Equity Market Misvaluation and Firm Financial Policies

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Abstract

We quantify the extent to which nonfundamental movements in the price of a firm's stock affect its policies, in particular cash, investment, dividend, equity issuance, and equity repurchase decisions. We estimate a version of a constant returns neoclassical investment model in which equity financing is costly, the firm can accumulate cash, and, most importantly, equity values can be subject to misvaluation shocks. In the model, firms naturally issue equity when it is overvalued and repurchase equity when it is undervalued. Depending on the model parameters, the funds flowing to and from these activities can come from either changes in cash balances or changes in investment. We find that a model in which we allow no mispricing fits the data worse than a model in which we do allow mispricing. In particular, the mispricing model does a much better job of matching moments related to cash balances and equity issuance. We find that the variance of misvaluation shocks is statistically significant, but small. Our counterfactual exercises show that firms do issue equity in response to misvaluation shocks, but the proceeds from these issuances are not used to fund investment. Instead, they augment cash balances. Finally, managers' rational responses to possible misvaluation increase intrinsic shareholder value from 0.2% to 1.1%.

1 Introduction

We estimate a dynamic model of a firm's investment and financing policies to understand and quantify the distortions to these policies that arise because of equity mispricing. This question is of interest in light of the marked increase in technology stock boom in the 1990s and bust in the early 2000s, and also in light of the sharp stock market crash of 2008, which was followed by the almost complete rebound over the subsequent two years. The mere existence of such wide swings in equity values begs the question of whether these swings reflect movements in intrinsic firm values. It is then natural to wonder whether possible nonfundamental movements in equity values affect managerial decisions.

These questions are both interesting and challenging. Equity misvaluation is by nature unobservable, and firms' potential reactions to any misvaluation shocks are endogenous. Tackling this question via regression analysis thus requires finding proxies for misvaluation. Regression analysis also requires instruments that are highly correlated with misvaluation and orthogonal to both the measurement error in the misvaluation proxy and the unobservable components of firm policies. Although it might be conceivable to find an instrument satisfying one of these exclusion restrictions, there are no obvious instruments that satisfy both of these two exclusion restrictions.

A feasible alternative method for tackling this question is estimation of an economic model. Our baseline model captures decisions about a firm's dividends, investment, cash, and equity issuances or repurchases in a dynamic setting. Its backbone is a standard neoclassical model of physical and financial capital accumulation in the face (1) uncertain demand, (2) constant returns to scale, (3) costs of adjusting the capital stock, and (4) underwriting costs in the equity market. The model then incorporates a new feature that is motivated by the behavioral finance literature. We allow for the market value of equity in the model to diverge from its true value, and this misvaluation can be persistent. The divergence between fundamental firm value and equity value affects the cost of capital. In particular, misvaluation affects the extent to which equity repurchases and issuances affect the dilution of the shares of long-term shareholders. This dilution effect then implicitly changes the cost of capital. In response to misvaluation, firms predictably repurchase shares when equity is underpriced and issue shares when equity is overpriced. The latter effect is much more pronounced than the former because the model incorporates a feature that mirrors the "safe harbor" provisions in the tax code that restrict the amount of equity repurchases that are immune from dividend taxes. The funds required for repurchases or received from issuances can flow to and from either cash balances or investment depending on the model parameters.

Quantifying the relative magnitudes of these different effects therefore requires estimating the model's parameters. We use SMM, which matches model generated moments to real-data moments, that is, which minimizes model errors. We obtain estimates of parameters governing the firm's technology and, more importantly, the variance and persistence of misvaluation shocks. Briefly, we find that a baseline model without any misvaluation shocks is unable to reconcile many features of our data. When we add misvaluation shocks to the model, its fit improves significantly, and we obtain significant estimates of the variance and serial correlation of misvaluation shocks. These findings are stronger for small firms than for large firms and for firms during the dot-com bubble than for firms in the 2000s. However, our parameter estimates imply that although firms issue equity when equity is overvalued, they only use a small fraction of the proceeds for capital investment. Instead, they tend for the most part to hoard the proceeds as cash, and then to use the proceeds to repurchase shares when equity is undervalued. Thus, although equity misvaluation appears important for financial policies, its impact on real policies is much smaller.

Further, inclusion of misvaluation shocks in the model cannot completely close the gap between the high variance of equity values in the data, and the low variance of equity values implied by standard neoclassical models (Liu, Whited, and Zhang (2009)). Because we identify the moments of the misvaluation shocks by comparing real and financial data moments within the framework of a dynamic optimization model, this finding implies misvaluation cannot by itself explain the difference the smoothness of real economic variables and the volatility in equity markets.

We also run a horserace between our misvaluation model and two alternatives: one with stochastic costs of equity issuance, and another with a stochastic discount factor. We find that our model does a better job of fitting the data. We also find that it does a better job of matching features of the data that are not used in estimation.

One of the advantages of structural estimation is that we can conduct counterfactual exercises in order to quantify the effect of misvaluation on fundamental firm value. We compare a firm with parameters estimated in the data to one that is identical except that it is never misvalued. Not surprisingly, we find that the volume of repurchases and especially of issuances is smaller for the perfectly valued firm. Of more interest is our finding that equity market timing actually increases intrinsic shareholder value from 0.2% to 1.1%, depending on the estimates of our model parameters. We also examine the extent to which investment, saving, and equity transactions are sensitive to movements in Tobin's q, and the extent to which these sensitivities depend on the variance of misvaluation shocks. These comparative statics are of interest because these types of exercises have been popular in the behavioral literature as a tool to determine whether misvaluation affects firm policies (e.g. Baker and Wurgler (2002, 2004)). We find that the sensitivity of equity transactions to Tobin's q increases as misvaluation shocks become more important, but that the sensitivity of investment to Tobin's q remains unchanged.

Our paper falls into several literatures. The first is the literature on structural estimation of dynamic models in corporate finance, such as Hennessy and Whited (2005, 2007), DeAngelo, DeAngelo, and Whited (2011), Morellec, Nikolov, and Schürhoff (2009), and Matvos and Seru (2011). These papers examine such issues as capital structure, financial constraints, agency problems, and corporate diversification. Our paper departs from these predecessors specifically by asking whether behavioral factors affect firm decisions.

Our paper also falls into the large empirical behavioral literature that has examined the effects of market misvaluation on firm policies. For example, Graham and Harvey (2001) find survey evidence that managers explicitly consider the possibility of equity overvaluation when deciding whether to issue shares. Eckbo, Masulis, and Norli (2007) and Baker and Wurgler (2012) provide excellent surveys of the empirical literature that has tested the more general proposition that market timing is important for many firm decisions. More recently, Jenter, Lewellen, and Warner (2011) find managerial timing ability by examining firms' sales of put options on their own stock, and DeAngelo, DeAngelo, and Stulz (2010) find that both fundamental factors and market timing affect capital structure. Our results add to this literature by pointing out that timing is more likely to be important for financial than for real decisions.

The papers most closely related to ours are Bolton, Chen, and Wang (2011), Yang (2011), and Alti and Tetlock (2011). The first paper uses a model similar to ours but does not attempt to estimate the model or quantify any effects of misvaluation. Instead, it focuses on understanding the directional implications of mispricing and the comparative statics of risk management. Yang (2011) examines the theoretical implications for capital structure of mispricing that arises from differences in beliefs. Our goal, in contrast, is not to understand where mispricing comes from, but to quantify its effects empirically. Alti and Tetlock (2011) is similar to our work in that it also performs a structural estimation of a neoclassical investment model augmented to account for behavioral biases. However, Alti and Tetlock (2011) do not explicitly examine the role of financing and instead examine the effects of specific behavioral biases on asset returns

The paper is organized as follows. Section 2 describes our data and presents descriptive evidence. Section 3 presents the model and discusses its optimal policies. Section 4 outlines the estimation and describes in detail our identification strategy. Section 5 presents the estimation results and counterfactual exercises. Section 6 discusses model robustness, and Section 7 concludes. The Appendix contains proofs.

2 Data and Summary Statistics

Our data are from the 2011 Compustat files. Following the literature, we remove all regulated utilities (SIC 4900-4999), financial firms (SIC 6000-6999), and quasi-governmental and non-profit firms, with a one digit SIC code equal to 9. Observations with missing values for the SIC code, total assets, the gross capital stock, market value, and cash are also excluded from the final sample. As a result of these selection criteria, we obtain a panel data set with 55,726 observations for the time period between 1987 and 2010 at an annual frequency. We use this specific time period because distribution taxes play an important role in our model. Therefore, we need to examine time periods in which tax policy is relatively constant. Our first time period runs from the 1986 tax reforms until the major tax cuts at the end of 2003. Our second period then runs from 2004 to 2010.

We define total assets as Compustat variable AT, the capital stock as GPPE, investment as capital expenditures (CAPX) minus sales of capital goods (SPPE), cash and equivalents as CHE, operating income as OIBDP, equity issuances as SSTK, equity repurchases as PRSTK, dividends as the sum of common and preferred dividends (DVC + DVP), depreciation as DP, and Tobin's q as the ratio of (AT + PRCC_F×CSHO − TXDB − CEQ) to AT. All other variables except investment and depreciation are expressed as fractions of total assets. Investment and depreciation are expressed as fractions of the capital stock.

Suggestive evidence of a role for stock market mispricing in firm decision making is contained in Figures 1 and 2. Figure 1 contains results for small firms, that is, those whose real (2001) total assets fall below the median, and Figure 2 contains results for large firms. The top panel of Figure 1 plots yearly averages repurchases, dividends, equity issuance, and equity capital gains, where the last variable is calculated as the change in the market value of equity divided by the lagged value of market equity. We find several patterns of interest. First, we see that capital gains and equity issuance track one another fairly closely, especially in the mid-1990s and the late 2000s. Second, although repurchases are much smoother over time than equity issuances, they do appear to be slightly negatively correlated with capital gains. Finally, dividends are the smoothest series of all, and they appear uncorrelated with the other variables in the graph.

The next panel contains plots of cash, investment, saving, and again equity capital gains. We multiply saving by 10 to make its magnitude comparable to those of the other variables. The most striking result here is the strong positive comovement between saving and capital gains.

Interestingly, investment in physical assets appears, if anything, slightly negatively correlated with capital gains, and the level of cash appears unrelated to capital gains, but negatively related to investment, especially in the latter part of the sample, in which cash increases dramatically and investment also falls noticeably.

Figure 2 contains similar plots for large firms. The general trends evident for small firms are also evident for large firms, especially the strong comovement between saving and capital gains. A few important exceptions do stand out, however. First, equity issuance is much less volatile, and repurchases are much more volatile than they are for small firms, although the correlations of issuance and repurchases with capital gains appear to be similar to those for small firms. Second, investment is much higher than average cash in the first part of the sample for the large firms, whereas for the small firms these two variables are much closer together. In contrast, in the second half of the sample, investment and cash are relatively close together for the large firms, while cash is much higher than investment for the small firms.

To quantify these visual patterns, in Table 1 we give more texture to the differences between large and small firms by presenting simple time-series correlations among these aggregate variables. As also seen in Figures 1 and 2, for both groups of firms, saving and capital gains are strongly positively correlated. Investment is also strongly negatively correlated with capital gains. This second pattern occurs because investment is strongly positively with Tobin's q, and Tobin's q is strongly negatively correlated with returns via the well-documented value effect. The other large effect in this table is the negative correlation between cash and dividends for both groups of firms.

Table 1 also highlights several important differences between these two groups that are not easy to spot in Figures 1 and 2. In particular, equity transactions (issuance and repurchases) are more strongly correlated with capital gains for the large than for the small firms. The final important difference is the positive correlation between investment and equity issuance for the small firms, but the slight negative correlation for the large firms.

We have for the most part avoided interpreting these results because a correlation between equity returns and corporate policies might or might not indicate market timing. Market timing is important if equity values contain a component unrelated to the intrinsic value of the firm and if managers react to this misvaluation component. If this is the case, then the high correlations between equity transactions and capital gains are clearly consistent with timing. Further, if timing is indeed occurring, then the high positive correlation between saving and capital gains suggest that the funds to conduct equity transactions flow in and out of cash stocks. Of course, if equity is not misvalued or if managers do not pay any attention to misvaluation, these high correlations could also simply be a result of managers' attempts to fund profitable investment projects, which are naturally correlated with intrinsic firm value. To disentangle these competing explanations, we therefore estimate a dynamic model.

3 Model

This section presents the model. It then describes the optimal policies implied by the model solution.

3.1 Model Components

As a basis for our estimation we use a simple model that captures a firm's dividend, investment, cash and equity issuance/repurchase decisions in a dynamic setting. The model is based on a standard neoclassical model with financing frictions (e.g. Gomes (2001); Hennessy and Whited (2005)). However, it incorporates a new feature that is motivated by the strand of the behavioral literature that studies equity misvaluation and investor sentiment. In particular, we allow for the market value of equity in the model to diverge from its true value. This divergence affects the cost of capital for the firm and therefore affects its real and financial decisions. We start by describing the firm's production technology. Then we move on to explain financing, taxation, and equity misvaluation.

We consider an infinitely lived firm in discrete time. At each time period the firm's risk-neutral manager chooses how much to invest in capital goods and how to finance these purchases. The firm is characterized by a constant returns to scale production technology, zK, that uses only capital, K, and that is subject to a profitability shock, z. The shock follows an $AR(1)$ in logs:

$$\ln\left(z'\right) = \mu + \rho_z \ln\left(z\right) + \varepsilon_z, \tag{1}$$

in which a prime denotes a variable in the next period, μ is the drift of z, ρ_z the autocorrelation coefficient, and ε_z is an *i.i.d.*, random variable with a truncated normal distribution. It has a mean of 0 and a variance of σ_z. We define the Markov transition function associated with (1) as $g^z\left(\varepsilon_z', \varepsilon_z\right)$.

Firm investment in physical capital is defined to be

$$I = K' - (1-\delta)\,K, \tag{2}$$

in which δ is the depreciation rate of capital. When the firm invests, it incurs adjustment costs, which can be thought of as profits lost as a result of the process of investment. These adjustment costs are convex in the rate of investment, and are given by

$$A\left(I, K\right) \equiv \frac{\lambda I^2}{2K}, \tag{3}$$

in which λ is a parameter governing the curvature of the adjustment cost function.

The firm finances its production activities by retaining its earnings and by issuing equity. When the firm retains earnings, it holds them as one-period bonds that earn the risk-free rate, r_f, and which we denote as C. Equity issuances are denoted by E, with a negative number indicating repurchases. When the firm issues equity, it pays a proportional cost, a_1. This cost can be thought of as an intermediation cost for a seasoned offering. As we discuss below, it can also be interpreted as a price concession the firm makes to the intermediary.

The firm's profits are taxed at a rate τ_c, with the tax bill, T, given by

$$T = (zK - \delta K + Cr_f)\tau_c. \tag{4}$$

Note that the tax schedule is linear, so that the tax bill can be negative. This simplifying feature is intended to capture tax carryforwards and carrybacks. The final financing option available to the firm is adjustment of its level of dividends, D. These are given by a standard sources and uses of funds identity:

$$D = zK - I - \frac{\lambda I^2}{2K} + C(1+r) - C' - T + E - a_1 E\mathcal{I}(E > 0), \tag{5}$$

in which $\mathcal{I}(\cdot)$ is an indicator function. In words, this definition states that the cash flow net of taxes and equity issuance or repurchases equals the total dividend payout. Dividends are taxed at a rate τ, and $D > 0$. The tax rate τ should be interpreted as the tax rate on dividends relative to the tax rate on capital gains, inasmuch as we do not model capital gains taxation. In this model, the differential taxation of repurchases and dividends implies that it is optimal for firms to distribute funds to shareholders solely through repurchases. Therefore, we next specify a constraint on firms' equity repurchases:

$$-E \leq b_0 K + b_1 D. \tag{6}$$

This constraint captures the notion that firms cannot systematically avoid dividends through repurchases, as specified in the U.S. tax code. The constraint is linear in capital and dividends, implying that firms can pay out a certain amount via repurchases before they have to issue dividends, with larger firms being able to pay out more.

Thus far the model is a standard neoclassical model of investment with financing. We now depart from this setting by allowing the firm to be subject to misvaluation shocks. First, let $V(K, C, \psi, z)$ denote the intrinsic value of the firm's equity, in which ψ is the state variable denoting a misvaluation shock that affects observed ex-dividend equity values, V^*. In particular, V^* is a stochastic multiple of ex-dividend intrinsic equity value:

$$V^* = \psi \left(V(K, C, \psi, z) - D(1-\tau) \right). \tag{7}$$

The misvaluation shock, ψ, also follows and $AR(1)$ process in logs that is given by

$$\ln\left(\psi'\right) = -\frac{\sigma_{\psi}^{2}}{2(1+\rho_{\psi})} + \rho_{\psi}\ln\left(\psi\right) + \varepsilon_{\psi}. \tag{8}$$

Here, ρ_{ψ} is the serial correlation of the shock, and ε_{ψ} is a truncated normally distributed *i.i.d.* shock with mean zero and variance σ_{ψ}. We define the Markov transition function associated with (8) as $g^{\psi}\left(\varepsilon'_{\psi}, \varepsilon_{\psi}\right)$.When $\psi = 1$,the firm is valued correctly; when $\psi < 1$, the firm is undervalued, and when $\psi > 1$, the firm is overvalued.

Three features of this misvaluation shock are important. First, the manager can observe the shock; that is, he knows the intrinsic value of the firm and can therefore observe deviations of intrinsic from market values. Second, intrinsic equity value is a function not only of capital, cash, and the profitability shock, but also of the misvaluation shock. As shown below, managers' optimal reactions to these shocks affect their decisions regarding cash and capital, and thereby the intrinsic value of the firm. Finally, the misvaluation shock does not affect current period dividends given by (5). This model feature is important because it makes it difficult to argue that the shock, ψ, is simply a component of intrinsic value.

3.2 Dilution and concentration of holdings

Equity issuances and repurchases act to dilute and concentrate the dividend claims of long-term shareholders, that is, those long-term investors that neither provide equity to the firm nor repurchase shares. We assume that the equity issuance or repurchase, E, is priced according to the current market value, V^{*}. The degree of dilution/concentration then depends on the misvaluation of the firm because managers attempt to engage in market timing by issuing or repurchasing equity when the firm is misvalued. This market-timing activity will create value for long-term shareholders. The degree of dilution/concentration equals:

$$\frac{V^{*}}{V^{*}+E} = \frac{\psi(V - D(1-\tau))}{\psi(V - D(1-\tau)) + E},$$

where the degree of dilution for a given level of equity issuance (positive E) decreases as the level of misvaluation, ψ, increases. Symmetrically, the degree of concentration of dividend claims of long-term shareholders from repurchases (negative E) increases as the firm becomes increasing undervalued (as ψ declines).

In the model thus far, nothing limits firms from engaging in very large equity transactions in response to misvaluation. However, market participants are likely to infer the size of the potential misvaluation from the relative size of the equity transaction. See, for example, the evidence in Brockman and Chung (2001). To capture this effect and thus to restrain the size of equity transactions, we assume that the size of the dilution/concentration is also affected by the size of the transaction scaled by the capital stock. The modified dilution/concentration ratio is then given by:

$$\frac{V^*}{V^* + E + \frac{\nu E^2}{2K}} = \frac{\psi(V - D(1-\tau))}{\psi(V - D(1-\tau)) + E + \frac{\nu E^2}{2K}}, \tag{9}$$

where ν is a parameter that determines the degree of market reaction to the equity transaction.

3.3 Value Maximization

In a model in which firms can be misvalued, it is important to be precise about specifying the payoff to shareholders the firm wishes to maximize. The total payoff includes dividends and net equity issuances. However, if we wish to think about market timing by managers, we cannot simultaneously maximize both components of the total payoff. Therefore, we assume that the manager aims to maximize the payoff to a long-term investor that neither provides equity to the firm nor repurchases shares. We denote the actual net payout to long-term shareholders by P, which is given by $P \equiv D(1-\tau)$.

We can now write the valuation equation that managers wish to maximize as a Bellman equation, in which we take account the dilution/concentration of dividend claims that arises through equity issuance and repurchases.[1] Let $\beta = (1 + r_f)^{-1}$. Then the Bellman equation is

[1] Bazdresch (2005) uses a similar specification.

$$V(K,C,\psi,z)=\max_{K',C',E}\left\{D(1-\tau)+\beta\frac{\psi(V-D(1-\tau))}{\psi(V-D(1-\tau))+E+\frac{\nu E^2}{2K}}\int\int V\left(K',C',\psi',z'\right)dg^{\psi}\left(\varepsilon'_{\psi},\varepsilon_{\psi}\right)dg^{z}\left(\varepsilon'_{z},\varepsilon_{z}\right)\right\}. \tag{10}$$

The Bellman equation thus shows that the value of the firm for long-term shareholders $V(K,C,\psi,z)$ equals the present value of dividends adjusted for dilution/concentration. The Bellman equation also reveals the intuition that the misvaluation shock affects the firm's discount rate, with overvaluation leading the manager to discount future cash flows at higher rate. Further, this effect on discounting only operates when the manager is either issuing or retiring equity.

The relevant constraints in the maximization problem are the capital stock accumulation identity (2), the definition of dividends in (5), the repurchase constraint (6), and the following nonnegativity constraints

$$C'\geq 0,\qquad K'\geq 0,\qquad D\geq 0.$$

It is not obvious that a solution to (10) exists, inasmuch as the discount factor need not always be less than one. However, the following proposition allows the Bellman equation (10) to be written with a constant discount factor.

Proposition 1 *The solution to equation (10) is identical to the solution of*

$$V(K,C,\psi,z)=\max_{K',C',E}\left\{D(1-\tau)-\frac{E}{\psi}-\frac{\nu E^2}{2\psi K}+\beta\int\int V\left(K',C',\psi',z'\right)dg^{\psi}\left(\varepsilon'_{\psi},\varepsilon_{\psi}\right)dg^{z}\left(\varepsilon'_{z},\varepsilon_{z}\right)\right\}. \tag{11}$$

It is straightforward to demonstrate that (11) satisfies the conditions necessary to prove existence and uniqueness in Stokey and Lucas (1989).

3.4 Constant returns to scale specification

The problem can be further simplified by taking advantage of the constant returns to scale nature of the problem, and redefining all of the quantities in the model as a fraction of the capital stock,

K. Define the following scaled variables:

$$c \equiv \frac{C}{K}, d \equiv \frac{D}{K}, e \equiv \frac{E}{K}, i \equiv \frac{I}{K}, v(c, \psi, z) \equiv \frac{V(K, C, \psi, z)}{K}.$$

Then, one obtains the following Bellman equation:

$$v(c, \psi, z) = \max_{c', e, i} \left\{ d(1-\tau) - \frac{e}{\psi} - \frac{\nu e^2}{2\psi} + \beta \int \int v\left(c', \psi', z'\right)(1-\delta+i) dg^{\psi}\left(\varepsilon'_{\psi}, \varepsilon_{\psi}\right) dg^{z}\left(\varepsilon'_{z}, \varepsilon_{z}\right) \right\}, \tag{12}$$

and the constraints become

$$d - e + \mathcal{I}(e > 0) a_1 e = z(1-\tau_c) - i - \frac{\lambda i^2}{2} + c(1 + r - r\tau_c) - c'(1-\delta+i) + \delta\tau_c,$$

$$-e \leq b_0 + b_1 d,$$

$$c' \geq 0, \qquad d \geq 0.$$

3.5 Solution algorithm

We use value function iteration to solve (12). The solution algorithm is conceptually simple. We can think of the firm as choosing the optimal value for next period investment and cash, given the optimal allocation of the total payout into equity issuance/repurchases and dividends. Thus, given a particular choice for future cash and investment, we solve for the optimal allocation of the payout using the first-order conditions of (12), and the constraint on the size of repurchases. Once we have the optimal allocations, we can then search over the optimal policies for next period investment and cash.

We construct our simulated variables as follows. "Cash" is c, "investment" is i, "saving" is $c' - c$, "equity issuance" is e when $e > 0$, "repurchases' are also e but when $e < 0$, and Tobin's q is given by

$$q \equiv \int \int \psi v\left(c', \psi', z'\right)(1-\delta+i) dg^{\psi}\left(\varepsilon'_{\psi}, \varepsilon_{\psi}\right) dg^{z}\left(\varepsilon'_{z}, \varepsilon_{z}\right).$$

3.6 Optimal Policies

Figure 3 plots the policy functions for investment, cash, issuances/repurchases, and dividends, which we denote as $\{c', i, e, d\} = h(c, \psi, z)$. Note that a positive value for e indicates an equity issuance, and a negative value indicates a repurchase. We parameterize the model using the results from the first estimation reported in Table 3. (Exercises using parameterizations from our other estimations are qualitatively similar.) Because we use data estimates to parameterize our model, these policy functions can be interpreted as empirically relevant.

The top panel depicts the optimal choices of cash, investment, equity issuances/repurchases, and dividends as a function of the misvaluation shock, where a value near 1 indicates no misvaluation. The profit shock is fixed at its mean value, and the choice of next period's cash is fixed at the sample mean. The most salient feature of this panel is that the policy functions are not flat. This result implies that misvaluation shocks can affect firm policies, given the parameterization from our data. Interestingly, the two policies that appear most responsive to the misvaluation shock are cash and equity issuances, but this responsiveness is only apparent for shocks that are greater than 1.5 standard deviations from the mean. In this case, we see a modest response of investment, but sharp increases in both cash and equity issuances. The increase in equity issuance makes sense given the Bellman equation (12), which shows that high values of the misvaluation shock, ψ, increase the payout to long-term shareholders by making equity issuance implicitly less expensive. What is interesting is the distribution of the proceeds from the issuances between investment in capital and cash accumulation. The modest increase in investment also makes sense, given the presence of investment adjustment costs. It is worth noting that the modest response of investment is not necessarily hardwired into the model. The investment adjustment cost parameter is not picked arbitrarily but is instead estimated from the data.

This pattern is not symmetric. For undervaluation shocks, the firm does not repurchase large quantities of equity because of the constraint on repurchases given by (6), which is motivated by the safe harbor tax provisions for repurchases. Repurchases do increase for shocks more than 2 standard deviations below the mean, but this response is muted at best. Taken together, the main conclusions we can draw from examining these policy functions is that misvaluation shocks have almost no effect on dividend policy, only modest effects on investment policy, and strong effects on equity issuance and cash policy, but only for large positive shocks.

The next panel depicts the response of investment, cash, issuances/repurchases, and dividends to the profitability shock, z. In contrast to the result in the first panel, investment responds strongly and positively to the profitability shock. The sawtooth pattern in the response of cash to z is interesting in that it indicates that cash is an important source of funding for the firm. When the response of investment to z is flat, the response of cash is positive, and when the response of investment to z is positive, the response of cash to z is negative. That is, it appears that the firm saves in periods of no investment and then disgorges part of these funds to help finance periods in which the firm does invest. Finally, dividends, equity issuances, and repurchases do not respond strongly to the profitability shock.

In the end, the main conclusions to be drawn from Figure 3 are as follows. First, investment is mostly affected by shocks to profitability and not by equity market misvaluations. Second, cash policy appears to respond to both profitability and misvaluation shocks, but the reasons are different. The response to profitability shocks results from firms needing to use internal funds for investment in the face of costly external finance. The response to misvaluation shocks results from firms saving the proceeds of equity issuances. Third, equity issuance does appear to respond to very large positive misvaluation shocks, but repurchases do not respond strongly to negative misvaluation shocks.

4 Estimation and Identification

In this section, we explain how we take the model derived in Section 2 to the data. We first outline the estimation procedure. We then discuss our identification strategy and present our results.

4.1 Estimation

We estimate most of the structural parameters of the model using simulated method of moments. However, we estimate some of the model parameters separately. For example, we estimate the risk-free interest rate, r_f, to equal 0.031, which is the average over our sample period of the three-month t-bill rate. Similarly, we estimate the depreciation rate, δ, as the average depreciation of the gross capital stock. Finally, we set the corporate tax rate equal to its statutory rate of 35%.

We then estimate the following 11 parameters using simulated method of moments: the equity issuance cost parameter, a_1; the drift, standard deviation, and autocorrelation of the profitability process, μ, σ_z and ρ_z; the quadratic adjustment cost parameter, λ; the standard deviation and autocorrelation of the misvaluation process, σ_ψ and ρ_ψ, the parameters governing the equity repurchase constraint, b_0 and b_1, and the quadratic equity transactions cost, ν. Finally, we estimate the tax rate on dividends, τ.

Simulated method of moments, although computationally cumbersome, is conceptually simple. First, we generate a panel of simulated data using the numerical solution to the model. Specifically, we take a random draw from the distribution of $\left(\varepsilon_z', \varepsilon_\psi'\right)$, conditional on $\left(\varepsilon_z, \varepsilon_\psi'\right)$, and then compute $v\left(c, \psi, z\right)$, $\left(c', e, i\right) = h\left(c, \psi, z\right)$, and various functions of $v\left(c, \psi, z\right)$, c', e, and i, such as dividends and Tobin's q. We continue drawing values of $\left(\varepsilon_z', \varepsilon_\psi'\right)$ and use these computations to generate an artificial panel of firms. Next, we calculate interesting moments using both these simulated data and actual data. The objective of SMM is then to pick the model parameters that make the actual and simulated moments as close to each other as possible. Details regarding the estimation can be found in DeAngelo, DeAngelo, and Whited (2011).

The next issue in SMM is whether to match moments using an identity or optimal weight matrix. Using an identity matrix implicitly puts the most weight on the moment that is the largest in absolute value. Because the size of a moment rarely corresponds to a relevant economic or statistical objective, we match moments using the optimal weight matrix, which is the inverse of the covariance matrix of the moments. Roughly speaking, this scheme puts the most weight on the most precisely estimated moments, which is a sensible statistical objective. See DeAngelo, DeAngelo, and Whited (2011) for details concerning the estimation of the weight matrix.

One final issue is unobserved heterogeneity in our data from Compustat. These firms differ along a variety of dimensions, such as technology and access to external finance. In contrast, our simulations produce *i.i.d.* firms, with the only source of heterogeneity being the individual draws of $(\varepsilon_z, \varepsilon_\psi)$. Therefore, in order to render our simulated data comparable to our actual data, we can either add heterogeneity to the simulations, or remove the heterogeneity from the actual data. We opt for the latter approach, using fixed firm and year effects in the estimation of our regression-based data moments and the estimation of variances.

This issue of heterogeneity implies that SMM estimates the parameters of an average firm—not the average of the parameters across firms. These two quantities are not the same because the model is nonlinear. Because it is often difficult to conceptualize an average firm in a large population of firms over a long time span, we examine subsamples of firms that are homogeneous along two dimensions. In particular, Figures 1 and 2 and Table 1 indicate that small firms are different in important ways from large firms, and 1980s and 1990s are different from the 2000s. We therefore analyze four separate groups of firms. We examine separately the time periods before and after the Jobs and Growth Tax Relief Reconciliation Act of 2003, which was enacted at the end of the year. Within these two time periods we then analyze small and large firms.

4.2 Identification

The success of this procedure relies on model identification. Global identification of a simulated moments estimator obtains when the expected value of the difference between the simulated moments and the data moments equal zero if and only if the structural parameters equal their true values. A sufficient condition for identification is a one-to-one mapping between the structural parameters and a subset of the data moments of the same dimension. Because our model does not yield such a closed-form mapping, we take care to choose moments that are sensitive to variations in the structural parameters such as the adjustment cost parameter, λ. On the other hand, we do not "cherry-pick" moments. Instead, we examine the mean, variance, and serial correlation of the all of the variables we can compute from our model: investment, profits, equity issuances, equity repurchases, cash, dividends, and Tobin's q.

We now describe and rationalize the 19 moments that we match. Of particular interest is the identification of the variance and serial correlation of the misvaluation shock, ρ_ψ and σ_ψ. Because of the feedback in the model from misvaluation to firm investment and financing decisions, this task is difficult. However, it is plausible to imagine that the misvaluation shocks affect moments involving market values more directly than they affect moments involving real quantities, such as investment, or especially profits, which are also driven by demand shocks. Therefore, our identifying assumption is that by including both market-value moments and real moments, we will be able to infer the moments of the misvaluation process.

We use three moments related to market values: the mean, variance, and serial correlation of Tobin's q. The variance and serial correlation of Tobin's q are useful for identifying the variance and the serial correlation of the misvaluation process, σ_ψ and ρ_ψ. Because changes in almost all of the model parameters induce significant changes in firm value, the mean of Tobin's q ends up being a "catch-all" identifying moment. The fourth moment we use to identify misvaluation shocks is the slope coefficient from regressing equity issuances on Tobin's q.

Our next three moments are the mean, variance and serial correlation of operating profits, which are defined in the model as z. These three moments are useful for identifying the drift, variance, and serial correlation of the profitability shock, ε_z.

Our next moments are the mean, serial correlation, and variance of the rate of investment, i. The variance is useful for identifying the adjustment cost parameter, λ, because higher λ produces less volatile investment. The serial correlation is primarily affected by the smooth adjustment cost parameter but also by the serial correlation of the profitability process, ρ_z. Although the mean of investment in this class of models is primarily determined by the depreciation rate of capital, it is also affected to the variance of the profitability shocks and the adjustment cost parameter. When investment is more variable, because it is also naturally skewed, its mean rises.

The rest of the moments pertain to the firm's financing decisions. We include the mean, serial correlation, and variance of the ratio of cash to capital c. We also include the mean and variance of the ratio of equity issuance to capital, e, as well as the mean and variance of the ratio of repurchases to capital and the ratio of dividends to capital. These seven moments are useful for identifying the equity issuance cost parameter, a_1, the parameters defining the repurchase constraint, b_0 and b_1, and the parameter restricting equity transactions, ν.

5 Results

In the first part of this section, we present estimations from two versions of the model: one as presented in Section 2 and one in which the variance and serial correlation of the misvaluation shocks are set to be near zero. In the second part of this section, we perform comparative statics exercises and examine impulse response functions.

5.1 Estimation Results

Table 2 shows that a version of the model without misvaluation shocks fits the data poorly. In part this poor performance is to be expected inasmuch as we are confronting the model with many moments. In comparison to previous studies in corporate finance that use SMM, our model is overidentified by many more degrees of freedom. Because all models by definition eventually fail when confronted with data, the intent behind using a large number of moments is to find out on which important dimensions the model fails and on which it succeeds, and why.

The top panel shows the actual and simulated moments for each of our four subsamples, with t-statistics in parentheses under the simulated moments. In each sample most of the simulated moments are statistically different from their real-data counterparts. Two important exceptions to this general pattern are the variance and serial correlation of profits, which are well-matched. Nonetheless, although the differences in the two sets of moments are almost all statistically significant, only some of these differences are economically significant. Two important moments that are reasonably well matched in most samples are average dividends and repurchases. On the other hand, five other important moments tend to be poorly matched. First, for three of the four samples, simulated Tobin's q is less than actual Tobin's q. Second, more striking than these differences in means are the differences in the variances of Tobin's q, especially in the earlier period, in which the simulated variance is from seven to nine times as small as the actual variance. Third, for all samples simulated average cash is much smaller than actual average cash. In this simplified version of the model, costly external finance is the only reason firms hold cash, and these results suggest that this motive is not sufficient for the model to be able to fit this feature of the data. Fourth, simulated average investment is too low in the early period (when actual investment is high) and too high in the later period (when actual investment is low). Finally, the biggest failure of the model is its inability to match average equity issuance. Model-simulated average issuances are up to seven times smaller than actual average issuances. This large difference also manifests in the near zero simulated variances of equity issuance, and a sensitivity of equity issuances to Tobin's q that is often negative. This sensitivity is uniformly positive in the data. Anticipating, many but not all of these model failures are improved with the addition of misvaluation shocks to the model.

The bottom panel of Table 2 presents the parameter estimates we obtain from each of our four samples. Most are statistically significant. The exceptions are two of the estimates of the parameter, ν, that restricts equity transactions, three of the estimates of average equity issuance costs, one estimate of τ, the tax on dividends relative to the tax on repurchases, and five of the estimates of the parameters, b_0 and b_1, which define the repurchase constraint .

The economic magnitudes of many of these parameters are also of interest because they can be compared to easily available stylized facts.. First, two of the estimates of equity issuance costs are near 0.2, which are high relative to the estimates of underwriter fees in, for example, Altinkilic and Hansen (2000). Second, three out of the four estimates of τ (the tax rate on dividends relative to repurchases) all fall in a reasonable range between 0.12 and 0.17. Finally, the estimates of b_0 and b_1 imply that average repurchases should be less than average dividends, which is not true in any of our samples of firms.

Table 3 shows that adding misvaluation shocks to the model improves its performance along many but not all dimensions. In the top panel we see many fewer instances in which the model and data moments are statistically different from one another. The economic significance of these differences also decreases in many cases. First, the model now can match average cash balances, even the extremely high cash balances of the small firms in the latter part of the sample. Second, although the model fails to match average investment in the early part of the sample, it does match average investment in the latter part. Third, the model does a much better job of matching average equity issuance. The simulated moments are now only smaller than the actual moments by a factor of two to three, instead of by a factor of seven. Further, all of the simulated estimates of the sensitivity of equity issuance to q are now positive. The results on cash and equity issuance make sense in light of the policy functions from Figure 3, which show that equity issuance can respond strongly to misvaluation shocks, with most of the proceeds going into cash balances.

Although adding misvaluation shocks to the model improves its fit in some dimensions, it fails in others. In particular, the simulated variance of Tobin's q is still much smaller than the actual variance, although in three out of the four cases the gap narrows. This result implies that the well-documented inability of neoclassical investment models to match equity volatilities (Gomes, Yaron, and Zhang, 2006; Liu, Whited, and Zhang, 2009) can only be attributed to mispricing to a very small extent. Also, along with the model's improved ability to match average equity issuance comes a slightly decreased ability to match average repurchases. Finally, average simulated repurchases are still smaller than average simulated dividends.

The second panel of Table 3 contains the parameter estimates. Most importantly, for all four samples, the standard deviation and serial correlation of the misvaluation shocks are highly statistically significant. The estimates of the standard deviation range from 0.028 to 0.078, and the estimates of the serial correlation range from 0.42 to 0.67. Interestingly, the estimates of the standard deviation are higher in the early period, which contains the dot-com bubble and the 1987 market crash. Although statistically significant, these estimates are much smaller than the standard deviation of the profitability shocks, which hover around 0.35 and 0.73, respectively. Thus, our estimates imply that misvaluation shocks are much less important than profitability shocks in the firm's decision making process. The rest of the parameter estimates are largely the same as those in Table 2. However, the interpretation of the equity issuance cost parameter differs in a model with misvaluation shocks. Because issuances need not be priced at intrinsic value, this parameter captures not only underwriting fees but also "money left on the table." Thus, the estimates are not necessarily too high.

5.2 Counterfactual Experiments

Although the economic significance of many of our model parameters is not immediately obvious, it is possible to gauge their economic significance by conducting counterfactual exercises. First, we ask how much intrinsic equity value would be lost if the standard deviation and serial correlation of the misvaluation shocks were near zero. We find only modest losses, which range from 0.2% of equity value for the large firms in the later period to 1.1% of equity value in the case of the small firms in the early period. Thus, although managerial exploitation of equity misvaluation can create value for long-term shareholders, the magnitudes are small. We do find a large effect on equity issuance, which falls by as much as a factor of ten. The effect on repurchases is much more modest, as they fall only by 0.4%.

Second, we use comparative statics exercises to examine the extent to which investment, saving, and equity issuance and repurchases are sensitive to movements in Tobin's q, and the extent to which these sensitivities depend on the variance of misvaluation shocks. These comparative statics are of interest because these types of exercises have been popular in the behavioral literature as a tool to determine whether misvaluation affects firm policies (e.g. Baker and Wurgler, 2002, 2004).

Our comparative statics results are in Figure 4. To construct this figure, we solve the model 20 times, each time corresponding to a different value of the standard deviation of the misvaluation shock, ψ. Each time we solve the model, we simulate 500,000 firm/year observations, and then run four simple regressions of equity issuance, equity repurchases, investment, and saving on Tobin's q. We parameterize the model as in Figure 3.

The results are mixed. In support of the general idea that equity issuance is affected by mispricing, we find that the sensitivity of equity issuances to Tobin's q increases as the variance of ψ increases. However, the relation between repurchases and q becomes smaller in absolute value as the variance of ψ rises. We conjecture that this behavior arises because of the constraint on equity repurchases. Interestingly, the sensitivity of saving to q increases sharply with the variance of ψ. This result makes sense given that misvaluation affects q and given that the model implies that saving optimal responds to movements in ψ. Finally, the response of investment to q is unaffected by misvaluation shocks, a result that counters the intuitive prediction in Baker, Stein, and Wurgler (2003) that this sensitivity ought to rise with the importance of misvaluation. Again, this result makes sense given the optimal policy functions in Figure 3.

Third, we examine the impact of misvaluation shocks by calculating impulse response functions. Once again, we parameterize the model using the estimates from the small firms in the early period. Figure 5 plots the reaction of investment, saving, cash, and equity issuances/repurchases to a three standard deviation misvaluation shock. For the first 300 periods the firm is allowed to evolve according to the transition functions for the misvaluation shock and the profitability shock. At time 300 the misvaluation shock is set to 1, and then the shock remains at 1 for 100 more periods. Then at what is labeled Event Time 0, the firm receives a three standard deviation misvaluation shock. After Event Time 0, the misvaluation shock is returned to a value of 1. During this experiment, the profitability shock is allowed to vary according to its probability transition function. The top panel depicts a positive shock, and the bottom panel depicts a negative shock.

We find a dramatic response to the positive shock. Both equity issuance and saving (the change in cash) spike upwards at the time of the shock. The spike in saving results in a spike in cash balances in the following period, so that almost all of the proceeds of the equity issuance end up as cash balances. This shock appears to have a long lasting effect. In the period immediately following the shock, a small portion of the issuance is repurchased as the equity again becomes fairly priced, and accumulated cash is used to repurchase these shares. However, after this transaction cash balances remain much higher than they were before the shock. In contrast, although investment increases slightly at the time of the misvaluation shock, it change is of the same (or smaller) order of magnitude as the changes that occur in response to profitability shocks. Thus, it appears that the small value increase from exploitation of misvaluation shocks appears in large part to come from the financial flexibility attained via higher cash balances and only in small part from investment. The value of financial flexibility has also been documented in Gamba and Triantis (2008).

In sharp contrast, we find almost no response to the negative shock. Repurchases increase very slightly, cash moves not at all, and investment moves slightly upward, although this last result is the product of an incident concurrent positive profitability shock.[2] This result is due to the model's constraint on repurchases.

These two exercises also consist of an interesting "out-of-sample" test of the validity of the model, in the sense that no time series patterns in the data are used to fit the model. Recall from Figures 1 and 2 that average capital gains are highly correlated in the time series with both saving and equity issuance. This evidence is consistent with the patterns observed with the positive shock. Recall also that repurchases are much less highly correlated with capital gains. This evidence is consistent with patterns observed with the negative shock.

6 Model Robustness

Although we model misvaluation shocks, our estimation need not be picking up actual misvaluation if there exist other shocks in the economy that mimic the effects of our modeled misvaluation shocks. For example, in our model misvaluation induces variation in the cost of capital. Two other types of shocks that might have similar effects are time-varying risk premia and a stochastic cost of external finance, as modeled in Covas and Haan (2011), Jermann and Quadrini (2012), and Eisfeldt and

[2] We have also conducted these impulse response functions so that they are concurrent with positive, neutral, and negative profitability shocks, and the qualitative results are the same.

Muir (2011).

To investigate these alternatives, we compare the fit of our model with the fit of two alternative models. In the first, we remove the misvaluation shocks and replace them with a stochastic cost of external finance so that the parameter, a_1, becomes a stochastic process given by

$$a' = \mu_a + \rho_a a + \varepsilon'_a.$$

In the second, we also remove the misvalution shocks, but we keep the constant cost of external finance, a_1, and we modify the profit function so that it is affected by two uncorrelated shocks: $z\chi K$. The second shock, χ, which can be interpreted as an aggregate shock, also follows an $AR(1)$ in logs:

$$\ln(\chi') = \rho_\chi \ln \chi + \varepsilon'_\chi$$

We then model a reduced-form stochastic discount factor, m, as in Zhang (2005) or Gomes and Schmid (2010):

$$\ln(m') = \ln\left(\frac{1}{1+r}\right) - \gamma \ln(\chi'/\chi), \tag{13}$$

in which the parameter $\gamma > 0$. The idea behind this specification is that risk premia are directly related to aggregate cash flow growth. This type of specification has had a great deal of success in furthering the understanding of the cross section of returns, so it is interesting to understand whether it can also aid in the understanding of firm policies.

In this case the Bellman equation can be expressed as

$$v(c,\chi,z) = \max_{c',e,i}\left\{d(1-\tau) - e + \int\int m' v\left(c',\psi',z'\right)(1-\delta+i)dg^\chi\left(\varepsilon'_\chi,\varepsilon_\chi\right)dg^z\left(\varepsilon'_z,\varepsilon_z\right)\right\}, \tag{14}$$

in which $g(\cdot)$ is the transition function for χ.

Our next step is to run a horserace between our model and these two alternative models. We therefore estimate all three using the same set of moments. The results are in Table 4, which presents the actual moments from the small/late sample and the simulated moments from the three different models. Three results stand out. First, in terms the model fit, the misvaluation model does the best job in terms of matching the most features of the data. For the misvaluation model, 5 of the 19 moments are significantly different from one another. For the model with a stochastic cost of equity, this number jumps to 8, and for the stochastic discount factor model, this number jumps to 10. Second, while the stochastic equity cost model can match average cash, and while it does as good a job as the misvaluation model of matching moments related to equity issuance. It does a poor job matching moments related to repurchases. This result makes sense inasmuch as the stochastic equity cost does not affect the price at which the firm can repurchase shares. Third, the model with a stochastic discount factor has a difficult time matching variances, and it cannot match average cash. The one interesting feature of this last model is that it does the best job of matching the variance of Tobin's q.

To investigate this issue further, we consider a simple out-of-sample experiment. Recall that in the data on small firms, the percent change in firm value is highly positively correlated with the change in cash, the change in cash is highly positively correlated with equity issuance, and repurchases are negatively correlated with the percent change in firm value. We therefore compute these three correlations for each of our models to examine whether these models can match moments not used to estimate them. We find that the misvaluation model does a good job for all three correlations. The correlations are all within 0.1 of the figures reported in Table 1. In contrast, while the stochastic equity cost model can match the correlation between equity issuances and saving almost exactly, it produces no correlation between repurchases and the percent change in firm value, and it produces only a small positive correlation between saving and the percent change in firm value. Finally, the stochastic discount factor model does a good job of matching the correlations between the change in firm value and both repurchases and saving, but it only produces a small positive correlation between saving and equity issuance. Thus, this validation exercise provides the most support for the misvaluation model.

7 Conclusion

This paper quantifies the extent to which nonfundamental movements in the price of a firm's stock affect its various policies. Although this topic has been addressed by a large number of studies, we approach the problem in a new way—structural estimation. We estimate a version of a constant returns neoclassical investment model in which equity financing is costly, the firm can accumulate cash, and, most importantly, equity values can be subject to misvaluation shocks. In the model, firms naturally issue equity when it is overvalued and repurchase equity when it is undervalued. Depending on the model parameters, the funds flowing to and from these activities can come from either changes in cash balances or changes in investment.

Our estimation results are nuanced. First, a version of the model in which we allow mispricing fits the data better than a model in which we restrict mispricing to be almost negligible. In particular, we do a much better job of matching moments related to cash balances and equity issuance. Allowing mispricing does not help much in matching moments related to investment. Our counterfactual exercises show that firms do issue equity in response to misvaluation shocks, but the proceeds from these issuances are not used to fund investment. Instead, they augment cash balances. Finally, managers' rational responses to possible misvaluation increase intrinsic shareholder value from 0.2% to 1.1%.

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Appendix

This appendix contains the proof of Proposition 1.

Proof. Let $\tilde{V}$ be a solution to equation (10), with corresponding policy functions $\tilde{D}$ and $\tilde{E}$. Then one obtains from (10):

$$\tilde{V}(K,C,\psi,z) = \tilde{D}(1-\tau) + \beta \frac{\psi(V-\tilde{D}(1-\tau))}{\psi(V-\tilde{D}(1-\tau)) + \tilde{E} + \frac{\nu\tilde{E}^2}{2K}} \int\int V\left(K',C',\psi',z'\right) dg^{\psi}\left(\varepsilon'_{\psi},\varepsilon_{\psi}\right) dg^{z}\left(\varepsilon'_{z},\varepsilon_{z}\right).$$

Rearranging the dividend term and dividing the numerator and denominator of the left hand side by ψ gives

$$\tilde{V}(K,C,\psi,z) - \tilde{D}(1-\tau) = \beta \frac{(V-\tilde{D}(1-\tau))}{(V-\tilde{D}(1-\tau)) + \frac{\tilde{E}}{\psi} + \frac{\nu\tilde{E}^2}{2\psi K}} \int\int V\left(K',C',\psi',z'\right) dg^{\psi}\left(\varepsilon'_{\psi},\varepsilon_{\psi}\right) dg^{z}\left(\varepsilon'_{z},\varepsilon_{z}\right).$$

Next, divide the above equation throughout by $\tilde{V}(K,C,\psi,z) - \tilde{D}(1-\tau)$ and multiply by $\tilde{V}(K,C,\psi,z) - \tilde{D}(1-\tau) + \tilde{E}/\psi + \nu\tilde{E}^2/2\psi K$ to obtain

$$\tilde{V}(K,C,\psi,z) - \tilde{D}(1-\tau) + \frac{\tilde{E}}{\psi} + \frac{\nu\tilde{E}^2}{2K} = \beta \int\int V\left(K',C',\psi',z'\right) dg^{\psi}\left(\varepsilon'_{\psi},\varepsilon_{\psi}\right) dg^{z}\left(\varepsilon'_{z},\varepsilon_{z}\right),$$

Thus $\tilde{V}$, $\tilde{D}$, and $\tilde{E}$ also solve equation (11).

Conversely, let $\hat{V}$ be a solution to equation (11), with corresponding policy functions $\hat{D}$ and $\hat{E}$. One can use a similar approach to the above to show that $\hat{V}$, $\hat{D}$, and $\hat{E}$ also solve (10). ■

Table 1: Simple Time-Series Correlations

Calculations are based on a sample of nonfinancial, unregulated firms from the annual 2011 COMPUSTAT industrial files. The sample period is from 1987 to 2010. "Investment" is the ratio of capital expenditures to the gross capital stock. "Cash," "Dividends," and "Equity Issuance," "Saving," and "Repurchases" are all scaled by total book assets. Saving is the change in the stock of cash. "Capital Gain" is the change in the market value of equity dividend by the market value of equity. Each variable is aggregated by taking the average across all firms in the sample in each year. The indicated correlations are then time-series correlations of these aggregated variables.

	Cash	Investment	Capital Gain	Saving	Repurchases	Dividends	Equity Issuance
Small Firms							
Cash	1.000						
Investment	-0.663	1.000					
Capital Gain	0.300	-0.402	1.000				
Saving	0.444	-0.217	0.725	1.000			
Repurchases	0.329	0.239	-0.340	-0.177	1.000		
Dividends	-0.800	0.202	-0.102	-0.532	-0.371	1.000	
Equity Issuance	0.133	0.435	0.096	0.555	0.347	-0.478	1.000
Large Firms							
Cash	1.000						
Investment	-0.705	1.000					
Capital Gain	0.187	-0.383	1.000				
Saving	-0.049	0.014	0.709	1.000			
Repurchases	0.080	0.390	-0.603	-0.556	1.000		
Dividends	-0.563	0.183	-0.153	-0.117	-0.077	1.000	
Equity Issuance	0.609	-0.141	0.273	0.452	0.040	-0.694	1.000

Table 2: Simulated Moments Estimation: Model with Restricted Misvaluation

Calculations are based on a sample of nonfinancial, unregulated firms from the annual 2011 COMPUSTAT industrial files. The sample period is from 1987 to 2010. The sample is split into four groups: small firms in the first part of the sample (through 2003), small firms in the second part of the sample, and large firms in each time period. The estimation is done with SMM, which chooses structural model parameters by matching the moments from a simulated panel of firms to the corresponding moments from the data. The first panel reports the simulated and actual moments and the t-statistics for the differences between the corresponding moments. The second panel reports the estimated structural parameters, with standard errors in parentheses. a_1 is the linear equity issuance cost, λ is the cost of adjusting the capital stock, b_0 and b_1 are parameters that constrain firms from repurchasing stock, μ is the drift of the profitability process, ρ_z is its serial correlation, and σ_z governs its variance. ν is a quadratic cost of both equity issuance and repurchases, and τ is the tax rate on dividends, relative to the tax rate on capital gains. Standard errors are in parentheses under the parameter estimates.

A. Moments

	Early/Small		Early/Large		Late/Small		Late/Large	
	Actual	Simulated	Actual	Simulated	Actual	Simulated	Actual	Simulated
Average cash	0.1481	0.0795	0.1008	0.0841	0.2349	0.1550	0.1471	0.1108
		(-4.7798)		(-2.9446)		(-7.9872)		(-8.2406)
Variance of cash	0.0063	0.0056	0.0036	0.0017	0.0054	0.0175	0.0036	0.0137
		(-0.4087)		(-1.8464)		(4.8238)		(5.2058)
Serial correlation cash	0.8742	0.8753	0.8764	0.5610	0.8853	0.2695	0.8507	0.3213
		(0.0500)		(-3.9881)		(-5.1072)		(-10.0175)
Average investment	0.1421	0.1057	0.1547	0.1031	0.1126	0.1625	0.1275	0.1496
		(-3.1250)		(-5.9016)		(4.9796)		(2.7517)
Variance of investment	0.0092	0.0016	0.0083	0.0019	0.0057	0.0025	0.0048	0.0044
		(-2.4923)		(-2.2994)		(-1.2301)		(-0.2054)
Serial correlation investment	0.4581	0.7240	0.5810	0.7076	0.4777	0.6582	0.5834	0.7168
		(3.4956)		(0.5142)		(0.9101)		(0.7495)
Average profits	0.1231	0.1095	0.1632	0.0777	0.0711	0.0708	0.1464	0.0907
		(-2.4404)		(-2.6750)		(-0.0209)		(-4.5938)
Serial correlation profits	0.7454	0.7092	0.7222	0.7048	0.7852	0.7204	0.7392	0.7283
		(-0.3666)		(-0.5437)		(-0.5669)		(-0.0801)
Residual variance of profits	0.0081	0.0131	0.0044	0.0077	0.0083	0.0049	0.0044	0.0063
		(0.8044)		(2.2992)		(-0.4110)		(0.3416)
Average Tobin's q	1.6505	1.5455	1.7857	1.4485	1.8823	1.9455	1.7513	1.5646
		(-2.6072)		(-6.0926)		(1.4014)		(-2.7900)
Variance of Tobin's q	0.4135	0.0434	0.3416	0.0569	0.3670	0.1153	0.2038	0.1245
		(-1.9319)		(-2.7375)		(-2.7817)		(-1.0130)
Serial correlation Tobin's q	0.7099	0.7699	0.7715	0.7126	0.7330	0.6014	0.7717	0.6812
		(0.3929)		(-0.4856)		(-0.9329)		(-2.4508)
Average equity issuance	0.0324	0.0098	0.0227	0.0031	0.0427	0.0060	0.0206	0.0034
		(-3.5661)		(-11.2134)		(-7.3837)		(-3.3362)
Variance of equity issuance	0.0046	0.0000	0.0027	0.0000	0.0048	0.0000	0.0017	0.0000
		(-2.3021)		(-6.5202)		(-2.1421)		(-2.4548)
Average repurchases	0.0107	0.0129	0.0176	0.0212	0.0116	0.0055	0.0259	0.0157
		(2.1373)		(6.0131)		(-2.7553)		(-4.4278)
Variance of repurchases	0.0005	0.0010	0.0007	0.0013	0.0005	0.0000	0.0009	0.0001
		(8.5778)		(3.7195)		(-10.2605)		(-3.6675)
Average dividends	0.0077	0.0097	0.0138	0.0115	0.0073	0.0057	0.0107	0.0053
		(2.3694)		(-0.7843)		(-2.2994)		(-4.2368)
Variance of dividends	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003
		(8.3218)		(0.6409)		(0.2008)		(7.4277)
Coefficient from regressing equity issuance on Tobin's q	0.0245	-0.0005	0.0182	-0.0001	0.0216	-0.0003	0.0153	0.0011
		(-1.2519)		(-3.9089)		(-0.8746)		(-0.7983)

B. Parameter estimates

	a_1	λ	b_0	b_1	μ	ρ_z	σ_z	ν	τ
Early Small									
	0.0133	5.8356	0.0015	0.4210	-0.4493	0.7344	0.4307	1.0900	0.1642
	(0.0661)	(0.0164)	(0.0647)	(5.8778)	(0.0002)	(0.0001)	(0.0001)	(0.1437)	(0.0044)
Early Large									
	0.2085	4.8655	0.0002	0.4710	-0.4399	0.7332	0.3469	1.4142	0.1480
	(0.1271)	(0.1542)	(0.0131)	(0.8965)	(0.0001)	(0.0003)	(0.0001)	(0.2536)	(0.0274)
Late Large									
	0.0643	3.0181	0.0128	0.4994	-0.4412	0.7457	0.3443	1.5348	0.1208
	(0.0497)	(0.0154)	(0.0010)	(0.0253)	(0.0001)	(0.0002)	(0.0001)	(1.1512)	(0.3112)
Late Small									
	0.1983	3.7005	0.0467	0.4195	-0.4430	0.7337	0.3046	1.1899	0.0066
	(0.0421)	(0.0241)	(0.0485)	(0.0896)	(0.0001)	(0.0003)	(0.0001)	(1.4534)	(0.0081)

Table 3: Simulated Moments Estimation: Model with Unrestricted Misvaluation

Calculations are based on a sample of nonfinancial, unregulated firms from the annual 2011 COMPUSTAT industrial files. The sample period is from 1987 to 2010. The sample is split into four groups: small firms in the first part of the sample (through 2003), small firms in the second part of the sample, and large firms in each time period. The estimation is done with SMM, which chooses structural model parameters by matching the moments from a simulated panel of firms to the corresponding moments from the data. The first panel reports the simulated and actual moments and the t-statistics for the differences between the corresponding moments. The second panel reports the estimated structural parameters, with standard errors in parentheses. a_1 is the linear equity issuance cost, λ is the cost of adjusting the capital stock, b_0 and b_1 are parameters that constrain firms from repurchasing stock, μ is the drift of the profitability process, ρ_z is its serial correlation, and σ_z governs its variance. ν is a quadratic cost of both equity issuance and repurchases, and τ is the tax rate on dividends, relative to the tax rate on capital gains. Standard errors are in parentheses under the parameter estimates.

A. Moments

	Early/Small		Early/Large		Late/Small		Late/Large	
	Actual	Simulated	Actual	Simulated	Actual	Simulated	Actual	Simulated
Average cash	0.1481	0.1090	0.1008	0.0896	0.2349	0.2102	0.1471	0.1526
		(-2.1488)		(-2.7590)		(-1.8084)		(1.1941)
Variance of cash	0.0063	0.0018	0.0036	0.0006	0.0054	0.0040	0.0036	0.0032
		(-4.3477)		(-2.2817)		(-1.6528)		(-0.6239)
Serial correlation cash	0.8742	0.8233	0.8764	0.6043	0.8853	0.8335	0.8507	0.6109
		(-1.2683)		(-2.3401)		(-1.0926)		(-6.0832)
Average investment	0.1421	0.1177	0.1547	0.1121	0.1126	0.1224	0.1275	0.1133
		(-2.3667)		(-3.4433)		(0.8840)		(-1.1856)
Variance of investment	0.0092	0.0021	0.0083	0.0018	0.0057	0.0020	0.0048	0.0026
		(-1.6361)		(-2.3148)		(-0.9883)		(-0.8574)
Serial correlation investment	0.4581	0.6782	0.5810	0.6862	0.4777	0.6665	0.5834	0.7030
		(1.2961)		(0.7208)		(1.0769)		(0.5105)
Average profits	0.1231	0.1178	0.1632	0.1478	0.0711	0.0762	0.1464	0.1213
		(-1.7543)		(-1.4888)		(0.3066)		(-2.3256)
Serial correlation profits	0.7454	0.7169	0.7222	0.7215	0.7852	0.7167	0.7392	0.7039
		(-0.1748)		(-0.0045)		(-0.4131)		(-0.1701)
Residual variance of profits	0.0081	0.0073	0.0044	0.0058	0.0083	0.0066	0.0044	0.0098
		(-0.0782)		(0.1944)		(-0.1411)		(0.6350)
Average Tobin's q	1.6505	1.6820	1.7857	1.5207	1.8823	1.7245	1.7513	1.5430
		(0.4437)		(-5.6235)		(-2.8907)		(-2.8110)
Variance of Tobin's q	0.4135	0.1014	0.3416	0.0723	0.3670	0.0911	0.2038	0.1014
		(-1.3194)		(-1.7921)		(-2.3517)		(-0.8955)
Serial correlation Tobin's q	0.7099	0.7286	0.7715	0.7234	0.7330	0.7397	0.7717	0.7330
		(0.0850)		(-0.7665)		(0.0376)		(-0.2332)
Average equity issuance	0.0324	0.0122	0.0227	0.0097	0.0427	0.0164	0.0206	0.0075
		(-2.4770)		(-1.9657)		(-3.1103)		(-2.1858)
Variance of equity issuance	0.0046	0.0002	0.0027	0.0001	0.0048	0.0001	0.0017	0.0001
		(-1.3786)		(-1.4436)		(-2.4562)		(-0.9556)
Average repurchases	0.0107	0.0069	0.0176	0.0074	0.0116	0.0090	0.0259	0.0165
		(-4.6688)		(-9.3379)		(-1.5723)		(-5.7750)
Variance of repurchases	0.0005	0.0006	0.0007	0.0003	0.0005	0.0009	0.0009	0.0016
		(1.3089)		(-4.3460)		(4.9039)		(2.0279)
Average dividends	0.0077	0.0078	0.0138	0.0123	0.0073	0.0078	0.0107	0.0129
		(0.3788)		(-0.8551)		(1.8006)		(1.1253)
Variance of dividends	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
		(6.2938)		(0.4043)		(0.1214)		(1.4678)
Coefficient from regressing equity issuance on Tobin's q	0.0245	0.0044	0.0182	0.0473	0.0216	0.0082	0.0153	0.0008
		(-0.7876)		(-0.9891)		(-0.4761)		(0.6004)

B. Parameter estimates

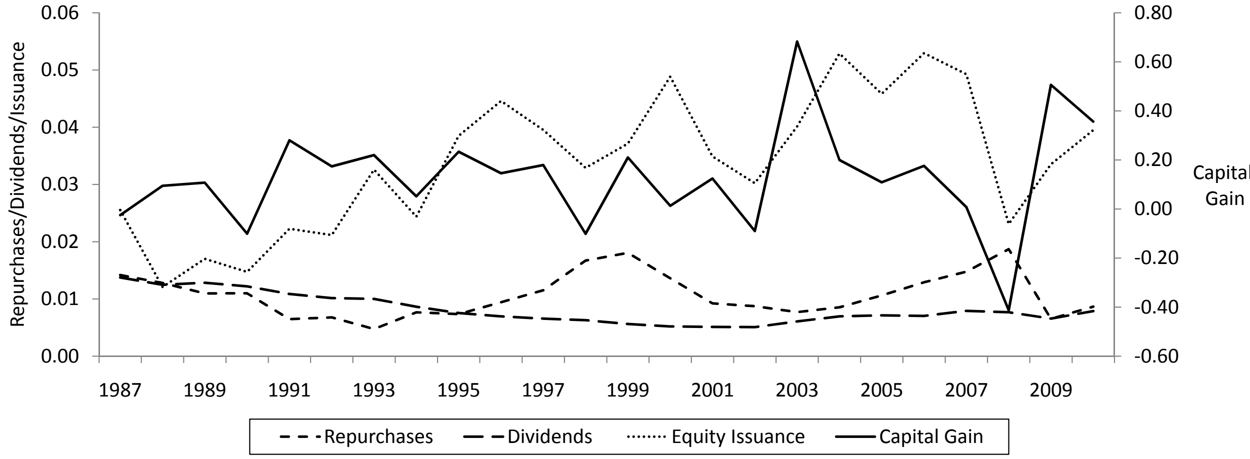
	a_1	λ	ρ_ψ	σ_ψ	b_0	b_1	μ	ρ_z	σ_z	ν	τ
Early Small											
	0.1255	4.7175	0.5125	0.0776	0.0000	0.3108	-0.4417	0.7315	0.3461	1.0027	0.1008
	(0.0410)	(0.0045)	(0.0605)	(0.0074)	(0.0189)	(1.2775)	(0.0001)	(0.0001)	(0.0003)	(0.1720)	(0.0094)
Early Large											
	0.1906	4.3102	0.4972	0.0897	0.0002	0.3170	-0.4417	0.7336	0.3185	1.6392	0.1792
	(0.0416)	(0.0157)	(0.0743)	(0.0001)	(0.0814)	(0.8541)	(0.0001)	(0.0002)	(0.0002)	(0.0863)	(0.0336)
Late Large											
	0.1291	4.7402	0.6677	0.0280	0.0002	0.2015	-0.4439	0.7278	0.3831	1.6025	0.1925
	(0.0667)	(0.0330)	(0.0373)	(0.0004)	(0.0112)	(0.7219)	(0.0002)	(0.0001)	(0.0001)	(0.0150)	(0.0020)
Late Small											
	0.1179	4.3923	0.4237	0.0513	0.0001	0.3062	-0.4409	0.7315	0.3344	1.4011	0.1682
	(0.0242)	(0.0136)	(0.0627)	(0.0045)	(0.0007)	(0.0497)	(0.0005)	(0.0003)	(0.0002)	(0.1406)	(0.0104)

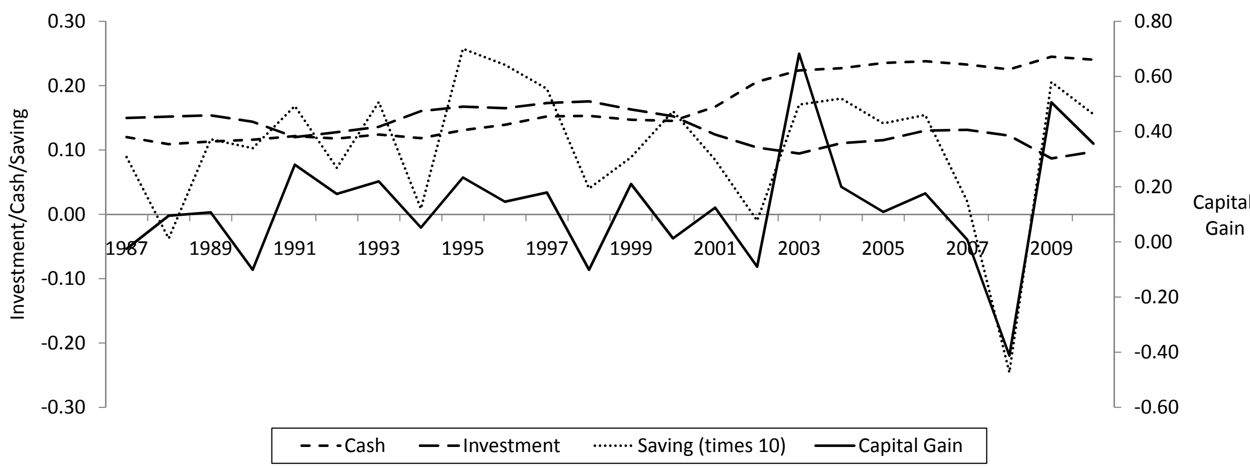
Table 4: Model Comparisons

Calculations are based on a sample of nonfinancial, unregulated firms from the annual 2011 COMPUSTAT industrial files. The sample period is from 2003 to 2010. The sample consists only of small firms. The estimation is done with SMM, which chooses structural model parameters by matching the moments from a simulated panel of firms to the corresponding moments from the data. We report the actual moments and the simulated moments from three models: our misvaluation model, a model with stochastic equity costs, and a model with a stochastic discount factor t-statistics for the differences between the simulated and actual moments are in parenthesesunder the simulated moments.

	Actual	Misvaluation	Stochastic Equity Costs	Stochastic Discount Factor
Average cash	0.2349	0.2102	0.2240	0.1724
		(-1.8084)	(-1.7389)	(-4.1667)
Variance of cash	0.0054	0.0040	0.0038	0.0035
		(-1.6528)	(-1.9703)	(-2.0363)
Serial correlation cash	0.8853	0.8335	0.8266	0.8495
		(-1.0926)	(-1.0794)	(-1.4210)
Average investment	0.1126	0.1224	0.1137	0.1228
		(0.8840)	(0.1436)	(0.8906)
Variance of investment	0.0057	0.0020	0.0029	0.0143
		(-0.9883)	(-1.6961)	(2.7805)
Serial correlation investment	0.4777	0.6665	0.4758	0.6682
		(1.0769)	(-0.7306)	(1.0534)
Average profits	0.0711	0.0762	0.0778	0.0779
		(0.3066)	(0.7650)	(0.7383)
Serial correlation profits	0.7852	0.7167	0.7262	0.5176
		(-0.4131)	(-0.3656)	(-2.0437)
Residual variance of profits	0.0083	0.0066	0.0093	0.0192
		(-0.1411)	(0.3266)	(2.1690)
Average Tobin's q	1.8823	1.7245	1.7358	1.7595
		(-2.8907)	(-2.4429)	(-2.6519)
Variance of Tobin's q	0.3670	0.0911	0.0932	0.2567
		(-2.3517)	(-2.7534)	(-0.8415)
Serial correlation Tobin's q	0.7330	0.7397	0.6846	0.6924
		(0.0376)	(-1.3639)	(-0.4085)
Average equity issuance	0.0427	0.0164	0.0216	0.0093
		(-3.1103)	(-2.2314)	(-3.0579)
Variance of equity issuance	0.0048	0.0001	0.0009	0.0074
		(-2.4562)	(-2.2013)	(2.3905)
Average repurchases	0.0116	0.0090	0.0022	0.0088
		(-1.5723)	(-4.3981)	(-1.1964)
Variance of repurchases	0.0005	0.0009	0.0000	0.0012
		(4.9039)	(-6.8825)	(7.9231)
Average dividends	0.0073	0.0078	0.0077	0.0073
		(1.8006)	(1.5368)	(-0.3604)
Variance of dividends	0.0001	0.0001	0.0003	0.0004
		(0.1214)	(2.0009)	(3.5181)
Coefficient from regressing	0.0216	0.0082	0.0064	0.0167
equity issuance on Tobin's q		(-0.4761)	(-1.3895)	(-0.9565)

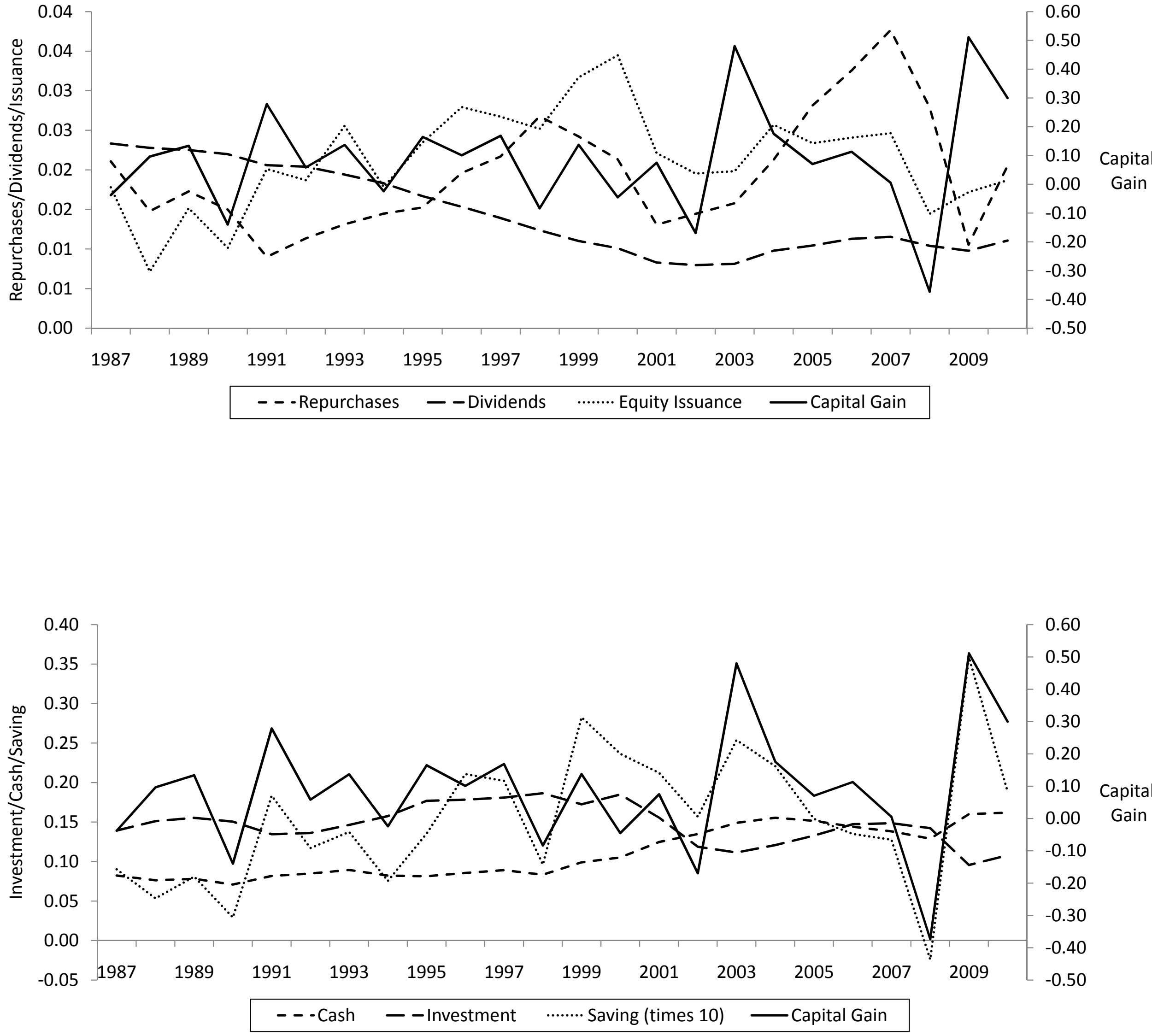
Figure 1: Summary Statistics: Small Firms





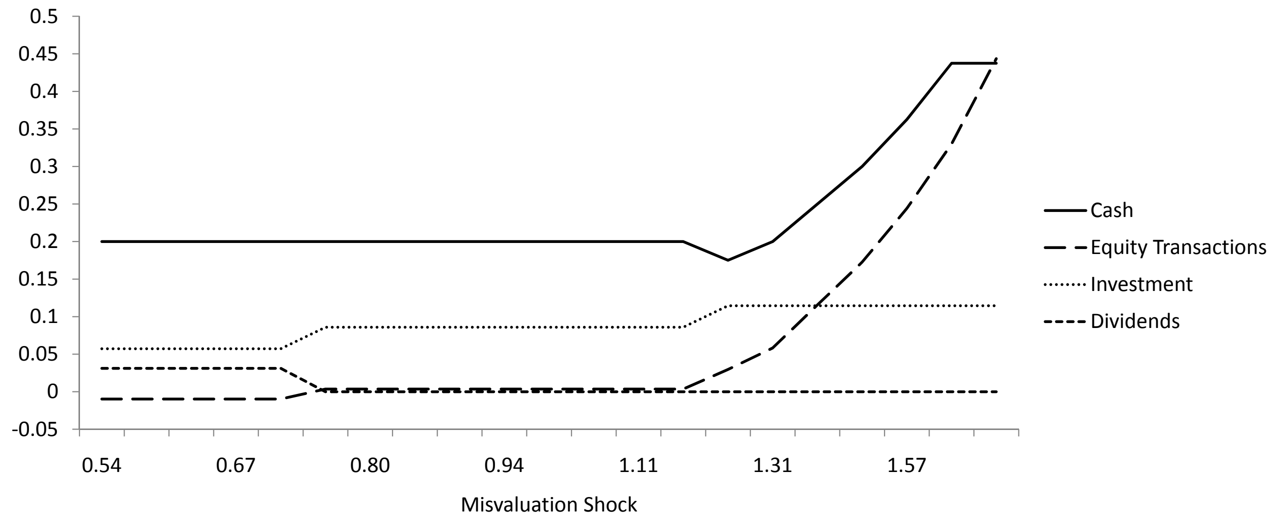
Calculations are based on a sample of nonfinancial, unregulated firms from the annual 2011 COMPUSTAT industrial files. The sample period is from 1987 to 2010. Small firms are those whose assets are below the median for a particular year in the sample. "Investment" is the ratio of capital expenditures to the gross capital stock. "Cash," "Dividends," and "Equity Issuance," "Saving," and "Repurchases" are all scaled by total book assets. Saving is the change in the stock of cash. "Capital Gain" is the change in the market value of equity dividend by the market value of equity. Capital Gain is divided by 10. Each variable is aggregated by taking the average across all firms in the sample in each year. The indicated correlations are then time-series correlations of these aggregated variables.

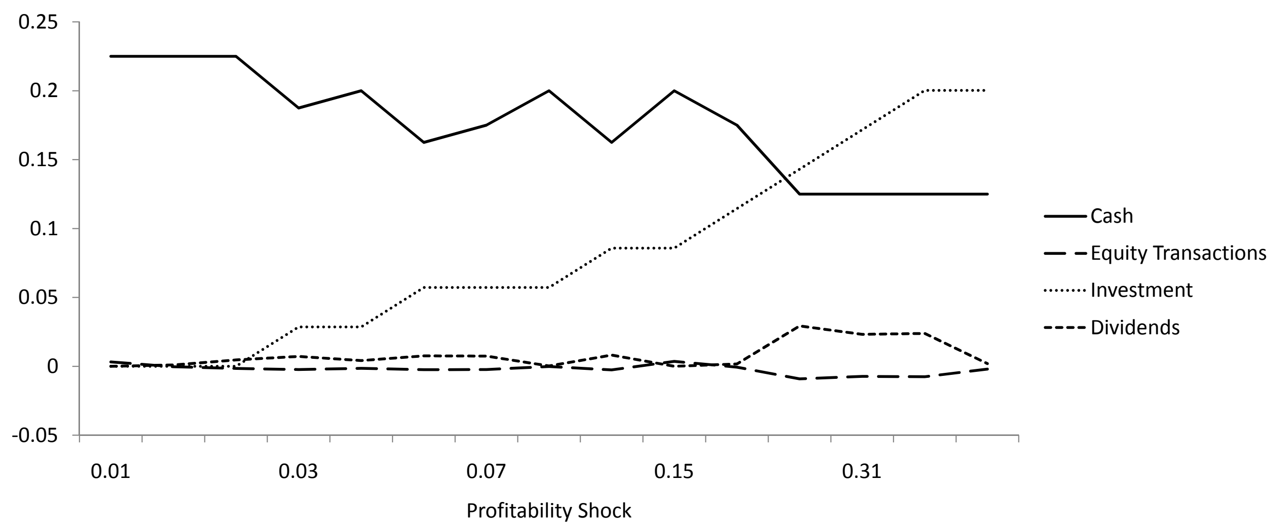
Figure 2: Summary Statistics: Large Firms



Calculations are based on a sample of nonfinancial, unregulated firms from the annual 2011 COMPUSTAT industrial files. The sample period is from 1987 to 2010. Large firms are those whose assets are above the median for a particular year in the sample. "Investment" is the ratio of capital expenditures to the gross capital stock. "Cash," "Dividends," and "Equity Issuance," "Saving," and "Repurchases" are all scaled by total book assets. Saving is the change in the stock of cash. "Capital Gain" is the change in the market value of equity dividend by the market value of equity. Capital Gain is divided by 10. Each variable is aggregated by taking the average across all firms in the sample in each year. The indicated correlations are then time-series correlations of these aggregated variables.

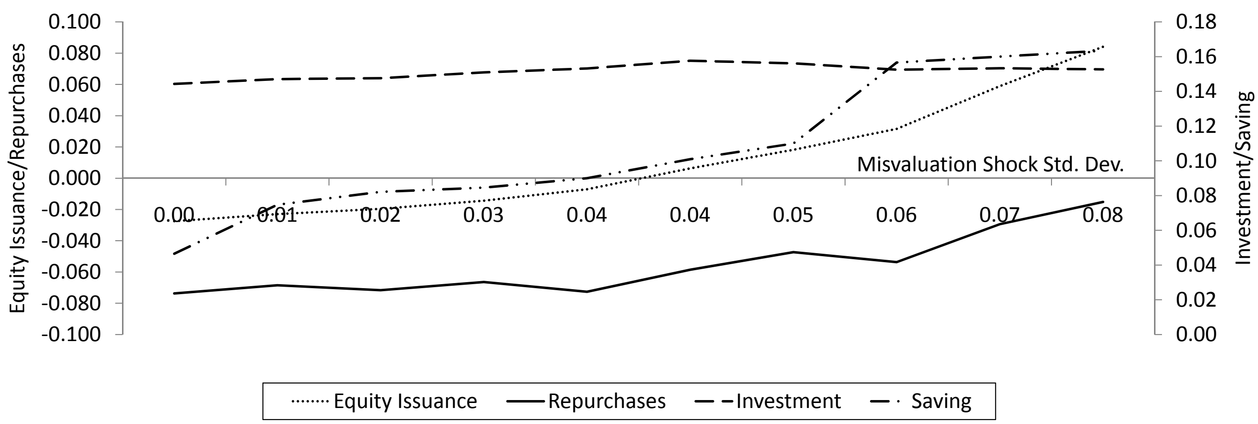
Figure 3: Policy Functions



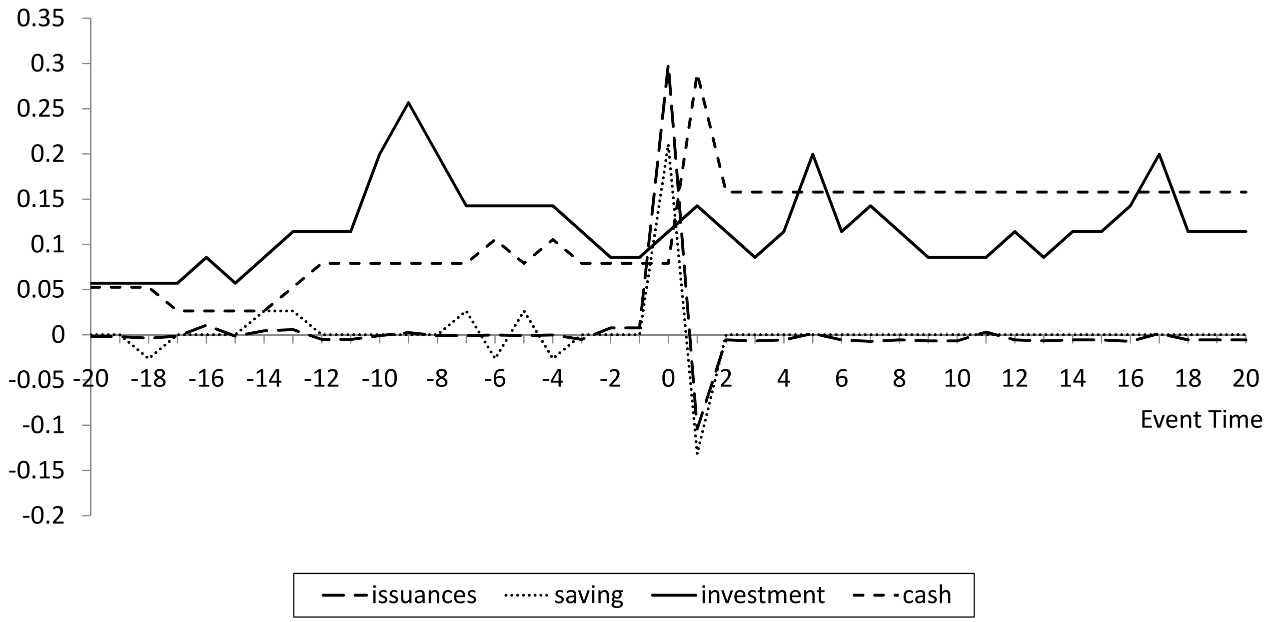


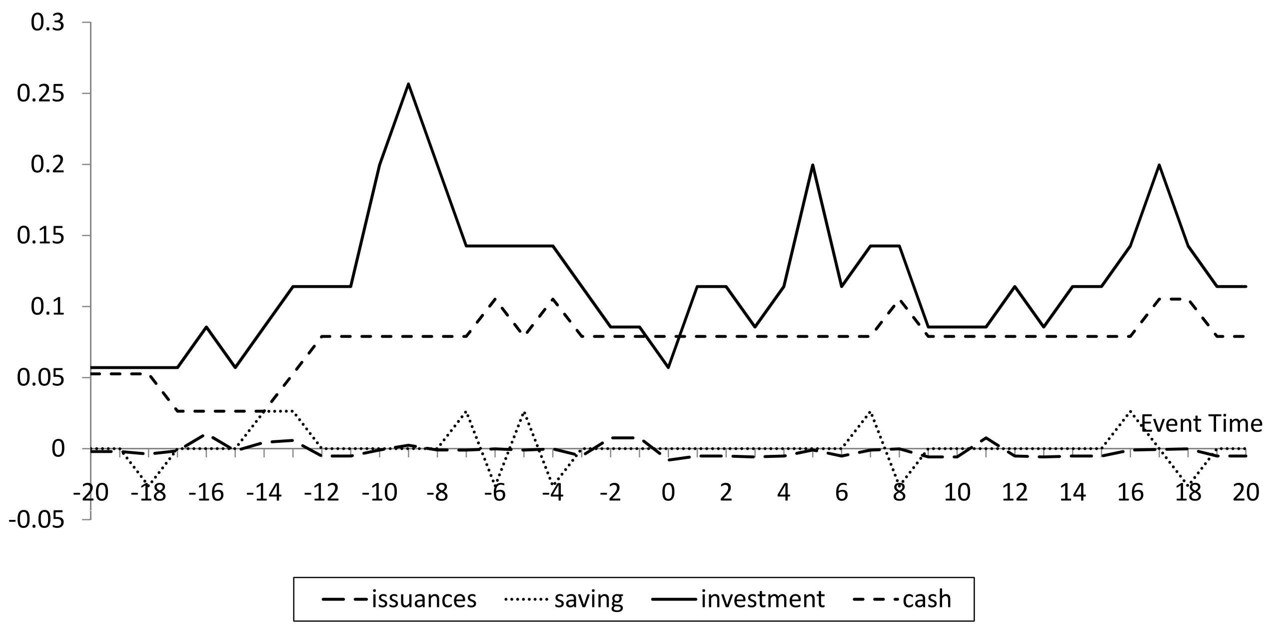
This figure depicts the optimal response of investment, equity transactions, cash, and dividends in response to the misvaluation shock, ψ in the top panel, and to the productivity shock, z, in the bottom panel. Positive equity transactions are issuances, and negative equity transactions are repurchases. All variables are scaled by the capital stock, K.

Figure 4: Comparative Statics



This figure depicts the relation between the standard deviation of the misvaluation shock ψ and and the regression coefficients from simple regressions of equity issuance, equity repurchases, investment, and saving on Tobin's q.





This figure plots the reaction of investment, saving, cash, and equity issuances/repurchases to a three standard deviation misvaluation shock. For the first 300 periods the firm is allowed to evolve according to the transition functions for the misvaluation shock and the profitability shock. At time 300 the misvaluation shock is set to 1, and then the shock remains at 1 for 100 more periods. Then at what is labeled Event Time 0, the firm receives a three standard deviation misvaluation shock. After Event Time 0, the misvaluation shock is returned to a value of 1. During this experiment, the profitability shock is allowed to vary according to its probability transition function. The top panel depicts a positive shock, and the bottom panel depicts a negative shock.