolaev [2017]). Our study suggests the workhorse dynamic-investment model presents a useful starting point for accounting researchers in search of a model for the dynamics of economic earnings. Future research, by adding particular measurement systems (e.g., conservative accounting rules; accruals (Nikolaev [2017]; Choi

[2017])) or other frictions (e.g., agency problems (DeMarzo et al. [2012]; Nikolov and Whited [2014]); earnings management (Beyer, Guttman, and Marinovic [2014]); short-termism (Terry [2017])) to our basic model, can derive novel predictions about the incremental effect of these systems and frictions on earnings, return, and investment patterns. Concurrent work by Liang, Sun, and Tam [2017] is a recent example following this promising route.

Second, we advance the vast literature on accounting conservatism by providing a model-based explanation for correlated omitted variable concerns. Although the conservatism literature recognized the threat of correlated variables early on (e.g., Basu [1997]; Ball, Kothari, and Robin [2000]), we still lack an understanding of which fundamental variables may distort the measurement of accounting conservatism via the earnings-return asymmetry. Our model suggests that investment dynamics, and uncertainty in particular, are a first-order determinant of the earnings-return asymmetry. This insight is particularly acute, as prior literature frequently invokes an argument about outsiders' increased demand for conservative accounting in situations of heightened uncertainty to rationalize the robust associations between the earnings-return asymmetry and uncertainty-related variables (e.g., firm size, competition, information asymmetry proxies). Our study suggests these empirical associations can arise even without such a demand for accounting conservatism.

The remainder of this paper proceeds as follows. In Section 2, we discuss the relation of our model and insights to the literature, before we describe our model setup and solution in Section 3. In Section 4, we derive our model predictions and benchmark them against empirical patterns documented in the literature. In Section 5, we empirically test two novel predictions of our model, before we conclude in Section 6.

2. Related Literature

a. Related models of earnings processes and properties

Our study is related to concurrent work by Hemmer and Labro [2016] and Dutta and Patatoukas [2017]. Similar to our study, Hemmer and Labro [2016] describe an investment-based model that, without conservative accounting rules and managerial reporting discretion, generates a number of commonly documented earnings and return properties. Hemmer and Labro [2016] assume that managers learn from internally reported earnings, whereas the market updates its expectations about firm value based on less frequent and aggregated releases of these internal earnings reports. They find that losses are less persistent than profits, market responses to earnings are S-shaped, the earnings distribution is asymmetric with excess mass to the right of zero, and that the earnings-return relation is asymmetric. Our model generates similar results and further implications. Our model, however, is arguably more general (e.g., investment payoffs are continuous rather than binary), relies on a different, very basic, mechanism to generate dynamics (i.e., short-run fixed input factors rather than gradual managerial learning), closely resembles a firm (e.g., due to an infinite rather than finite horizon), allows straightforward adaptations and extensions (e.g., adding working capital accruals), and lends itself to estimation (e.g., Strebulaev and Whited [2012]). Hence, our proposed model provides a more comprehensive benchmark for earnings-return dynamics absent (accounting) measurement issues, particularly useful for future research.

Concurrent work by Dutta and Patatoukas [2017] proposes a valuation-based model to investigate potential economic determinants of the earnings-return asymmetry. Consistent with our model, Dutta and Patatoukas [2017] show that economic factors can contribute to the earnings-return asymmetry. In contrast to their work, however, we do not assume that the asset-to-be-priced is fixed. Following recent asset pricing work (e.g., Kogan and Papanikolaou [2014]), we consider the firm as a combination of assets-in-place and growth opportunities that vary dynamically due to managerial investment decisions in response to profitability shocks. We document that this dynamic perspective endogenously generates some of the crucial economic patterns (e.g., asymmetric return distribution) taken as exogenous primitives in Dutta and Patatoukas [2017]. Hence, our approach provides a more fundamental understanding of the underlying process generating the asymmetries found in the data.

b. Dynamics of investments, returns, and earnings

Our study is based on and related to recent studies in economics, finance, and accounting stressing the importance of dynamics. Our basic model is the canonical investment model in economics and finance (e.g., Lucas and Prescott [1971]; Strebulaev and Whited [2012]), which provides the micro-foundation for q-theory (e.g., Brainard and Tobin [1968]; Tobin [1969]; Hayashi [1982]). In the field of economics, this model of investment under uncertainty with short-run adjustment frictions has importantly contributed to the understanding of firms' investment behavior and observed dispersion in productivity across firms and countries (Asker, Collard-Wexler, and De Loecker [2014]). In the field of corporate finance and asset pricing, the dynamic-investment model has recently furthered our understanding of prima facie anomalous patterns in corporate financing and asset returns (e.g., Strebulaev and Whited [2012]; Berk, Green, and Naik [1999]; Li, Livdan, and Zhang [2009]; Liu, Whited, and Zhang [2009]; Wu, Zhang, and Zhang [2010]; Kogan and Papanikolaou [2014]; Obreja [2013]; Fama and French [2015]). Finally, in the field of accounting, dynamics play an important role as, for example, evidenced by the intertemporal concept of accrual accounting (e.g., Dechow [1994]; Gerakos [2012]). Accordingly, recent work by Gerakos and Kovrijnykh [2013], Beyer, Guttman, and Marinovic [2014], Nikolaev [2017], and Bloomfield, Gerakos, and Kovrijnykh [2017], among others, exploits time-series patterns in earnings introduced by accounting rules and managerial discretion. Most closely related to our study, Liang, Sun, and

Tam [2017] marries a dynamic-investment process with a static real effects model (e.g., Kanodia and Sapra [2016]). Compared to Liang, Sun, and Tam [2017], we take one step back and ask: before considering the impact of any information asymmetries and measurement systems, what do investment dynamics already imply for the relation between investments, returns, and earnings?

c. Accounting conservatism

Our dynamic model suggests the existence of inputs that are fixed (i.e., unaffected by managerial responses to current shocks) in the short run, but can be adjusted in the long run results in a concave earnings-return relation. A number of prior cross-sectional patterns of the earnings-return asymmetry already hint at this mechanism. Notably, Basu [1997] documents that the earnings-return asymmetry decreases over longer aggregation horizons (e.g., four year cumulative earnings and returns instead of annual earnings and returns). Over longer horizons, fixed inputs become more variable, resulting in an attenuation of the asymmetry. Similarly, Khan and Watts [2009] show that the earnings-return asymmetry increases with the length of the investment cycle. Hence, the mismatch between short-run earnings and long-run returns is accentuated when short-run production and investment responses are particularly inelastic. Most recently, Banker et al. [2016] suggest that sticky or fixed costs increase the earnings-return asymmetry and confound the measurement of accounting conservatism. Our findings provide a complementary explanation for their results. Our model suggests that short-run fixed production factors—the underlying reason for the existence of fixed costs—naturally create concave earnings-return relations.

3. Economic model

We propose a variant of the canonical dynamic-investment model under uncertainty with convex capital adjustment costs as a simple starting point to think about firm dynamics absent measurement issues. Strebulaev and Whited [2012] provide a detailed description of this discrete-time infinite-horizon model. Our following discussion and notation draws heavily on their work.

a. Model description

Our partial-equilibrium investment model features a risk-neutral manager who, on behalf of shareholders, maximizes the present value of future cash flows (V_t) by choosing the optimal capital stock (e.g., property, plant, and equipment) for all future periods (k_{t+j}):

$$V_t = \max_{k_{t+j} | j=1,\dots,\infty} E_t \left[\sum_{j=0}^{\infty} \left(\frac{1}{1+r} \right)^j c(k_{t+j}, I_{t+j}, z_{t+j}) \right].$$

The current period cash flow is determined by the firm's profitability (z_t), capital (k_t), and investment in capital (I_t):

$$c(k_t, I_t, z_t) = \pi(k_t, z_t) - \psi(k_t, I_t) - I_t .$$

The payoff from the production process—absent production disruptions due to investments—is defined as:

$$\pi(k_t, z_t) = z_t k_t^{\theta} ,$$

where capital (k_t) is the only fixed production factor and θ determines the curvature of the profit function.[4] When the firm invests, it incurs (convex) adjustment costs due to disruptions to the production process (e.g., the planning and implementation of investments), which are defined as follows:

[4] Although capital being the only fixed production factor seems restrictive, we note that expressing the payoffs of the production process (rather than production itself) as a function of capital does not imply that variable input factors, such as labor or short-term working capital, are neglected. We can think of these factors as being maximized out of the problem, i.e., already accounted for in the level of the production payoffs (Strebulaev and Whited [2012]). Note also that the curvature (theta) of the profit function does not mechanically induce a concavity in the earnings-return relation (as it applies to the installed capital, not the profitability shock). For an alternative model with constant returns to capital, refer to Section D "Alternative Investment Model" in our Online Appendix.

$$\psi(k_t, I_t) = \psi \frac{I_t^2}{2k_t}.$$

We follow prior literature in specifying the adjustment costs and use a (symmetric) standard quadratic functional form, where adjustment costs are increasing and convex in the size of the investments and weakly decreasing in the level of existing capital.

Given this setup, the manager faces an infinite-horizon dynamic program with two states, profitability and capital. Profitability evolves following an exogenous Markov process. We specify the profitability process as a first-order autoregressive process (AR(1)):

$$z_t = (1-\rho)\overline{z} + \rho z_{t-1} + \varepsilon_t,$$

where $\overline{z}$ is the unconditional average profitability, ρ is the persistence of profitability shocks, and ε_t is the current period shock to profitability. This shock can, for example, represent a demand or a productivity shock. We assume that the shocks are identically and independently normally distributed with mean zero and variance σ_ε^2 ($\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$). We deliberately assume normality, deviating from log-normality commonly assumed in prior literature (e.g., Strebulaev and Whited [2012]). The benefit is twofold: First, our underlying profitability shock process is symmetric. Hence, we do not mechanically induce any asymmetries in earnings. Second, our profitability process allows for negative profitability instead of being truncated at zero.[5] This is particularly useful as the frequency of realized losses among Compustat firms is substantial and plays a central role in the earnings-return relation (e.g., Hayn [1995]). This benefit, however, also comes at a cost. Our normality assumption could lead to negative firm values for sufficiently large negative profitability draws. In reality, limited liability rules out negative firm values as owners possess a

[5] A negative profitability means that even if the firm can adjust all other variable input factors, it cannot completely avoid costs (above and beyond the depreciation charge) related to the scale of its fixed capital.

financial put option (e.g., Berger, Ofek, and Swary [1996]). As we do not explicitly model a default option, we need to ensure that negative firm values do not materialize in our simulations through the careful choice of suitable parameter values.

As is standard in the dynamic-investment literature, capital evolves endogenously as the result of capital deprecation and the manager's investment choice:

$$k_{t+1} = (1-\delta)k_t + I_t ,$$

where δ denotes the constant rate of economic depreciation. The price of capital is normalized to unity. Based on current period's capital and next period's expected profitability, the manager optimally chooses current period investment (policy function).

The investment decision trades off the marginal cost of investing today against the marginal benefit of additional capital in the future. The marginal benefit of capital can be expressed as:

$$\chi_t = E_t\left[\sum_{j=1}^{\infty}\left(\frac{1}{1+r}\right)^j (1-\delta)^{j-1}\left(\pi_k(k_{t+j}, z_{t+j}) - \psi_k(k_{t+j}, I_{t+j})\right)\right],$$

where χ_t is the expected value of future marginal benefits from using the additional capital also referred to as marginal q (Strebulaev and Whited [2012]). The benefits comprise increased future production payoffs ($\pi_k(k_{t+j}, z_{t+j})$) and reduced future capital adjustment costs ($\psi_k(k_{t+j}, I_{t+j})$).

At the optimum, the manager is indifferent between investing an additional unit of capital today and waiting to invest until next period:

$$1+\psi_I(k_t, I_t) = E_t\left[\frac{1}{1+r}\left(\pi_k(k_{t+1}, z_{z+1}) - \psi_k(k_{t+1}, I_{t+1}) + (1-\delta)\left(1+\psi_I(k_{t+1}, I_{t+1})\right)\right)\right].$$

The left-hand side represents the marginal cost of investing today which is the sum of the marginal price of investment and the marginal adjustment cost. The right-hand side denotes the expected marginal cost of waiting to invest until the next period. This marginal cost is composed of the discounted marginal investment cost $(1+\psi_I(k_{t+1}, I_{t+1}))$ and the discounted opportunity cost of waiting ($\pi_k(k_{t+1}, z_{z+1}) - \psi_k(k_{t+1}, I_{t+1})$).

b. Model solution

Our model has no analytical solution. However, we can numerically solve our model (e.g., Strebulaev and Whited [2012]; Miranda and Fackler [2005]). We can reformulate our dynamic program in the form of a Bellman equation (Bellman, Martin, and Price [1954]):

$$V(k,z) = \max_{k'} \left\{ \pi(k,z) - \psi(k, k' - (1-\delta)k) - (k' - (1-\delta)k) + \frac{1}{1+r} E_z \left[V(k', z') \right] \right\},$$

where (k', z') are next period's states, investment is reformulated as $k' - (1-\delta)k$, and E_z denotes the expectation operator conditional on the current profitability state z.

We solve for the value function ($V(k,z)$) and the policy function, i.e., optimal investment given the current states, via value function iteration (for more details refer to, e.g., Strebulaev and Whited [2012]). To implement the value function iteration, we discretize the state space. For capital, we create a 600×600 grid of all combinations of current and next period capital. For profitability, we construct a 100×100 transition matrix for the evolution of profitability (z).

We obtain the value function and policy function for all 600×100 possible combinations of the current state space (k,z). The solutions to the value function and policy function allow us to simulate the manager's optimal investment decision and the firm's value given a certain capital stock and realization of the profitability shock process.

c. Model simulation

We calibrate the majority of our model parameters following prior literature (Table 1). We need to choose own calibrations for the level and variability of our profitability process as prior literature uses a lognormal instead of our normal profitability process. We explicitly calibrate our model with a relatively high unconditional profitability level to avoid negative continuation (or value function) values. Similarly, we choose the standard deviation of the profitability shock such that there is a non-negligible probability of negative profitability draws while ensuring positive continuation values. Overall, the parameters are calibrated such that we avoid bunching at the bounds of the capital grid (i.e., the state space of our endogenous state variable). This circumvents artificial nonlinearities due to an unintentionally restricted choice set (e.g., a binding lower or upper limit of the possible capital values).

We solve our model for the value and policy functions given our calibrated parameters. Equipped with the resulting value and policy functions, we simulate a time-series of 101,000 observations given starting values for capital and profitability and a series of realized profitability shocks. We discard the first 1,000 observations to avoid undue influence of the initial conditions.

The simulated data provides us with a time-series of firm values (V_t), current and next period capital (k_t, k_{t+1}), profitability (z_t), and cash flows ($c(k_t, I_t, z_t)$). We use these simulated data items to generate our variables of interest (Table 2): investment (I_t), cash flow from operations (cfo_t), earnings (ear_t), and returns (ret_t).

We calculate investment (I_t) as the difference between next period's capital and current period's depreciated capital. We define cash flow from operations (cfo_t) as the payoff from production minus capital adjustment costs. In our model, cash flow from operations is free from timing errors (e.g., Dechow [1994]; Nikolaev [2017]). Hence, cash flow from operations is closely related to the "economic payoff or dividend" of the period or can be thought of as earnings with perfect accruals offsetting any timing error in cash flows. Thus, we define earnings as cash flow from operations less depreciation charge. Depreciation charge is the only explicit accrual in our basic model which serves to address the timing error associated with investment cash flows. Given this setup, we cannot explicitly investigate the relation between accruals and returns in our basic model. However, if we consider working capital accounts as complements to fixed capital (e.g., Wu, Zhang, and Zhang [2010]; Arif, Marshall, and Yohn [2016]), we expect that accruals in the data behave similar to capital investments. (In Section C "Accruals Model" of our Online Appendix, we corroborate this intuition using an extended model including working capital accounts.) We define price (p_t) as the (cum-dividend) firm value (V_t) of the all-equity financed firm and (abnormal) return (ret_t) as the percentage change in price (excluding the previous period's dividend) less the expected return (discount rate: r) (Table 2).

d. Policy function

Before investigating the earnings and return patterns predicted by our model, we briefly build intuition for the manager's optimal investment policy. Figure 1 depicts the average level of current and next period capital as a function of current period profitability in the simulated data. We observe that the manager, on average, increases next period's capital if this period's profitability is above the unconditional profitability level ($\bar{z} = 1.5$), whereas the manager decreases next period's capital if this period's profitability is below the unconditional profitability level. Given a concave profit function ($\theta = 0.7$), we can also observe that the relation between capital and investment is convex.[6] The intuition behind this is that in times of high profitability, capital needs to increase more to take advantage of the high profitability than it needs to decrease to contain poor performance in low profitability times. In essence, Figure 1 summarizes the dynamic-investment decision that is core to our model: choosing next period capital as a function of current period capital and profitability.

In the Online Appendix ("Model Comparison"), we contrast the optimal investment policy under convex adjustment costs with the optimal investment policy absent any adjustment frictions. The key difference between these two policies is that the adjustment frictions reduce the manager's immediate investment response to profitability shocks, spreading investments over time (Figure 2). Hence, investment responses are dampened and serially correlated compared to a setting without adjustment costs.

4. Model predictions

In this section, we present our model predictions for a wide range of investment, earnings, and return patterns and compare them with their empirical counterparts documented in prior accounting literature.

a. Distributions

We first investigate the distributions of investment, earnings, and returns generated by our model (Figure 3). By construction, the profitability of capital is symmetric and approximately normally distributed. In contrast, investment, earnings, and returns—the three variables affected by managerial decision making—exhibit right skewness in their univariate distributions. The skewness

[6] Our assumption of a concave profit function does not mechanically induce a concave earnings-return relation. On the contrary, absent adjustment frictions, the relation between earnings and returns is convex (see Section 4.e). To further clarify this point, we also examine an alternative model in continuous time with constant returns to capital (i.e., $\theta = 1$; for model details, see Section D "Alternative Investment Model" in our Online Appendix). We thank an anonymous reviewer for suggesting this alternative approach.

is least visible in the return distribution, which appears close to normally distributed. The right-skewness is more obvious for the distribution of investments and most obvious for the distribution of earnings. Hence, we see that—despite symmetric profitability shocks—earnings are highly right-skewed. Optimal investment behavior by the manager appears to avoid negative earnings. In this vein, our model predicts missing mass in the left tail of the earnings distribution compared to a normal distribution (Figure 3), and a left-skewed earnings distribution after scaling by lagged price (Figure 4), consistent with findings in Durtschi and Easton [2005].

b. Persistence of earnings levels and changes

With a view to the persistence of earnings, our model predicts that profits are more persistent than losses due to divestments in response to negative profitability shocks and investments in response to positive shocks (Table 3, Column 1). The differential persistence of profits and losses is consistent with empirical evidence in Hayn [1995]. However, in our model this pattern emerges from the manager's optimal use of real expansion and adaption options (e.g., Burgstahler and Dichev [1997]; Wysocki [1999]) rather than from shareholders exercising their financial abandonment option (due to limited liability) as suggested by Hayn [1995].

Our model does not predict that negative changes in earnings are less persistent than positive changes (Table 3, Column 2). After scaling earnings changes by lagged price or capital (as is done in prior literature), however, our model generates conditional time-series correlations between current earnings changes and lagged earnings changes consistent with findings in Basu [1997] and Ball and Shivakumar [2005] (Table 3, Columns 3 and 4). In contrast to the interpretation in Basu [1997] and Ball and Shivakumar [2005], these conditional correlations are not due to differential accounting treatment of profits and losses, but due to the manager's optimal investment behavior in our model.

c. Earnings-response coefficient

Turning to the contemporaneous relation between earnings and returns, we first investigate our model predictions regarding the earnings-response coefficient; that is, the coefficient on (unexpected) earnings in a regression of (abnormal) returns on (unexpected) earnings. We find that our model predictions match many of the fundamental empirical findings in the earnings-response coefficient literature. Consistent with the early literature (e.g., Kormendi and Lipe [1987]; Collins and Kothari [1989]; Easton and Zmijewski [1989]), our model predicts the earnings-response coefficient decreases in the (exogenous) discount rate and increases in the persistence of profitability shocks (Figure 5). Similarly, our model predicts the earnings-response coefficient is positively associated with the (endogenous) market-to-book ratio (Figure 5) (e.g., Collins and Kothari [1989]) and negatively associated with the absolute earnings surprise (e.g., Freeman and Tse [1992]) and losses (e.g., Hayn [1995]).

In terms of magnitude, our model generates an earnings-response coefficient of about 3, close to current estimates in the literature that account for the effect of outliers and nonlinearities (e.g., Gipper, Leuz, and Maffett [2017]) (Table 4).[7] This estimate is much lower than the expected magnitude of 8 to 20 derived under the assumption of reasonable discount rates and a random walk earnings process (Kothari [2001]). In our case, the earnings response coefficient deviates from the typical benchmark of 11 ($1+{}^{1}\!/_{r}$ using a 10% discount rate), because our model features an exogenous mean reverting profitability process and an endogenous earnings process.[8]

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[7] We acknowledge that the magnitude of the earnings-response coefficient, unlike its cross-sectional determinants and patterns, is clearly dependent on the choice of parameter values.

[8] With a mean-reverting process, the capitalization rate is reduced: $1+{}^{1}\!/_{(r-\rho)}$.

With respect to the shape of the earnings-response coefficient, our model predicts that the manager's loss avoidance leads to a hockey stick earnings-response coefficient when using the correct earnings expectation model which perfectly accounts for all future investment and earnings implications (e.g., Hayn [1995]; Burgstahler and Dichev [1997]) (Figure 6). By contrast, we find a strongly S-shaped earnings-response coefficient as documented in prior literature (e.g., Freeman and Tse [1992]) when using an approximate earnings expectation model based on an AR(1) model of earnings. Notably, the managerial influence in our model leads to deviations from an AR(1) process in earnings (making positive earnings more and negative earnings less persistent) despite an underlying AR(1) process in profitability.

Thus, our model suggests the empirical earnings-response coefficients, after accounting for poor expectation model properties especially in the tail of the earnings surprise distribution, are not necessarily "too" small, as for example argued in Lev [1989]. Our model rather suggests imperfect expectation models (relying on an AR(1) process or analyst forecasts) may already explain much of the attenuated tails/nonlinearity (e.g., Schütt [2013]). Hence, low empirical earnings-response coefficients due to attenuation in the tails do not per se allow the conclusion that accounting earnings are of poor quality.[9]

In this vein, Collins et al. [1994] argue that the explanatory power of earnings for contemporaneous returns arises because of poor expectation models and lack of earnings

[9] As an aside, our model also suggests the R^2 of a regression of returns on earnings is not necessarily an informative measure of the valuation usefulness of earnings. In our model, earnings only capture current period performance. They do not anticipate any future impacts, unlike returns. However, due to the outsiders' knowledge of the policy and value function (i.e., what the manager will do given current period earnings and how this will influence future value), current period earnings and capital are sufficient statistics to value the firm perfectly. Hence, forward looking earnings are not necessarily more useful for firm valuation than earnings reflecting merely the current period performance.

"timeliness" rather than poor quality of accounting earnings.[10] They document that an augmented earnings-return regression including future earnings and returns substantially increases the coefficient on contemporaneous earnings and the explanatory power for contemporaneous returns. Supporting the descriptiveness of our model for the joint dynamic patterns of earnings and returns, our model generates comparable lead-lag patterns in coefficients and explanatory power as the "future earnings response coefficient" regression of Collins et al. [1994] (Table 5).

d. Earnings-return asymmetry

Finally, we investigate the predictions of our model for the shape of the reverse earnings-return relation popularized by Basu [1997]. Our model predicts both earnings and earnings scaled by lagged price (as defined in Basu [1997]) exhibit concave relationships with returns (Figure 7).[11] Unlike the interpretation in Basu [1997], however, this concavity is not due to differential accounting treatment of profits versus losses in our model.[12]

Rather, two economic channels jointly generate the asymmetric earnings-return relation in our model: an "earnings-news concavity" and a "return-news convexity." First, earnings before adjustment costs exhibit a linear relation to "news" (in our case: profitability shocks), because current period capital is fixed, and thus, symmetric profitability shocks are simply scaled by a constant (i.e., fixed capital). After accounting for the costs of capital adjustments, however, earnings exhibit a concave relationship with "news", because both, positive and negative profitability shocks trigger adjustments to the firm's existing capital stock (taking effect in the next period) and

[10] Collins et al. [1994] consider earnings as lacking timeliness, because they only capture current period performance, whereas returns capture changes in expectations about current and future period performance.

[11] We find similar asymmetries in the operating cash flow-return relation. Hence, the earnings-return asymmetry is not merely driven by the depreciation charge, i.e., a short-run fixed cost (e.g., Banker et al. [2015]).

[12] The concavity is also not merely or even solely due to the scale or "placebo" effect documented by Patatoukas and Thomas [2011] and Patatoukas and Thomas [2016]. Consistent with such "placebo" effect, our model generates an (untabulated) convex relationship between the inverse of lagged price and returns. Our model, however, also predicts that unscaled—not just scaled—earnings exhibit a concave relationship with returns, ruling out that the concave earnings-return relation is merely an artifact of the scaler of the dependent variable (Figure 7 and Table A5).

corresponding adjustment costs (Figure 8). This dampens current period profits given a positive shock and exacerbates current period losses given a negative shock.

Second, and most importantly, returns exhibit a convex relationship with "news," because the manager's optimal investment behavior takes advantage of positive shocks and alleviates the impact of negative shocks in the long run. In particular, the manager expands the firm's capital (in the future) in response to positive profitability shocks and abandons part of the firm's capital (in the future) in response to negative profitability shocks. This magnifies the return response given a positive shock and limits the return response given a negative shock (Figure 8). Accordingly, returns are *not* a linear function of "news" as assumed, for example, by Basu [1997] and Ball, Kothari, and Nikolaev [2013b].

Taken together, current period earnings respond more strongly to negative than to positive shocks, whereas the opposite is true for returns. Thus, plotting earnings against returns produces a concave relationship. Notably, our model suggests that the return-news convexity is a central reason for the earnings-return concavity.[13] In support of our model, Del Viva, Kasanen, and Trigeorgis [2017] empirically document the return-news convexity and Dutta and Patatoukas [2017] theoretically and empirically show that the asymmetry in returns explains a large fraction of the earnings-return asymmetry. Importantly, however, Dutta and Patatoukas [2017] simply assume the asymmetry of returns in their theoretical framework, whereas our model endogenously and jointly generates the return-news convexity and the earnings-return concavity from a symmetric primitive (i.e., profitability shocks).

[13] Consistent with this prediction, we document notable differences in conditional return variances, contributing to the earnings-return asymmetry (Table A6).

An important implication of the return-news convexity is that any variable (e.g., cash flow of operations as in Basu [1997], sales as in Banker et al. [2016], or investment as in Papadakis [2007]) will exhibit a more concave relationship with respect to returns than "news." That is, it is not the dependent variable (e.g., earnings), but the independent variable (positive versus negative returns) that drives much of the concavity in reverse earnings-return regressions. In this vein, our model predicts both profitability and investment exhibit a concave relationship with returns (Figure 9). The profitability-return concavity is noteworthy given that profitability, by construction, is a symmetric or linear function of news in our model. Thus, the concavity is entirely driven by the return-news convexity. The investment-return concavity is noteworthy given that this relationship has previously been attributed to "asymmetric" capital adjustment costs (Papadakis [2007]). In contrast, our model generates the investment-return concavity due to the return-news convexity, which endogenously arises in our model with symmetric adjustment costs.[14]

With respect to mediating factors of the earnings-return asymmetry, our model predicts three noteworthy patterns. First, the earnings-return concavity increases in the volatility of the underlying profitability process (Figure A3). This prediction holds when, all else equal, increasing the (unobserved) exogenous parameter of firms' shock volatility as well as when estimating the earnings-return concavity separately for firms ordered by quintiles of their (observed) earnings volatility (measured as the standard deviation of earnings over lagged price) (Table 6, Panel A).[15] Second, the earnings-return concavity decreases across quintiles of firms' (endogenous) investment

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[14] The investment-return concavity is also important because (working capital) accruals can be considered as investments in short-term adjustable production factors (e.g., Wu, Zhang, and Zhang [2010]; Arif, Marshall, and Yohn [2016]). Extending our model to include optimal working capital choices in Section C "Accruals Model" in the Online Appendix, we show that the accruals-return relation is indeed also concave. Hence, focusing on the accruals portion of earnings does not free the measurement of accounting-related conservatism from confounding influences related to economic fundamentals (e.g., Collins, Hribar, and Tian [2014]; Schrand [2014]).

[15] We generate firms in our simulated data by designating each block of 25 consecutive time-series observations as a separate firm.

levels (Table 6, Panel B). Lastly, the earnings-return concavity, if anything, decreases in the magnitude of symmetric adjustment cost parameter (Figure A3). Thus, our model does *not* predict that, all else equal, greater adjustment frictions increase the earnings-return asymmetry. This echoes recent findings by Asker, Collard-Wexler, and De Loecker [2014] that volatility given adjustment frictions, but not the level of adjustment frictions per se matters for the model's ability to explain investment dynamics. We explore the role of adjustment frictions for the model predictions further in the next section.

e. Model comparison

Our dynamic model of investment under uncertainty with adjustment frictions nests several models previously used in accounting research to understand earnings and return patterns. Our model defines firm value as the present value of future (net) cash flows. In so far, it is similar to the standard present value models used in the value relevance literature (e.g., Ohlson [1995]; Feltham and Ohlson [1995]; Holthausen and Watts [2001]). This explains why our model generates the basic earnings-response coefficient patterns (e.g., its relation to the discount rate and persistence of earnings) documented in prior literature (e.g., Kormendi and Lipe [1987]; Kothari [2001]). In addition, our model exhibits real expansion and adaption options, similar to more elaborate models such as Zhang [2000] and Hiemann [2017]. The real options introduce crucial nonlinearities (e.g., return convexities and conditional earnings persistence) into the earnings and return patterns (e.g., Hayn [1995]; Burgstahler and Dichev [1997]; Wysocki [1999]). Lastly, our model adds short-run adjustment frictions (time-to-build and convex adjustment costs) following prior models of dynamic investment (e.g., Lucas and Prescott [1971]; Hayashi [1982]; Strebulaev and Whited [2012]).

The adjustment frictions render capital a short-run fixed input factor (e.g., Strebulaev and Whited [2012]). This feature is not only necessary to better match firms' actual investment behavior (e.g., Cooper and Haltiwanger [2006]), it is also pivotal to generate the earnings-return concavity in our model. Without any adjustment frictions, there are no short-run fixed input factors and no interesting investment dynamics as current period investment is independent of past investment levels and current capital. Absent any investment dynamics, the relationship between earnings and returns is convex (similar to the high managerial "decision making impact" scenario in Hemmer and Labro [2016]).[16] This convexity obtains because the earnings-news relation is even more convex than the return-news relation absent short-run frictions, as current period earnings make the most of current period shocks through the immediate and optimal choice of input factors.

Notably, either of our adjustment frictions—time-to-build or convex adjustment costs—is sufficient to generate such concave earnings-return relation. Convex adjustment costs, however, are needed to generate investment dynamics matching observed investment behavior (e.g., autocorrelation of investments) and the asymmetric investment-return relation that we link to the accruals-return asymmetry.[17] We focus on the combination of time-to-build and convex adjustment costs because this is the baseline model used in the economics and finance literature to explain investment dynamics and fits the data best. (In Section B "Model Comparison" in the Online Appendix, we provide an explicit comparison of our model with its nested variants (e.g., without both or either adjustment friction) in terms of its ability to match empirical investment and earnings-return moments.)

[16] The convex earnings-return relation absent adjustment frictions allays concerns that our assumption of a concave profit function could mechanically result in a concave earnings-return relation. See also Section D "Alternative Investment Model" in our Online Appendix.

[17] The investment-return relation turns concave given capital adjustment costs. This is a consequence of dampened—rather than merely delayed—investment responses due to the combination of uncertainty and partial irreversibility of capital.

5. Empirical patterns

a. Research design

Our model predictions match a number of central earnings-return patterns empirically documented in prior accounting research, supporting our model's descriptiveness. In this section, we further assess its descriptiveness, confronting two novel model-specific predictions with actual data.[18] Our model predicts that the earnings-return concavity increases in the volatility of firms' underlying shock processes and decreases in the level of firms' investments (Table 6). To test these predictions, we implement the same quintile sort approach used in estimating the model predictions one-for-one to estimate the predicted relation in the actual (Compustat) data.

b. Data

We use a sample of all firms from the intersection of the CRSP/Compustat Merged annual file and the CRSP monthly returns file. The sample period is 1963 to 2014. We consider only firms with common equity (CRSP share code 10, 11, or 12) traded on the NYSE, AMEX, or NASDAQ stock exchanges (CRSP exchange code 1, 2, or 3). For consistency with prior literature (e.g., Patatoukas and Thomas [2011], Ball, Kothari, and Nikolaev [2013a]), we exclude firm-year observations with a beginning-of-period price lower than $1 per share. The above selection criteria yield a maximum sample of 190,592 firm-year observations from 18,927 firms. The actual sample size for each analysis varies with data availability and the data requirements described above. To mitigate the effect of outliers, we delete the top and bottom percentile of the distributions of all continuous variables.

[18] Besides testing the validity of our novel model predictions, we validate the parameterization of our model and assess its model fit by estimating its parameters via the SMM (Simulated Method of Moments) in Section A "Model Estimation" in the Online Appendix.

c. Results

Panel A of Table 7 presents the estimates of the earnings-return concavity by earnings volatility quintile using actual (Compustat) data. Consistent with the pattern in the simulated data (Table 6, Panel A), we find that the earnings-return asymmetry increases monotonically in the (measured) earnings volatility (Figure 10). We observe similar patterns for the operating cash flow-return asymmetry and the accrual-return asymmetry (Panel B and Panel C in Table 7). Panel A of Table 8 presents the estimates of the earnings-return concavity by investment quintile (measured as firms' investment-to-assets ratio computed following Lyandres, Sun, and Zhang [2008]) using actual data. Again, consistent with the pattern in the simulated data (Table 6, Panel B), we find that the earnings-return asymmetry decreases in firms' investment levels (Figure 10). These results suggest a close link between our dynamic-investment model and the earnings-return patterns generated in the actual data.

These novel findings have important implications for the conservatism literature. They suggests the measurement of conservatism via the earnings-return relation is plagued by correlated omitted variable concerns related to firms' fundamental shock processes, similar to other earnings quality measures (e.g., Hribar and Nichols [2007]; Owens, Wu, and Zimmerman [2017]; Nikolaev [2017]). Notably, prior literature frequently documents a positive association between firms' earnings-return asymmetry and volatility proxies such as information uncertainty/asymmetry (e.g., LaFond and Watts [2008]) or capital and product market competition (e.g., Gormley [2010]; Dhaliwal et al. [2014]). Although this literature often interprets these associations as documenting heightened demand for conservative accounting, our model suggests these outcomes are expected even absent conservative accounting systems. Moreover, our model highlights that the earnings-return asymmetry and firms' investment behavior are endogenously related, complicating recent efforts to establish a causal effect of conservatism on firms' investment behavior (e.g., García Lara, García Osma, and Penalva [2016]).

6. Conclusion

We propose the standard dynamic-investment model under uncertainty with adjustment frictions as a benchmark for earnings and return properties absent accounting influences. Such benchmark is essential for accounting researchers interested in the effect of accounting rules or managerial reporting discretion on earnings and return properties.

We document the descriptiveness of our model for a wide range of earnings and return patterns empirically documented in previous accounting research. Most notably, we document short-run adjustment frictions in combination with optimal adjustment decisions in the long-run naturally result in a concave earnings-return relation. We further present evidence that the volatility of firms' fundamentals is an important economic determinant of the earnings-return concavity. These findings suggest economic (i.e., non-accounting) explanations for a number of earnings-return patterns commonly attributed to accounting rules and managerial reporting interventions in prior literature. The descriptiveness of our model for prominent earnings-return patterns highlights the importance of dynamics for understanding economic phenomena in economics, finance, and accounting (e.g., Strebulaev and Whited [2012]; Gerakos [2012]).

Going forward, we suggest three immediate applications of our findings. First, we suggest extending the dynamic-investment model by adding information frictions (e.g., timing error of cash flows or information asymmetry between managers and outsiders) and explicit accounting systems (e.g., accrual accounting and/or conservative accounting rules) (e.g., in the vein of Beyer, Guttman, and Marinovic [2014], Nikolaev [2017], Liang, Sun, and Tam [2017], and Choi [2017]). Such extensions can produce novel predictions for the incremental effect of information frictions and accounting rules/systems on the dynamic properties of investment, earnings, and returns. These theory-grounded predictions could create fruitful opportunities for empirical testing using either reduced form or structural approaches. Second, we suggest carefully considering the direct (non-accounting) effect of investment dynamics and uncertainty in studies concerned with the measurement, causes, and consequences of accounting conservatism. Lastly, we propose using the simulated data of our dynamic-investment model as a placebo dataset to test improvements to the earnings-return specification (e.g., Ball, Kothari, and Nikolaev [2013a]) and the development of new conservatism measures based on earnings dynamics (e.g., Dutta and Patatoukas [2017]).[19] The improved measures of conservatism should not falsely identify accounting conservatism in the placebo dataset which, by construction, is free of accounting conservatism.

[19] For example, Ball, Kothari, and Nikolaev [2013b] suggest that firm fixed effects can alleviate omitted variable concerns, especially those related to earnings and return expectations. Both, the influence of expectations and the usefulness of firm fixed effects to allay omitted variable concerns (more broadly) can be tested explicitly in our simulated data. The model allows a perfect specification of the earnings and return expectation. Hence, these parts can perfectly be removed. Thus, one can assess how much of the total asymmetry found in our placebo dataset is due to the expectations related omitted variable. One can further explicitly gauge how much of the "economic" asymmetry can be filtered out by the inclusion of firm fixed effects in the Basu [1997] specification. Notably, we include firm fixed effects in all specifications as suggested by Ball, Kothari, and Nikolaev [2013b]. Despite the inclusion of firm fixed effects, however, we continue to reject the null of no asymmetry in our placebo dataset.

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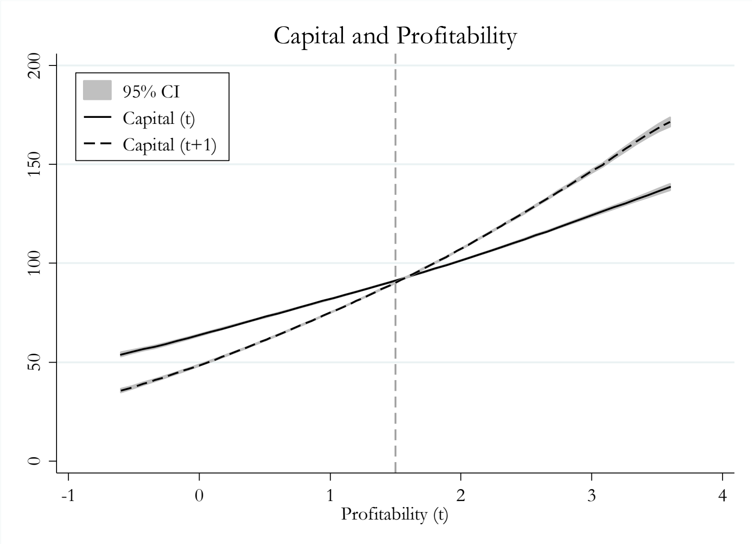
Appendix

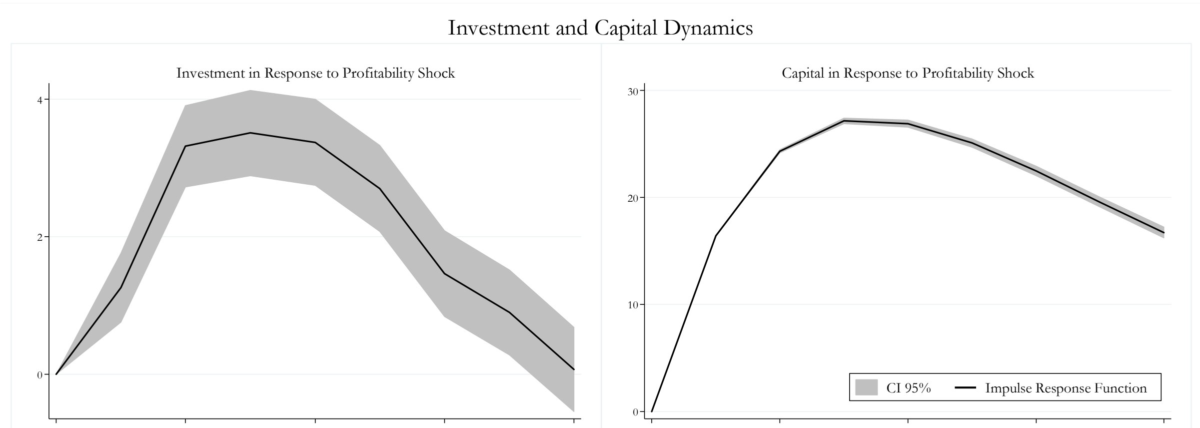
Figures

Figure 1



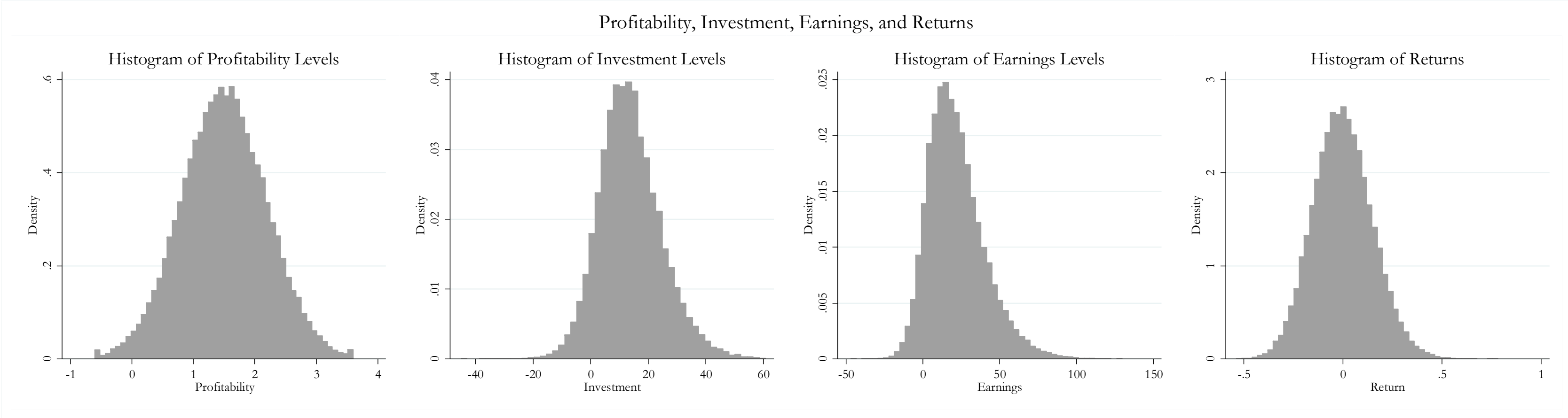
Notes: The figure depicts the relation between the exogenous state variable profitability (z) and the endogenous state variable capital (k). The (dashed) line represents average current (next) period capital levels as a function of profitability levels. The grey area represents pointwise 95% confidence bands. The figure is based on 100,000 observations simulated using our dynamic-investment model calibrated with the parameter values as provided in Table 1.

Figure 2



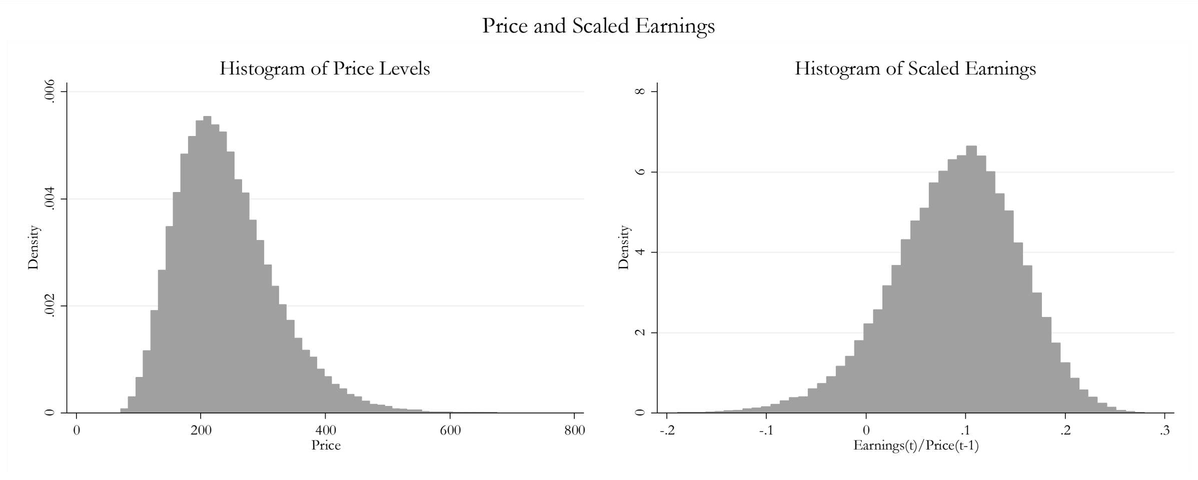
Notes: The figure presents the impulse response functions of investment and capital with respect to a current-period profitability shock. The impulse response functions are estimated using a vector autoregressive model of order 10 (for investment/capital and profitability). The figure is based on 100,000 observations simulated using our dynamic-investment model calibrated with the parameter values as provided in Table 1.

Figure 3



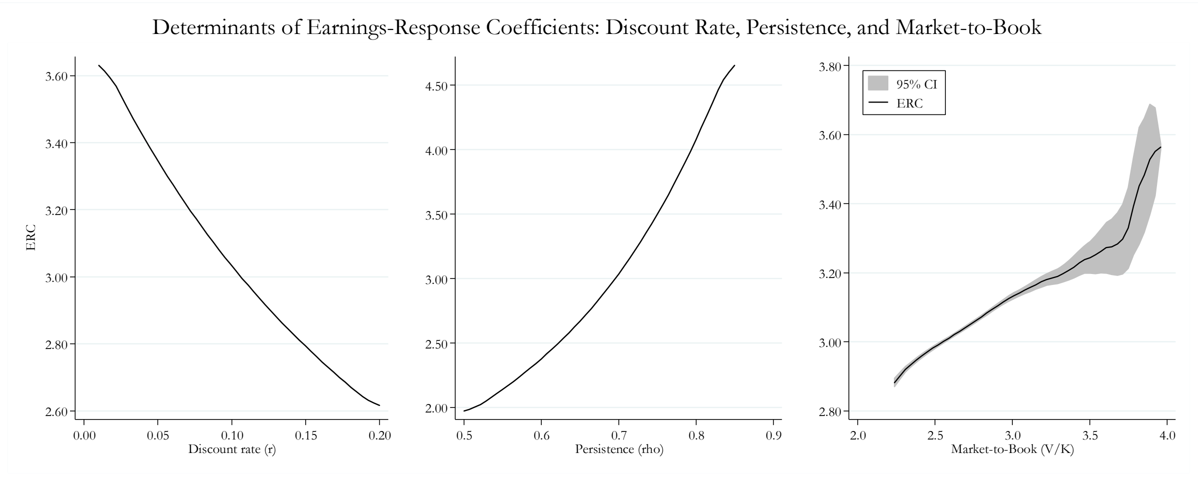
Notes: The figure provides histograms for current period profitability, investment, earnings, and returns. The figure is based on 100,000 observations simulated using our dynamic-investment model calibrated with the parameter values as provided in Table 1.

Figure 4



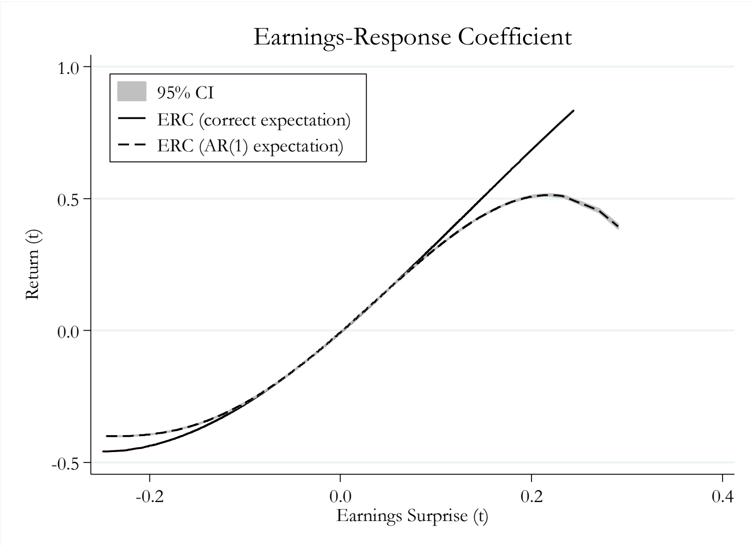
Notes: The figure provides histograms for current firm values (prices) and earnings scaled by lagged price. The figure is based on 100,000 observations simulated using our dynamic-investment model calibrated with the parameter values as provided in Table 1.

Figure 5



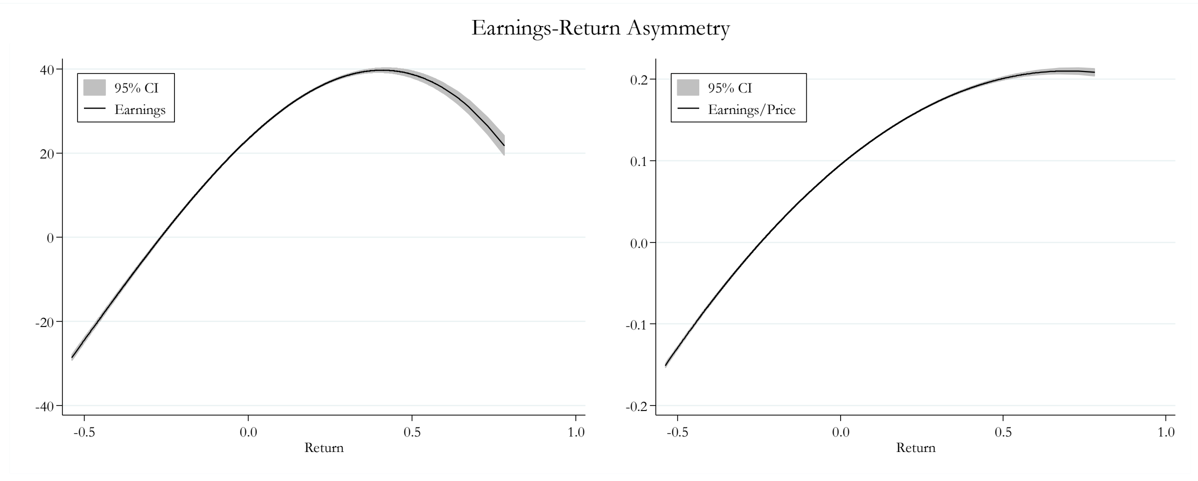
Notes: The figure plots the earnings-response coefficient as a function of the discount rate, persistence, and market-to-book. The left (center) graph depicts the effect of varying the exogenous discount rate (persistence) on the earnings-response coefficient while holding all other parameters at our calibrated values. For these graphs, we simulate earnings-return asymmetry or earnings-response coefficients for 101 different parameter values (using equally-sized steps between reasonable parameter bounds) holding all other parameters constant. The right graph plots earnings-response coefficients (estimated at the firm level using our simulated data) across endogenous (average) market-to-book ratios (at the firm level). The grey area in the right graph represents the pointwise 95% confidence band.

Figure 6



Notes: The figure presents the earnings-response coefficients (ERCs) as flexible polynomial approximations of the relation between (abnormal) returns and earnings surprises. The relation labeled "ERC (correct expectation)" is calculated using the difference between realized earnings and expected earnings (accounting for all future states and investment responses) given prior period profitability and capital scaled by lagged price as the earnings surprise. The relation labeled "ERC (AR(1) expectation)" is calculated using the residual of an autoregressive expectation model of order 1 scaled by lagged price as the earnings surprise. The grey area represents pointwise 95% confidence bands. The figure is based on 100,000 observations simulated using our dynamic-investment model calibrated with the parameter values as provided in Table 1.

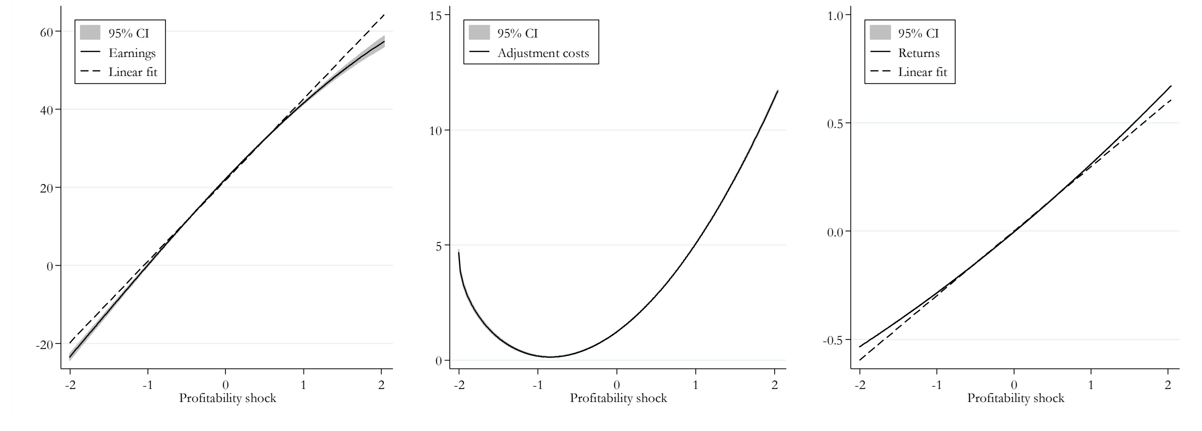
Figure 7



Notes: The figure depicts flexible polynomial approximations of the relations between (scaled) earnings and returns. The left graph plots earnings levels against returns. The right graph plots earnings scaled by lagged price against returns. The grey area represents pointwise 95% confidence bands. The figure is based on 100,000 observations simulated using our dynamic-investment model calibrated with the parameter values as provided in Table 1.

Figure 8

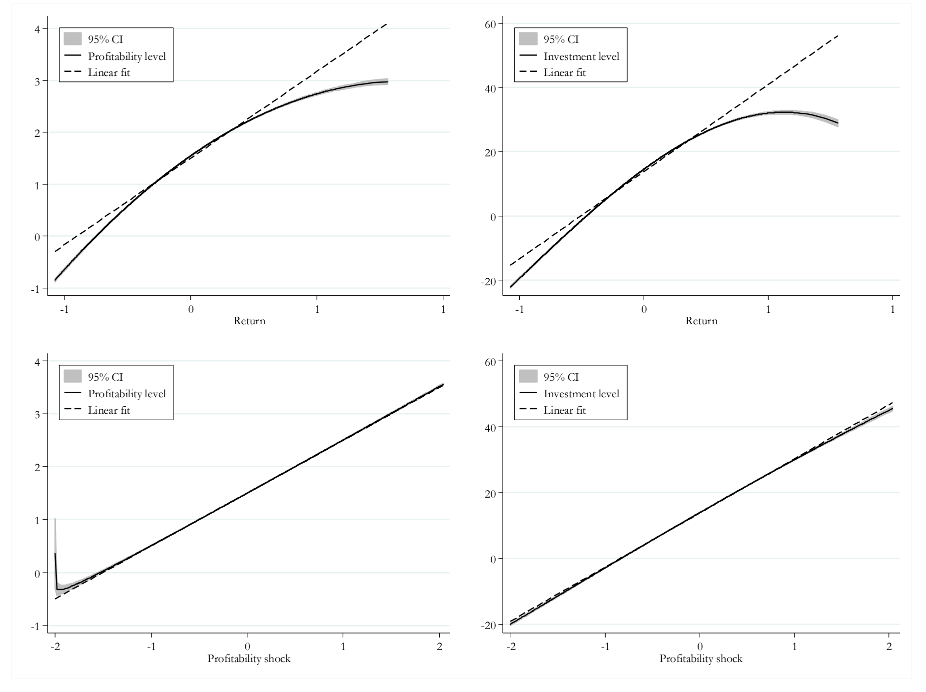
Relation of Earnings, Adjustment Costs, and Returns to Profitability Shocks (News)



Notes: The figure plots earnings, adjustment costs, and returns as linear and flexible polynomial functions of profitability shocks. The grey area represents pointwise 95% confidence bands. The figure is based on 100,000 observations simulated using our dynamic-investment model calibrated with the parameter values as provided in Table 1.

Figure 9

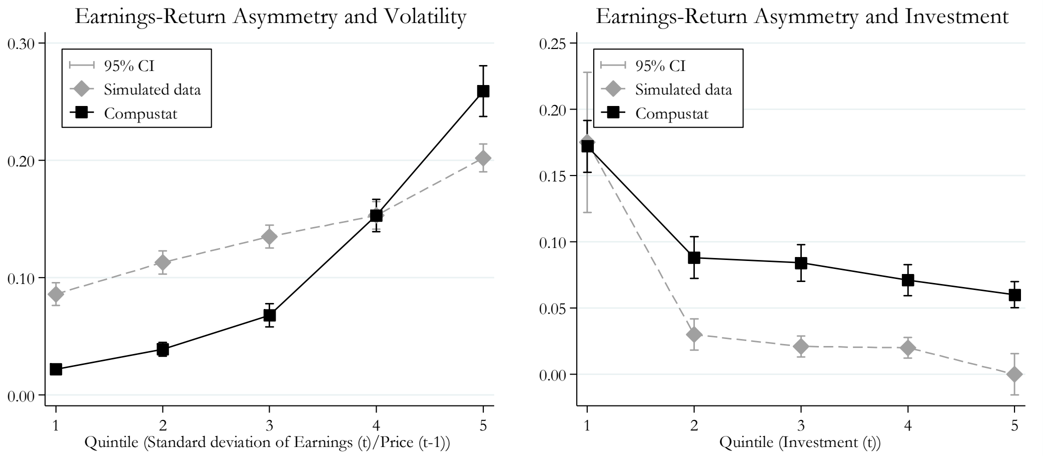
Relation of Profitability and Investment to Returns and Profitability Shocks (News)



Notes: The figure plots profitability and investment as linear and flexible polynomial functions of returns (upper graphs) and profitability shocks (lower graphs). The grey area represents pointwise 95% confidence bands. The figure is based on 100,000 observations simulated using our dynamic-investment model calibrated with the parameter values as provided in Table 1.

Figure 10

Earnings-Return Asymmetry, Volatility, and Investment



Notes: The figure depicts the earnings-return asymmetry coefficient estimated separately for earnings volatility and investment quintiles in our simulated data (Table 6) and Compustat data (Table 7 and Table 8). Earnings volatility is measured as the standard deviation of earnings scaled by lagged price estimated at the firm level. The figure is based on 100,000 observations simulated using our dynamic-investment model calibrated with the parameter values as provided in Table 1.

Tables

Table 1

Parameter Values		
Parameter	**Value**	**Source**
$\bar{z}$	1.50	Own calibration
ρ	0.70	Strebulaev and Whited [2012]
σ_{ε}	0.50	Own calibration
r	0.10	Kothari [2001]
θ	0.70	Strebulaev and Whited [2012]
δ	0.15	Strebulaev and Whited [2012]
ψ	1.00	Liu et al. [2009]

Notes: The table summarizes the calibrated parameter values used in our simulation. The unconditional profitability is 1.50, the profitability persistence is 0.70, the standard deviation of the profitability shock is 0.50, the annual discount rate is 10%, the profit function curvature (with respect to capital) is 0.70, the exponential economic depreciation rate is 15%, and the convex adjustment cost coefficient is 1. We rely on prior literature for all parameters but the unconditional profitability level and the standard deviation of the profitability shock. As we employ a normal profitability shock process instead of a log-normal process to better match the empirical earnings distribution, we rely on own calibrations for these profitability process parameters. Our own calibration of the profitability parameters is chosen such that the value function (i.e., firm value) is (almost surely) always positive and the endogenous state variable (i.e., capital) is not restricted by our state space (i.e., there is no bunching at the bounds of the capital grid).

Table 2

Correspondence		
Variable	**Model correspondence**	**Data correspondence (CRSP/Compustat)**
I_t	$k_{t+1} - (1-\delta)k_t$	Δppegt+Δinvt, capx+xrd, -ivncf
cfo_t	$z_t k_t^{\theta} - \psi \frac{I_t^2}{2k_t}$	oancf-xidoc
ear_t	$z_t k_t^{\theta} - \psi \frac{I_t^2}{2k_t} - \delta k_t$	ib
p_t	V_t	prcc_f*cshpri
ret_t	$\frac{V_t}{V_{t-1} - (cfo_{t-1} - I_{t-1})} - (1+r)$	$\exp\left(\sum \ln(1+ret)\right) - \exp\left(\sum \ln(1+vwret)\right)$
k_t	k_t	$ppegt_{t-1}$, at_{t-1}

Notes: The table summarizes the correspondence between simulated variables and CRSP/Compustat items. Note three important pieces of information: (1) To calculate returns, we have to deduct the prior period cash flow from last period's firm value as this amount can be considered distributions to or capital injections from shareholders. Hence, the ex-dividend price of the last period is the reference value for current period returns. We also use the ex-dividend price of last period in, for example, scaling earnings by lagged price. (2) Capital at time t in the model corresponds to capital at the beginning of the period (e.g., $ppegt_{t-1}$, at_{t-1}). (3) Fixed assets and total assets can both be considered to correspond to capital in our model. Given the high correlation and similar magnitudes of property, plant, and equipment and total assets, we consider these Compustat items as interchangeable for our purposes. Depending on the variable choice of prior literature, we rely either on total assets or property, plant, and equipment in distinct specifications.

Table 3

Asymmetric Earnings Persistence				
	(1)	(2)	(3)	(4)
Specification:	Levels	Changes	Price-Scaled Changes (Basu [1997])	Capital-Scaled Changes (Ball and Shivakumar [2005])
Dependent variable (Y_t):	Earnings (t)	ΔEarnings (t)	ΔEarnings (t)/Price (t-1)	ΔEarnings (t-1)/Capital (t-2)
Y_{t-1}	0.733***	-0.116***	0.028***	0.059***
	(0.003)	(0.009)	(0.006)	(0.007)
$D(Y_{t-1}<0)$	0.404***	-0.294**	-0.004***	-0.007***
	(0.152)	(0.125)	(0.001)	(0.001)
$Y_{t-1}*D(Y_{t-1}<0)$	**-0.286*** **	**0.017**	**-0.415*** **	**-0.435*** **
	(0.020)	**(0.013)**	**(0.012)**	**(0.012)**
Firm fixed effects	Yes	Yes	Yes	Yes
Obs.	96,000	92,000	96,000	96,000
# Clusters	4,000	4,000	4,000	4,000
Adj. R^2	0.513	0.009	0.033	0.029

Notes: The table presents estimates of conditional autoregressive models of earnings (levels and (scaled) changes). The estimates are based on 100,000 observations simulated using our dynamic-investment model calibrated with the parameter values as provided in Table 1. A firm is defined as 25 consecutive (non-overlapping) simulated observations. The regressions are estimated with firm fixed effects. Standard errors in parentheses are clustered by firm. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 4

Determinants of the Earnings-Response Coefficient		
	(1) Return (t)	(2) Return (t)
UE	3.032***	1.355***
	(0.003)	(0.008)
UE*Persistence		**0.015*** **
		(0.003)
|UE|		-0.139***
		(0.002)
UE*|UE|		**-0.595*** **
		(0.035)
Market-to-Book		-0.001***
		(0.000)
UE*MTB		**0.659*** **
		(0.003)
Loss		0.006***
		(0.000)
UE*Loss		**-0.017*** **
		(0.005)
Firm fixed effects	Yes	Yes
Obs.	100,000	100,000
# Clusters	4,000	4,000
Adj. R^2	0.983	0.999

Notes: The table presents estimates of regressions of returns on earnings surprise and its interaction with cross-sectional determinants. "UE" denotes unexpected earnings (i.e., earnings surprise), calculated using the difference between realized earnings and expected earnings (accounting for all future states and investment responses) given prior period profitability and capital scaled by lagged price as the earnings surprise. "Persistence" denotes the realized persistence of simulated earnings, estimated as the AR(1) coefficient of firms' earnings. "|UE|" denotes the absolute unexpected earnings. "Market-to-Book" denotes the ratio of the value function to the capital stock. "Loss" denotes an indicator variable taking the value of one for firm-years with negative earnings. The estimates are based on 100,000 observations simulated using our dynamic-investment model calibrated with the parameter values as provided in Table 1. A firm is defined as 25 consecutive (non-overlapping) simulated observations. The regressions are estimated with firm fixed effects. Standard errors in parentheses are clustered by firm. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 5

Future Earnings-Response Coefficient			
	(1) Return (t)	(2) Return (t)	(3) Return (t)
Ln(Earnings (t)/Earnings (t-1))	0.109***	0.132***	0.156***
	(0.001)	(0.002)	(0.002)
Ln(Earnings (t+1)/Earnings (t))		-0.008***	0.042***
		(0.001)	(0.002)
Ln(Earnings (t+2)/Earnings (t+1))		-0.019***	0.005***
		(0.001)	(0.001)
Ln(Earnings (t+3)/Earnings (t+2))		-0.014***	-0.006***
		(0.001)	(0.001)
Return (t+1)			-0.210***
			(0.006)
Return (t+2)			-0.069***
			(0.006)
Return (t+3)			-0.011***
			(0.005)
Earnings (t-1)/Price (t-1)			0.676***
			(0.033)
Ln(Capital (t)/Capital (t-1))			-0.026***
			(0.006)
Firm fixed effects	Yes	Yes	Yes
Obs.	86,759	63,369	63,369
# Clusters	4,000	3,998	3,998
Adj. R^2	0.426	0.555	0.577

Notes: The table presents estimates of future earnings-response coefficients following the firm-level specifications of Collins et al. [1994]. The estimates are based on 100,000 observations simulated using our dynamic-investment model calibrated with the parameter values as provided in Table 1. A firm is defined as 25 consecutive (non-overlapping) simulated observations. The regressions are estimated with firm fixed effects. Standard errors in parentheses are clustered by firm. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 6

Simulated Earnings-Return Asymmetry, Volatility, and Investment					
Panel A: Volatility					
	Quintile: Standard Deviation of Earnings(t)/Price(t-1)				
	(1)	(2)	(3)	(4)	(5)
Return*D(Return<0)	**0.086***	**0.113***	**0.135***	**0.153***	**0.202***
	(0.005)	**(0.005)**	**(0.005)**	**(0.006)**	**(0.006)**
Main effects	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Obs.	20,000	20,000	20,000	20,000	20,000
# Clusters	800	800	800	800	800
Adj. R^2	0.618	0.617	0.614	0.608	0.606
Panel B: Investment					
	Quintile: Investment (t)				
	(1)	(2)	(3)	(4)	(5)
Return*D(Return<0)	**0.175***	**0.030***	**0.021***	**0.020***	**0.000**
	(0.027)	**(0.006)**	**(0.004)**	**(0.004)**	**(0.008)**
Main effects	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Obs.	20,151	19,947	20,029	19,964	19,909
# Clusters	3931	3947	3973	3949	3684
Adj. R^2	0.220	0.005	0.054	0.239	0.415

Notes: The table presents estimates of the earnings-return asymmetry across volatility and investment quintiles. Each column presents estimates of the earnings-return asymmetry coefficient from regressions of earnings (scaled by lagged price) on returns ("Return"), an indicator for negative returns ("D(Return<0)"), and the interaction of returns and the negative return indicator ("Return*D(Return<0)"; i.e., the earnings-return asymmetry). The main effects (i.e., coefficients on "Return" and "D(Return<0)") are included in the estimation but not tabulated for brevity. Panel A estimates the earnings-return asymmetry for groups of firms within the same volatility quintile. The volatility quintile is defined as the firm-level standard deviation of earnings scaled by price. Panel B estimates the earnings-return asymmetry for firm-year observations within the same investment quintile. The estimates are based on 100,000 observations simulated using our dynamic-investment model calibrated with the parameter values as provided in Table 1. A firm is defined as 25 consecutive (non-overlapping) simulated observations. The regressions are estimated with firm fixed effects. Standard errors in parentheses are clustered by firm. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 7

Compustat Asymmetries and Volatility					
Panel A: Earnings-Return Asymmetry					
	Quintile: Standard Deviation of Earnings/Price(t-1)				
	(1)	(2)	(3)	(4)	(5)
Return*D(Return<0)	**0.022*****	**0.039*****	**0.068*****	**0.153*****	**0.259*****
	(0.002)	**(0.003)**	**(0.005)**	**(0.007)**	**(0.011)**
Main effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Obs.	33,704	40,195	36,520	32,684	27,152
#Clusters	2,323	2,322	2,323	2,322	2,322
Adj. R^2	0.206	0.281	0.193	0.139	0.126
Panel B: Cash-Flow-Return Asymmetry					
	Quintile: Standard Deviation of Cash Flows/Price(t-1)				
	(1)	(2)	(3)	(4)	(5)
Return*D(Return<0)	**0.017*****	**0.020*****	**0.030*****	**0.049*****	**0.053*****
	(0.003)	**(0.004)**	**(0.006)**	**(0.009)**	**(0.013)**
Main effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Obs.	28,560	33,503	35,120	32,126	26,490
#Clusters	2,256	2,256	2,256	2,256	2,256
Adj. R^2	0.093	0.105	0.116	0.116	0.087
Panel C: Accruals-Return Asymmetry					
	Quintile: Standard Deviation of Accruals/Price(t-1)				
	(1)	(2)	(3)	(4)	(5)
Return*D(Return<0)	**0.001**	**0.023*****	**0.060*****	**0.115*****	**0.217*****
	(0.002)	**(0.004)**	**(0.007)**	**(0.011)**	**(0.016)**
Main effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Obs.	31,098	34,236	33,230	31,764	25,566
#Clusters	2,256	2,256	2,256	2,256	2,256
Adj. R^2	0.057	0.066	0.074	0.073	0.070

Notes: The table presents estimates of the earnings-, cash flow-, and accruals-return asymmetry for groups of firms within the same volatility quintile. The volatility quintile is defined as the firm-level standard deviation of the dependent variable. Panel A provides estimates of regressions of earnings (scaled by lagged price) on returns, a negative return indicator, and their interaction (i.e., the earnings-return asymmetry). Panel B provides estimates of regressions of cash flow (scaled by lagged price) on returns, a negative return indicator, and their interaction (i.e., the cash flow-return asymmetry). Panel C provides estimates of regressions of accruals (scaled by lagged price) on returns, a negative return indicator, and their interaction (i.e., the accruals-return asymmetry). Across all panels, the main effects (returns and the negative return indicator) are included in the estimation but their coefficient estimates are untabulated for brevity. The estimates are based on Compustat firms from 1963 to 2014. The regressions are estimated with year and firm fixed effects. Standard errors in parentheses are clustered by firm. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 8

Compustat Asymmetries and Investment

Panel A: Earnings-Return Asymmetry					
	Quintile: Investment-to-Assets Ratio				
	(1)	(2)	(3)	(4)	(5)
Return*D(Return<0)	**0.172***** **(0.010)**	**0.088***** **(0.008)**	**0.084***** **(0.007)**	**0.071***** **(0.006)**	**0.060***** **(0.005)**
Main effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Obs.	31,448	30,615	31,032	31,031	31,031
#Clusters	10,261	9,611	9,811	9,876	10,256
Adj. R^2	0.104	0.084	0.155	0.195	0.154
Panel B: Cash-Flow-Return Asymmetry					
	Quintile: Investment-to-Assets Ratio				
	(1)	(2)	(3)	(4)	(5)
Return*D(Return<0)	**0.078***** **(0.010)**	**0.039***** **(0.008)**	**0.035***** **(0.008)**	**0.049***** **(0.007)**	**0.036***** **(0.007)**
Main effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Obs.	31,448	30,615	31,032	31,031	31,031
#Clusters	10,261	9,611	9,811	9,876	10,256
Adj. R^2	0.123	0.101	0.132	0.115	0.073
Panel C: Accruals-Return Asymmetry					
	Quintile: Investment-to-Assets Ratio				
	(1)	(2)	(3)	(4)	(5)
Return*D(Return<0)	**0.095***** **(0.012)**	**0.049***** **(0.009)**	**0.049***** **(0.008)**	**0.022***** **(0.008)**	**0.024***** **(0.007)**
Main effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Obs.	31,448	30,615	31,032	31,031	31,031
#Clusters	10,261	9,611	9,811	9,876	10,256
Adj. R^2	0.054	0.034	0.030	0.030	0.043

Notes: The table presents estimates of the earnings-, cash flow-, and accruals-return asymmetry for firm-year observations within the same investment quintile. Investment is the investment-to-assets ratio computed following Lyandres, Sun, and Zhang [2008] as the change in gross property, plant, and equipment plus the change in inventories divided by lagged total assets. Panel A provides estimates of regressions of earnings (scaled by lagged price) on returns, a negative return indicator, and their interaction (i.e., the earnings-return asymmetry). Panel B provides estimates of regressions of cash flow (scaled by lagged price) on returns, a negative return indicator, and their interaction (i.e., the cash flow-return asymmetry). Panel C provides estimates of regressions of accruals (scaled by lagged price) on returns, a negative return indicator, and their interaction (i.e., the accruals-return asymmetry). Across all panels, the main effects (returns and the negative return indicator) are included in the estimation but their coefficient estimates are untabulated for brevity. The estimates are based on Compustat firms from 1963 to 2014. The regressions are estimated with year and firm fixed effects. Standard errors in parentheses are clustered by firm. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Online Appendix

Investment Dynamics and Earnings-Return Properties: A Structural Approach

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Section A: Model Estimation

In this section, we confront our model with actual data via indirect inference (or simulated method of moments). Thereby, instead of imposing a set of key model parameters (Θ) from prior literature, we estimate the model parameters from Compustat data and assess the fit of our proposed model.

We estimate the shock process parameters ($\bar{z}, \rho, \sigma_{\varepsilon}$), depreciation ($\delta$), and the convex adjustment cost parameter (ψ) by minimizing the distance between a set of simulated moments ($\hat{M}_S = \frac{1}{S}\sum_{s=1}^{S}\hat{m}_s(\Theta)$) and their counterparts in the actual data ($\hat{M}_D$):

$$\hat{\Theta} = \arg\min_{\Theta}\left(\hat{M}_D - \frac{1}{S}\sum_{s=1}^{S}\hat{m}_s(\Theta)\right)' W \left(\hat{M}_D - \frac{1}{S}\sum_{s=1}^{S}\hat{m}_s(\Theta)\right),$$

where S is the number of simulations and W is a weighting matrix.

We attempt to match six moments to identify our five free parameters.[24] The market-to-book ratio pins down the average profitability value ($\bar{z}$). The standard deviation of cash flow from operations scaled by beginning of period capital contributes to the identification of the volatility of the profitability process (σ_{ε}). The autocorrelation of cash flow from operations helps to pin down the persistence of the profitability process (ρ). The average of investment scaled by beginning of period capital contributes to the identification of the depreciation rate (δ). The volatility of investment scaled by beginning of period capital and the autocorrelation of investment identify the adjustment cost parameter (ψ).

[24] We do not directly target the earnings-return coefficient as a moment. We rather target fundamental cash flow/earnings and investment moments and expect the resulting model naturally yields a concave earnings-return relation. This approach prevents that we force our estimated model to match the earnings-return asymmetry by taking on "unnatural" parameter values.

Our moments intentionally exclude earnings information. All moments can be constructed from cash flow data (for a summary of moment definitions refer to Table A1). Hence, we do not confound our estimation with accounting influences (e.g., accounting conservatism in earnings). All moments are calculated at the firm level to discard across-firm heterogeneity.

Our estimation then proceeds as follows. We estimate the data moments once. To obtain the model moments, we solve our model for a given set of parameter values. Given the optimal investment behavior (solution), we simulate 125 time-series observations of which we discard the first 100 to avoid influence from initial values. We calculate the corresponding moments for this simulated series. We repeat this simulation step $S = 10,000$ times (i.e., we simulate a panel of 10,000 firms with 25 observations per firm). We average the estimated moments across the S simulations. Now, we compare the weighted distance between the data moments and the simulated moments.[25] We employ a global optimization routine (genetic algorithm) to find the combination of model parameters that minimizes the weighted difference.

Table A1 presents the data moments and model moments of our estimated model. We note that our model is able to match all six moments with the five free parameters reasonably well.[26] The corresponding parameter estimates are shown in Table A2. The parameters are fairly precisely estimated and reasonably close to our simulation values and prior literature. The parameters of the shock process differ somewhat from our calibrated parameters. The unconditional profitability and the standard deviation of the profitability shock are lower, whereas the profitability persistence is higher than their calibrated counterparts are. We, however, highlight that these parameters are

[25] We use the identity matrix as our weighting matrix to avoid undue influence of more precisely estimated but less interesting moments (e.g., Asker *et al.* [2014]). For the standard error calculation and over-identification test, we use the inverse of the variance-covariance matrix of the simulated moments.
[26] The model appears to struggle to simultaneously match the relatively low autocorrelation of cash flow from operations and the relatively high average investment rate.

interdependent. The standard deviation of the profitability is given by $\frac{\sigma_{\varepsilon}}{\sqrt{1-\rho^2}}$. Hence, the decrease of the shock standard deviation is at least partially offset by the increase of the profitability persistence. Moreover, recall that we calibrated the profitability level and volatility jointly to obtain a profitability distribution that ensures positive continuation values while allowing for negative profitability draws. Given the lower estimated unconditional profitability level, we would want to have a lower volatility of profitability, just as estimated.

We find using the estimated instead of our simulation parameters does not qualitatively alter our prior model predictions. Given this close correspondence, we present our model implications in the main paper using the calibrated parameters, which are explicitly chosen such that there is no bunching at the bounds of the capital grid avoiding artificial nonlinearities due to an unintentionally restricted choice set.[27]

Table A3 provides a model fit comparison of our main model (time-to-build and convex adjustment costs) with alternative models without short-run adjustment frictions or only one of our two adjustment frictions (time-to-build or convex adjustment costs). We note that although our main model matches the data moments quite closely, the over-identification test soundly rejects the hypothesis that the actual data is produced by our proposed model. This, however, in general is a tough hurdle to jump over for a parsimonious model. Moreover, our choice of the weighting matrices makes the hurdle even more challenging. Notably, we estimate our parameters using the identity matrix (following Asker, Collard-Wexler, and De Loecker [2014]), whereas we assess their fit using the variance-covariance matrix of the simulated parameters. This clearly contributes to the

[27] More generally, our model predictions and inferences are robust to varying the fundamental parameters of our model within reasonable bounds. Specific comparative statics of our model with respect to key parameter values are depicted in Figure A3.

rejection, as we have not chosen the "optimal" parameters for the variance-covariance matrix used in the over-identification test. Accordingly, we do not view the J-statistics as an informative absolute criterion of model fit in our case, but rather as a way to document the gradual improvement of fit as we add additional frictions to our model (e.g., Andrews and Lu [2001]). Focusing on the relative fit, we find that our main model provides the best fit of all four alternatives; notably, this conclusion is not merely a result of additional parameters.[28]

Section B: Model Comparison

Our model combines uncertainty about future profitability with two short-run adjustment frictions (time-to-build and convex adjustment costs). To transparently document which of our model features contributes to the distinct patterns generated by our main model, we estimate three further models. Model 1 abstracts away from both adjustment frictions and merely focuses on the effect of optimal investment given uncertainty. Model 2 adds a one-period time-to-build to the setup in Model 1. Model 3 adds a convex adjustment cost to the setting in Model 1. Model 4 is our main model that combines investment under uncertainty given one-period time-to-build and convex adjustment costs. Table A4 provides a comparison of the (untargeted) earnings-return properties/moments generated by these four models.

Optimal investment under uncertainty but absent any adjustment frictions (Model 1) produces convex earnings-return and investment-return relations. Hence, optimal decision making without adjustment frictions can immediately alleviate negative shocks and capitalize on positive shocks (e.g., Hemmer and Labro [2016]). Despite the counterfactual earnings/investment-return

[28] For example, consider Models 3 and 4. Both models exhibit the same number of parameters. However, Model 4 contains one more friction (i.e., a lag between investment decisions and installation of capital) than Model 3. This friction, rather than a greater number of degrees of freedoms, contributes to the superior fit of Model 4 over Model 3. Overall, adjustments for different numbers of parameters across the four nested models as suggested by Andrews and Lu [2001] do not change the ranking of relative model fit derived from our simple J-statistic comparison.

relations, Model 1 already generates a number of earnings and return patterns documented by our full model and found in the data (e.g., the conditional time-series pattern of earnings changes and cross-sectional earnings-response coefficient patterns)

The introduction of a one-period time-to-build (i.e., a fixed production factor) turns the earnings-return and the cash flow from operations-return relations from convex to concave (Model 2). Hence, a short-run fixed production factor binds the manager's hand in the short-run but allows long-run adjustments causing a concave earnings-return relation. Notably, the investment-return relation is still convex as there are no adjustment costs to investment. Hence, investment is optimally chosen in the current period after observing the current shock just as in Model 1. The only difference is that the investment only results in capital adjustments at the beginning of the next instead of the current period. Despite the counterfactual convex investment-return relation, Model 2 already generates many of our patterns of interest.

An investment model with uncertainty and convex capital adjustment costs (Model 3) turns the investment-return relation from convex to concave consistent with conservative investment behavior given uncertainty and partial irreversibility (e.g., Dixit and Pindyck [1994], Bloom, Bond, and Van Reenen [2007]). The model also generates the increasing relationship between the earnings-return asymmetry and the volatility of firms' profitability. Thus, a model with uncertainty and capital adjustment costs—with instantaneous capital adjustment—already generates most of the patterns documented with our main model (Model 4). This indicates that the adjustment cost friction is sufficient to dampen the short-run capital adjustment response by the firm such that the earnings-response relation turns concave.

Section C: Accruals Model

In this section, we extend our basic model to explicitly incorporate working capital as an input in the production process complementary to capital (Wu, Zhang, and Zhang [2010]; Gonçalves, Xue, and Zhang [2017]). In particular, we reformulate the dynamic decision problem as follows:

$$V_t = \max_{\{k_{t+j}, w_{t+j}\}|j=1,\ldots,\infty} E_t\left[\sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^j c(k_{t+j}, I_{t+j}, w_{t+j}, w_{t+j+1}, z_{t+j})\right],$$

where w_t denotes working capital in period t. Hence, the manager not only decides how much to invest in capital but also how much to invest in working capital. Current period cash flow is defined as follows:

$$c(k_t, I_t, w_t, w_{t+1}, z_t) = \pi(k_t, w_t, z_t) - \psi(k_t, I_t) - I_t - w_{t+1}.$$

The payoff from the production process is defined as:

$$\pi(k_t, w_t, z_t) = z_t k_t^{\theta} w_t^{\nu},$$

where ν denotes the returns to scale of working capital. We assume that working capital adjustments do not cause any adjustment costs (apart from the working capital investment cost) but take one period to be restocked (time-to-build). We further assume that working capital is fully consumed within one period.

Assuming that next period's working capital is paid for in this period but only used and expensed in the next period, we can define working capital accruals as:

$$a_t = -w_t + w_{t+1},$$

i.e., the expense of this period's used working capital (or synonymously, last period's accrued working capital investment) and the accrual of next period's stocked working capital (or synonymously, this period's working capital investment). This provides a natural definition of the accrual process similar to Bloomfield, Gerakos, and Kovrijnykh [2017] and Nikolaev [2017].

To simulate this model, we need to add a discrete working capital grid to our previous state variables. Given that the additional state variable increased the dimensionality of the dynamic decision problem notably, we use rather coarse profitability (10×10), capital (100×100), and working capital (50×50) grids to be able to solve for the policy function via the slow but robust value function iteration approach. We set the returns to scale of working capital to a low value of $\nu = 0.2$ to reflect that working capital is a necessary but per se not a very productive input factor.

Section D: Alternative Investment Model (Closed-Form Solution)

In this section, we describe an alternative infinite-horizon dynamic-investment model in continuous time featuring quadratic adjustment costs ($\frac{\Psi I^2}{2}$) in investment (independent of the level of installed capital) and a production function with constant returns to capital ($\theta = 1$). The benefit of this alternative model is that it permits a closed-form solution and does not assume a concave profit function.[29] Notably, this alternative model produces the concave relation between earnings and returns through the same channels as our main model. Therefore, the alternative model alleviates concerns about any potential undue influence of the concave profit function in our main model and further clarifies the forces behind the earnings-return concavity.

In the continuous-time model, the risk-neutral manager maximizes the present value of future cash flows (V) by choosing the optimal capital stock (i.e., investment) for all future periods. Therefore, the manager solves the following optimal control problem:

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[29] We thank an anonymous reviewer for suggesting this alternative approach.

$$V(k_0, z_0) = \max_{\{i(t)\}} \int_0^\infty e^{-rt} \left(zk(t) - I(t) - \frac{\Psi I(t)^2}{2} \right) dt ,$$

subject to the law of motion of the firm's capital stock, $\dot{k} = I - \delta k$, and the evolution of the profitability of the firm's capital, $\dot{z} = \rho(\overline{z} - z)$.

Given the above optimal control problem, the Hamilton-Jacobi-Bellman (HJB) equation characterizing the optimal firm value takes the following form:

$$rV(k, z) = \max_{\{i\}} \left(zk - I - \frac{\Psi I^2}{2} \right) + \frac{\partial V(k, z)}{\partial k}(I - \delta k) + \frac{\partial V(k, z)}{\partial z}\rho(\overline{z} - z) ,$$

where the flow measure of the manager's value function $rV(k, z)$ on the left-hand side is equal to the instantaneous net cash flow effect (including investment) on firm value and the expected changes in the value of the firm due to capital accumulation and changes in firm's profitability. The first-order condition (FOC) of the HJB is:

$$-1 - \Psi I + \frac{\partial V(k, z)}{\partial k} = 0 .$$

Conjecturing the following functional form of the optimal value function $V(k, z) = \phi_0 + \phi_1 k + \phi_2 z + \phi_3 z^2 + \phi_4 zk$, and substituting it into the FOC (i.e., $1 + \Psi I = \phi_1 + \phi_4 z$), we derive the following optimal investment policy function:

$$I^* = \frac{\phi_1 + \phi_4 z - 1}{\Psi} .$$

Using the optimal value function, the optimal policy function, and the HJB equation, we can obtain a closed-form solution with the following equilibrium coefficients:

$$\phi_0 = \frac{(\phi_1 - 1)^2 + 2\overline{z}\rho\psi\phi_2}{2r\psi} ,$$

$$\phi_1 = \frac{\overline{z}\rho\phi_4}{r + \delta} ,$$

$$\phi_2 = \frac{2\bar{z}\rho\psi\phi_3 + (\phi_1 - 1)\phi_4}{(r+\rho)\psi},$$

$$\phi_3 = \left(\frac{1}{r+2\rho}\right) * \frac{\phi_4{}^2}{2\psi},$$

$$\phi_4 = \frac{1}{r+\delta+\rho}.$$

The solution of the model shows that, due to the optionality of investment, firm value V is a convex function of the profitability shock z. Given that the optimal investment policy is linear in z and that earnings are a concave function of in I (i.e., $ear = zk - \psi\frac{I^2}{2} - \delta k$), earnings are a concave function of z. Thus, the relation between earnings and returns is concave as a result of the same two channels highlighted by our main model: (1) the current-period earnings-news linearity/concavity due to a short-run fixed capital input and the costs of adjustments to this input, and (2) the return-news convexity resulting from the optimal real-option exercise.

Section E: Further Results

Asymmetries

The patterns in the actual data closely mirror the patterns generated by our model-generated data. In particular, our model-generated data suggests that earnings, cash flow from operations, accruals, and investment exhibit a significant concavity in their relation with returns. Table A5 presents the corresponding estimates of piecewise-linear regressions in the actual data in the vein of Basu [1997]. Unsurprisingly, we find that earnings, cash flow from operations, and accruals exhibit an asymmetric relation to returns characterized by a stronger association with negative than positive returns (e.g., Basu [1997]; Collins, Hribar, and Tian [2014]). More interestingly, we find that investment proxies such as investment-to-assets ratio (Lyandres, Sun, and Zhang [2008]), investment growth (Xing [2008]), and cash flow from investing activities also exhibit a concave relationship with returns (e.g., Papadakis [2007]). This empirical pattern is consistent with our model prediction and suggests the existence of (convex) capital adjustment costs. Given the close connection between capital investments and accruals (e.g., Wu, Zhang, and Zhang [2010]; Arif, Marshall, and Yohn [2016]), the investment asymmetry suggests that accruals (especially working capital accruals) naturally exhibit a concave relation with returns as predicted by our model and documented in the data.

Decomposition

The decomposition of the earnings-return asymmetry into conditional covariances and conditional variances further supports the descriptive validity of our proposed model (Table A6). In particular, we find that the covariance between earnings and returns at the firm level is larger for negative than for positive returns. We further find that the variance of returns is substantially larger for positive than for negative returns (e.g., Dutta and Patatoukas [2017]). This not only is inconsistent with the assumption made in Ball, Kothari, and Nikolaev [2013b], but also highlights the role of expansion and contraction options in return patterns (e.g., Del Viva, Kasanen, and Trigeorgis [2017]). Together, the asymmetry in the numerator (conditional covariance difference) and the denominator (conditional variance difference) contribute to the well-known earnings-return asymmetry. However, the denominator, i.e., the conditional variance influence, is the greater contributor in the actual data. This is consistent with the patterns generated by our model and seems inconsistent with an accounting-based explanation. Notably, the accounting-based explanation relates to the conditional covariance difference (numerator) but not to the conditional return variance difference (denominator) (e.g., Ball, Kothari, and Nikolaev [2013b]).

Non-parametric patterns

Lastly, we document non-linear patterns of earnings-response coefficients and the earnings-return asymmetry generated by our model closely align with the corresponding patterns in the actual data. In particular, Figure A2 shows similar flexible polynomial functions of returns and earnings surprises or earnings (scaled by lagged price) and returns in the model-generated and the actual data. Moreover, Figure A2 documents similar non-parametric relation between firm-level earnings-return asymmetry estimates and earnings volatility in the model-generated and the actual data. Similarly, Figure A2 shows a close correspondence of the non-parametric relations between firm-level earnings-response coefficient estimates, earnings volatility, and market-to-book ratios in the model-generated and the actual data.

Section F: Model Features and Omissions

In this section, we briefly review the key features and omissions of our simple dynamic investment model.

Features

Our model features a production process with one fixed production factor. While this seems restrictive, we note that expressing the payoffs of the production process (rather than production itself) as a function of capital does not imply that variable input factors, such as labor or short-term working capital, are neglected. We can think of these factors as being maximized out of the problem, i.e., already accounted for in the level of the production payoffs (Strebulaev and Whited [2012]).

Our model further features an exogenous profitability process. We model this process as a mean reverting process. Importantly, shocks to current period profitability—think of these as demand or productivity shocks—are partially persistent, i.e., have value and investment implications for future periods, and symmetric. The latter is noteworthy as we are interested in explaining asymmetries in the data using a symmetric primitive in our model.

Lastly, our model features an endogenous investment process. Investment affects capital with a one-period lag (time-to-build), is costly, and causes disruptions to the production process. Notably, we model these disruptions as a symmetric function of investments, i.e., we do not introduce any asymmetries due to resale discounts or the like. Importantly, the capital adjustment costs make capital investments partially irreversible. This feature makes the decision on next period's capital stock dependent on this period's stock, leading to hysteresis and inter-temporal dynamics in the firm's investment and production process.

Omissions

Our model abstracts from a number of arguably important frictions. We purposefully do so for the sake of parsimony but even more so because of our intent to focus on the key primitives of dynamics in firm value, investment, cash flow, and earnings.

Our model is a partial equilibrium model. Hence, we abstract from general equilibrium effects related to, e.g., aggregate capital allocation and capital pricing (e.g., Gomes [2001]). Given the interest in firm-level properties of earnings and returns, we argue that modelling the firm as a price taker and abstracting from general equilibrium effects is suitable in our setting.

Our model is situated in a Modigliani and Miller [1958] world. We abstract from financing frictions, e.g., related to information asymmetry (e.g., Myers and Majluf [1984]) or agency issues (e.g., Jensen [1986]). While prior literature suggests that firms faced with different financing environments exhibit distinct earnings and return properties (e.g., Ball, Kothari, and Robin [2000]; Ball, Robin, and Wu [2003]; Ball, Robin, and Sadka [2008]), we note that these environments importantly differ in terms of firms' fundamentals such as the volatility of firms' profitability (e.g., Makaew and

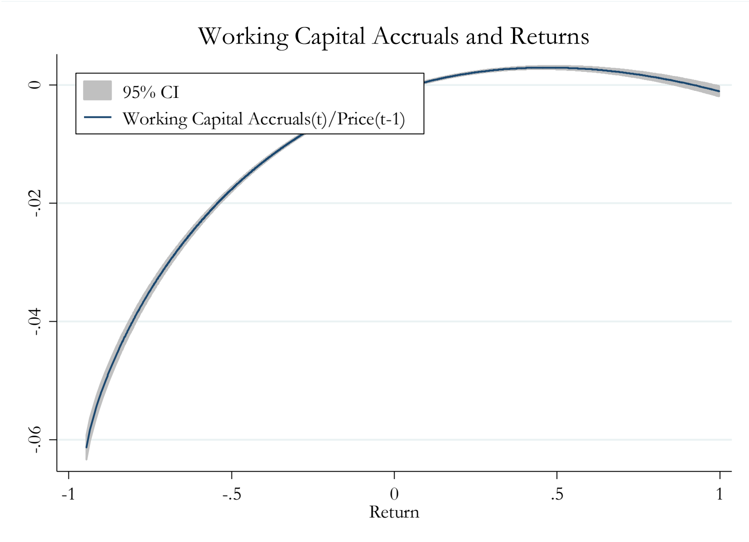
Maksimovic [2015]) and their capital adjustment cost (e.g., Fuchs, Green, and Papanikolaou [2016]; Meier [2017]). These primary differences are captured in our parsimonious model without the need to add financing frictions.

Our model does not provide the manager with a default option (e.g., Hayn [1995]). Hence, we abstract from the effect of abandonment in the form of firm exit on the cross-sectional earnings and return properties of surviving firms. Our focus is on the earnings and return properties of an individual firm. This firm has to survive to estimate these properties. Hence, the unconditional profitability in our model simulations is calibrated such that the continuation value is (almost surely) always positive, rendering the exit option—not the abandonment or curtailment of capital—superfluous.

Lastly, we abstract from measurement issues related to accounting rules or managers' reporting discretion. In particular, managers as well as any outsiders know the current period states (profitability and capital) and their implication for investment behavior and firm value (policy and value function) in our model. For our purposes, this is exactly what we want as we set out to study the economic null for earnings and return properties absent measurement issues. For future research on the impact of specific accounting rules/measurement systems, this is the place to add noise in the measurement/learnings process or information asymmetries between the manager and outsiders (e.g., Beyer, Guttman, and Marinovic [2014]; Liang, Sun, and Tam [2017]; Zhou [2016]; Choi [2017]).

Online Appendix Figures

Figure A1



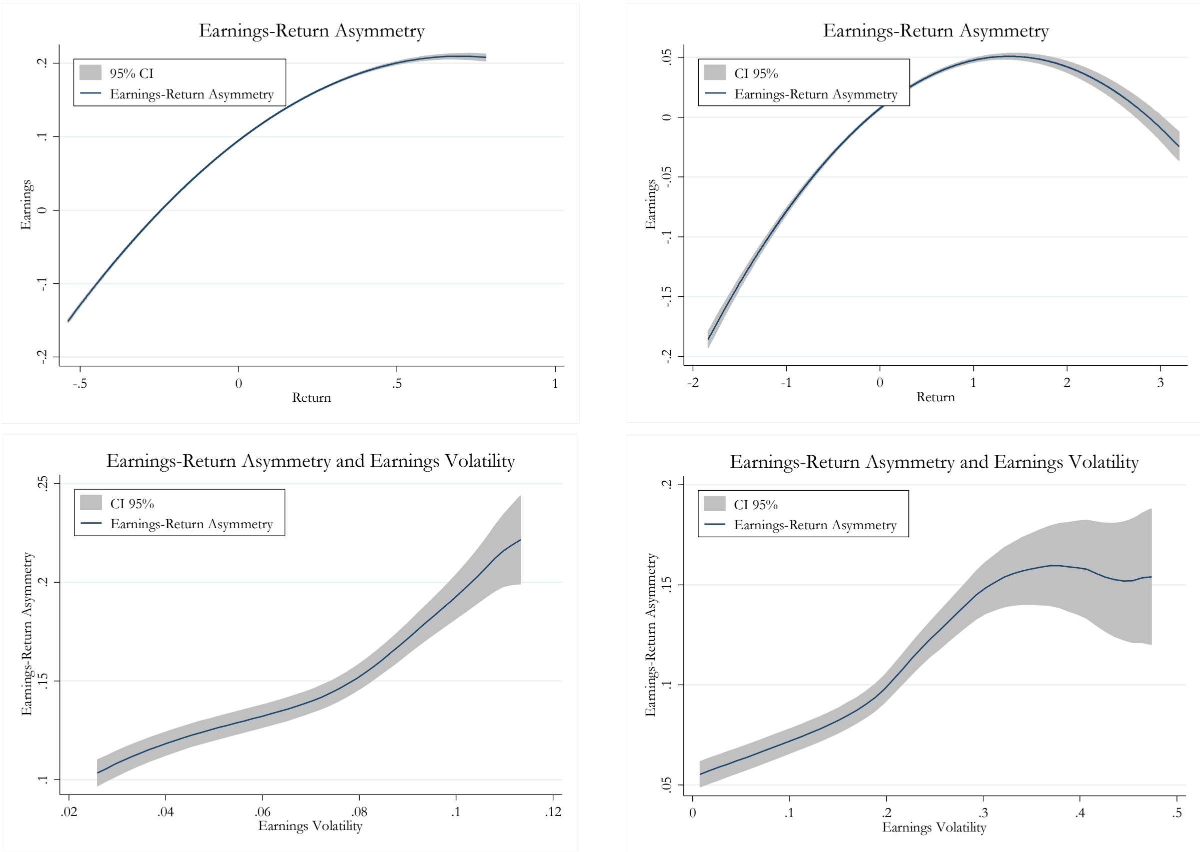
Notes: The figure depicts the flexible polynomial relation between working capital changes scaled by lagged price and returns. The grey area represents pointwise 95% confidence bands. The figure is based on 100,000 observations simulated using an extension of our dynamic-investment model adding endogenous working capital accounts to our base model as described in Appendix "Accruals Model".

Figure A2

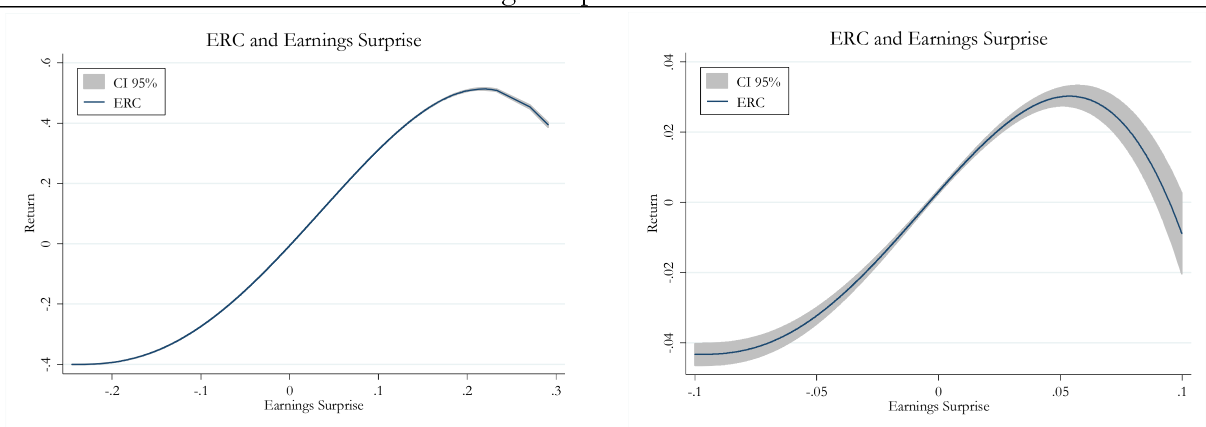
Non-Parametric Comparison of Simulated and Compustat Earnings-Return Patterns

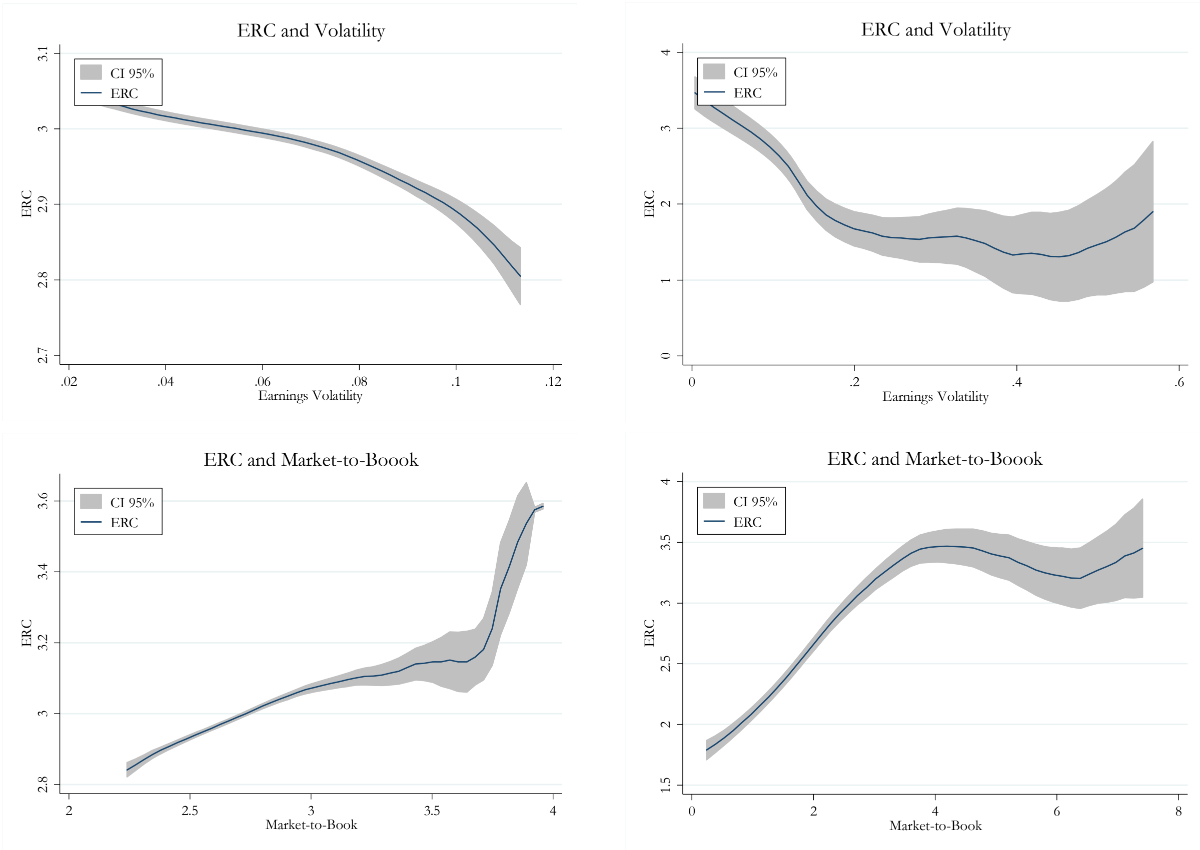
Simulated Data	**Compustat Data**

Earnings-Return Asymmetry



Earnings-Response Coefficient

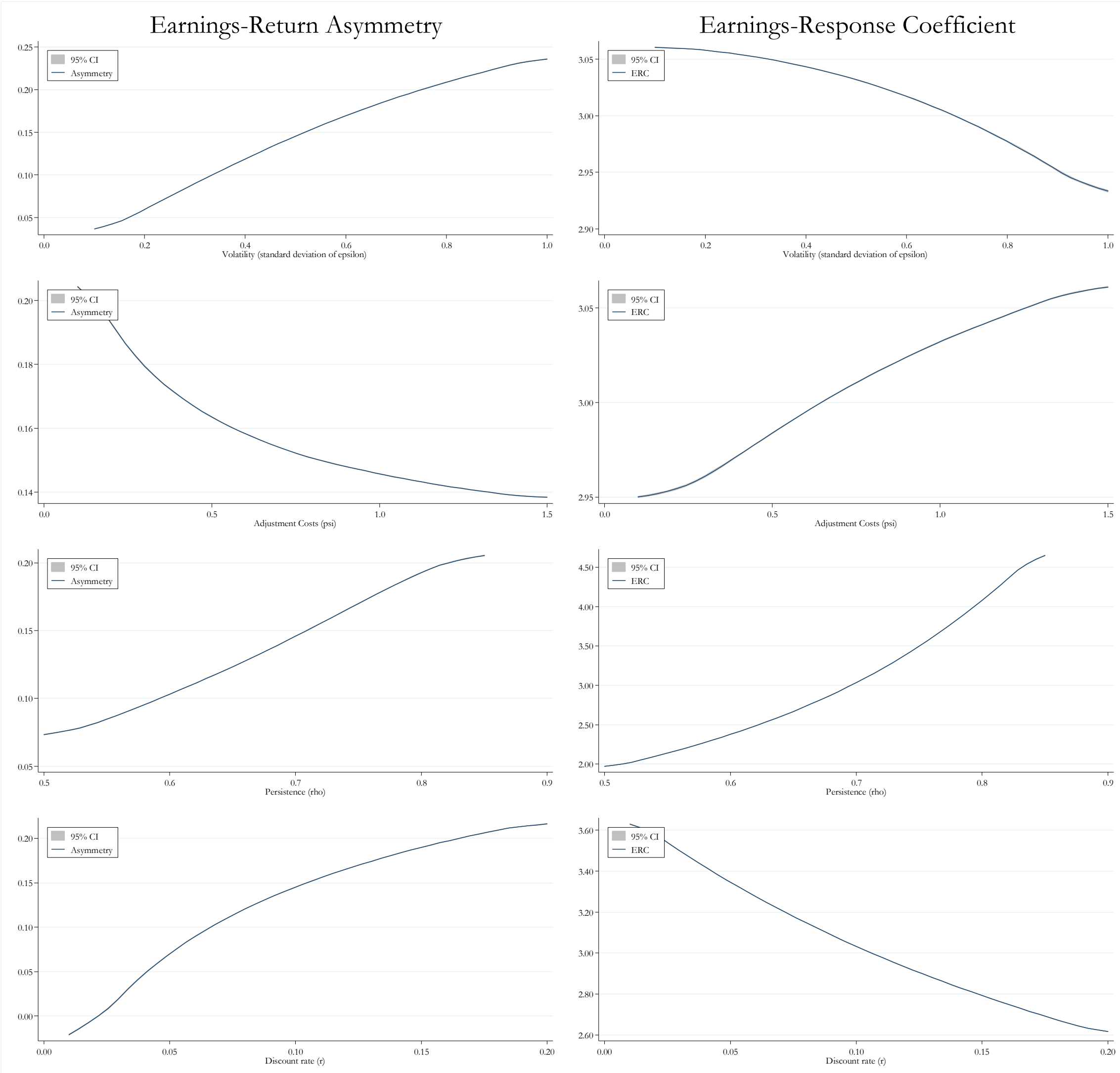




Notes: The figure depicts earnings-return patterns observed in our simulated data and Compustat data. The graphs plot locally smoothed averages of earnings scaled by lagged price against (abnormal) returns (earnings-return asymmetry), (abnormal) returns against earnings surprise, and firm-level earnings-return asymmetry and earnings-response coefficients against earnings volatility and market-to-book. The earnings surprise is based on an AR(1) expectation of earnings in the simulated data and the I/B/E/S consensus earnings forecast in the Compustat data. The grey area in the lower graphs represents pointwise 95% confidence bands.

Figure A3

Comparative Statics



Notes: The figure depicts earnings-return asymmetry and earnings-response coefficients as a function of key model parameters (standard deviation of the profitability shock, adjustment costs, shock persistence, discount rate). Each graph depicts the effect of varying one particular parameter while holding all other parameters at our calibrated values on the earnings-return asymmetry or the earnings-response coefficient. For each graph, we simulate earnings-return asymmetry or earnings-response coefficients for 101 different parameter values (using equally-sized steps between reasonable parameter bounds) holding all other parameters constant. The grey area in the lower graphs represents pointwise 95% confidence bands.

Online Appendix Tables

Table A1

Moment Estimates			
Model formula	**Compustat formula**	**Data moments**	**Model moments**
$mean(V_t / k_t)$	$mean(mkvalt_t / ceq_t)$	2.544	2.545
$sd(cfo_t / k_t)$	$sd(oancf_t / at_{t-1})$	0.076	0.077
$corr(cfo_t, cfo_{t-1})$	$corr(oancf_t, oancf_{t-1})$	0.842	0.850
$mean(I_t / k_t)$	$mean(-ivncf_t / at_{t-1})$	0.094	0.135
$sd(I_t / k_t)$	$sd(-ivncf_t / at_{t-1})$	0.133	0.115
$corr(I_t, I_{t-1})$	$corr(ivncf_t, ivncf_{t-1})$	0.503	0.509

Notes: The table summarizes the target values for our six moments obtained in Compustat data ("Data moments") and the corresponding model moments ("Model moments"). The model moments are obtained by minimizing the joint (weighted) distance between the data moments and the model (or simulated) moments via the choice of five model parameters (unconditional profitability, shock persistence, standard deviation of profitability shock, depreciation rate, and capital adjustment cost) using a global (gradient-free) optimization algorithm (genetic algorithm) and the identity matrix as our weighting matrix (Asker, Collard-Wexler, and De Loecker [2014]).

Table A2

Parameter Estimates			
Parameter	**Simulation values**	**Estimation values**	**Standard errors**
$\bar{z}$	1.50	0.92	0.22
ρ	0.70	0.83	0.08
σ_ε	0.50	0.17	0.08
δ	0.15	0.13	0.03
ψ	1.00	0.83	0.25

Notes: The table summarizes the calibrated parameter values used in our simulation, the corresponding parameter values estimated via the method of simulated moments, and the pertaining standard errors of the parameter value estimates. The estimated values are obtained by minimizing the (identity matrix) weighted distance between data and model moments (Table A1) using a global (gradient-free) optimization algorithm (genetic algorithm). We follow Asker, Collard-Wexler, and De Loecker [2014] in using the identity matrix as the weighting matrix (e.g., instead of the variance-covariance matrix of the data moments) to avoid the excessive influence of any single moment. In particular, the correlation-based moments are important for the investment dynamics but are less precisely estimated in the data than simple averages and standard deviations. Hence, they would receive little weight in the parameter estimation despite their centrality for investment dynamics and the underlying model parameters.

Table A3

Model Fit			
No.	**Model**	**J statistic**	**p value**
(1)	No adjustment friction	20,730	0.000
(2)	Time-to-build	1,857	0.000
(3)	Convex adjustment cost	761	0.000
(4)	Time-to-build + Convex adjustment cost	166	0.000

Notes: The table summarizes the J-statistic of the over-identification test for four (nested) models. The J-statistic is calculated using the variance-covariance matrix of the model parameters as the weighting matrix. Given that the model parameters are chosen using the identity matrix as a weighting matrix, the J-statistics are comparably large and the null of the model representing the data generating process underlying the Compustat data is rejected for all models. Hence, we focus on the relative J-statistic values as they are informative about the relative fit of the distinct models and the contributions to fit by the distinct adjustment frictions (e.g., Andrews and Lu [2001]). Model (1) features no short-run fixed input factor as it abstracts from adjustment frictions, i.e., there are no time-to-build and no convex adjustment costs. Model (2) adds a one period delay (time-to-build) between the time of investment and the time of capital accumulation/installation. Model (3) builds upon Model (1) by adding a convex capital adjustment cost (rather than time-to-build). Model (4) incorporates both adjustment frictions: time-to-build and convex adjustment costs.

Table A4

Model Comparison					
Panel A: Predictions					
Friction		**Uncertainty**	**Uncertainty+Short-Run Friction**		
Model Mechanism		Optimization	Optimization+ Time-To-Build	Optimization+ Convex Adjustment Costs	Optimization+ Time-To-Build+ Convex Adjustment Costs
Figure/ Table	**Property/Prediction**	(1)	(2)	(3)	(4)
Table 3	Incremental negative earnings persistence	negative	negative	negative	negative
	Incr. neg. earnings change persistence	positive	positive	positive	insignificant
	Incr. neg. earnings change (scaled by price) persistence	negative	negative	negative	negative
	Incr. neg. earnings change (scaled by capital) persistence	negative	negative	negative	negative
Figure 5	ERC and discount rate	negative	negative	negative	negative
	ERC and persistence	positive	positive	positive	positive
	ERC and market-to-book	positive	positive/flat	positive	positive
Table 4	ERC	0.9	2.9	2.5	3.0
	ERC and persistence	positive	negative	negative	positive
	ERC and absolute surprise	negative	negative	negative	negative
	ERC and market-to-book	positive	positive	positive	positive
	ERC and loss	negative	positive	positive	negative
Figure 6	ERC (correct expectation)	linear	s-shaped	s-shaped	hockey-stick/ s-shaped
	ERC (AR(1) expectation)	linear	s-shaped	s-shaped	s-shaped
Table 5	Current earnings response	positive (increasing across columns)	positive (increasing across columns)	positive (increasing across columns)	positive (increasing across columns)
	Future earnings response	positive (decreasing with time)	positive (decreasing with time)	positive (decreasing with time)	positive (decreasing with time)
	Future returns response	negative (decreasing with time)	negative (decreasing with time)	negative (decreasing with time)	negative (decreasing with time)
Figure 7	Earnings-return asymmetry	s-shaped	concave	concave	concave
	Scaled earnings-return asymmetry	convex	concave	concave	concave
Figure 8	Earnings-news	convex	linear/concave	linear/convex	concave
	Adjustment costs-news	-	-	convex	convex
	Returns-news	convex	convex	convex	convex
Figure 9	Profitability-returns	concave	concave	concave	concave
	Profitability-news	linear	linear	linear/convex	linear
	Investment-returns	s-shaped	s-shaped	concave	concave
	Investment-news	convex	convex	linear/concave	linear/concave
Table 6	Earnings-return asymmetry and volatility	negative	inverse U-shaped	positive	positive
	Earnings-return asymmetry and investment	non-monotonic/ unclear	non-monotonic/ unclear	negative	negative
Panel B: Model Fit					
J-Statistic (Hansen)		20,730	1,857	761	166

Panel C: Parameters				
Friction	**Uncertainty**	**Uncertainty+Short-Run Friction**		
Model Mechanism	Optimization	Optimization+ Time-To-Build	Optimization+ Convex Adjustment Costs	Optimization+ Time-To-Build+ Convex Adjustment Costs
Parameter	(1)	(2)	(3)	(4)
$\bar{z}$	1.5	1.5	1.5	1.5
ρ	0.7	0.7	0.7	0.7
σ_ε	0.5	0.5	0.5	0.5
r	0.1	0.1	0.1	0.1
θ	0.7	0.7	0.7	0.7
δ	0.15	0.15	0.15	0.15
ψ	0	0	1	1
State space				
Profitability transition matrix	100×100	100×100	100×100	100×100
Capital grid	1,200×1,200	1,000×1,000	1,000×1,000	600×600
Capital minimum	1	1	1	1
Capital maximum	2,400	2,000	1,000	600

Notes: The table presents a comparison of variants of our main dynamic-investment model. Panel A compares the predicted (untargeted) earnings-return properties generated by our main model with the other variant. We use grey shading to highlight predictions generated by the other model variants that correspond to the predictions of our main model. The model predictions are based on 100,000 observations simulated using parameter values as presented in Panel C. Panel B presents model fit (J-statistics) of the different models. The fit reflects the (weighted) squared difference between targeted data moments (see Table A1) and model-generated moments (using SMM). Panel C summarizes the model parameter values and state space parameters used in simulating the data and generating the model predictions in Panel A. We use higher maximum capital amounts and a greater number of discrete capital grid points for models with fewer investment frictions. Thereby, we account for the fact that optimal investment and capital values are more volatile and extreme without adjustment frictions.

Table A5

Asymmetries

Panel A: Simulated Data

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Variable:	Earnings	Earnings/ Price(t-1)	Cash Flow	Cash Flow/ Price(t-1)	Investment	Investment/ Price(t-1)
Return*D(Return<0)	**40.448*** **	**0.139*** **	**44.172*** **	**0.133*** **	**20.774*** **	**0.069*** **
	(0.904)	**(0.003)**	**(1.120)**	**(0.003)**	**(0.518)**	**(0.001)**
Main effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	100,000	100,000	100,000	100,000	100,000	100,000
# Clusters	4,000	4,000	4,000	4,000	4,000	4,000
Adj. R^2	0.334	0.626	0.218	0.612	0.557	0.790

Panel B: Compustat Data

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Variable:	Earnings/ Price(t-1)	Cash Flow/ Price(t-1)	Accruals/ Price(t-1)	Investment/ Assets Ratio	Investment Growth	Investing Cash Flow
Return*D(Return<0)	**0.126*** **	**0.037*** **	**0.087*** **	**0.027*** **	**0.094*** **	**0.016*** **
	(0.003)	**(0.004)**	**(0.004)**	**(0.003)**	**(0.020)**	**(0.004)**
Main effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	190,592	169,640	169,754	171,557	176,191	115,962
# Clusters	18,927	17,679	17,683	16,921	17,756	14,191
Adj. R^2	0.111	0.082	0.048	0.056	0.019	0.020

Notes: The table reports estimates of earnings-, cash-flow-, accruals-, and investment-return asymmetries. Panel A presents estimates of regressions of earnings, cash flow, and investment (levels and scaled by lagged price) on returns ("Return"), an indicator for negative returns ("D(Return<0)"), and the interaction of returns and the negative return indicator ("Return*D"). The main effects (i.e., coefficients on "Return" and "D(Return<0)") are included in the estimation but not tabulated for brevity. The estimates are based on 100,000 observations simulated using our dynamic-investment model calibrated with the parameter values as provided in Table 1. A firm is defined as 25 consecutive (non-overlapping) simulated observations. The regressions are estimated with firm fixed effects. Panel B presents estimates of earnings, cash flow, accruals, and investment (scaled by lagged price) on returns ("Return"), an indicator for negative returns ("D(Return<0)"), and the interaction of returns and the negative return indicator ("Return*D"). The main effects (i.e., coefficients on "Return" and "D(Return<0)") are included in the estimation but not tabulated for brevity. The estimates are based on a sample of Compustat firms from 1963 to 2014 (except for Investing Cash Flow, for which data is only available starting in 1987). "Earnings" is earnings per share (Compustat ib/cshpri). "Cash Flow" is cash flow from operations per share (Compustat (oancf-xidoc)/cshpri). "Accruals" is earnings per share minus cash flow from operations per share. If cash flow from operations per share is missing, we obtain accruals from balance sheet amounts where total accruals is change in current assets (Compustat act) minus change in current liabilities (Compustat lct) minus change in cash (Compustat che) plus change in short-term liabilities (Compustat dlc) plus change in income tax payable (Compustat txp) minus depreciation (Compustat dp). "Investment-to-Assets-Ratio" is change in property, plant & equipment (Compustat ppegt) plus change in inventory (Compustat invt) over lagged total assets (Lyandres, Sun, and Zhang [2008]). "Investment Growth" is the percentage change in capital expenditures (Compustat capx) plus expenses for research and development (Compustat xrd) (Xing [2008]). "Investing Cash Flow" is cash flow from investing activities (Compustat ivncf) scaled by lagged total assets. "Return" is the market-adjusted return for each firm-year, measured over a period of 12 months ending three months after the fiscal year-end. "D(Return<0)" or "D" is an indicator variable representing bad (good) news; "D" is 1 if Return is negative (bad news), and 0 otherwise (good news). The regressions are estimated with year and firm fixed effects. Observations with a beginning-of-period price less than $1 are excluded from the sample and all continuous variables are truncated at the top and bottom one percent to decrease the influence of outliers. Standard errors in parentheses are clustered by firm. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table A6

Decomposition of Earnings-Return Asymmetry						
Asymmetry Coefficient:	$\beta_{Basu} = \frac{\operatorname{cov}\left(\frac{ear_t}{p_{t-1}}, ret_t \mid ret_t < 0\right)}{\operatorname{var}\left(ret_t \mid ret_t < 0\right)} - \frac{\operatorname{cov}\left(\frac{ear_t}{p_{t-1}}, ret_t \mid ret_t \geq 0\right)}{\operatorname{var}\left(ret_t \mid ret_t \geq 0\right)}$					
Data:	**Simulated Data**			**Compustat Data**		
Numerator:	Conditional Earnings-Return Covariance					
	$ret_t < 0$	$ret_t \geq 0$	Difference	$ret_t < 0$	$ret_t \geq 0$	Difference
	0.0026	0.0021	0.0005	0.0050	0.0035	0.0015
Denominator:	Conditional Return Variance					
	$ret_t < 0$	$ret_t \geq 0$	Difference	$ret_t < 0$	$ret_t \geq 0$	Difference
	0.0069	0.0087	-0.0018	0.0478	0.1587	-0.1109

Notes: The table provides estimates of the distinct components of the asymmetry coefficient decomposition (provided above). The estimates provided under "Simulated Data" are based on 100,000 observations simulated using our dynamic-investment model calibrated with the parameter values as provided in Table 1. The estimates provided under "Compustat Data" are based on Compustat firms from 1963 to 2014.