Anomalies

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We take a simple q-theory model and ask how well it can explain external financing anomalies, both qualitatively and quantitatively. Our central insight is that optimal investment is an important driving force of these anomalies. The model simultaneously reproduces procyclical equity issuance waves, the negative relation between investment and average returns, long-term underperformance following equity issues, positive long-term drift following cash distributions, the mean-reverting operating performance of issuing and cash-distributing firms, and the failure of the CAPM in explaining the long-term stock-price drifts. However, the model cannot fully capture the magnitude of the positive drift following cash distributions observed in the data. (*JEL* D21, D92, E22, E44, G12, G14, G31, G32, G35)

We take a simple q-theory model and ask how well it can explain external financing anomalies, both qualitatively and quantitatively. Our central insight is that optimal investment is an important driving force of these anomalies.

Our economic question is important. The empirical finance literature has uncovered tantalizing evidence that firms raising capital earn lower average

returns, whereas firms distributing capital earn higher average returns in the future three to five years. A leading explanation of this evidence is behavioral market timing. Loughran and Ritter (1995) argue that managers can create value for existing shareholders by timing financing decisions to exploit mispricing caused by market inefficiencies. Managers can issue equity when their stock prices are overvalued and turn to internal funds or debt when stock prices are undervalued. Further, investors underreact to the pricing information conveyed by market timing.

We provide a neoclassical explanation of the anomalies. Our q-theory model reproduces simultaneously many stylized facts that have been interpreted as behavioral market timing: (i) The frequency of equity issuance is procyclical; (ii) investment is negatively related to future stock returns in the cross-section, and the magnitude of this correlation is stronger in firms with higher cash flows; (iii) firms conducting seasoned equity offerings underperform nonissuers with similar size and book-to-market in the long run; (iv) the operating performance of issuing firms substantially improves prior to equity offerings, but then deteriorates; (v) firms distributing cash back to shareholders outperform other firms with similar size and book-to-market, and the outperformance is stronger in value firms than in growth firms; and (vi) relative to industry peers, firms announcing share repurchases exhibit superior operating performance, but the performance declines following the announcements. However, while the model goes a long way in quantitatively explaining the negative investment-return relation and the post-issuance underperformance, the model cannot fully capture the empirical magnitude of the positive stock-price drift following cash distributions.

In the model, investment and the discount rate are negatively related through two channels. First, firms invest more when their marginal q (the net present value of future cash flows generated from one additional unit of capital) is high. All else equal, low discount rates give rise to high marginal q and high investment, and high discount rates give rise to low marginal q and low investment. Second, decreasing returns to scale mean that more investments lead to lower marginal product of capital, which in turn means lower expected returns.

The negative investment-return relation drives the external financing anomalies. The flow of funds constraint (that equates the sources of funds with the uses of funds) implies that all else equal, equity-issuing firms are disproportionately high investment firms, and cash-distributing firms are disproportionately low investment firms. Thus, raising capital is related to high investment and low expected returns, and distributing capital is related to low investment and high expected returns.

The investment-return relation and the new equity-return relation are anomalous because they cannot be explained by the CAPM in the data. The dynamic single-factor structure means that the conditional CAPM holds exactly in our model. But standard empirical tests performed on simulated data reject the

CAPM. Two reasons: First, estimated betas are noisy proxies for true betas, a point made as early as Miller and Scholes (1972). Second, even if we can measure betas perfectly, linear regressions are misspecified because the true model is nonlinear (due to time-varying price of risk).

Profitability is mean-reverting in the model and in the data (e.g., Fama and French 1995, 2000, 2006). *Ex post*, equity issuers tend to be firms that have recently experienced sizable positive profitability shocks. Going forward, however, issuers face the same distribution of shocks as other firms do. Looking back at historical data, we are likely to observe that the operating performance of issuing firms improves substantially prior to the issuance but deteriorates afterward.

Cochrane (1991, 1996) is the first to use q-theory to derive the negative relation between investment and expected returns. We apply his insight to study external financing anomalies. Pástor and Veronesi (2005) develop a model of optimal timing, in which waves of initial public offerings are driven by declines in expected market returns and increases in expected aggregate profitability. Carlson, Fisher, and Giammarino (2006) use a real options model to explain the underperformance following seasoned equity offerings. We study the long-term performance following equity issues and cash distributions simultaneously. Leary and Roberts (2005), Hennessy and Whited (2005), and Strebulaev (2007) cast doubt on behavioral market timing, but from the capital structure perspective. We contribute by studying the relation between equity financing decisions and average returns.

1. The Model

1.1 Technology
Production requires capital and is subject to aggregate productivity and firm-specific productivity shocks. The aggregate productivity x_t has a stationary and monotone Markov transition function, $Q_x(x_{t+1}|x_t)$, and is given by

$$x_{t+1} = \overline{x}(1 - \rho_x) + \rho_x x_t + \sigma_x \varepsilon_{t+1}^x, \tag{1}$$

in which ε_{t+1}^x is an i.i.d. standard normal variable. The aggregate shock serves as the source of systematic risk. Without it, all firms will earn expected returns that equal the real interest rate.

The firm-specific productivity z_{jt} has a common stationary and monotone Markov transition function, $Q_z(z_{jt+1}|z_{jt})$, given by

$$z_{jt+1} = \rho_z z_{jt} + \sigma_z \varepsilon_{jt+1}^z, \tag{2}$$

in which ε_{jt+1}^z (an i.i.d. standard normal variable) is the firm-specific productivity shock, which works as the ultimate source of firm heterogeneity. ε_{jt+1}^z

and ε_{it+1}^z are uncorrelated for any pair (i, j) with $i \neq j$, and ε_{t+1}^x is independent of ε_{jt+1}^z for all j.

The production function is given by

$$\pi_{jt} = e^{x_t + z_{jt}} k_{jt}^\alpha - f, \qquad (3)$$

in which π_{jt} and k_{jt} are the operating profits and capital of firm j at time t, respectively, and f denotes nonnegative fixed costs of production. The production function exhibits decreasing returns to scale: The curvature parameter satisfies $0 < \alpha < 1$ (low α means high curvature in the production technology). Decreasing returns to scale capture the idea that firms grow by taking on more investment opportunities. Because better opportunities are taken first, an increase in productive scale causes output to increase by a smaller proportion. Alternatively, decreasing returns to scale can be motivated by limited managerial or organizational resources that result in problems of managing large, multi-unit firms such as increasing costs of coordination (e.g., Lucas 1978).

1.2 "Tastes"

We parameterize the stochastic discount factor, denoted m_{t+1}:

$$\log m_{t+1} = \log \eta + \gamma_t(x_t - x_{t+1}), \qquad (4)$$
$$\gamma_t = \gamma_0 + \gamma_1(x_t - \bar{x}), \qquad (5)$$

in which $1 > \eta > 0$, $\gamma_0 > 0$, and $\gamma_1 < 0$ are constant parameters and x_t is aggregate productivity. Equations (4) and (5) imply that the real interest rate is $1/E_t[m_{t+1}] = (1/\eta) \exp(-\mu_m - \sigma_m^2/2)$ and the maximum Sharpe ratio is $\sigma_t[m_{t+1}]/E_t[m_{t+1}] = \sqrt{\exp(\sigma_m^2) - 1}$, in which $\mu_m \equiv [\gamma_0 + \gamma_1(x_t - \bar{x})](1 - \rho_x)(x_t - \bar{x})$ and $\sigma_m \equiv \sigma_x[\gamma_0 + \gamma_1(x_t - \bar{x})]$. When $\gamma_1 = 0$, the Sharpe ratio is constant. Thus, we set $\gamma_1 < 0$ to make the Sharpe ratio countercyclical à la Campbell and Cochrane (1999) and Zhang (2005).

1.3 Corporate policies

Upon observing current aggregate and firm-specific productivity shocks, firm j chooses optimal investment, i_{jt}, to maximize its market value of equity. The capital accumulation follows:

$$k_{jt+1} = i_{jt} + (1 - \delta)k_{jt}, \qquad (6)$$

in which δ denotes the constant rate of capital depreciation. Capital investment entails quadratic adjustment costs, denoted by c_{jt}, which are given by

$$c_{jt} \equiv c(i_{jt}, k_{jt}) = \frac{a}{2}\left(\frac{i_{jt}}{k_{jt}}\right)^2 k_{jt}, \qquad (7)$$

in which $a > 0$ is a constant parameter. Because of capital adjustment costs, the market value of the firm divided by its capital (Tobin's Q) is larger than one even with constant returns to scale ($\alpha = 1$).

When the sum of investment, i_{jt}, and adjustment costs, c_{jt}, exceeds internal funds, π_{jt}, the firm raises new equity capital, e_{jt}, from external markets:

$$e_{jt} \equiv \max(0, i_{jt} + c_{jt} - \pi_{jt}). \qquad (8)$$

We assume that new equity is the only source of external finance.

This modeling choice befits our empirical objectives. The external financing anomalies are mostly concentrated on issuing new equity and repurchasing shares (e.g., Ritter 1991; Loughran and Ritter 1995; Ikenberry, Lakonishok, and Vermaelen 1995). Firms issuing straight debts only weakly underperform, if at all (e.g., Spiess and Affleck-Graves 1999 and Lyandres, Sun, and Zhang 2008). Debt issuers underperform only when issuing convertible bonds, which are often treated as new equity (e.g., Fama and French 2005). From the distribution side, Ikenberry et al. (1995), among others, document that firms outperform after distributing capital to shareholders (such as paying dividends and repurchasing shares). But we are unaware of similar evidence for firms distributing capital to bondholders (such as paying interest and retiring corporate bonds).

Finally, the leverage-return relation is ambiguous in the data, and leverage is often dominated by other characteristics in explaining the cross-section of returns. For example, Fama and French (1992, p. 427) argue: "Two easily measured variables, size and book-to-market equity, combine to capture the cross-sectional variation in average stock returns associated with market β, size, leverage, book-to-market equity, and earnings-price ratios." Fama and French show that market leverage predicts returns with a positive sign, but book leverage predicts returns with a negative sign, and they interpret this evidence as reflecting the book-to-market effect.

External equity is costly (e.g., Smith 1977; Lee 1996; Altinkilic and Hansen 2000). To capture this effect, we follow Gomes (2001) and Hennessy and Whited (2005) and assume that for each dollar of external equity raised, firms must pay proportional flotation costs. There also are fixed costs of financing. Thus, we parameterize the total financing-cost function as

$$\lambda_{jt} \equiv \lambda(e_{jt}) = \lambda_0 \mathbf{1}_{\{e_{jt} > 0\}} + \lambda_1 e_{jt}, \qquad (9)$$

in which $\lambda_0 > 0$ captures the fixed costs, $\mathbf{1}_{\{e_{jt} > 0\}}$ is the indicator function that takes the value of one if the event described in $\{\cdot\}$ occurs, and $\lambda_1 e_{jt} > 0$ captures the proportional costs.

When the sum of investment and adjustment costs is lower than internal funds, the firm pays the difference back to shareholders. The payout, d_{jt}, is

given by

$$d_{jt} \equiv \max(0, \pi_{jt} - i_{jt} - c_{jt}). \tag{10}$$

Firms do not incur costs when paying dividends or repurchasing shares. Also, for simplicity, we do not model corporate cash holdings or the specific forms of the payout. Equation (10) pins down only the total amount paid to shareholders, not the methods of distribution. Because there are costs associated with raising capital but not with distributing payout, firms will only use external equity as the last resort when internal funds are not sufficient to finance investments.

1.4 Equity value, risk, and expected returns

Let $v(k_{jt}, z_{jt}, x_t)$ denote the cum-dividend value of equity for firm j. Define

$$o_{jt} \equiv d_{jt} - e_{jt} - \lambda(e_{jt}) = \pi_{jt} - i_{jt} - c_{jt} - \lambda(e_{jt}) \tag{11}$$

to be the effective cash flow accrued to shareholders (cash distributions minus the sum of external equity raised and the financing costs). The dynamic value-maximizing problem for firm j is

$$v(k_{jt}, z_{jt}, x_t) = \max_{\{i_{jt}\}} \left\{ o_{jt} + \iint m_{t+1} v(k_{jt+1}, z_{jt+1}, x_{t+1})\, Q_z(dz_{jt+1}|z_{jt}) \right.$$
$$\left. \times\, Q_x(dx_{t+1}|x_t) \right\}, \tag{12}$$

subject to equations (6) and (11).

Risk and expected returns are determined endogenously along with value-maximizing corporate policies in our model. Evaluating the value function at the optimum yields

$$v_{jt} = o_{jt} + E_t[m_{t+1} v_{jt+1}] \quad \Rightarrow \quad 1 = E_t[m_{t+1} r_{jt+1}], \tag{13}$$

in which firm j's stock return is $r_{jt+1} \equiv v_{jt+1}/(v_{jt} - o_{jt})$. $v(k_{jt}, z_{jt}, x_t)$ is the cum-dividend equity value. If we define $p_{jt} \equiv v_{jt} - o_{jt}$ as the ex-dividend market value of equity, r_{jt+1} reduces to the usual definition of $(p_{jt+1} + o_{jt+1})/p_{jt}$.

We can rewrite Equation (13) as the beta-pricing form, following Cochrane (2001, p. 19):

$$E_t[r_{jt+1}] = r_{ft} + \beta_{jt}\varsigma_{mt}, \tag{14}$$

in which $r_{ft} \equiv 1/E_t[m_{t+1}]$ is the real interest rate, β_{jt} is risk defined as

$$\beta_{jt} \equiv \frac{-\mathrm{Cov}_t[r_{jt+1}, m_{t+1}]}{\mathrm{Var}_t[m_{t+1}]}, \tag{15}$$

and ς_{mt} is the price of risk defined as $\varsigma_{mt} \equiv \mathrm{Var}_t[m_{t+1}]/E_t[m_{t+1}]$.

All the endogenous variables including risk and expected returns are functions of three state variables (the endogenous state, k_{jt}, and the two exogenous states, x_t and z_{jt}). Although the functional forms are not available analytically, we can easily solve for them numerically.

2. Properties of the Model Solution

2.1 Calibration

We calibrate 14 parameters (α, $\bar{x}$, ρ_x, σ_x, ρ_z, σ_z, η, f, γ_0, γ_1, δ, a, λ_0, λ_1) in monthly frequency. The parameter values are largely comparable to those in previous studies. We use three aggregate moments (the mean and volatility of real interest rate and the average Sharpe ratio) to pin down the three parameters in the pricing kernel, $\eta = 0.994$, $\gamma_0 = 50$, and $\gamma_1 = -1000$. The long-run average level of the aggregate productivity, $\bar{x}$, is a scaling variable. We set $\bar{x} = -3.751$ such that the average long-run capital in the economy is roughly one. For technology parameters, we set the persistence of the aggregate productivity $\rho_x = \sqrt[3]{0.95}$ and its conditional volatility $\sigma_x = 0.007/3$. With the specification of x_t in Equation (1), these monthly values correspond to quarterly values of 0.95 and 0.007, respectively, as in Cooley and Prescott (1995). The persistence ρ_z and conditional volatility σ_z of the firm-specific productivity are 0.965 and 0.10, respectively, which are close to the values in Zhang (2005). The curvature of the production function α is 0.70, close to the value estimated by Cooper and Ejarque (2001) and Hennessy and Whited (2007).

We restrict other parameters by targeting the summary statistics of quantity variables. The mean and volatility of the investment-to-assets ratio help identify the depreciation rate $\delta = 0.01$ and the adjustment-cost parameter $a = 15$, respectively. These values are close to those in Zhang (2005). The frequency of equity issuance and the average net equity-to-assets ratio help identify the financing-cost parameters $\lambda_0 = 0.08$ and $\lambda_1 = 0.025$, which are close to the values in Gomes (2001). Finally, we set $f = 0.005$ to match the average aggregate market-to-book ratio.

2.2 The value and optimal policy functions

We use the value function iteration on a discrete state space to solve the model (see Appendix A for details). Figure 1 plots the value and optimal policy functions. To focus on the cross-sectional variation, we fix the aggregate productivity at its long-run average and plot the functions against capital stock, k_{jt}, and firm-specific productivity, z_{jt}.

Panel A shows that firm value increases in both capital and firm-specific productivity. Because of decreasing returns to scale, firm value is concave in the capital stock. From panel B, decreasing returns to scale also imply that the optimal investment-to-assets ratio decreases in capital: Small firms with less capital invest more and grow faster than big firms with more capital, consistent
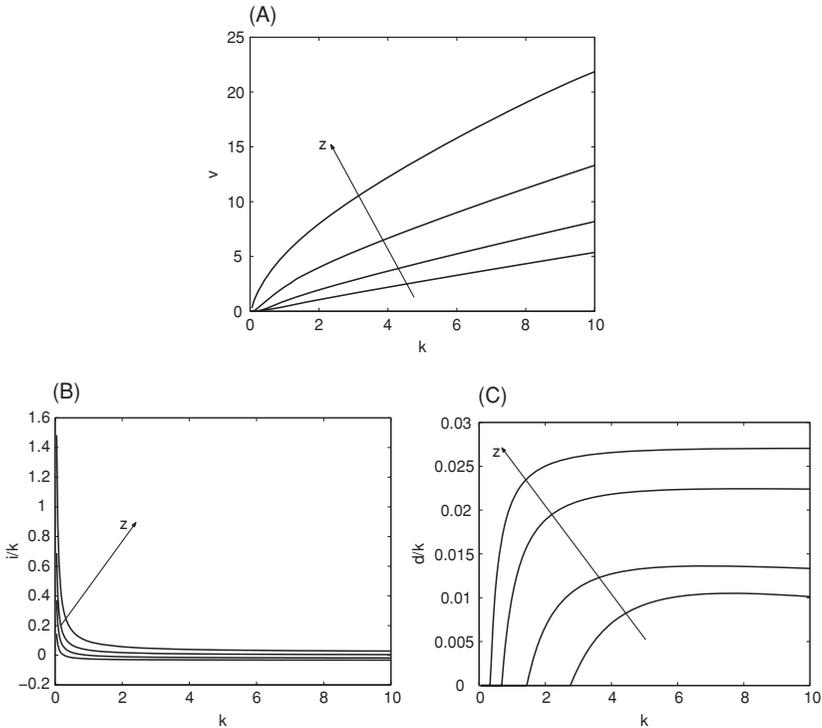
Figure 1
The value and optimal policy functions
This figure plots the value function ($v(k, z, \bar{x})$, panel A), optimal investment-to-assets ratio ($i/k(k, z, \bar{x})$, panel B), and optimal payout-to-assets ratio ($d/k(k, z, \bar{x})$, panel C) as functions of capital stock k and firm-specific productivity z. We fix the aggregate productivity at its long-run average level, $x = \bar{x}$, to focus on the cross-sectional variation of these variables. The arrows in each panel indicate the direction along which z increases. (A) $v(k, z, \bar{x})$; (B) $\frac{i}{k}(k, z, \bar{x})$; (C) $\frac{d}{k}(k, z, \bar{x})$.

with the evidence in Evans (1987) and Hall (1987). Also, more profitable firms invest more than less profitable firms, consistent with the evidence in Fama and French (1995). The new equity-to-assets ratio behaves similarly as investment-to-assets (untabulated). Smaller firms and more profitable firms issue more equity than bigger firms and less profitable firms, consistent with the evidence in Fama and French (2005). This result is natural given the flow of funds constraint in Equation (8).

From panel D, small firms hardly distribute any cash back to shareholders, whereas big firms distribute more. This prediction is consistent with Barclay, Smith, and Watts (1995), who document that dividend yields correlate positively with the log of total sales (a measure of firm physical size). Moreover, more profitable firms distribute more than less profitable firms, consistent with the evidence in Jagannathan, Stephens, and Weisbach (2000) and Lie (2005).

2.3 Fundamental determinants of risk

To preview the results, risk (β_{jt} defined in Equation 15) decreases with the capital stock and investment. Risk also increases with fixed costs of production, the adjustment costs, and the fixed and variable financing costs, but decreases with the curvature of the production function.

2.3.1 The physical-size effect. From panel A of Figure 2, small firms with less capital are riskier than big firms with more capital. We call this result the physical-size effect to be distinguished from the size (market capitalization) effect of Banz (1981). The physical-size effect is present in the data.[1]

Decreasing returns to scale are the main driver of the physical-size effect. We use a simple example to illustrate the mechanism. Although the setup is extremely simple, the mechanism is likely to be present in more realistic models. There are two periods, 1 and 2. A firm's production function is given by k_t^α with $t = 1, 2$. k_1 depreciates at the rate of δ, meaning $k_2 = i + (1 - \delta)k_1$, in which i is investment in period 1. There are no adjustment costs of capital. The firm faces a gross discount rate (expected return) of r, which is known at the beginning of period 2. The value-maximization problem is

$$\max_{\{k_2\}} \left(k_1^\alpha - k_2 + (1 - \delta)k_1 + \frac{1}{r}\left[k_2^\alpha + (1 - \delta)k_2 \right] \right).$$

The first-order condition says that

$$r = \alpha k_2^{\alpha-1} + 1 - \delta. \tag{16}$$

Taking the derivative of r with respect to k_2:

$$\frac{\partial r}{\partial k_2} = \alpha(\alpha - 1)k_2^{\alpha-2} < 0,$$

which explains the physical-size effect. The effect disappears with constant returns to scale and reverses sign with increasing returns to scale.

2.3.2 The capital investment effect. There are two channels driving the negative relation between the discount rate and capital investment. The cash flow channel works through decreasing returns to scale, and the discount rate channel works through capital adjustment costs. Both channels are present in our dynamic model.

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[1] We form ten portfolios by sorting all stocks on book assets (Compustat annual item 6). From 1951 to 2005, the equal-weighted small-minus-big portfolio earns an average return of 0.93% per month ($t = 3.07$). Using sales (item 12) as the sorting variable yields an average return of 0.62% per month ($t = 2.20$) for the small-minus-big portfolio.
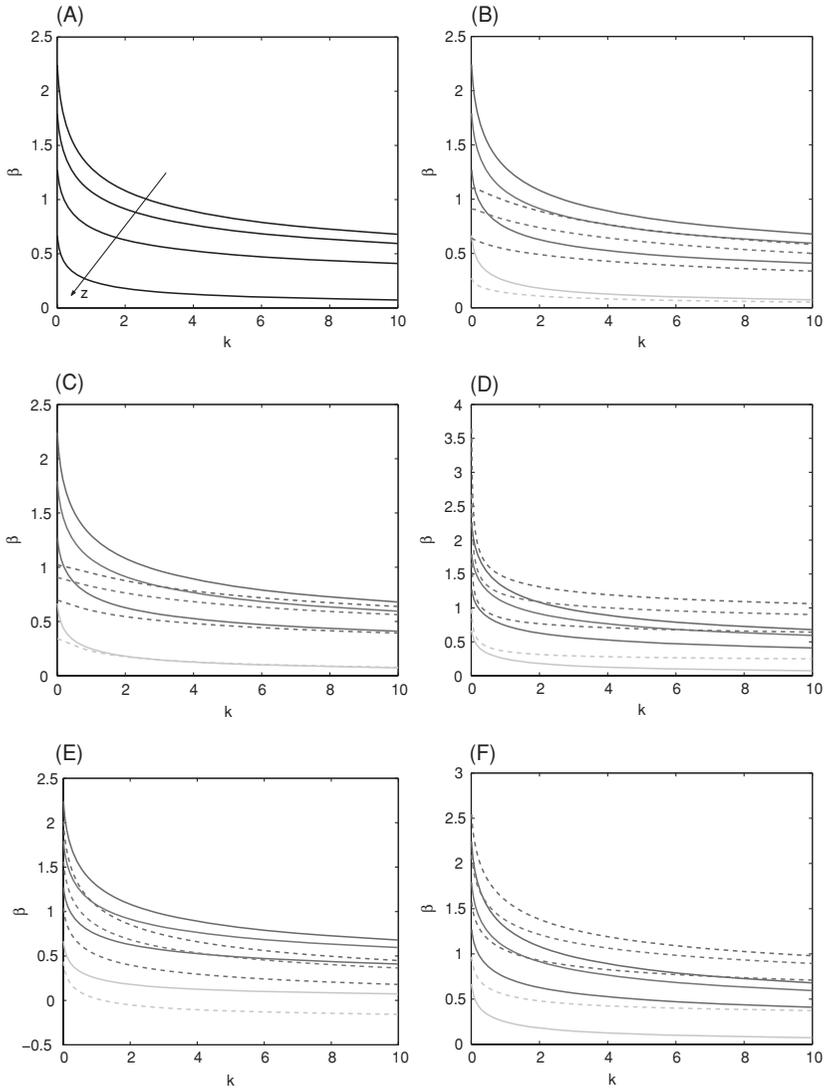
Figure 2
Fundamental determinants of risk
This figure plots beta (β_{jt} defined in Equation 15) as a function of capital stock, k_{jt}, and firm-specific productivity, z_{jt}, while fixing the aggregate productivity at its long-run average, $x_t = \bar{x}$. Panel A plots β_{jt} in the benchmark parameterization. The arrow in panel A indicates the direction along which z_{jt} increases. We also conduct five comparative static experiments: (i) high curvature in the production function, $\alpha = 0.50$ (panel B); (ii) low fixed costs of production, $f = 0$ (panel C); (iii) high physical adjustment costs, $a = 50$ (panel D); (iv) low fixed costs of financing, $\lambda_0 = 0.04$ (panel E); and (v) high variable costs of financing, $\lambda_1 = 0.075$ (panel F). In panels B–F, the solid curves are from the benchmark parameterization, and the broken lines are from alternative parameter specifications. (A) $\beta(k, z, \bar{x})$, the benchmark parameterization; (B) $\beta(k, z, \bar{x})$, high curvature in the production function, $\alpha = 0.50$; (C) $\beta(k, z, \bar{x})$, low fixed costs of production, $f = 0$; (D) $\beta(k, z, \bar{x})$, high physical adjustment costs, $a = 50$; (E) $\beta(k, z, \bar{x})$, low fixed costs of financing, $\lambda_0 = 0.04$; (F) $\beta(k, z, \bar{x})$, high variable costs of financing, $\lambda_1 = 0.075$.

To see the cash flow channel, we plug $k_2 = i + (1 - \delta)k_1$ into Equation (16) and take the derivative of r with respect to i to obtain

$$\frac{\partial r}{\partial i} = \alpha(\alpha - 1)k_2^{\alpha-2} < 0. \tag{17}$$

Intuitively, diminishing returns to scale mean that more investments lead to lower marginal product of capital, which in turn means lower expected returns. This cash flow channel disappears with constant returns to scale and reverses its sign with increasing returns to scale.

To see the discount rate channel, we introduce into the setup capital adjustment costs. Suppose the adjustment costs are quadratic, $(a/2)(i/k_1)^2 k_1$, with $a > 0$. The value-maximization problem becomes

$$\max_{\{k_2\}} \left(k_1^{\alpha} - k_2 + (1 - \delta)k_1 - \frac{a}{2}\left[\frac{k_2}{k_1} - (1 - \delta)\right]^2 k_1 + \frac{1}{r}\left[k_2^{\alpha} + (1 - \delta)k_2\right]\right).$$

The first-order condition implies that

$$r = \frac{\alpha[i + (1 - \delta)k_1]^{\alpha-1} + 1 - \delta}{1 + a(i/k_1)}$$

$$\Rightarrow \quad \frac{\partial r}{\partial i} = \frac{\alpha(\alpha - 1)k_2^{\alpha-2}}{1 + a(i/k_1)} - \frac{\alpha k_2^{\alpha-1}a}{[1 + a(i/k_1)]^2 k_1} < 0.$$

With constant returns to scale ($\alpha = 1$), the first term in $\partial r/\partial i$ (the cash flow channel) disappears. But the discount rate channel persists because the second term in $\partial r/\partial i$ is negative. Intuitively, firms invest more when their marginal q is high. All else equal, low discount rates mean high marginal q and high investment, and high discount rates mean low marginal q and low investment. The discount rate channel has been discussed in the prior literature (e.g., Cochrane 1991), but the cash flow channel is new.

2.3.3 Comparative statics.

We also ask how risk is affected by key structural parameters in our economy. Panels B–F of Figure 2 report results from five comparative static experiments: (i) high curvature in the production function ($\alpha = 0.50$); (ii) low fixed costs of production ($f = 0$); (iii) high adjustment costs ($a = 50$); (iv) low fixed costs of financing ($\lambda_0 = 0.04$); and (v) high variable costs of financing ($\lambda_1 = 0.075$), respectively. The broken lines in each panel are from the alternative specifications, and the solid lines are from the benchmark calibration (same as in panel A) to facilitate comparison.

From panel B, increasing the curvature in the production function by decreasing α from 0.70 to 0.50 decreases risk. Panel C shows that risk decreases once we lower the fixed costs of production, f. This result is consistent with Carlson, Fisher, and Giammarino (2004), who argue that operating leverage causes risk to increase: When a firm is hit with negative shocks, its operating

profits fall relative to the fixed costs. As a result, cash flows are more sensitive to aggregate shocks. Panel D shows that risk increases with the adjustment cost parameter a. The risk of a firm in production economies is inversely related to its flexibility in using investment to mitigate the effect of productivity shocks on its dividend stream (e.g., Zhang 2005). The more flexible a firm is in this regard, the less risky it is. The adjustment costs are the exact offsetting force of this dividend smoothing mechanism. The higher adjustment costs a firm faces, the less flexible it is in adjusting capital, and the riskier it will be. We extend this insight to the financing costs. The financing costs play a similar role as adjustment costs. Higher financing costs prevent firms from using capital investment to smooth dividend streams, giving rise to higher risk. This mechanism explains the results in panels E and F that risk increases in both fixed and variable financing costs.

3. Quantitative Results

We focus on evaluating the quantitative performance of the model in explaining the external financing anomalies. We simulate 1000 artificial panels, each of which has 5000 firms and 720 months. We start by assuming the initial capital stocks of all firms to be at their long-run average level (which equals one) and by drawing their firm-specific productivity levels from the unconditional distribution of z_{jt}. We drop the initial 240 months of data to neutralize the effect of the initial conditions. The remaining 480 months of data are treated as those from the stationary distribution. The sample size is largely comparable to the CRSP/COMPUSTAT merged data set used in most empirical studies.

On each artificial panel, we implement the same test procedures from several well-known empirical studies. We report cross-simulation averaged results and the empirical distributions of key test statistics, which are then compared with the statistics obtained in related empirical studies.

3.1 Preliminaries

The overall fit of the unconditional moments in Table 1 is reasonable. The means and volatilities for the risk-free rate, the aggregate investment-to-assets, and the aggregate book-to-market from the model are close to those in the data. However, the frequency of equity issuance in the model, 28.5%, is higher than that in the data, 9.9%, from Hennessy and Whited (2005). Hennessy and Whited measure new equity as sales of common and preferred stocks minus the purchase of common and preferred stocks. However, seasoned equity is unlikely to be the only way that public firms use to issue equity. Fama and French (2005) show that firms can issue equity in mergers and through private placements, convertible debt, warrants, direct purchase plans, rights issues, and employee options, grants, and benefit plans. From 1973 to 1982, on average 67% of firms issue some equity each year, and the proportion increases to 74% from 1983 to 1992, and 86% from 1993 to 2002.

Table 1
Unconditional moments from the simulated and real data

	Data	Model
The average annual risk-free rate	0.018	0.021
The annual volatility of risk-free rate	0.030	0.029
The average annual Sharpe ratio	0.430	0.405
The average annual investment-to-assets ratio	0.130	0.119
The volatility of investment-to-assets ratio	0.006	0.013
The frequency of equity issuance	0.099	0.285
The average new equity-to-asset ratio	0.042	0.043
The average market-to-book ratio	1.493	1.879
The volatility of market-to-book	0.230	0.242

This table reports unconditional moments from the simulated data and from the real data. We simulate 1000 artificial panels, each of which has 5000 firms and 480 monthly observations. We report the cross-simulations averaged moments. The average Sharpe ratio in the data is from Campbell and Cochrane (1999). The data moments of the real interest rate are from Campbell, Lo, and MacKinlay (1997). The data moments of aggregate market-to-book are from Pontiff and Schall (1998). All the other data moments are from Hennessy and Whited (2005).

Choe, Masulis, and Nanda (1993) report that the relative frequency of equity offers (the number of equity offerings per month scaled by the number of listed firms) is procyclical. To see whether the model can explain this stylized fact, we define expansions in our economy as times when the aggregate productivity is at least one unconditional standard deviation above its long-run average ($x_t > \bar{x} + \sigma_x/\sqrt{1 - \rho_x^2}$) and contractions as times when the aggregate productivity is at least one unconditional standard deviation below its long-run average ($x_t < \bar{x} - \sigma_x/\sqrt{1 - \rho_x^2}$). The relative frequency of equity issuance is measured as $(1/n)\sum_{j=1}^{n} \mathbf{1}_{\{e_{jt}>0\}}$, in which $\mathbf{1}_{\{e_{jt}>0\}}$ is the indicator function that takes a value of one if firm j issues equity and zero otherwise, and n is the total number of firms in the economy. Without entry and exit, n remains constant. Incorporating entry and exit is likely to reinforce our results because the frequency of entry (initial public offerings) tends to be procyclical and the frequency of exit (delisting) tends to be countercyclical.

We compute the average frequency of equity issuance conditional on business cycles in our economy. Consistent with Choe et al. (1993), the equity issuance is procyclical in our model: its relative frequency is 82.5% in expansions and only 1.5% in contractions.

3.2 Capital investment and stock returns

The external financing anomalies are intimately linked to the negative relation between investment and the discount rate. Richardson and Sloan (2003) document that the negative relation between external finance and future returns varies systematically with the use of proceeds. When the proceeds are invested in net operating assets as opposed to being stored as cash, there exists a stronger negative relation. But there is no negative relation for refinancing transactions. Thus, we study the investment-return relation before we turn to the external financing anomalies.

We focus on Titman, Wei, and Xie (2004), who interpret their evidence on the negative relation between investment and average subsequent returns as investors underreacting to empire-building behavior of managers. Following Titman et al., we define capital investment (CI) in the portfolio formation year t as $CI_{jt-1} = 3CE_{jt-1}/(CE_{jt-2} + CE_{jt-3} + CE_{jt-4}) - 1$, in which CE_{jt-1} is firm j's capital expenditure scaled by sales during year $t-1$. We measure CE_{jt-1} in the model as the investment-to-output ratio, $i_{jt-1}/(e^{x_{t-1}+z_{jt-1}}k_{jt-1}^{\alpha})$ (the output price is normalized to be one). The last three-year moving-average capital expenditure in the denominator of CI_{jt-1} is used to proxy for firm j's benchmark investment. In the beginning of year t, we sort all firms into quintiles based on CI_{jt-1} in ascending order. The firms remain in these portfolios for the whole year t, and the portfolios are rebalanced annually. We construct a CI-spread portfolio long in the lowest CI portfolio and short in the highest CI portfolio. The value-weighted monthly excess returns for each CI portfolio are calculated. Following Titman et al. (2004), we measure excess returns relative to benchmarks constructed to have similar size, book-to-market, and prior returns (see Appendix B.1 for details).

We also perform the following Fama-MacBeth (1973) cross-sectional regressions:

$$r_{jt+1}^{a} = l_{0t} + l_{1t}\, CI_{jt} + l_{2t}\, CI_{jt} \times DCF_{jt} + u_{jt+1}, \qquad (18)$$

in which r_{jt+1}^{a} is the benchmark-adjusted value-weighted return on individual stock j, and DCF is the dummy variable based on the cash flow (operating income-to-assets, measured as π_{jt}/k_{jt} in the model). If firm j's cash flow is above the median of the year, DCF equals one, and zero otherwise.

Consistent with Titman, Wei, and Xie (2004), panel A of Table 2 reports that firms with low CI earn higher average returns than firms with high CI. The model-implied average CI spread is 10.1% per annum, which falls short of the magnitude in the data: 16.9%. Panel A of Figure 3 reports the empirical distribution for the mean CI spread across 1000 simulations. The empirical estimate of 16.9% lies in the extreme right tail of the distribution (p-value $< 1\%$). Thus, the model cannot fully account for the high average CI spread observed in the data.

Panel B of Table 2 reports the results from the cross-sectional regression given by Equation (18). The relation between future stock returns and capital investment is negative in the simulated data. The average CI slope across simulations is -0.56 ($t = -3.14$), close to the empirical estimate of -0.79 ($t = 2.80$). Further, the magnitude of the investment-return relation increases with operating income-to-assets, as shown by the negative slope for the interaction term, $CI \times DCF$. The cross-simulation averaged slope is -0.47 ($t = 3.44$), whereas the empirical estimate is -0.76 ($t = -2.19$). To formally evaluate how far the simulated averages are from their empirical estimates, panels B and C of Figure 3 report on the joint empirical distribution of the CI and

Table 2
Excess returns of capital investment (*CI*) portfolios

	Panel A: Excess return distribution of capital investment portfolios									
CI portfolio	Mean		Std Dev		Max		Median		Min	
	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model
Low	0.042	0.064	0.010	0.050	3.38	0.16	0.06	0.07	−3.11	−0.07
2	0.083	0.010	0.007	0.031	2.26	0.08	0.10	0.01	−2.76	−0.06
3	0.055	−0.007	0.006	0.023	1.84	0.05	0.03	−0.01	−2.07	−0.06
4	−0.083	−0.021	0.005	0.027	1.38	0.04	−0.06	−0.02	−1.88	−0.08
High	−0.127	−0.038	0.010	0.046	2.61	0.06	−0.08	−0.04	−4.08	−0.13
CI spread	0.169	0.101	0.009	0.004	3.30	0.07	0.12	0.07	−2.63	0.04

Panel B: $r_{jt+1}^{a} = l_{0t} + l_{1t}\, CI_{jt} + l_{2t}\, CI_{jt} \times DCF_{jt} + \epsilon_{jt+1}$

	CI		$CI \times DCF$	
	Data	Model	Data	Model
Slopes	−0.79	−0.56	−0.76	−0.47
(*t*)	(−2.80)	(−3.14)	(−2.19)	(−3.44)

Panel C: Cross-sectional regressions of r_{jt+1}^{a} on CI, $CI \times DCF$, and rolling market betas ($\hat{\beta}_{jt}$); and on CI, $CI \times DCF$, and true betas (β_{jt})

	CI	$CI \times DCF$	$\hat{\beta}_{jt}$		*CI*	$CI \times DCF$	β_{jt}
Slopes	−0.32	−0.16	−0.04		−0.38	−0.41	0.43
(*t*)	(−2.31)	(−3.67)	(−3.37)		(−1.85)	(−1.65)	(4.83)

Panel A presents the distribution of excess returns on five *CI* portfolios and the *CI*-spread portfolio. *CI* denotes the capital-investment measure based on investment-to-assets. We report the monthly mean excess returns, the standard deviation, the maximum, the median, and the minimum of the excess returns. The *CI* portfolios are constructed as follows. In year *t*, all stocks are sorted into quintiles based on their *CI* measures in ascending order to form five portfolios. Value-weighted monthly excess returns on a portfolio are calculated from year *t* to year *t*+1. The excess return on an individual stock at time *t* is calculated by subtracting the returns of characteristics-based benchmark portfolios from the stock return at time *t*. See Appendix B.1 for construction details of the benchmark. The *CI* spread denotes the zero-investment portfolio that has a long position in the lowest *CI* portfolio and a short position in the highest *CI* portfolio. All portfolios are rebalanced annually. Panel B reports on the results of the Fama-MacBeth (1973) cross-sectional regression: $r_{jt+1}^{a} = l_{0t} + l_{1t}\, CI_{jt} + l_{2t}\, CI_{jt} \times DCF_{jt} + u_{jt+1}$, in which r_{jt+1}^{a} is the benchmark-adjusted value-weighted return on individual stock *j* at month *t* and *DCF* is the dummy variable based on cash flow, measured as operating income scaled by total assets, measured in the model as π_{jt}/k_{jt}. If the cash flow of one firm is above the median cash flow of the year, its *DCF* equals one, and zero otherwise. Panel C performs two cross-sectional regressions. The first regression is $r_{jt+1}^{a} = l_{0t} + l_{1t}\, CI_{jt} + l_{2t}\, CI_{jt} \times DCF_{jt} + l_{3t}\hat{\beta}_{jt} + u_{jt+1}^{1}$, in which $\hat{\beta}_{jt}$ is the 60-month rolling betas estimated by regressing r_{jt+1}^{a} on the value-weighted industry returns in excess of the risk-free rate. The second regression is $r_{jt+1}^{a} = l_{0t} + l_{1t}\, CI_{jt} + l_{2t}\, CI_{jt} \times DCF_{jt} + l_{3t}\beta_{jt} + u_{jt+1}^{2}$, in which β_{jt} is the true beta defined in Equation (15). We simulate 1000 artificial panels, each of which has 5000 firms and 480 monthly observations. The monthly flow variables are aggregated within one given year to create their corresponding annual variables. We perform the tests on each simulated panel and report the cross-simulation average slopes and test statistics. In panels A and B, we also compare our results to those reported in Table 1 (panel A) and Table 6 (panel A) in Titman, Wei, and Xie (2004), respectively.
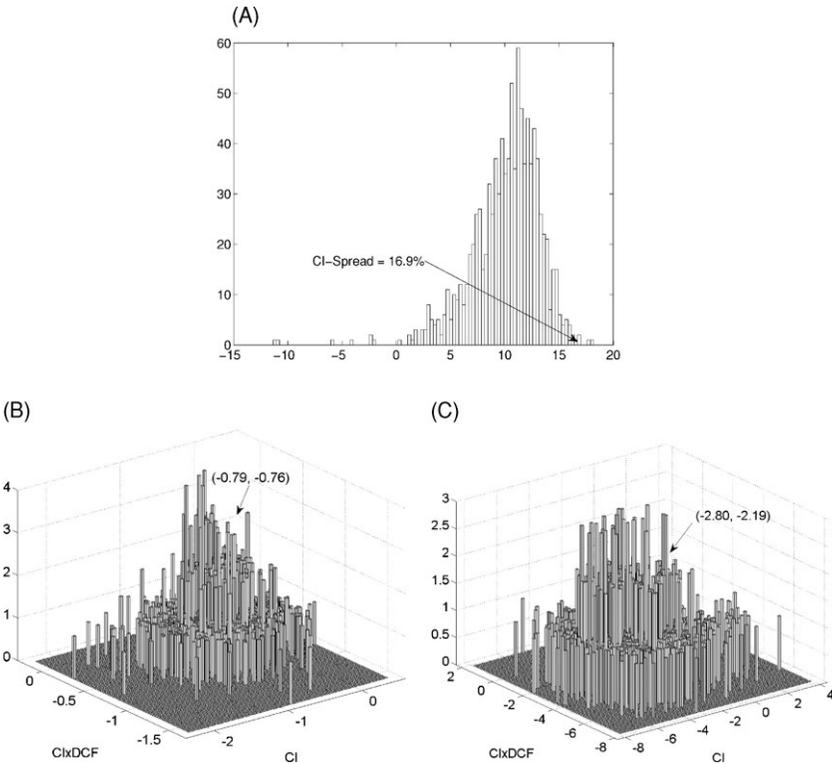
Figure 3
Empirical distributions for the mean *CI* spread and the slopes and *t*-statistics of the Fama-MacBeth (1973) cross-sectional regressions of benchmark-adjusted returns on *CI* and CI × *DCF*.
Panel A reports the mean *CI* spread across 1000 simulations as well as its value in the real data, 16.9% per annum. *CI* denotes capital investment. The *CI* spread is the zero-investment portfolio that has a long position in the lowest *CI* quintile and a short position in the highest *CI* quintile. In each simulation, we also run Fama-MacBeth (1973) cross-sectional regression: $r^a_{jt+1} = l_{0t} + l_{1t} CI_{jt} + l_{2t} CI_{jt} \times DCF_{jt} + u_{jt+1}$, in which r^a_{jt+1} is the benchmark-adjusted value-weighted return on individual stock j at month t. DCF is the dummy variable based on cash flow, measured as operating income scaled by total assets, measured in the model as π_{jt}/k_{jt}. If the cash flow of one firm is above the median cash flow of the year, its DCF equals one, and zero otherwise. Panel B reports the joint empirical distribution of average l_{1t} and average l_{2t}. Panel C reports the joint empirical distribution of their Fama-MacBeth *t*-statistics. (A) Mean *CI* spread; (B) Slopes of *CI* and *CI* × *DCF*; (C) *t*-statistics of *CI* and $CI \times DCF$.

$CI \times DCF$ slopes as well as that of their *t*-statistics in simulations. The panels show that the empirical estimates can be adequately explained by the model. Specifically, the *p*-value of the empirical *CI* and $CI \times DCF$ slopes calculated with the simulated distribution in panel B is 0.67. (The *p*-value is calculated by counting the number of simulations that have *CI* slopes higher than −0.79 and have $CI \times DCF$ slopes higher than −0.76 and dividing this number by 1000.) Further, the *p*-value of the *t*-statistics of the slopes in the data from the simulated distribution in panel C is 0.07.

Recent studies emphasize the importance for structural models to explain the failure of the CAPM (e.g., Lettau and Wachter 2007 and Lewellen and Nagel

2006). This issue is important given the single-factor structure in our model: Because the aggregate productivity growth is perfectly correlated with market excess returns conditionally, the conditional CAPM holds. However, because of the measurement errors in betas, empirical tests can reject the CAPM, even if the CAPM is the true data-generating model. This point has been made at least since Miller and Scholes (1972). Miller and Scholes use randomly generated returns constructed to obey the CAPM, and find that the results of the simulated asset pricing tests are virtually identical to those from using the real data.

Our results reported in panel C of Table 2 reinforce Miller and Scholes's (1972) view. When we use 60-month rolling-window regressions to estimate betas, characteristics such as CI and $CI \times DCF$ dominate betas in explaining average returns in cross-sectional regressions. But when we replace the rolling betas with the true betas (see Appendix A for their calculation details), characteristics are no longer significant, and the true betas are significant. These results are quantitatively similar to those of Gomes, Kogan, and Zhang (2003) in the context of the size and book-to-market effects. The results suggest that the failures of the CAPM in the data are likely to reflect deficiencies in test design, as opposed to deficiencies in the underlying economic theory.

3.3 Long-term underperformance following seasoned equity offerings

Loughran and Ritter (1995) document that firms issuing equity earn lower average returns in the future three to five years than nonissuing firms with similar characteristics (also see Spiess and Affleck-Graves 1995). Following Loughran and Ritter's test design in their Table VIII, we use simulated panels to perform Fama-MacBeth (1973) monthly cross-sectional regressions of percentage stock returns on market capitalization, book-to-market equity, and an issue dummy:

$$r_{jt+1} = b_0 + b_1 \log(ME_{jt}) + b_2 \log(BM_{jt}) + b_3 ISSUE_{jt} + u_{jt+1}, \quad (19)$$

where r_{jt+1} is the return on stock j over month t, and all the regressors are at the beginning of month t. ME_{jt} is the ex-dividend firm value, p_{jt}, on the most recent fiscal year-end prior to the month t. BM_{jt} is the book-to-market ratio of firm j, k_{jt}/p_{jt}, on the most recent fiscal year-end prior to the month t. $ISSUE_{jt} \equiv \mathbf{1}_{\{\sum_{\tau=0}^{59} e_{jt-\tau}>0\}}$ is a dummy variable that takes a value of one if firm j has conducted one or more equity issues in the previous five years, and zero otherwise. We also partition the sample on the basis of the fraction of the sample firms in a month that have issued equity during the prior five years. The light-volume sample contains the months with the fraction below its median, and the heavy-volume sample contains the months with the fraction above its median.

Panel A of Table 3 shows that the model does a reasonable job in quantitatively reproducing Loughran and Ritter's (1995) evidence. When the issue dummy is used alone, issuing firms underperform by 0.49% per month

Table 3
Fama-MacBeth (1973) monthly cross-sectional regressions of percentage stock returns on size, book-to-market, and the new issues dummy

Panel A: Replicating Loughran and Ritter (1995, Table VIII)						
	log(ME)		log(BM)		ISSUE	
Sample	Data	Model	Data	Model	Data	Model
All months					−0.49	−0.81
					(−3.98)	(−4.76)
	−0.05	0.63	0.30	0.89	−0.38	−0.44
	(−0.91)	(4.22)	(4.57)	(8.18)	(−2.32)	(−2.87)
Periods following light volume	−0.26	0.88	0.20	1.00	−0.17	0.06
	(−3.12)	(5.21)	(1.80)	(7.62)	(−1.19)	(0.31)
Periods following heavy volume	0.16	0.39	0.39	0.79	−0.60	−0.90
	(2.11)	(1.39)	(6.30)	(4.49)	(−3.98)	(−3.75)

Panel B: Cross-sectional regressions controlling for rolling betas ($\hat{\beta}_{jt}$), true betas (β_{jt}), or true expected returns ($E_t[r_{jt+1}]$)											
	log(ME)	log(BM)	ISSUE	$\hat{\beta}_{jt}$	log(ME)	log(BM)	ISSUE	β_{jt}	log(ME)	log(BM)	ISSUE	$E_t[r_{jt+1}]$
All months			−0.30	−0.95			−0.31	0.67			−0.31	0.96
			(−2.64)	(−3.09)			(−3.37)	(15.45)			(−1.52)	(9.99)
	0.63	0.55	−0.27	−0.20	−0.79	−0.70	−0.27	0.70	−0.07	0.58	−0.23	0.87
	(6.74)	(8.29)	(−2.25)	(−4.04)	(−1.12)	(−1.53)	(−2.96)	(9.15)	(−1.67)	(0.90)	(−1.28)	(9.39)
Periods following light volume	0.19	0.45	−0.07	−0.16	−0.91	−0.61	−0.16	0.82	−0.08	0.29	−0.15	0.89
	(4.63)	(3.15)	(−1.03)	(−2.02)	(−1.65)	(−1.03)	(−2.43)	(8.09)	(−1.67)	(0.92)	(−1.52)	(8.93)
Periods following heavy volume	1.08	0.66	−0.47	−0.24	−0.55	−0.79	−0.39	0.59	−0.06	0.86	−0.32	0.86
	(8.89)	(9.30)	(−3.73)	(−4.57)	(−1.41)	(−1.58)	(−3.19)	(7.18)	(−1.33)	(0.85)	(−1.06)	(9.79)

Panel A reports the Fama-MacBeth (1973) monthly cross-sectional regressions: $r_{jt+1} = b_0 + b_1 \log(ME_{jt}) + b_2 \log(BM_{jt}) + b_3 ISSUE_{jt} + u_{jt+1}$, in which r_{jt+1} denotes the percentage return on firm j during month t, ME_{jt} is the market value of firm j on the most recent fiscal year ending before month t, BM_{jt} is the ratio of the book value of equity to the market value of equity for firm j on the most recent fiscal year ending before month t, and $ISSUE_{jt}$ is the dummy variable that equals one if firm j has conducted equity offerings at least once within the past 60 months preceding month t and zero otherwise. The light-issuance sample has all the months with the fraction of issuing firms below its median, and the heavy-issuance sample has all the months with the fraction of issuing firms above its median. We simulate 1000 artificial panels, each of which has 5000 firms and 480 monthly observations. We perform the cross-sectional regressions on each simulated panel and report the cross-simulations averaged slopes and the Fama-MacBeth t-statistics. We compare our results to those of Loughran and Ritter (1995, Table VIII). In panel B, we rerun the Loughran and Ritter (1995) regressions but adding the estimated beta, $\hat{\beta}_{jt}$, the true beta, β_{jt}, or the true expected return, $E_t[r_{jt+1}]$, into the regressions. The estimated betas are from 60-month rolling-window regressions of individual stock excess returns, r_{jt+1}, on the value-weighted market excess returns, $p_{jt} r_{jt+1} / \sum_{j=1}^{n} p_{jt} r_{jt+1}$. Appendix A provides details of calculating the true betas and the true expected returns.

($t = -3.98$) in the data. The model-implied underperformance is 0.81% per month ($t = -4.76$). Controlling for size and book-to-market reduces the underperformance to 0.38% per month in the data ($t = -2.32$) and to 0.44% in the model ($t = -2.87$). In the data, issuing firms underperform by an insignificant amount of 0.17% per month following light issuance activity but by a significant amount of 0.60% following heavy issuance activity. Similarly, in the model, issuing firms following light issuance activity slightly overperform by an insignificant 0.06% per month, but those following heavy issuance activity underperform by a significant 0.90% per month.
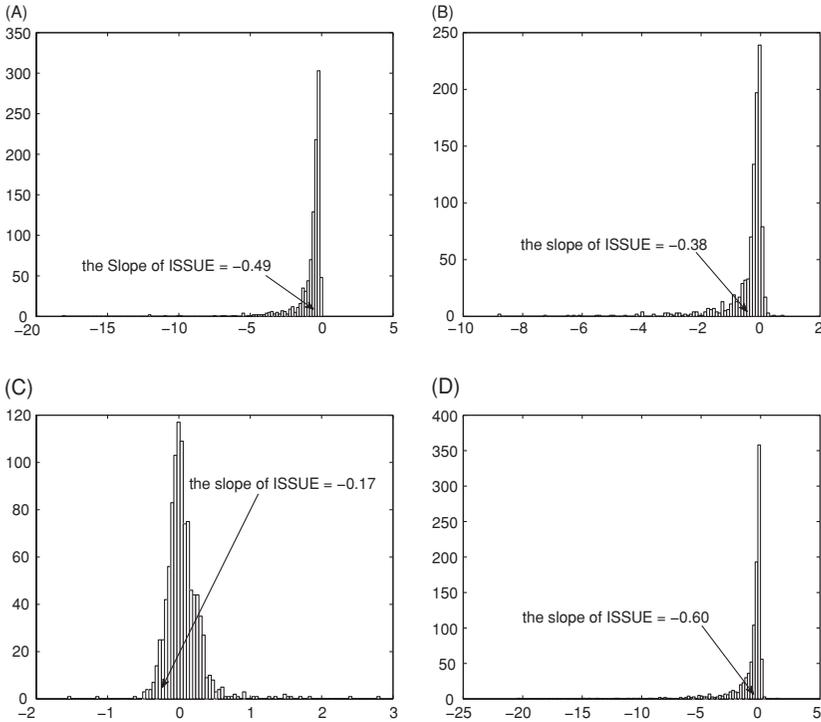
Figure 4 reports the empirical distributions for the *ISSUE* slopes from the cross-sectional regressions in panel A of Table 3. Across all four regressions, the empirical estimates of the *ISSUE* slopes are well within their respective empirical distributions from the model. For example, the *p*-value of the univariate *ISSUE* slope from its empirical distribution is 0.58. And the *p*-values for the *ISSUE* slope in the multiple regressions with size and book-to-market using the full, light-volume, and heavy-volume samples are 0.75, 0.69, and 0.89, respectively.

Panel B of Table 3 examines whether the model can quantitatively explain the failure of the CAPM in the context of the post-issue underperformance. Controlling for the 60-month rolling betas in the Loughran and Ritter (1995) cross-sectional regressions does not change the basic pattern that the *ISSUE* slopes are significantly negative. Even when we use the true betas in the cross-sectional regressions, the issue dummy has significantly negative slopes in all regressions. This result suggests another important reason why standard asset pricing tests are likely to overreject the CAPM. The risk-return relation given by Equation (14) is highly nonlinear. But when we fit linear regressions even without any measurement errors in betas, we implicitly assume that the price of risk, ζ_{mt}, is constant. This misspecification leads to the rejection of the CAPM, even when the conditional CAPM holds in the model. To account for the nonlinearity, we replace the true betas with the true expected returns (see Appendix A for their calculation details). Notably, none of the firm characteristics are significant in the regressions, and the true expected returns have slopes that are all reliably different from zero but insignificantly different from one.

3.4 Operating performance following seasoned equity offerings

Loughran and Ritter (1997) document that the operating performance of issuing firms displays substantial improvement prior to the equity offerings, but then deteriorates. Issuing firms also are disproportionately high-investing and high-growth firms. They interpret the evidence using Jensen's (1993) hypothesis that corporate culture excessively focuses on growth, and managers are as overly optimistic about the future profitability as outside investors.

We use simulated panels to replicate Loughran and Ritter's (1997) Table II by reporting the medians of the operating performance for issuing firms and matching firms for nine years around the issuance. Our matching

(A)

(B)

(C)

(D)

Figure 4

Empirical distributions for the slopes on the new issues dummy from the Fama-MacBeth (1973) cross-sectional regressions of percentage stock returns.

We simulate 1000 artificial panels, each of which has 5000 firms and 480 monthly observations. Panel A reports the histogram of the slope for the new issues dummy (*ISSUE*) from the Fama-MacBeth (1973) monthly cross-sectional regressions of percentage stock returns: $r_{jt+1} = b_0 + b_1 ISSUE_{jt} + e_{jt+1}$. r_{jt+1} is the percentage stock return of firm j during month t. $ISSUE_{jt}$ is a dummy variable that equals one if firm j has conducted equity offerings at least once within the past 60 months preceding month t, and zero otherwise. Panel B reports the histogram of the *ISSUE* slope from the monthly cross-sectional regressions: $r_{jt+1} = b_0 + b_1 \log(ME_{jt}) + b_2 \log(BM_{jt}) + b_3 ISSUE_{jt} + u_{jt+1}$, in which ME_{jt} is the market capitalization of firm j at the most recent fiscal year-end prior to month t, and BM_{jt} is the book value of equity divided by the market capitalization of firm j at the most recent fiscal year-end prior to month t. Panel B reports the results with the full sample. We also split each simulated sample into two: The light-volume sample contains the months with the fraction of issuing firms below the median fraction across all the months in the sample, and the heavy-volume sample contains the months with the fraction of issuing firms above its median. Panel C reports the histogram of the *ISSUE* slope using the light-volume sample, and panel D reports the histogram of the *ISSUE* slope using the heavy-volume sample. In each panel, we also report the corresponding *ISSUE* slope estimated by Loughran and Ritter (1995) using the real data. (A) The *ISSUE* slope in univariate regressions; (B) The *ISSUE* slope in multiple regressions (all months); (C) The *ISSUE* slope in multiple regressions (light volume); (D) The *ISSUE* slope in multiple regressions (heavy volume).

procedure follows that of Loughran and Ritter (see Appendix B.2 for details). We consider four operating performance measures: (i) operating income before depreciation scaled by assets, measured as π_{jt}/k_{jt} in the model; (ii) profitability, $(k_{jt+1} - k_{jt} + o_{jt})/k_{jt}$ from the clean surplus relation; (iii) investment-to-assets, i_{jt}/k_{jt}; and (iv) market-to-book, p_{jt}/k_{jt}.

Table 4
Median operating performance measures and market-to-book for issuers and matching non-issuers

Event year	Operating income-to-assets (%)		Profitability (%)		Investment-to-assets (%)		Market-to-book	
	Data	Model	Data	Model	Data	Model	Data	Model
				Panel A: Issuer medians				
−4	16.1	26.0	5.8	12.7	8.2	0.6	1.20	1.45
−3	16.6	26.9	6.0	16.0	8.5	1.8	1.42	1.54
−2	16.4	28.5	6.0	19.6	9.9	7.0	1.59	1.77
−1	17.0	30.1	6.4	23.4	10.2	13.5	2.40	1.95
0	15.8	27.8	6.3	27.2	10.0	23.1	1.96	2.48
+1	14.2	25.8	5.3	15.7	10.6	23.4	1.68	2.22
+2	12.7	24.5	3.9	13.1	9.3	19.2	1.65	2.09
+3	12.1	23.6	3.3	13.3	8.7	16.6	1.58	2.00
+4	12.1	23.0	3.2	13.1	8.1	14.7	1.43	1.97
				Panel B: Nonissuer medians				
−4	16.4	25.5	6.1	9.9	5.0	3.5	1.04	1.48
−3	15.6	25.8	5.8	12.2	5.4	1.3	1.12	1.45
−2	15.4	26.3	5.3	14.0	5.6	0.6	1.19	1.45
−1	15.1	27.0	5.5	15.7	5.7	1.2	1.30	1.48
0	15.8	27.8	5.7	17.4	5.9	3.0	1.45	1.55
+1	15.2	26.8	5.3	19.7	6.5	6.4	1.41	1.69
+2	14.1	25.6	4.8	18.3	6.5	10.1	1.43	1.81
+3	13.8	24.8	4.6	16.3	6.6	12.0	1.48	1.86
+4	13.5	24.2	4.2	15.8	6.6	13.4	1.44	1.91
			Panel C: Z-statistics testing the equality of distributions between the issuers and matching nonissuers					
−4	−0.92	−0.03	−2.10	4.84	12.00	−8.26	3.65	−4.14
−3	2.87	−2.74	1.12	9.36	13.69	3.71	5.64	10.41
−2	4.73	−7.48	3.42	15.40	16.16	23.56	8.87	32.07
−1	7.68	−14.69	6.58	23.56	17.10	43.96	16.98	42.53
0	−1.06	−49.80	6.50	32.77	15.46	49.58	10.36	47.56
+1	−3.02	5.65	0.35	−13.83	14.55	40.27	7.52	26.60
+2	−5.29	4.92	−5.26	−16.29	11.24	20.57	4.11	11.81
+3	−5.40	4.90	−6.58	−8.70	8.64	8.81	1.74	1.44
+4	−4.43	4.64	−5.76	−7.54	7.91	0.63	−0.51	−0.85
			Panel D: Z-statistics testing the equality of distributions between the change in the ratios from year 0 to year +4					
0 to +4	−4.59	−5.09	−5.57	−7.46	−5.96	59.25	−8.52	45.70

Panels A and B report the median operating performance measures for the issuing and matching firms, respectively. Panels C and D report the Z-statistics testing the equality of distributions between the issuers and matching nonissuers using the Wilcoxon matched-pairs signed-ranks test (see Appendix B.2 for details). We simulate 1000 artificial panels, each of which has 5000 firms and 480 monthly observations. The monthly flow variables are aggregated within a given year to create annual variables. Stock variables are measured at the beginning of the year. We perform the tests on each simulated panel and report the cross-simulations averaged results. We also compare our results to those of Loughran and Ritter (1997, Table II).

Table 4 reports the details. Consistent with Loughran and Ritter (1997), issuers in the model experience post-issue deterioration in the operating performance. After equity issuance, the operating income-to-assets and profitability of issuers become significantly lower than those of nonissuers. Issuers also have significantly higher investment-to-assets and market-to-book than matching nonissuers. However, the model-implied operating income-to-assets and profitability are higher than those observed in the data. A possible reason is that capital in the model corresponds to the fixed assets that are only part of the total assets in the data.

What drives the deteriorating accounting performance of firms after issuing equity? Intuitively, firm-level profitability in the model is driven by the persistent and mean-reverting firm-specific productivity given by Equation (2). *Ex post*, issuers tend to be firms that have recently experienced relatively high firm-specific shocks, ε^z_{jt+1}. But going forward, issuers face the same conditional, standard normal distribution of the shocks as other firms do. When we as econometricians look back at the historical sample, we are likely to observe the mean-reverting behavior in the firm-specific productivity, z_{jt}. Further, the more extreme the shocks on z_{jt} prior to equity issuance, the faster the speed of mean-reversion afterward that we are likely to observe.

3.5 Long-term stock-price performance following cash distributions
Firms raising capital underperform matching firms in the future three to five years. But when firms distribute cash back to shareholders, they outperform matching firms. Ikenberry, Lakonishok, and Vermaelen (1995) show that the average abnormal four-year buy-and-hold return after the announcements of open market share repurchases is 12.1% in 1980–1990. Further, the average abnormal return is 45.3% for value firms, but is insignificantly negative for growth firms. Similarly, Michaely, Thaler, and Womack (1995) show that stock prices continue to drift in the same direction in the years following the announcements of dividend initiations and omissions.

We aim to replicate Tables 3 and 4 in Ikenberry, Lakonishok, and Vermaelen (1995) using our simulated panels. We identify firms with positive dividends in the model as those conducting stock repurchases in the data. As noted, the model pins down only the total amount of payout, not its specific forms: The Miller-Modigliani (1961) dividend irrelevancy theorem holds in our model. We report mean annual returns from buying the equal-weighted portfolio of repurchasing firms, beginning in the month following the repurchase and for the subsequent four years. We also report total compounded returns for up to four years, and compare the returns of the cash distributing firms to the returns of the reference portfolio. Finally, we examine these annual buy-and-hold returns and compounded holding-period returns by book-to-market quintiles. We follow closely Ikenberry et al. (1995) in forming the reference portfolio (see Appendix B.3 for details).

Although qualitatively going in the right direction, the model cannot fully explain the magnitude of the positive long-term stock-price drift following cash distributions. Panel A of Table 5 reports annual buy-and-hold returns and compounded holding period returns up to four years following share repurchases. The model predicts that cash-distributing firms indeed earn higher average returns than nondistributing firms. But the magnitude of the average return differences in the simulated data is in general lower than that in the data.

Figure 5 reports the empirical distributions for the differences in annual buy-and-hold returns up to four years between the repurchase portfolio and its reference portfolio. The empirical estimates for the first three post-formation

Table 5
Annual buy-and-hold returns and compounded holding period returns up to four years following market share repurchases, the full sample and the subsamples by book-to-market quintiles

	Annual buy-and-hold returns						Compounded holding-period returns					
	Repurchase firms		Reference portfolio		Difference		Repurchase firms		Reference portfolio		Difference	
	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model
						Panel A: All firms						
Year 1	20.80	10.49	18.76	9.74	2.04	0.75	20.80	10.49	18.76	9.74	2.04	0.75
Year 2	18.12	8.85	15.81	8.61	2.31	0.24	42.69	19.30	37.53	18.23	5.16	1.06
Year 3	21.77	8.21	17.18	8.06	4.59	0.14	73.75	27.77	61.15	26.29	12.60	1.48
Year 4	8.56	7.85	9.51	7.73	−0.96	0.11	88.62	36.37	76.48	34.25	12.14	2.12
					Panel B: Book-to-market quintile 1 (growth stocks)							
Year 1	15.72	11.10	16.83	10.38	−1.11	0.73	15.72	11.10	16.83	10.38	−1.11	0.73
Year 2	17.86	9.86	16.60	9.73	1.26	0.13	36.40	21.25	36.22	20.30	0.18	0.95
Year 3	12.00	9.46	13.61	9.36	−1.61	0.10	52.77	31.60	52.77	30.28	−1.98	1.31
Year 4	4.98	9.12	6.42	9.03	−1.44	0.09	60.38	42.35	60.38	40.41	−4.31	1.94
						Panel C: Book-to-market quintile 2						
Year 1	20.59	10.95	18.43	10.26	2.16	0.69	20.59	10.95	18.43	10.26	2.16	0.69
Year 2	12.34	9.45	15.07	9.30	−2.73	0.15	35.47	20.50	36.28	19.57	−0.81	0.93
Year 3	22.39	8.89	17.29	8.77	5.10	0.11	65.80	29.89	59.84	28.57	5.96	1.33
Year 4	3.20	8.50	6.99	8.40	−3.79	0.10	71.10	39.49	71.02	37.50	0.08	1.99
						Panel D: Book-to-market quintile 3						
Year 1	19.49	10.85	16.46	10.23	3.03	0.62	19.49	10.85	16.46	10.23	3.03	0.62
Year 2	18.23	9.18	17.33	8.99	0.90	0.18	41.27	20.00	36.64	19.10	4.63	0.90
Year 3	20.77	8.51	16.57	8.37	4.20	0.14	70.61	28.79	59.29	27.46	11.32	1.34
Year 4	7.45	8.06	10.35	7.94	−2.90	0.12	83.32	37.64	75.78	35.62	7.54	2.02

Table 5
(Continued)

	Annual buy-and-hold returns						Compounded holding-period returns					
	Repurchase firms		Reference portfolio		Difference		Repurchase firms		Reference portfolio		Difference	
	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model
	Panel E: Book-to-market quintile 4											
Year 1	23.43	10.72	22.84	10.08	0.59	0.64	23.43	10.72	22.84	10.08	0.59	0.64
Year 2	15.16	8.85	12.73	8.64	2.43	0.21	42.14	19.45	38.48	18.50	3.66	0.95
Year 3	24.05	8.06	18.32	7.91	5.73	0.15	76.32	27.60	63.85	26.21	12.47	1.39
Year 4	12.44	7.60	11.06	7.48	1.38	0.13	98.24	35.73	81.97	33.66	16.27	2.07
	Panel F: Book-to-market quintile 5 (value stocks)											
Year 1	24.15	10.42	19.49	9.58	4.66	0.83	24.15	10.42	19.49	9.58	4.66	0.83
Year 2	26.01	8.29	17.23	7.98	8.78	0.31	56.44	18.50	40.08	17.27	6.36	1.23
Year 3	29.81	7.35	20.49	7.17	9.32	0.18	103.07	25.79	68.78	24.11	34.29	1.68
Year 4	16.17	6.88	12.94	6.75	3.23	0.13	135.91	32.96	90.62	30.64	45.29	2.32

This table reports annual and compounded buy-and-hold percentage returns following share repurchases for up to four years. Panel A reports the results using the full sample, and Panels B–F report the results by book-to-market quintile ranking. Compounded holding-period returns assume annual rebalancing. We form equally weighted portfolios for the whole sample. We construct the reference portfolio using benchmark returns corresponding to the repurchase sample, matched on the basis of size and book-to-market ranking. To form the reference portfolio, we sort all firms in our simulated panel each month into one of 50 size and book-to-market portfolios (the intersections of ten size deciles and five book-to-market quintiles). We rank all firms in the beginning of the calendar year and hold them for the following 12 months. Beginning in the next month, we calculate the one-year buy-and-hold return for each firm in a given portfolio. We then use the equally weighted average of all annual returns in a given portfolio as the benchmark returns for firms ranked in that particular size and book-to-market portfolio. We rebalance the portfolio annually. We simulate 1,000 artificial panels, each of which has 5,000 firms and 480 monthly observations. We perform the empirical analysis on each simulated panel and report the cross-simulations averaged results. We also compare our results to those reported in Ikenberry, Lakonishok, and Vermaelen (1995, Tables 3 and 4).
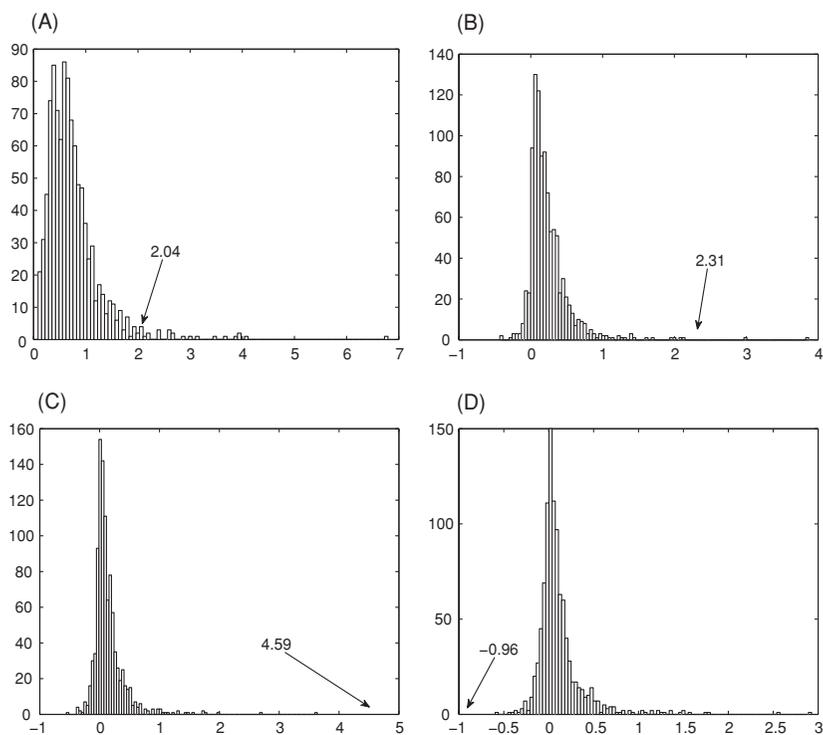
Figure 5
Empirical distributions for the differences in annual buy-and-hold returns up to four years between the repurchase portfolio and the reference portfolio.
We simulate 1000 artificial panels, each of which has 5000 firms and 480 monthly observations. In each simulation, we construct the reference portfolio using benchmark returns corresponding to the repurchase sample, matched on the basis of size and book-to-market ranking. To form the reference portfolio, we sort all firms in our simulated panel into one of 50 size and book-to-market portfolios (the intersections of ten size deciles and five book-to-market quintiles). We rank all firms in the beginning of the calendar year and hold them for the following 12 months. Beginning in the next month, we calculate the one-year buy-and-hold return for each firm in a given portfolio. We then use the equal-weighted average of all annual returns in a given portfolio as the benchmark returns for firms ranked in that particular size and book-to-market portfolio. We rebalance the portfolio annually. We perform the empirical analysis on each simulated panel and report the histogram of the difference in annual buy-and-hold returns up to four years between the repurchase portfolio and the reference portfolio. The empirical estimates from Ikenberry, Lakonishok, and Vermaelen (1995, Table 3) are also reported in each panel. (A) Difference in annual buy-and-hold returns (Year 1); (B) Difference in annual buy-and-hold returns (Year 2); (C) Difference in annual buy-and-hold returns (Year 3); (D) Difference in annual buy-and-hold returns (Year 4).

years are in the right tails of their corresponding simulated distributions (p-values $= 0.025$, 0.002, and 0, respectively). The empirical estimate for the fourth year is in the extreme left tail of its empirical distribution (p-value $= 1$). Further, panels B–F in Table 5 report that the magnitude of the long-run stock-price drift following cash distribution also is higher in value firms than that in growth firms in the model. However, the magnitude of the drift in the model is again lower than that in the data.

3.6 Long-term operating performance following cash distributions

Using data of announcements of open market share repurchases from 1981 to 2000, Lie (2005) finds that, relative to industry peers, firms that announce repurchases exhibit superior operating performance, but the performance declines following the announcements.

We replicate Lie's (2005) Table 3 by examining both unadjusted and adjusted operating performance around announcements of share repurchases. Unadjusted performance is the operating performance for the cash-distributing firms. We measure operating performance in the model as operating profits scaled by capital, π_{jt}/k_{jt}. Adjusted performance is the unadjusted performance less the performance for control firms. Following Lie, we use two sets of control firms. The first set consists of firms that are similar in book value of assets. We choose as the control firm the firm that has capital closest to that of the cash-distributing firm. The second set consists of firms that have similar pre-event performance characteristics and market-to-book (see Appendix B.4 for details).

Table 6 reports the results. The unadjusted performance displays deteriorations in performance from the announcement quarter to future quarters. The mean change of performance from quarter 0 to +4 is −0.40% in the data and −0.41% in the model. The industry-adjusted performance shows that, both in the data and in the model, cash-distributing firms perform better than their respective peers before and after the announcements. Moreover, the superior performance tends to diminish over time, suggesting that operating performance mean-reverts.

The model fails to reproduce the empirical pattern that the changes in performance-adjusted performance from quarter 0 to future quarters show significant improvements. The mean and median changes from quarter 0 to quarter +4 are 0.21% and 0.12% in the data, respectively. Lie (2005) interprets this evidence as suggesting that cash-distributing firms exhibit performance improvements relative to pre-event expectations. Because the firm-specific productivity is the primary source of firm heterogeneity, matching on pre-event performance adequately captures the expected decline in performance. As a result, the performance-adjusted performance for cash-distributing firms in the model is close to zero in magnitude.

4. Connection to the Literature

What drives the external financing anomalies? Our goal in this section is not to refute existing explanations of the anomalies but to show that our investment-based explanation differs in fundamental ways.

There are three leading explanations for the external financing anomalies. First, behavioral market timing argues that managers can create value for existing shareholders by timing financing decisions to exploit mispricing in inefficient markets. And investors underreact to the pricing implications of

Table 6
Quarterly operating performance around cash distributions

Quarter	Unadjusted				Industry-adjusted				Performance-adjusted			
	Mean		Median		Mean		Median		Mean		Median	
	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model
					Panel A: Levels of operating performance							
−2	0.0514	0.0709	0.0469	0.0671	0.0181	0.0550	0.0081	0.0514	0.0008	0.0054	0.0005	0.0041
−1	0.0488	0.0687	0.0455	0.0647	0.0156	0.0494	0.0072	0.0457	0.0006	0.0025	0.0003	0.0017
0	0.0462	0.0665	0.0442	0.0625	0.0144	0.0436	0.0065	0.0398	0.0002	0.0007	0.0000	0.0005
1	0.0450	0.0651	0.0434	0.0611	0.0146	0.0392	0.0063	0.0354	0.0017	0.0004	0.0007	−0.0001
2	0.0441	0.0641	0.0428	0.0601	0.0141	0.0354	0.0056	0.0317	0.0028	0.0002	0.0013	−0.0002
3	0.0430	0.0632	0.0419	0.0593	0.0114	0.0319	0.0046	0.0282	0.0019	0.0000	0.0012	−0.0004
4	0.0426	0.0624	0.0415	0.0585	0.0117	0.0287	0.0048	0.0251	0.0021	−0.0002	0.0014	−0.0005
5	0.0421	0.0617	0.0416	0.0579	0.0107	0.0259	0.0051	0.0223	0.0034	−0.0002	0.0017	−0.0006
6	0.0408	0.0611	0.0416	0.0573	0.0088	0.0232	0.0044	0.0196	0.0026	−0.0003	0.0016	−0.0006
7	0.0403	0.0606	0.0409	0.0568	0.0079	0.0207	0.0045	0.0171	0.0041	−0.0004	0.0016	−0.0008
8	0.0398	0.0602	0.0404	0.0564	0.0079	0.0184	0.0048	0.0148	0.0037	−0.0005	0.0018	−0.0009
					Panel B: Changes in operating performance							
0 to +1	−0.0011	−0.0014	−0.0003	−0.0013	−0.0004	−0.0044	−0.0002	−0.0044	0.0016	−0.0003	0.0005	−0.0006
0 to +2	−0.0024	−0.0024	−0.0006	−0.0023	−0.0006	−0.0082	−0.0007	−0.0081	0.0028	−0.0005	0.0013	−0.0008
0 to +4	−0.0040	−0.0041	−0.0013	−0.0039	−0.0027	−0.0149	−0.0013	−0.0147	0.0021	−0.0009	0.0012	−0.0011
0 to +8	−0.0075	−0.0063	−0.0031	−0.0061	−0.0049	−0.0252	−0.0010	−0.0250	0.0035	−0.0013	0.0016	−0.0014

This table reports levels of and changes in quarterly operating performance around announcements of cash distributions. In the model, operating performance is measured as operating income scaled by assets, π_{it}/k_{jt}, at the beginning and end of the fiscal quarter. Quarter 0 is the fiscal quarter of the announcement. Industry-adjusted operating performance is the paired difference between the operating performance of the sample firms and the operating performance of their respective industry- and size-matched control firms. Performance-adjusted operating performance is the paired difference between the operating performance of the sample firms and the operating performance of their respective industry-, performance-, and market-to-book-matched control firms. We simulate 1000 artificial panels, each of which has 5000 firms and 480 monthly observations. We perform the empirical analysis on each simulated panel and report the cross-simulations averaged results. We also compare our results with those reported in Lie (2005, Table 3).

market timing, generating long-term drifts following these corporate events (e.g., Ritter 1991; Loughran and Ritter 1995; Spiess and Affleck-Graves 1995). Second, inadequate risk adjustment argues that the anomalies arise because empirical expected-return models are misspecified (e.g., Brav, Geczy, and Gompers 2000; Eckbo, Masulis, and Norli 2000; Lyandres, Sun, and Zhang 2008). Third, pseudo-market timing (e.g., Schultz 2003) argues that event studies tend to find long-term underperformance *ex post*, even though there is no underperformance *ex ante*. If, early in a sample period, issuers underperform, there will be few equity issues in the future because investors would have lower demands for them. The average performance will be weighed more toward the early issues that underperformed. If early issuers outperform, there will be more equity issues in the future. The early positive performance will be weighed less in the average performance. Weighing each period equally as in calendar-time factor regressions solves this problem.

While sympathetic to the idea of managerial market timing (e.g., Graham and Harvey 2001), we argue that investor underreaction is unlikely to be the main driving force of the external financing anomalies. From the evidence that the announcement effects and the long-term drifts following equity offerings are both negative in the U.S. data, it appears that investors underreact to equity offerings. However, the announcement effects of private placements of equity and bank loan announcements in the U.S. as well as seasoned equity offerings in Japan are all positive, going in the opposite direction as their negative long-term drifts (e.g., Kang, Kim, and Stulz 1999; Hertzel et al. 2002; Billett, Flannery, and Garfinkel 2006). This evidence suggests overreaction.

This logic inconsistency does not exist in our neoclassical model. Intuitively, from the flow of funds constraint, firms raising capital should invest more and earn lower expected returns, and firms distributing capital should invest less and earn higher expected returns. More likely, short-term and long-term stock price movements are driven by different economic forces, with short-term movements driven by asymmetric information and long-term movements driven by time-varying expected returns related to capital investment. Equity offerings in the U.S. are likely to signal negative news such as insufficient internal funds and the intrinsic value (based on unobservable private signals) being lower than the market value (based on observable public signals). But private placements of equity and bank loans are likely to signal positive news because large block shareholders and banks, from their ongoing repeated relationships with the firms, possess information advantage and can monitor the operations of the firms. Further, because of the main bank system in Japan, equity shares in that country are held mostly by banks and other large institutional investors.

Our theoretical work provides the microfoundation for explanations based on inadequate risk adjustment. Brav, Geczy, and Gompers (2000) document that the underperformance following seasoned equity offerings is concentrated primarily in small-growth firms and suggest that the underperformance reflects

the more pervasive size and value effects in returns. We lend support to their argument because both equity issuers and small-growth firms invest more than other firms. Eckbo, Masulis, and Norli (2000) report that a multifactor model can reduce the post-issue underperformance to insignificance. Our investment mechanism can potentially drive their risk evidence. Lyandres, Sun, and Zhang (2008) show that adding an investment factor into standard calendar-time factor regressions substantially reduces the magnitude of the new issues puzzle. Our work provides the theoretical foundation for their empirical tests.

We also provide an economic explanation for Schultz's (2003) premise that firms are more likely to issue when stock prices are high. We show that equity financing is highly procyclical: Firms invest more and naturally issue more equity in expansions when stock prices are high. More important, our investment-based explanation applies to calendar-time as well as event-time evidence.

5. Conclusion

Our quantitative results suggest that q-theory is a good start to understanding external financing anomalies that are often interpreted as behavioral market timing. However, our simple model leaves many questions unanswered. We conclude by suggesting several directions for future work.

A dynamic structure of payout policy that characterizes the trade-offs between dividends and share repurchases can be incorporated into the neoclassical investment framework. Our simple model cannot fully capture the magnitude of the positive drift following cash distributions observed in the data. The most likely reason is that distributing capital is costless in our model. This assumption is unrealistic because dividends are highly persistent in the data, meaning that adjusting dividends must be quite costly. While adding capital distribution costs into our current setup can help, at least mechanically, a more satisfactory solution would be to thoroughly model the trade-offs underlying the payout policy.

The neoclassical investment model also can be extended to incorporate defaultable bond. The extended model can address the issue of time-series predictability with the new equity share (the ratio of common stock issues to the sum of common stock and bond issues in dollar volume per month). Baker and Wurgler (2000) document that the new equity share is a strong negative predictor of future stock market returns. Our results on procyclical equity issuance waves are encouraging, but a serious investigation of the time-series predictability with the new equity share requires a dynamic model of debt financing. The extended model also can shed light on why the magnitude of the long-term underperformance following equity issues is higher than that following debt issues and why we observe significant positive stock-price drift following capital distributions to shareholders but not to bondholders. Finally, the extended model can shed light on the puzzling negative relation between

financial distress and average stock returns (e.g., Dichev 1998 and Campbell, Hilscher, and Szilagyi 2008) and the credit-spread puzzle (e.g., Huang and Huang 2003).

Appendix A: Computation

To solve the dynamic value-maximization problem given in Equation (12), we use the value function iteration method on a discrete state space described by Burnside (1999). We use a grid with 50 points for the capital stock with an upper bound $\bar{k}$. The upper bound is large enough to be nonbinding at all times. We construct the grid for capital stock recursively, following McGrattan (1999): $k_i = k_{i-1} + c_{k1} \exp(c_{k2}(i-2))$, where $i = 1, \ldots, 50$ is the index of grid points and c_{k1} and c_{k2} are two constants chosen to provide the desired number of grid points and $\bar{k}$, given a pre-specified lower bound $\underline{k}$. This recursive construction assigns more grid points around $\underline{k}$, where the value function has most of its curvature. The state variables x and z in Equations (1) and (2), respectively, are defined on continuous state spaces. To compute the numerical solution to the model, we need to transform the continuous state spaces into discrete state spaces. Because both productivity processes are highly persistent in monthly frequency, we use the method described in Rouwenhorst (1995). We use 15 grid points for x process and 17 points for z process. In all cases our quantitative results are robust to finer grids.

Once the discrete state space is available, the conditional expectation operator in Equation (12) can be carried out as matrix multiplication. We calculate expected returns, $E_t[r_{jt+1}] = E_t[v_{jt+1}]/(v_{jt} - o_{jt})$, in the same way. Once expected returns are calculated, we can back out true betas, β_{jt}, from Equation (14). To this end, we solve the real interest rate, r_{ft}, and the price of risk, ζ_{mt}, on a grid of x_t based on Equations (4) and (5). We use piecewise linear interpolation extensively to obtain firm value, optimal investment, and expected returns that do not lie directly on the grid points. Finally, we maximize the right-hand side of the value function (12) by computing the objective function on an even-spaced grid of k, with boundary $[\underline{k}, \bar{k}]$ with 20,000 points.

Appendix B: Empirical Procedures

B.1 Calculating characteristic-adjusted excess returns for the corporate investment portfolios

To calculate the characteristic-adjusted excess returns of the *CI* portfolios, we follow Titman, Wei, and Xie (2004). We form 125 benchmark portfolios that capture these characteristics. Starting in year t, the universe of common stocks is sorted into five portfolios based on firm size at the end of year $t-1$. The breakpoints for size are obtained by sorting all firms into quintiles based on their size measures at the end of year $t-1$ in ascending order. Firms in each size portfolio are further sorted into quintiles based on their book-to-market ratio at the end of year $t-1$. Finally, the firms in each of the 25 size and book-to-market portfolios are sorted into quintiles based on their prior-year return. In all, we obtain 125 benchmark portfolios. We calculate excess returns using these 125 characteristic-based benchmark portfolios. Each year, each stock is assigned to a benchmark portfolio according to its rank based on size, book-to-market, and prior returns. Excess monthly returns of a stock are then calculated by subtracting the returns of the corresponding benchmark portfolio from the returns of this particular stock. The excess returns on individual stocks are then used to calculate the value-weighted excess monthly returns on the test portfolios formed on *CI*.

B.2 Matching issuers with nonissuers

Following Loughran and Ritter (1997), we choose matching nonissuers by matching each issuing firm with a firm that has not issued equity during the prior five years. If there is at least one

nonissuer with end-of-year zero assets within 25%–200% of the issuing firm, the nonissuer with the closest operating income-to-asset ratio is used. In the real data, if no nonissuer meets this criterion, Loughran and Ritter (1997) then rank all nonissuers with year 0 assets of 90%–110% of the issuer, and the firm with the closest, but higher, operating income-to-asset ratio is used. Because we do not distinguish different industries in the model, we use the 25%–200% restriction on end-of-year zero assets to choose matching nonissuer.

We also report the Z-statistics testing the equality of distributions between the issuers and nonissuers using the Wilcoxon matched-pairs signed-ranks test, and the Z-statistics testing the equality of distributions between the changes in the ratios from year 0 to year +4. Denote the difference in the accounting measure between issuer i and its matching firm by $\text{diff}_i \equiv \text{measure}$ (issuer$_i$)$-$ measure(nonissuer$_i$). We rank the absolute values of the diff$_i$ from 1 to the total number of issuing firms, denoted n^e. We then sum the ranks of positive values of diff$_i$, and denote the sum with D. The Z-statistics are computed as $Z = (D - \text{E}[D])/\sigma_D$, where $E[D] = n^e(n^e + 1)/4$ and $\sigma_D = n^e(n^e + 1)(2n^e + 1)/24$. Under the null hypothesis that the issuer and the nonissuer measures are drawn from the same distribution, Z follows the standard normal distribution.

B.3 Constructing the reference portfolios for cash-distributing firms

Following Ikenberry, Lakonishok, and Vermaelen (1995), we sort all firms in our simulated panel each month into one of 50 size and book-to-market portfolios by taking the intersections of ten size deciles and five book-to-market quintiles. All firms are ranked at the beginning of the calendar year, and are held for the following 12 months. Beginning in the next month, the one-year buy-and-hold return is calculated for each firm in a given portfolio. We use the equally weighted average of all annual returns in a given portfolio as the benchmark return for the firms ranked in that particular size and book-to-market portfolio. The ranking of a particular firm may change from year to year. To accommodate this feature, we allow the benchmark to change over time. To examine annual buy-and-hold returns and compounded holding-period returns by book-to-market quintiles, we rank all firms into size deciles, and further sort each decile into book-to-market quintiles. The lowest book-to-market ratios are assigned to quintile one. We form the reference portfolio using benchmark returns corresponding to the repurchase sample, matched on size and book-to-market.

B.4 Construction of the control firms following Lie (2005)

For each cash-distributing firm, we first identify all firms with operating performance within $\pm 20\%$ of the performance of the cash-distributing firm in the announcement quarter (quarter 0), operating performance for the four quarters ending with the quarter 0 within $\pm 20\%$ of the corresponding performance for the cash-distributing firm, and pre-announcement market-to-book value of assets within $\pm 20\%$ of that of the cash-distributing firm. From these firms indexed by i, we choose the firm with the lowest sum of absolute differences, defined as

$$|\text{Performance}_{\text{Quarter 0, Cash-Distributing firm}} - \text{Performance}_{\text{Quarter 0,Firm } i}|$$
$$+ |\text{Performance}_{\text{Four quarters ending with quarter 0, Cash-Distributing firm}} -$$
$$\text{Performance}_{\text{Four quarters ending with quarter 0, Firm } i}|.$$

References

Altinkilic, O., and R. S. Hansen. 2000. Are There Economies of Scale in Underwriting Fees? Evidence of Rising External Financing Costs. *Review of Financial Studies* 13:191–218.

Baker, M., and J. Wurgler. 2000. The Equity Share in New Issues and Aggregate Stock Returns. *Journal of Finance* 55:2219–57.

Banz, R. W. 1981. The Relationship between Return and Market Value of Common Stocks. *Journal of Financial Economics* 9:3–18.

Barclay, M. J., C. W. Smith, and R. L. Watts. 1995. The Determinants of Corporate Leverage and Dividend Policies. *Journal of Applied Corporate Finance* 7:4–19.

Billett, M. T., M. J. Flannery, and J. A. Garfinkel. 2006. Are Bank Loans Special? Evidence on the Post-Announcement Performance of Bank Borrowers. *Journal of Financial and Quantitative Analysis* 41:733–51.

Brav, A., C. Geczy, and P. A. Gompers. 2000. Is the Abnormal Return following Equity Issuances Anomalous? *Journal of Financial Economics* 56:209–49.

Burnside, C. 1999. Discrete State-Space Methods for the Study of Dynamic Economics. In Ramon Marimon and Andrew Scott (eds.), *Computational Methods for the Study of Dynamic Economies*. Oxford: Oxford University Press.

Campbell, J. Y., and J. H. Cochrane. 1999. By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior. *Journal of Political Economy* 107:205–51.

Campbell, J. Y., J. Hilscher, and J. Szilagyi. 2008. In Search of Distress Risk. *Journal of Finance* 63:2899–939.

Campbell, J. Y., A. W. Lo, and A. C. MacKinlay. 1997. *The Econometrics of Financial Markets*. Princeton, NJ: Princeton University Press.

Carlson, M., A. Fisher, and R. Giammarino. 2004. Corporate Investment and Asset Price Dynamics: Implications for the Cross Section of Returns. *Journal of Finance* 59:2577–603.

Carlson, M., A. Fisher, and R. Giammarino. 2006. Corporate Investment and Asset Price Dynamics: Implications for SEO Event Studies and Long-Run Performance. *Journal of Finance* 61:1009–34.

Choe, H., R. W. Masulis, and V. Nanda. 1993. Common Stock Offerings across the Business Cycle: Theory and Evidence. *Journal of Empirical Finance* 1:3–31.

Cochrane, J. H. 1991. Production-Based Asset Pricing and the Link between Stock Returns and Economic Fluctuations. *Journal of Finance* 46:209–37.

Cochrane, J. H. 1996. A Cross-Sectional Test of an Investment-Based Asset Pricing Model. *Journal of Political Economy* 104:572–621.

Cochrane, J. H. 2001. *Asset Pricing*. Princeton, NJ: Princeton University Press.

Cooley, T. F., and E. C. Prescott. 1995. Economic Growth and Business Cycles. In Thomas F. Cooley (ed.), *Frontiers of Business Cycle Research*. Princeton, NJ: Princeton University Press.

Cooper, R., and J. Ejarque. 2001. Exhuming *Q*: Market Power vs. Capital Market Imperfections. Working Paper #8182, NBER.

Dichev, I. 1998. Is the Risk of Bankruptcy a Systematic Risk? *Journal of Finance* 53:1141–48.

Eckbo, B. E., R. W. Masulis, and Ø. Norli. 2000. Seasoned Public Offerings: Resolution of the "New Issues Puzzle." *Journal of Financial Economics* 56:251–91.

Evans, D. S. 1987. The Relationship between Firm Growth, Size, and Age: Estimates for 100 Manufacturing Industries. *Journal of Industrial Economics* 35:567–81.

Fama, E. F., and K. R. French. 1992. The Cross-Section of Expected Stock Returns. *Journal of Finance* 47:427–65.

Fama, E. F., and K. R. French. 1995. Size and Book-to-Market Factors in Earnings and Returns. *Journal of Finance* 50:131–55.

Fama, E. F., and K. R. French. 2000. Forecasting Profitability and Earnings. *Journal of Business* 73:161–75.

Fama, E. F., and K. R. French. 2005. Financing Decisions: Who Issues Stocks? *Journal of Financial Economics* 76:549–82.

Fama, E. F., and K. R. French. 2006. Profitability, Investment, and Average Returns. *Journal of Financial Economics* 82:491–518.

Fama, E. F., and J. D. MacBeth. 1973. Risk, Return, and Equilibrium: Empirical Tests. *Journal of Political Economy* 81:607–36.

Gomes, J. F. 2001. Financing Investment. *American Economic Review* 90:1263–85.

Gomes, J. F., L. Kogan, and L. Zhang. 2003. Equilibrium Cross Section of Returns. *Journal of Political Economy* 111:693–732.

Graham, J. R., and C. R. Harvey. 2001. The Theory and Practice of Corporate Finance: Evidence from the Field. *Journal of Financial Economics* 60:187–243.

Hall, B. H. 1987. The Relationship between Firm Size and Firm Growth in the U.S. Manufacturing Sector. *Journal of Industrial Economics* 35:583–606.

Hennessy, C. A., and T. M. Whited. 2005. Debt Dynamics. *Journal of Finance* 60:1129–65.

Hennessy, C. A., and T. M. Whited. 2007. How Costly Is External Financing? Evidence from a Structural Estimation. *Journal of Finance* 62:1705–45.

Hertzel, M., M. Lemmon, J. Linck, and L. Rees. 2002. Long-Run Performance following Private Placements of Equity. *Journal of Finance* 57:2595–617.

Huang, J., and M. Huang. 2003. How Much of Corporate-Treasury Yield Spread Is Due to Credit Risk? A New Calibration Approach. Working Paper, Pennsylvania State University and Cornell University.

Ikenberry, D., J. Lakonishok, and T. Vermaelen. 1995. Market Underreaction to Open Market Share Repurchases. *Journal of Financial Economics* 39:181–208.

Jagannathan, M., C. P. Stephens, and M. S. Weisbach. 2000. Financial Flexibility and the Choice between Dividends and Stock Repurchases. *Journal of Financial Economics* 57:355–84.

Jensen, M. C. 1993. The Modern Industrial Revolution, Exit, and the Failure of Internal Control Systems. *Journal of Finance* 48:831–80.

Kang, J., Y. Kim, and R. M. Stulz. 1999. The Underreaction Hypothesis and the New Issues Puzzle: Evidence from Japan. *Review of Financial Studies* 12:519–34.

Leary, M. T., and M. R. Roberts. 2005. Do Firms Rebalance Their Capital Structures? *Journal of Finance* 60:2575–619.

Lee, I., S. Lochhead, J. R. Ritter, and Q. Zhao. 1996. The Costs of Raising Capital. *Journal of Financial Research* 19:59–74.

Lettau, M., and J. A. Wachter. 2007. Why Is Long-Horizon Equity Less Risky? A Duration-Based Explanation of the Value Premium. *Journal of Finance* 62:55–92.

Lewellen, J., and S. Nagel. 2006. The Conditional CAPM Does Not Explain Asset-Pricing Anomalies. *Journal of Financial Economics* 82:289–314.

Lie, E. 2005. Operating Performance following Open Market Share Repurchase Announcements. *Journal of Accounting and Economics* 39:411–36.

Loughran, T., and J. R. Ritter. 1995. The New Issues Puzzle. *Journal of Finance* 50:23–51.

Loughran, T., and J. R. Ritter. 1997. The Operating Performance of Firms Conducting Seasoned Equity Offerings. *Journal of Finance* 52:1823–50.

Lucas, R. E. 1978. On the Size Distribution of Business Firms. *Bell Journal of Economics* 9:508–23.

Lyandres, E., L. Sun, and L. Zhang. 2008. The New Issues Puzzle: Testing the Investment-Based Explanation. *Review of Financial Studies* 21:2825–55.

McGrattan, E. R. 1999. Application of Weighted Residual Methods to Dynamic Economic Models. In Ramon Marimon and Andrew Scott (eds.), *Computational Methods for the Study of Dynamic Economies*. Oxford: Oxford University Press.

Michaely, R., R. H. Thaler, and K. L. Womack. 1995. Price Reactions to Dividend Initiations and Omissions: Overreaction or Drift? *Journal of Finance* 50:573–608.

Miller, M., and F. Modigliani. 1961. Dividend Policy, Growth, and the Value of Shares. *Journal of Business* 34:411–33.

Miller, M., and M. S. Scholes. 1972. Rate of Return in Relation to Risk: A Reexamination of Some Recent Findings. In Michael C. Jensen (ed.), *Studies in the Theory of Capital Markets*. New York: Praeger.

Pástor, Ľ., and P. Veronesi. 2005. Rational IPO Waves. *Journal of Finance* 60:1713–57.

Pontiff, J., and L. Schall. 1998. Book to Market as a Predictor of Market Returns. *Journal of Financial Economics* 49:141–60.

Richardson, S. A., and R. G. Sloan. 2003. External Financing and Future Stock Returns. Working Paper, University of Pennsylvania.

Ritter, J. R. 1991. The Long-Run Performance of Initial Public Offerings. *Journal of Finance* 46:3–27.

Rouwenhorst, K. G. 1995. Asset Pricing Implications of Equilibrium Business Cycle Models. In Thomas Cooley (ed.), *Frontiers of Business Cycle Research*. Princeton, NJ: Princeton University Press.

Schultz, P. 2003. Pseudo Market Timing and the Long-Run Underperformance of IPOs. *Journal of Finance* 58:483–517.

Smith, C. W. Jr. 1977. Alternative Methods for Raising Capital. *Journal of Financial Economics* 5:273–307.

Spiess, K. D., and J. Affleck-Graves. 1995. Underperformance in Long-Run Stock Returns following Seasoned Equity Offerings. *Journal of Financial Economics* 38:243–67.

Spiess, K. D., and J. Affleck-Graves. 1999. The Long-Run Performance of Stock Returns following Debt Offerings. *Journal of Financial Economics* 54:45–73.

Strebulaev, I. 2007. Do Tests of Capital Structure Theory Mean What They Say? *Journal of Finance* 62:1747–87.

Titman, S., K. C. J. Wei, and F. Xie. 2004. Capital Investments and Stock Returns. *Journal of Financial and Quantitative Analysis* 39:677–700.

Zhang, L. 2005. The Value Premium. *Journal of Finance* 60:67–103.