Which Asset Pricing Model Do Firms Use?
A Revealed Preference Approach

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Abstract

Since firms time the stock market through equity net issuance, the direction of net issuance reveals their net present value calculation and perceived cost of equity. Building on this insight, we develop a test to identify the asset pricing model that most closely aligns with firms' perceived cost of equity based on their net issuance decisions. Our findings show that the CAPM-implied mispricing better explains net issuance decisions compared to other factor models or market multiples. Our results are not driven by issuance related to external financing needs and hold true even for firms with extreme size or value characteristics.

JEL classification: G11, G12, G31, G35

1 Introduction

Understanding how firms perceive their cost of equity is crucial, as it directly influences their investment decisions and resource allocation. Our goal in this paper is to identify which asset pricing model, among a set of candidates, aligns most closely with firms' perceived cost of equity, using the rich data on firms' trading of their own shares through issuance, repurchase, and dividend payouts ("net issuance").

To achieve this goal, we build on the revealed preference approach developed by Berk and Van Binsbergen (2016) (BVB) and Barber, Huang, and Odean (2016) (BHO). According to this approach, economic agents' actions reveal the risk model they likely use to compute net present value (NPV), as they respond to positive NPV opportunities. We adapt their techniques to a setting that reveals firms' NPV calculations: market timing through equity net issuance. Firm managers' valuation of the firm's equity, driven by their perceived cost of equity, may differ from the market price, which reflects the views of outside shareholders. Such a discrepancy reflects a perceived mispricing from the managers' perspective, offering a positive NPV opportunity that may drive equity issuance or repurchase decisions. Equity issuance suggests that managers perceive the firm as overpriced, while repurchases indicate it is viewed as underpriced. Our test examines which risk model best captures managers' perceived cost of equity by evaluating how well the model-implied mispricing aligns with the observed direction of equity net issuance.

Our approach builds on the extensive body of evidence that equity market timing—issuing when shares are overvalued and repurchasing when shares are undervalued—is a primary factor in equity issuance decisions.[1] In a survey of CFOs, Brav et al. (2005) identify misvaluation to be the most important driver of share *repurchase*: "The most popular response for all repurchase questions on the entire survey is that firms repurchase when their stock is a good value, relative to its true value: 86.4% of all firms agree or strongly agree" (p.514). Similarly, Graham and Harvey (2001) identify the magnitude of equity undervaluation/overvaluation to be the second (out of ten) most important factor that influences CFOs' decision to *issue* common equity.[2] Complementing

[1] A large behavioral corporate finance literature on this topic is surveyed by Baker, Ruback, and Wurgler (2007).
[2] 67% of the responses state that misvaluation is a very important or important factor in the decision on issuance.

the survey evidence is that equity issuance is positively related to ex-ante measures of mispricing and predicts subsequent underperformance in stock returns.[3]

We define model-implied mispricing as the percentage difference between the market price of equity and the present value of future dividends computed using the candidate model. We assume that firm managers have rational expectations of future cash flows. This simplifying assumption enables us to measure model-implied mispricing without needing to know their specific cash-flow expectations. We measure model-implied mispricing using three approaches: an ex-post measure based on the identity proposed by Cho and Polk (2024), expressing mispricing in terms of post-issuance realized abnormal returns; a simplified version of the ex-post measure based on cumulative abnormal returns; and an ex-ante measure constructed by projecting mispricing onto firm characteristics.

Applying the revealed preference approach to equity net issuance presents two main challenges. First, a firm's equity net issuance may be influenced by factors other than market timing. In such cases, an asset pricing model that produces NPV estimates more closely aligned with these omitted variables could have an artificial advantage over competing models. To address this concern, we develop a framework to incorporate control variables that serve as proxies for investment opportunities into the BVB method. Furthermore, we follow prior literature (Lamont, Polk, and Saaá-Requejo (2001); Baker, Stein, and Wurgler (2003); Polk and Sapienza (2008)) by restricting our sample to firms that are unlikely to face financial constraints. According to the pecking order theory, such firms are less reliant on equity issuance for financing. We find consistent results using alternative measures of financial constraint provided by Whited and Wu (2006), Kaplan and Zingales (1997), Hadlock and Pierce (2010), and Campello and Graham (2013).

The second issue arises in tests that rely on post-issuance mispricing measures. While a firm's pre-issuance mispricing triggers net issuance, there is concern that equity net issuance could elim-

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This is a close second to the factor identified to be the most important, namely the availability of investment projects (measured by the earnings-per-share dilution post issuance), which 69% of the responses identify as very important or important.

[3]See for example Loughran, Ritter, and Rydqvist (1994); Ikenberry, Lakonishok, and Vermaelen (1995); Ikenberry, Lakonishok, and Vermaelen (1995); Spiess and Affleck-Graves (1995); Hovakimian, Opler, and Titman (2001); and Ritter (2003) among others.

inate or reverse the mispricing, making post-issuance mispricing a poor proxy for pre-issuance mispricing. However, a simple model based on Gilchrist, Himmelberg, and Huberman (2005) justifies using post-issuance mispricing as a valid proxy for pre-issuance mispricing. Intuitively, because a firm acts as a monopolist in the supply of its own shares, optimal corporate arbitrage moves the price closer to, but not all the way to, its intrinsic value. As a result, equity market mispricing persists after share issuance and retains the same sign as the issuance, allowing us to use post-issuance mispricing in our tests.

We conduct a horse race among several well-known single- and multifactor risk models, controlling for firm characteristics that may serve as proxies for investment opportunities, such as the estimated average q. We find that the CAPM consistently outperforms the other models, meaning that firm managers' perceived cost of equity—and, consequently, their net equity issuance decisions—most closely align with the CAPM's predictions. Notably, the CAPM also outperforms the market returns model (with the CAPM beta fixed at one), suggesting that firm managers are able to internalize the CAPM's beta in their perceived cost of equity. Our results complement survey evidence indicating that the CAPM is the most widely used risk model among firm managers (Bruner et al. (1998); Graham and Harvey (2001)). However, our test has the advantage of using actual firm decisions, thereby avoiding the potential issues of misreporting and selection bias in survey-based studies.

We also compare the performance of the CAPM with that of firm valuation models commonly used in the industry, which rely on various market multiples such as the price-to-earnings ratio and the price-to-book ratio. We find that CAPM-implied mispricing significantly outperforms market multiples in predicting the direction of equity issuance.

The rich cross-section offered by the data allows us to see how the results change, if any, depending on the type of firms we look at. We zoom into the firms that strongly load on the size or value risk factors, as these firms would make the largest errors by relying on the the CAPM if the true model of risk includes the size and value factors. Interestingly, CAPM-implied mispricing better explains the direction of equity issuance even for these firms in the highest or lowest size or value quintiles, with the Fama French three factor model being a close contender.

Overall, our results support the idea that firms rely on selective information about their own risk, such as market beta, when making real-world decisions. This finding aligns with Gormsen and Huber (2024), who find that market beta, leverage, and size can explain the variation in perceived cost of capital, with market beta having the largest effect, but overlook other variables that drive actual cost of capital variation.

It is important to clarify a few points. First, as in previous revealed preference studies, differences in estimation errors can influence comparisons among asset pricing models.[4] For example, if CAPM-implied mispricing has smaller estimation errors, the test is more likely to identify the CAPM as the best model. Second, while studies on fund flows assume that only investors trade on positive NPV opportunities, in our setting, both firm managers and investors can influence mispricing—through net issuance and trading, respectively. Our test remains valid in the presence of these two equilibrating mechanisms. A net equity issuance initiated by firm managers indicates that, from their perspective, the firm's equity is mispriced. Since mispricing is not completely eliminated by net issuance (Gilchrist, Himmelberg, and Huberman (2005)), it generates subsequent alphas over a short or long horizon, depending on the intensity of other investors' trading. Third, one may worry that the net issuance itself could change the firm's risk exposures and that this could influence our findings based on post-net-issuance mispricing. However, an optimizing firm would internalize such a change in factor exposures to ensure that, with respect to their asset pricing model, the shares after net issuance remain mispriced in the same direction as before the net issuance.

Finally, Ben-David et al. (2021) show that tests of asset pricing models for mutual fund investors can be sensitive to how observations are weighted across periods, due to time variation in flow-performance sensitivity. Since our test does not rely on investor flows, this issue does not affect our results. Nonetheless, we take two precautions. First, we follow Ben-David et al.'s recommendation to include time fixed effects and use weighted least squares, ensuring that our test coefficient reflects a time-series average of cross-sectional coefficients. We confirm that our

[4] "Consequently, our tests cannot differentiate whether these models underperform because they rely on variables that are difficult to measure, or because the underlying assumptions of these models are flawed" (Berk and Van Binsbergen (2016), p.2)

results are consistent with Fama-MacBeth regressions. Second, we test whether firms use market multiples for net issuance decisions and find that CAPM mispricing better explains net issuance than market multiples.

Our work contributes to the growing literature that uses revealed preferences to infer a risk model used by economic agents. Berk and Van Binsbergen (2016) and Barber, Huang, and Odean (2016) use different empirical methodologies to infer the risk model that investors use to evaluate mutual funds' performance. Agarwal, Green, and Ren (2018) and Blocher and Molyboga (2017) adapt the same methods to hedge funds. All of these studies reach the same conclusion that fund flows are best explained by CAPM alpha. Relatedly, Dessaint et al. (2021) explore the real implications of using the CAPM based on M&A data, and Baker, Hoeyer, and Wurgler (2019) study the effect on financing decisions. Hommel, Landier, and Thesmar (2021) find that the implied cost of capital imputed from comparable firms works better than discount rates inferred from factor models in justifying the actual equity prices. Whereas the paper asks how firms *should* discount cash flows, we ask how firms *do* in fact discount cash flows, especially in the context of net issuance.

Our work is also related to the literature on stock prices and net issuance, although our paper is unique in inferring firms' asset pricing model from the interaction between share prices and net issuance. Jung, Kim, and Stulz (1996) and Hovakimian, Opler, and Titman (2001) find a strong relation between stock prices and seasoned equity offerings. Ritter (1991), Spiess and Affleck-Graves (1995), Loughran and Ritter (1995), and Ritter (2003) use different sample periods and find that IPO firms and equity issuers earn lower average returns over the next five years and high market to book issuers earn even lower returns. Ikenberry, Lakonishok, and Vermaelen (1995) and Ikenberry, Lakonishok, and Vermaelen (2000) show that repurchasers have higher subsequent average returns and that low market-to-book repurchasers earn even higher returns. Pagano, Panetta, and Zingales (1998), Lerner (1994), Loughran, Ritter, and Rydqvist (1994) show that aggregate stock market indexes are positively related to IPO volume.

The rest of the paper is organized as follows. Section 2 presents the theoretical framework. Section 3 describes the data and variable construction. Section 4 conducts the horse race of asset pricing models. Section 5 presents robustness checks and additional analysis. Section 6 concludes.

2 Theoretical framework

Our test in subsequent sections builds on two theoretical results highlighted in this section. First, a financially unconstrained firm issues equity shares to exploit stock market mispricing but does not fully eliminate the mispricing, since the firm is a monopolist in the supply of its own shares. Second, the revealed preference test on asset pricing models can be done while controlling for other variables that could affect the choice variable. Combining the first two results allows us to infer an asset pricing model most likely to be used by firm managers.

2.1 Equity issuance and equilibrium mispricing

A stylized model of stock price bubble and equity issuance based on Gilchrist, Himmelberg, and Huberman (2005) shows that corporate arbitrage does not fully eliminate stock mispricing. This prediction implies that the sign of post-issuance mispricing perceived by firm managers matches the sign of net equity issuance. This result is important because while *pre*-issuance mispricing is difficult to observe in the data, *post*-issuance mispricing can be inferred from the long-run behavior of the stock after the net issuance.

In a two-period setting, a rational firm manager chooses the level of capital K, which determines the present value of installed capital $\Pi(K)$. The firm is financially unconstrained and finances the purchase of the capital good K by issuing risk-free debt of L or selling a fraction n of the firm's market value of equity P.[5] Then, the intrinsic value of the firm's equity, perfectly observed by the firm manager, is

$$V(K, L) = \Pi(K) - L \tag{1}$$

where

$$K = L + nP. \tag{2}$$

The fraction n has an upper bound of one, $n < 1$, so long as the market value of equity before net issuance is positive.

[5] $n > 0$ implies net issuance and $n < 0$ implies equity repurchase.

The market value of equity P could deviate from the intrinsic value V and this "bubble" component of the market value, denoted B, can be corrected by the firm's equity net issuance:

$$P = (1 + B(n))V(K, L), \tag{3}$$

where $B'(n) < 0$ so that the demand curve for the firm's shares slopes downward.[6] All cash flows to shareholders occur in the second period so that the existing shareholders are prevented from raising external equity for the purpose of paying dividends to themselves in the concurrent period.

The firm manager chooses K and n to maximize the present value of cash flows to the existing shareholders:

$$\max_{K,n} (1 - n)(\Pi(K) - L), \tag{4}$$

subject to the resource constraint in equation (2) restated as

$$L = \frac{K - n(1 + B(n))\Pi(K)}{1 - n(1 + B(n))}. \tag{5}$$

We focus on the firm's equity net issuance decision.

The first order condition with respect to the equity net issuance decision n implies that the sign of equilibrium post-net-issuance mispricing matches the sign of net equity issuance:

$$B(n) = \underbrace{-B'(n)}_{+} \underbrace{(1 - n)}_{+} n, \tag{6}$$

where $-B'(n) > 0$ because demand curve slopes downward and $(1 - n) > 0$ because n is bounded above at one.

Mispricing triggers equity issuance. However, since the firm is a monopolist in the supply of its own shares facing a downward-sloping demand curve, the usual monopoly pricing logic implies that the optimal equity issuance does not eliminate mispricing. Instead, stock bubble $B(n)$ persists

[6] See Gilchrist, Himmelberg, and Huberman (2005) for the microfoundation for this assumption based on investor belief heterogeneity and short-sale constraints.

in equilibrium even after net issuance n in the same direction. Firm arbitrage pushes the prices towards but not all the way down to the intrinsic value.

In this simple model, determining the exact magnitude of optimal equity issuance requires specifying the elasticity of demand further. However, it shows that the sign of post-issuance mispricing matches the sign of equity net issuance. Define mispricing as a monotonic transformation of the bubble term: $\delta = 1 - V/P = 1 - 1/(1 + B)$. Also, define $\phi(.)$ as the sign function taking a value of 1 if the argument is positive and 0 if the argument is negative. Then, the model implies that the sign of optimal equity net issuance, n, and post-issuance mispricing, δ, must be the same:

$$\phi(n) = \phi(\delta). \tag{7}$$

In reality, the benefit of the corporate arbitrage would increase with the magnitude of the price bubble, and therefore, in the presence of transaction costs, firms would be more likely to issue equity the larger is the magnitude of the mispricing. A larger magnitude of pre-issuance mispricing would also mean, holding all else fixed, a larger post-issuance mispricing. Furthermore, equity net issuance could be driven by stock characteristics other than mispricing, such as investment opportunities. As a result, we express the ideas from our stylized theoretical model as the following assumption in our empirical implementation.[7]

Assumption 1. *Conditional on stock characteristics X, the probability of positive net issuance increases with the magnitude of the post-issuance mispricing.*

$$\frac{\partial Pr[\phi(n) = 1|\delta, X]}{\partial \delta} > 0 \tag{8}$$

Under this assumption, we show how to employ the revealed preference approach to infer the firm manager's model of risk. We then explain our empirical estimator of δ.

[7] Since the observations with zero net issuance contain less information about the firm's asset pricing model, we do not define ϕ for when $x = 0$ and drop such observations in the empirical analysis.

2.2 Inferring firms' asset pricing model from net issuance decisions

Our goal is to use equity issuance decisions and estimated mispricing with respect to different asset pricing models to infer the model of risk closest to the one used by the firm managers. When evaluating asset pricing models, we aim to make minimal assumptions about the distribution of estimation errors. Therefore, we compare models based on their ability to accurately rank firms by their level of mispricing, rather than using the estimated level of mispricing itself. This approach makes our analysis robust to potential shifts in the distribution of estimated mispricing.

Let subscript (i, t) denote the value for firm i at time t. Within each characteristic group X_{it}, sort all firms based on their mispricing into two groups:

$$\Delta_{it} = \begin{cases} 1 & \text{Top half of the firms based on } \delta_{it} \text{ at time } t \\ 0 & \text{Bottom half of the firms based on } \delta_{it} \text{ at time } t \end{cases} \tag{9}$$

The following propositions adapts the BvB framework in a way that applies to the rank of misprincing and controls for the observable characteristics.

Proposition 1. *Probability of positive issuance increases with the rank of mispricing:*

$$Pr[\phi(n_{it}) = 1 | \Delta_{it} = 1, X_{it}] > Pr[\phi(n_{it}) = 1 | \Delta_{it} = 0, X_{it}],$$

Proof of all propositions will come in the appendix.

Proposition 2. *The regression coefficient of the sign of equity issuance on the rank of mispricing is positive.*

$$\beta = \frac{Cov(\phi(n_{it}), \Delta_{it})}{Var(\Delta_{it})} > 0 \tag{10}$$

Equation (A.2) in the appendix shows that β has a clear interpretation as the difference in the probability of a positive issuance between the firms in the top versus bottom half of the mispricing:

$$\beta = Pr[\phi(n_{it}) = 1 | \Delta_{it} = 1] - Pr[\phi(n_{it}) = 1 | \Delta_{it} = 0] \tag{11}$$

Proposition 2 provides a simple test for asset pricing models: mispricing with respect to the candidate asset pricing model must predict the direction of equity issuance. However, as we will see in the next section, all asset pricing models that we consider satisfy this condition. Therefore, we need a test to directly compare the performance of two asset pricing models. The next three propositions establish the foundations for this test. Before we do so, we make the following assumption made in BVB.

Assumption 2. *In the presence of a true asset pricing model, a false risk model has no additional explanatory power for the direction of equity issuance.*

$$Pr[\phi(n_{it}) = 1|\Delta_{it}^T, \Delta_{it}^F, X_{it}] = Pr[\phi(n_{it}) = 1|\Delta_{it}^T, X_{it}] \tag{12}$$

Proposition 3. *The regression coefficient of the sign of equity issuance on the rank of mispricing is maximized under the true risk model; i.e.,* $\beta^T > \beta^F$.

Definition 1. *Define model* c *as a better approximation of the true asset pricing model than model* d *if and only if:*

$$\begin{aligned} Pr[\Delta_{it} = 1|\Delta_{it}^c = 1] + Pr[\Delta_{it} = 0|\Delta_{it}^c = 0] > \\ Pr[\Delta_{it} = 1|\Delta_{it}^d = 1] + Pr[\Delta_{it} = 0|\Delta_{it}^d = 0] \end{aligned} \tag{13}$$

Proposition 4. *Model c is a better approximation of the true asset pricing model than model d if and only if* $\beta^c > \beta^d$.

Proposition 5 gives us a straightforward way to empirically test competing asset pricing models.

Proposition 5. *Consider an OLS regression of* $\phi(n_{it})$ *on the* $\Delta_{it}^c - \Delta_{it}^d$*:*

$$\phi(n_{it}) = \gamma_0 + \gamma_1(\Delta_{it}^c - \Delta_{it}^d) + \xi_{it} \tag{14}$$

Model c is a better approximation of the true asset pricing model than model d if and only if $\gamma_1 > 0$

3 Data and variable construction

We use stock price data from the Center for Research in Security Prices (CRSP) and annual accounting data from Compustat. We take one month treasury bill and factor returns data from Kenneth French's data library.

We construct our data in quarterly frequency. At the end of each quarter, we estimate issuance over the past quarter. We also use accounting data from the past calendar year to construct financial constraint measures. Next, we use future monthly returns to estimate post-issuance mispricing. In all of our main tests we drop observations with zero issuance.

3.1 Post-issuance mispricing

We proxy for post-issuance mispricing with long-horizon abnormal returns with respect to a candidate asset pricing model. Since the exact horizon relevant for the net issuance decision is unknown, we repeat the analysis using different horizons to look for consistent results.

For each stock i and time t, we use past 3 years of monthly returns to estimate stock-level factor betas associated with the candidate asset pricing model. We then use the estimated factor betas $\hat{\mathbf{b}}^c$ and realized factor returns $\mathbf{F}^c$ to estimate the benchmark return implied by model c:[8]

$$R^c_{i,t} = (\hat{\mathbf{b}}^c_{i,t})'\mathbf{F}^c_t. \tag{15}$$

We then estimate the time-and-firm-specific post-issuance mispricing based on a T-period horizon (up to 10 years) from the following equation:

$$\hat{\delta}^T_{i,t} = -\left(\prod_{s=t+1}^{t+T}(1 + R_{i,s} - R^c_{i,s}) - 1\right) \tag{16}$$

When the firm delists, we set the abnormal return to be zero so that delisting does not bias the mispricing measure.

[8] We express all vectors as column vectors.

We prefer our proxy for mispricing because it is simple and transparent. In robustness checks, we use a different estimator derived from a precise definition of mispricing, as we explain in Appendix B. We also consider a naive asset pricing model that simply uses the market return as the benchmark return and subtracts it from the stock return regardless of the stock's market beta. We call this model "excess market."

We limit the beginning of the sample to the earliest time that we have data for all models, which is 1969. Also, since we need a long horizon of 120 month (10 years) ex-post returns to estimate mispricing, the last year for which we can construct our 10-year mispricing measure is 2009.

3.2 Asset pricing models

We run a horse race among some of the popular asset pricing models in the finance literature: the Capital Asset Pricing Model (CAPM) (Sharpe (1964); Lintner (1965)), the three-factor model of Fama and French (1993), the Carhart (1997) four-factor model, the five factor model of Fama and French (2015), the q-factor model of Hou, Xue, and Zhang (2015), and the intertemporal CAPM (ICAPM) model of Campbell et al. (2018).

We also consider simple alternatives to the factor models. This includes naively using expected stock market returns or expected industry returns as the cost of equity capital as well as inferring mispricing by comparing the firm's valuation multiples to industry peers.

3.3 Equity net issuance

Our left-hand side variable is the sign of the equity net issuance. Consistent with the literature on fund flows and following Daniel and Titman (2006), we construct our measure of equity net issuance as the percentage of firm's growth that is not attributable to the stock returns:

$$n_{i,t} = \frac{ME_{i,t}}{ME_{i,t-1}} - (1 + R_{i,t}). \tag{17}$$

Corporate actions such as splits and stock dividends leave this measure unchanged. However, any action that trades firm ownership for cash or services, like actual equity issues or employee stock option plans increases n. In contrast, any cash payout from the firm, like actual share repurchase or dividends decreases n. We find the results to be similar when using an alternative measure of equity net issuance that excludes dividend payments: $n_{i,t} = N_{i,t}/N_{i,t-1} - 1$, where N is the adjusted number of shares outstanding.

3.4 Financial constraint

Section 5 uses a measure of financial constraint to limit our sample to the firms that are not equity dependent. Whited and Wu (2006) measure the degree of financial constraint based on firm accounting characteristics as follows:

$$\begin{aligned} WW_{it} = & -0.091 \times CF_{it} + 0.021 \times TLTD_{it} - 0.062 \times DIVPOS_{it} \\ & -0.044 \times LNTA_{it} + 0.102 \times ISG_{it} - 0.035 \times SG_{it}, \end{aligned} \tag{18}$$

where CF_{it} stands for cash flow, $TLTD_{it}$ is the debt to equity ratio, $DIVPOS_{it}$ is a dummy variable that is equal to one if the firm has paid any dividends in the previous fiscal year, $LNTA_{it}$ is the logarithm of the total assets, ISG_{it} is the three digit SIC industry sales growth, and SG_{it} is the firm's sales growth. Intuitively, large firms with high cash flows and low leverage ratio that tend to pay dividends and do not have too many investment opportunities are less likely to be financially constrained.[9]

[9] Sales growth proxies for investment opportunities, thus firms with low sales growth in the industries with high sales growth are likely to have more investment opportunities. In unreported robustness checks, we have also used Kaplan-Zingales, size-age index, payout ratio, and size to measure financial constraint and we get similar results. As constructed by Lamont, Polk, and Saaá-Requejo (2001), the KZ index is given by:

$$\begin{aligned} KZ_{it} = & -1.002 \times CF_{it} + 3.139 \times TLTD_{it} \\ & -39.368 \times TDIV_{it} - 1.314 \times CASH_{it} + 0.283 \times Q_{it} \end{aligned} \tag{19}$$

Definition of new variables is as follows: $TDIV_{it}$ is the ratio of total dividends to assets, $CASH_{it}$ is the ratio of liquid assets to total assets, and Tobin's Q is defined as the market value of assets divided by the book value of assets. Hadlock and Pierce (2010) construct their measure of financial constraint by using only size and age:

$$SA_{it} = -0.737 \times SIZE_{it} + 0.043 \times SIZE_{it}^2 - 0.040 \times AGE_{it} \tag{20}$$

3.5 Summary statistics

Table 1 reports summary statistics of our sample of 599,415 firm×quarter observations between 1969 to 2009 (2009 is the last year in which the 10-year mispricing measure available). [10] The quarterly issuance has a mean of 1.04 percent and standard deviation of 6.40 percent. The logarithm of total assets for the average firm is equal to 5.38 and age of 12.79 years. Estimated mispricing with respect to different factor models have different distributional properties. As we can see, the mean and the standard deviation have substantial variations across different models. However, we have defined our tests based on the rank of mispricing rather than its level. Therefore, our tests are robust to arbitrary shifts in the distribution.[11] Pearson and Spearman pairwise correlation between different mispricing measures are reported in Table 2. All measures of mispricing tend to be highly correlated, and the naive "excess market" model is the one closest to the CAPM. Despite these correlations, we show that mispricing with respect to the CAPM significantly outperforms all other models at predicting the direction of equity issuance.

4 Results

We begin our analysis by regressing the sign of equity issuance on the binary rank of estimated mispricing (equation (10)). To control for the characteristics that might be correlated with the mispricing and drive equity issuance, such as the availability of investment projects, we rank mispricing within each characteristic group. We report the results for different choices of control characteristics likely to be correlated with investment opportunities: size and book-to-market (value), size and the Peters and Taylor (2017) measure of (average) Q, size and momentum, and value and Q. We use 25 groups for each choice of controls based on 5×5 quintiles so that the incentives

[10]Our sample also includes a total of 235,234 firm × quarter observations with zero equity net issuance. These observations are excluded from our main tests as they are less informative. However, results are robust if one aggregates zero issuances with either of repurchases (Table C.1) or positive net issuances.

[11]Suppose for example that there are more repurchases than positive equity issuances in the data. In this case, an asset pricing model with a negative bias in the estimation of mispricing will have an artificial advantage over the competing models. Using the relative rank of estimated mispricing Δ_{it} rather than the absolute value of mispricing δ_{it} makes our tests robust to the arbitrary change in the mean or standard deviation of estimation error.

to engage in net issuance other than mispricing (e.g., investment opportunities) are likely to be similar among firms in the same characteristic group.

If size and value characteristics *perfectly* proxy for future size and value factor exposures, respectively, controlling for these characteristics makes the comparison between the CAPM and the three-factor model of Fama and French moot. However, there is substantial variation in the size and value factor exposures not associated with the characteristics and the other way around (Daniel and Titman (1997)), especially when the comparison is between the characteristic at the time of net issuance and factor exposures in the following ten years. Note that these controls do not affect our ability to distinguish between the naive "excess market" method and the CAPM.

All of our tests include time fixed effects and weigh different time periods equally using weighted least squares, which makes the test coefficients identical to those based on Fama-MacBeth regressions. This is in response to Ben-David et al. (2021)'s finding that weighing different time periods equally in a revealed preference test generates results that survive a falsification test.

Table 3 reports the estimates of β (from Proposition 2) for different control groups. The numbers in the table report the percentage difference in the probability of positive equity net issuance when comparing the top versus the bottom rank of mispricing (equation (11)) . We expect this measure to be equal to zero if equity net issuance is unrelated to mispricing. Each column of the table corresponds to a different time horizon over which mispricing (equation (16)) is estimated. The table shows that none of asset pricing models can be rejected in their ability to explain the direction of net issuance; i.e., all of estimated betas are significantly positive. Also, estimating mispricing over longer horizons improves its performance. For all time horizons and within all control groups, we see that CAPM mispricing best matches the direction of equity net issuance. Importantly, the CAPM also outperforms the naive model that simply subtracts the market return from the stock return to measure abnormal returns that feed our mispricing measure. Among other models, the Fama-French three-factor model also tends to provide a good proxy for actual mispricing used by firms.

To formally test whether the difference in the regression coefficients is statistically significant, we run a pairwise horse race among different asset pricing models (equation (14)). Table 4 reports the *t*-statistics of the estimated γ_1 (in Proposition 5). A positive number means that the model in the row is closer to the asset pricing model of firm managers than the model in the column. Across all choices of control groups, the CAPM significantly outperforms other asset pricing models in rationalizing the equity net issuance decision. The t-statistics tend to be higher than typically found in asset pricing studies because we use the rank of estimated mispricing instead of its level as our right-hand side variable, which limits the variance of the errors in the regressions.

In all of our main tests we exclude observations with zero net issuance. Since survey evidence identifies market timing as the primary motivation for share repurchase, we repeat the horse race between asset pricing models using repurchase decisions only, not excluding the firms with zero net issuance this time. The results reported in Table C.1 confirm our previous finding that CAPM outperforms other asset pricing models in rationalizing firms' decision to repurchase equity.

It is interesting to compare the performance of the CAPM to that of other factor models for the firms in the highest or lowest size or value groups. These are the firms that strongly load on size or value factors that the CAPM fails to take into account. Table 5 shows that even for these extreme cases, CAPM outperforms all other factor models. Table 6 shows the *t*-statistics for γ_1 from the comparison of the CAPM against other factor models for all of the 25 size and value groups. The results collectively support that CAPM mispricing best explains firms' equity net issuance decisions.

5 Additional Analysis

5.1 The BHO method

Barber, Huang, and Odean (2016) (BHO) develop a similar technique to run horse races among asset pricing models. The advantage of the BHO method is that we can easily control for other characteristics in a linear regression, although the added complexity makes the regression coefficients more challenging to interpret.

Following the BHO method, we first sort firms into deciles based on their estimated 10 year post-issuance mispricing.[12] Next, for each pairwise comparison of asset pricing models, we construct 100 dummy variables based on the decile ranking of estimated mispricing as defined by the two models:

$$D_{jkit} = \begin{cases} 1 & \Delta^c_{it} = j, \Delta^d_{it} = k \qquad \forall j,k = 1,...,10 \\ 0 & otherwise \end{cases} \tag{21}$$

Figure C.1 in the appendix shows all decile rankings and dummy variables for the comparison of CAPM and the three factor model. Gray cells correspond to firm-quarter observations that have similar mispricing rank based on both models and the black cell is the omitted dummy variable. We regress the sign of equity issuance on the full set of dummy variables, as well as time and industry fixed effects and controls. We then compare off-diagonal coefficients of dummy variables. For example, we compare estimated coefficients on the dummy variable corresponding to decile 4 based on the CAPM and decile 1 based on the three factor model (red cell, b_{41}) to the coefficient of the dummy corresponding to decile 1 based on the CAPM and decile 4 based on the three factor model(green cell, b_{14}). If a firm manager uses the CAPM rather than the three factor model, we expect $b_{41} > b_{14}$. Thus, similar to the BHO, we test the null hypothesis that the sum of the difference between off-diagonal coefficients is equal to zero. We also calculate a binomial test statistic which tests the null hypothesis that the proportion of differences equals 50%.

Table 7 collects the results from pairwise model comparisons. Panel A reports the sum of the differences and the corresponding p-values. A positive (negative) number means that the model on the row (column) of the table wins the race. Panel B reports the percentage of cases in which the first model (row) beats the second model (column) out of the 45 comparisons and the p-value of the binomial test. It shows that the CAPM is favored by an overwhelming majority and that it significantly outperforms the other models. This again supports that the CAPM is the closest asset pricing model to what firm managers use to estimate the intrinsic value of the firm.

Ben-David et al. (2021) find that the test for the asset pricing model used by mutual fund investors can be sensitive to how the test weighs the observations in different periods. The ap-

[12]This ranking is unconditional, as opposed to the ranking in previous parts which was within the control groups

pendix shows that, since we include time fixed effects and use weighted least squares to give equal weights to all years, our univariate regression coefficients coincide with the Fama-MacBeth coefficients. Although our multivariate regression coefficients may not be identical to those from Fama-MacBeth regressions, we repeat the BHO analysis above using Fama-Macbeth regressions to find similar results. Table C.2 presents the time-series average of the cross-sectional coefficients.

5.2 Financial constraint

Despite our effort to control for them, one may still worry that equity issuance can happen for reasons unrelated to market timing, such as the financing of investment projects. We address this concern by limiting our sample to the firms that are not equity dependent, as previously done in Lamont, Polk, and Saaá-Requejo (2001), Baker, Stein, and Wurgler (2003), and Polk and Sapienza (2008).

Each quarter, we sort firms based on a measure of financial constraint and drop top half (most constrained firms). Table 8 presents the results of pairwise model comparison among unconstrained firms identified by the Whited and Wu (2006) measure. The results are close to the previous estimates in Table 4 and the CAPM outperforms all other models at explaining the direction of equity net issuance. The results are similar when an alternative measure of financial constraint is used (Kaplan and Zingales (1997); Hadlock and Pierce (2010); Campello and Graham (2013)).

5.3 Comparison to market multiples

Although not directly related to our research question on factor models, it is interesting to compare the performance of different risk models to that of simple market multiples. We consider price-to-book, price-to-earnings, and price-to-sales ratio as our test market multiples. In each quarter, we estimate mispricing with respect to the market multiples as the difference of the logarithm of the firm's lagged market multiple from the industry average for each of the 49 industry groups. Firms are considered overpriced (underpriced) if their lagged multiple is higher (lower) than the industry average. Table 9 shows that the CAPM significantly outperforms all market multiples in the race.

The table also includes the horse race between factor models and mispricing with respect to the average industry returns.

5.4 An alternative measure of mispricing

Our main analysis measures mispricing as the compounded alpha over the post-issuance time horizon. While this measure is easy to understand and compute, it is not an expression derived from an exact definition of mispricing. As a robustness check, we define mispricing as the NPV of the buy-and-hold strategy on the firm and show that the ratio of NPV to price can be inferred from the long-run behavior of stock returns (see Appendix B). Repeating the analysis with this alternative measure of mispricing does not affect our findings (Table C.3).

6 Conclusion

Which asset pricing model do firm managers use to compare payoffs across time and state under uncertainty? In this paper, we use a revealed preference approach similar to Berk and Van Binsbergen (2016) and Barber, Huang, and Odean (2016) but adopted to net issuance decisions to answer this question. We find that firm managers are most likely to be using discount rates implied by the CAPM to discount future cash flows and make net issuance decisions. Our results deepen our understanding of how firms make decisions under uncertainty and shed further light on the asset pricing model most likely used by actual economic agents.

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Table 1: Summary statistics

Variables	N	Mean	SD	1^{st} pctile	99^{th} pctile
Issuance	599,415	1.04	6.40	-8.28	36.98
Size	538,308	5.38	2.18	0.83	10.73
Age	544,912	12.78	11.14	1	49
	Estimated mispricing over 120 month				
CAPM	505,801	-0.23	1.33	-6.69	1.00
FF3	505,801	-0.13	1.28	-6.80	1.00
Carhart	505,801	-0.23	1.43	-7.89	1.00
ICAPM	486,369	-1.49	3.69	-20.93	1.00
Excess market	592,579	-0.16	1.28	-6.59	1.00
FF5	505,801	-0.37	2.04	-12.35	1.00
Q-theory	505,801	-0.74	3.23	-20.10	1.00

This table presents summary statistics of variables. Data is quarterly between 1969 and 2009. Size is defined as the log of total assets. We use past three years of monthly data to estimate factor betas. For the purpose of this table, estimated mispricing is winsorized at 1 and 99 percent cutoffs. This winsorization does not affect any of our empirical results, which are based on the rank of mispricing.

Table 2: Pairwise correlation of estimated mispricing with respect to different models

	CAPM	FF3	Carhart	ICAPM	Excess market	FF5	Q-theory
			Panel A: Pearson Correlations				
CAPM	1						
FF3	0.829	1					
Carhart	0.758	0.888	1				
ICAPM	0.828	0.721	0.674	1			
Excess Market	0.902	0.769	0.723	0.847	1		
FF5	0.600	0.769	0.721	0.574	0.589	1	
Q-theory	0.499	0.559	0.635	0.480	0.473	0.607	1
			Panel B: Spearman Correlations				
CAPM	1						
FF3	0.872	1					
Carhart	0.816	0.922	1				
ICAPM	0.857	0.754	0.717	1			
Excess Market	0.927	0.823	0.784	0.863	1		
FF5	0.725	0.851	0.805	0.642	0.700	1	
Q-theory	0.667	0.712	0.761	0.601	0.635	0.719	1

This table presents average cross sectional correlation between estimated mispricing over a 10-year horizon with respect to different risk models. Data is quarterly from 1969q1 to 2008q2. For the purpose of this table, estimated mispricing is winsorized at 1 and 99 percent cutoffs. This winsorization does not affect any of our empirical results, which are based on the rank of mispricing.

Table 3: Single model regressions

	3	12	36	60	120
	Panel A: 25 Size and value groups				
CAPM	**0.029**	**0.053**	**0.070**	**0.078**	**0.087**
	(7.540)	(12.005)	(13.692)	(15.543)	(17.237)
FF3	0.025	0.045	0.060	0.068	0.076
	(9.052)	(14.004)	(14.784)	(16.016)	(16.408)
Carhart	0.023	0.041	0.054	0.062	0.067
	(8.322)	(13.299)	(14.715)	(15.787)	(15.166)
ICAPM	0.019	0.034	0.045	0.054	0.063
	(5.108)	(7.811)	(9.471)	(11.182)	(12.431)
Excess market	0.021	0.039	0.050	0.054	0.055
	(4.121)	(7.250)	(10.184)	(11.414)	(11.642)
FF5	0.015	0.028	0.030	0.035	0.041
	(6.237)	(10.412)	(9.226)	(9.862)	(10.062)
Q-theory	0.015	0.029	0.034	0.037	0.042
	(5.451)	(9.325)	(10.126)	(9.842)	(10.213)
	Panel B: 25 size and Q groups				
CAPM	**0.027**	**0.056**	**0.075**	**0.086**	**0.094**
	(6.947)	(12.295)	(14.879)	(16.103)	(17.371)
FF3	0.020	0.041	0.059	0.068	0.075
	(7.372)	(13.417)	(14.935)	(15.427)	(15.541)
Carhart	0.018	0.039	0.055	0.063	0.068
	(6.771)	(12.548)	(14.776)	(14.929)	(14.303)
ICAPM	0.017	0.038	0.052	0.063	0.074
	(4.290)	(8.194)	(10.772)	(12.679)	(13.408)
Excess market	0.020	0.042	0.057	0.063	0.065
	(4.163)	(8.128)	(11.761)	(12.762)	(12.918)
FF5	0.011	0.022	0.026	0.033	0.037
	(4.596)	(7.743)	(7.831)	(9.049)	(8.879)
Q-theory	0.012	0.027	0.036	0.040	0.044
	(4.208)	(7.831)	(9.705)	(9.871)	(9.904)

	3	12	36	60	120
	Panel C: 25 Size and momentum groups				
CAPM	**0.033**	**0.061**	**0.080**	**0.091**	**0.102**
	(8.396)	(12.268)	(13.788)	(15.827)	(18.318)
FF3	0.025	0.046	0.065	0.075	0.083
	(9.176)	(13.597)	(15.277)	(16.819)	(17.858)
Carhart	0.024	0.044	0.060	0.068	0.073
	(9.215)	(12.987)	(15.637)	(16.733)	(16.967)
ICAPM	0.022	0.042	0.057	0.067	0.077
	(5.693)	(8.809)	(10.536)	(12.438)	(14.316)
Excess market	0.027	0.051	0.066	0.074	0.075
	(5.114)	(9.149)	(12.280)	(14.491)	(15.188)
FF5	0.015	0.030	0.037	0.042	0.047
	(6.293)	(10.833)	(10.728)	(11.416)	(11.802)
Q-theory	0.017	0.033	0.041	0.046	0.050
	(5.810)	(8.824)	(10.577)	(11.273)	(11.966)
	Panel D: 25 Value and Q groups				
CAPM	**0.036**	**0.065**	**0.086**	**0.097**	**0.107**
	(7.328)	(12.847)	(15.440)	(16.957)	(18.273)
FF3	0.031	0.054	0.072	0.080	0.087
	(9.127)	(15.098)	(16.677)	(17.063)	(16.801)
Carhart	0.027	0.050	0.068	0.077	0.081
	(8.608)	(14.333)	(17.013)	(17.172)	(16.316)
ICAPM	0.028	0.050	0.069	0.081	0.097
	(5.810)	(9.655)	(12.529)	(14.437)	(14.874)
Excess market	0.031	0.056	0.073	0.080	0.083
	(5.557)	(9.676)	(13.681)	(15.005)	(15.552)
FF5	0.018	0.032	0.035	0.039	0.043
	(6.482)	(10.473)	(9.690)	(10.216)	(9.868)
Q-theory	0.016	0.031	0.039	0.042	0.045
	(5.052)	(8.314)	(10.454)	(10.331)	(9.666)

This table reports the results of the regression of the sign of equity issuance $\phi(n)$ on the binary rank of post-issuance mispricing Δ^c with respect to a candidate asset pricing model c.

$$\phi(n_{it}) = \mu_t + \gamma^c \Delta^c_{i,t} + \epsilon_{it}$$

The sign of equity net issuance is either zero (repurchase) or one (positive equity issuance), and observations with zero net equity issuance are excluded. The right-hand variable is the binary, cross-sectional rank of mispricing Δ with respect to model c measured by post-issuance cumulative abnormal return over the horizon specified in the column (in months). Each panel specifies the characteristic groups within which the rank of mispricing is computed. Each cell represents a separate regression pertaining to a particular choice of model and the estimation window of mispricing. All regressions include time fixed effects and the observations are deflated by the number of firms in each quarter. The *t*-statistics are calculated using double clustered standard errors by firm and quarter. Largest β across different models in each horizon is bolded.

Table 4: Pairwise model comparisons

	CAPM	FF3	Carhart	ICAPM	Excess market	FF5	Q-theory
			Panel A: 25 Size and value groups				
CAPM	0.00	4.13	6.03	8.74	11.31	12.26	11.60
FF3	-4.13	0.00	4.67	3.34	6.29	13.65	9.32
Carhart	-6.03	-4.67	0.00	0.62	3.76	8.92	7.70
ICAPM	-8.74	-3.34	-0.62	0.00	2.69	5.74	5.24
Excess market	-11.31	-6.29	-3.76	-2.69	0.00	3.27	2.97
FF5	-12.26	-13.65	-8.92	-5.74	-3.27	0.00	-0.30
Q-theory	-11.60	-9.32	-7.70	-5.24	-2.97	0.30	0.00
			Panel B: 25 Size and Q groups				
CAPM	0.00	6.81	7.55	7.13	9.36	13.50	11.24
FF3	-6.81	0.00	3.43	-0.09	2.77	13.35	8.14
Carhart	-7.55	-3.43	0.00	-1.84	0.75	9.45	6.89
ICAPM	-7.13	0.09	1.84	0.00	2.39	7.73	6.14
Excess market	-9.36	-2.77	-0.75	-2.39	0.00	6.42	4.64
FF5	-13.50	-13.35	-9.45	-7.73	-6.42	0.00	-2.16
Q-theory	-11.24	-8.14	-6.89	-6.14	-4.64	2.16	0.00
			Panel C: 25 Size and momentum groups				
CAPM	0.00	6.12	7.67	9.33	11.91	13.81	12.74
FF3	-6.12	0.00	5.31	1.83	4.57	14.95	9.74
Carhart	-7.67	-5.31	0.00	-1.03	1.42	9.53	7.67
ICAPM	-9.33	-1.83	1.03	0.00	2.04	7.13	6.30
Excess market	-11.91	-4.57	-1.42	-2.04	0.00	5.77	4.98
FF5	-13.81	-14.95	-9.53	-7.13	-5.77	0.00	-0.76
Q-theory	-12.74	-9.74	-7.67	-6.30	-4.98	0.76	0.00
			Panel D: 25 Value and Q groups				
CAPM	0.00	6.67	7.21	3.63	8.35	13.52	11.85
FF3	-6.67	0.00	2.70	-2.71	1.08	14.35	10.04
Carhart	-7.21	-2.70	0.00	-3.59	-0.41	11.64	9.86
ICAPM	-3.63	2.71	3.59	0.00	3.75	9.34	8.66
Excess market	-8.35	-1.08	0.41	-3.75	0.00	8.82	7.43
FF5	-13.52	-14.35	-11.64	-9.34	-8.82	0.00	-0.71
Q-theory	-11.85	-10.04	-9.86	-8.66	-7.43	0.71	0.00

This table reports the *t*-statistics associated with γ_1 from the BvB test (equation (14)):

$$\phi(n_{it}) = \gamma_{0t} + \gamma_1(\Delta_{it}^c - \Delta_{it}^d) + \xi_{it}.$$

The sign of equity net issuance $\phi(n)$ is either zero (equity repurchase) or one (positive equity issuance), and observations with zero net equity issuance are excluded. The right-hand variable is the difference in the binary rank of mispricing Δ with respect to asset pricing model c vs. d. The models are compared on mispricing estimated by post-issuance cumulative abnormal return over 10 years. Each panel determines the control sub-groups. In each quarter and within each control sub-group, firms are ranked by estimated mispricing relative to a candidate model of risk. Each cell reports the *t*-statistics from a different regression. A positive number means that the model in the row wins the race against the model in the column and vice versa. All regressions include time fixed effects and the observations are deflated by the number of firms in each quarter. The *t*-statistics are calculated using double clustered standard errors by firm and quarter.

Table 5: Pairwise model comparisons, extreme quintiles within 25 size and value groups

	CAPM	FF3	Carhart	ICAPM	Excess market	FF5	Q-theory
				Panel A: Low market equity			
CAPM	0.00	2.13	4.07	6.56	8.80	6.45	5.67
FF3	-2.13	0.00	3.27	3.72	5.32	6.54	4.65
Carhart	-4.07	-3.27	0.00	1.32	2.81	3.56	3.21
ICAPM	-6.56	-3.72	-1.32	0.00	0.91	1.32	1.26
Excess market	-8.80	-5.32	-2.81	-0.91	0.00	0.38	0.27
FF5	-6.45	-6.54	-3.56	-1.32	-0.38	0.00	-0.07
Q-theory	-5.67	-4.65	-3.21	-1.26	-0.27	0.07	0.00
				Panel B: High market equity			
CAPM	0.00	1.86	2.43	2.98	5.33	8.55	7.14
FF3	-1.86	0.00	1.33	1.05	3.00	9.34	6.40
Carhart	-2.43	-1.33	0.00	0.20	2.06	7.61	5.70
ICAPM	-2.98	-1.05	-0.20	0.00	1.69	6.15	4.77
Excess market	-5.33	-3.00	-2.06	-1.69	0.00	4.97	3.65
FF5	-8.55	-9.34	-7.61	-6.15	-4.97	0.00	-1.72
Q-theory	-7.14	-6.40	-5.70	-4.77	-3.65	1.72	0.00
				Panel C: Low market to book ratio			
CAPM	0.00	0.88	4.08	2.89	5.72	6.36	7.00
FF3	-0.88	0.00	5.12	1.77	4.31	7.62	7.11
Carhart	-4.08	-5.12	0.00	-1.38	1.06	2.80	4.50
ICAPM	-2.89	-1.77	1.38	0.00	2.31	3.49	4.56
Excess market	-5.72	-4.31	-1.06	-2.31	0.00	1.29	2.76
FF5	-6.36	-7.62	-2.80	-3.49	-1.29	0.00	1.35
Q-theory	-7.00	-7.11	-4.50	-4.56	-2.76	-1.35	0.00
				Panel D: High market to book ratio			
CAPM	0.00	6.21	5.86	7.56	8.01	11.44	8.44
FF3	-6.21	0.00	0.99	1.06	1.22	9.86	4.98
Carhart	-5.86	-0.99	0.00	0.47	0.51	8.19	4.87
ICAPM	-7.56	-1.06	-0.47	0.00	-0.39	5.93	3.68
Excess market	-8.01	-1.22	-0.51	0.39	0.00	6.72	3.97
FF5	-11.44	-9.86	-8.19	-5.93	-6.72	0.00	-2.22
Q-theory	-8.44	-4.98	-4.87	-3.68	-3.97	2.22	0.00

This table reports the *t*-statistics associated with γ_1 from the BvB test (equation (14)):

$$\phi(n_{it}) = \gamma_{0t} + \gamma_1(\Delta_{it}^c - \Delta_{it}^d) + \xi_{it}.$$

among the firms in the highest or lowest size or value group. The sign of equity net issuance $\phi(n)$ is either zero (equity repurchase) or one (positive equity issuance), and observations with zero net equity issuance are excluded. The right-hand variable is the difference in the binary rank of mispricing Δ with respect to asset pricing model c vs. d. The models are compared on mispricing estimated by post-issuance cumulative abnormal return over 10 years. In each quarter and within each of the 25 size and value sub-groups, firms are ranked by estimated mispricing relative to a candidate model of risk. Each panel determines the set of firms among which the horse race is run. Each cell reports the *t*-statistics from a different regression. A positive number means that the model in the row wins the race against the model in the column and vice versa. All regressions include time fixed effects and the observations are deflated by the number of firms in each quarter. The *t*-statistics are calculated using double clustered standard errors by firm and quarter.

Table 6: Pairwise model comparisons against CAPM, extreme quintiles within 25 size and value groups

ME	PB	FF3	Carhart	ICAPM	Excess market	FF5	Q-theory
1	1	0.45	2.01	3.17	2.94	2.67	2.64
1	2	0.19	1.28	2.70	6.41	3.30	3.61
1	3	-0.13	2.91	4.76	7.57	3.31	4.38
1	4	3.25	4.82	5.15	6.93	6.11	5.05
1	5	2.02	1.89	3.42	3.37	4.20	2.12
2	1	1.42	4.12	1.80	3.98	4.23	5.50
2	2	0.57	2.35	4.76	6.40	3.23	4.76
2	3	1.49	2.22	3.99	7.98	4.27	4.45
2	4	2.76	2.48	5.30	6.77	3.85	5.74
2	5	3.29	2.48	4.92	3.99	5.72	5.61
3	1	0.41	2.14	1.98	3.17	2.96	4.90
3	2	1.60	2.28	3.63	6.14	3.55	5.04
3	3	0.85	2.42	4.64	6.81	4.14	4.93
3	4	2.35	3.80	4.17	6.61	5.48	6.03
3	5	3.99	5.04	4.84	5.12	6.48	4.73
4	1	0.49	2.80	2.10	5.56	4.54	4.73
4	2	1.18	2.27	1.95	3.71	4.90	3.59
4	3	1.54	2.04	1.92	5.52	6.05	3.82
4	4	1.55	1.68	2.66	4.33	6.00	4.96
4	5	4.73	5.04	3.49	5.18	8.22	6.55
5	1	-0.19	1.74	-0.86	2.34	3.61	3.05
5	2	-1.62	-1.26	-0.48	1.19	3.44	1.87
5	3	1.18	1.35	2.79	3.16	4.65	3.23
5	4	1.09	1.75	1.55	2.73	5.39	5.03
5	5	3.55	2.96	4.74	5.94	8.86	6.69

This table reports the *t*-statistics associated with γ_1 from the BvB test (equation (14)):

$$\phi(n_{it}) = \gamma_{0t} + \gamma_1(\Delta^c_{it} - \Delta^d_{it}) + \xi_{it}.$$

among the firms in each of the 25 size and value groups. The first two columns determine the size and value group. The sign of equity net issuance $\phi(n)$ is either zero (equity repurchase) or one (positive equity issuance), and observations with zero net equity issuance are excluded. The right-hand variable is the difference in the binary rank of mispricing Δ with respect to the CAPM (model c) vs. another asset pricing model d. The models are compared on mispricing estimated by post-issuance cumulative abnormal return over 10 years. In each quarter and within each of the 25 size and value groups, firms are ranked by estimated mispricing relative to a candidate model of risk. Each cell reports the *t*-statistics from a different regression. A positive number means that the CAPM wins the race against the model in the column and vice versa. All regressions include time fixed effects and the observations are deflated by the number of firms in each quarter. The *t*-statistics are calculated using double clustered standard errors by firm and quarter.

Table 7: Pairwise model comparison, BHO method

	FF3	Carhart	ICAPM	Excess market	FF5	Q-theory
			Sum of differences			
CAPM	1.393	2.936	3.450	5.788	3.742	3.775
	(0.012)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FF3		3.224	1.016	1.310	4.118	2.766
		(0.000)	(0.008)	(0.016)	(0.000)	(0.000)
Carhart			-0.499	-0.396	1.580	1.803
			(0.123)	(0.359)	(0.000)	(0.000)
ICAPM				-1.445	1.826	1.941
				(0.052)	(0.000)	(0.000)
Excess market					1.556	1.651
					(0.000)	(0.000)
FF5						0.307
						(0.322)
			% of differences > 0			
CAPM	86.667	95.556	93.333	92.857	100.000	100.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FF3		93.333	73.333	80.000	97.778	100.000
		(0.000)	(0.002)	(0.000)	(0.000)	(0.000)
Carhart			37.778	48.889	88.889	95.556
			(0.135)	(1.000)	(0.000)	(0.000)
ICAPM				51.111	88.889	97.778
				(1.000)	(0.000)	(0.000)
Excess market					84.444	80.000
					(0.000)	(0.000)
FF5						68.889
						(0.016)

This table presents the results of pairwise horse race between competing risk models using BHO method. We estimate the relation between the sign of equity issuance and dummy variables denoting the decile ranks of post-issuance mispricing with respect to two competing asset pricing models:

$$\phi(n_{it}) = \mu_t + \nu_i + \sum_j \sum_k b_{jk} D_{jkit} + \kappa X_{i,t} \epsilon_{it}$$

The sign of equity net issuance is either zero (equity repurchase) or one (positive equity issuance), and observations with zero net equity issuance are excluded. Controls include time and firm fixed effects, lagged equity issuance, lagged logarithm of total assets, lagged market to book ratio, age, profitability, investment, and asset growth. All mispricings are estimated over a 10-year time horizon. We compare off diagonal coefficients of dummy variables as in Figure C.1. Panel A presents sum of the differences of off-diagonal coefficient estimates and their p-values. A positive number indicates that the model in the row wins the race against the model in the column. Panel B shows the percentage of cases in which the first model (row) beats the second model (column) out of the 45 comparisons and the p-value of the binomial test. Data is quarterly from 1969 to 2009. All observations are deflated by the number of firms in each quarter and t-statistics are calculated using double clustered standard errors by firm and quarter.

Table 8: Pairwise model comparisons among financially unconstrained firms

	CAPM	FF3	Carhart	ICAPM	Excess market	FF5	Q-theory
			Panel A: 25 Size and value groups				
CAPM	0.00	3.48	5.08	6.25	9.39	10.55	10.36
FF3	-3.48	0.00	3.54	2.45	6.05	10.98	8.46
Carhart	-5.08	-3.54	0.00	0.43	4.09	7.81	7.28
ICAPM	-6.25	-2.45	-0.43	0.00	3.27	5.72	5.58
Excess market	-9.39	-6.05	-4.09	-3.27	0.00	2.56	2.68
FF5	-10.55	-10.98	-7.81	-5.72	-2.56	0.00	0.08
Q-theory	-10.36	-8.46	-7.28	-5.58	-2.68	-0.08	0.00
			Panel B: 25 Size and Q groups				
CAPM	0.00	5.26	6.11	4.95	8.39	11.65	10.34
FF3	-5.26	0.00	2.97	0.34	3.86	10.69	7.97
Carhart	-6.11	-2.97	0.00	-1.29	2.26	8.07	6.97
ICAPM	-4.95	-0.34	1.29	0.00	3.10	7.10	6.39
Excess market	-8.39	-3.86	-2.26	-3.10	0.00	4.49	3.92
FF5	-11.65	-10.69	-8.07	-7.10	-4.49	0.00	-0.71
Q-theory	-10.34	-7.97	-6.97	-6.39	-3.92	0.71	0.00
			Panel C: 25 Size and momentum groups				
CAPM	0.00	4.52	5.97	5.69	9.02	11.00	10.04
FF3	-4.52	0.00	3.76	1.15	4.43	10.22	7.97
Carhart	-5.97	-3.76	0.00	-0.87	2.31	7.07	6.40
ICAPM	-5.69	-1.15	0.87	0.00	2.85	6.15	5.85
Excess market	-9.02	-4.43	-2.31	-2.85	0.00	3.44	3.23
FF5	-11.00	-10.22	-7.07	-6.15	-3.44	0.00	-0.03
Q-theory	-10.04	-7.97	-6.40	-5.85	-3.23	0.03	0.00
			Panel D: 25 Value and Q groups				
CAPM	0.00	4.43	5.25	4.28	8.65	11.26	10.43
FF3	-4.43	0.00	2.40	0.04	3.95	11.01	8.31
Carhart	-5.25	-2.40	0.00	-1.11	2.46	8.70	7.59
ICAPM	-4.28	-0.04	1.11	0.00	3.62	7.27	6.79
Excess market	-8.65	-3.95	-2.46	-3.62	0.00	4.85	4.51
FF5	-11.26	-11.01	-8.70	-7.27	-4.85	0.00	-0.35
Q-theory	-10.43	-8.31	-7.59	-6.79	-4.51	0.35	0.00

This table reports the *t*-statistics associated with γ_1 from the BvB test (equation (14)):

$$\phi(n_{it}) = \gamma_{0t} + \gamma_1(\Delta^c_{it} - \Delta^d_{it}) + \xi_{it}.$$

among the financially unconstrained firms. Each quarter, we first drop half of the observations that are more likely to be financially constrained based on the Whited and Wu index. The sign of equity net issuance $\phi(n)$ is either zero (equity repurchase) or one (positive equity issuance), and observations with zero net equity issuance are excluded. The right-hand variable is the difference in the binary rank of mispricing Δ with respect to asset pricing model c vs. d. The models are compared on mispricing estimated by post-issuance cumulative abnormal return over 10 years. Each panel determines the control sub-groups. In each quarter and within each control sub-group, firms are ranked by estimated mispricing relative to a candidate model of risk. Each cell reports the *t*-statistics from a different regression. A positive number means that the model in the row wins the race against the model in the column and vice versa. All regressions include time fixed effects and the observations are deflated by the number of firms in each quarter. The *t*-statistics are calculated using double clustered standard errors by firm and quarter.

Table 9: Pairwise model comparison against market multiples

	PB	PE	PS	Excess industry
	Panel A: 25 Size and value groups			
CAPM	16.92	11.40	16.38	9.44
FF3	15.46	10.34	14.94	6.28
Carhart	14.43	9.18	13.70	3.10
ICAPM	12.79	7.17	12.48	1.52
Excess market	13.14	5.72	11.02	-1.73
FF5	11.64	5.10	10.30	-4.75
Q-theory	12.13	5.73	10.71	-3.97
	Panel B: 25 Size and Q groups			
CAPM	5.36	5.39	12.22	10.86
FF3	2.39	2.56	9.47	4.33
Carhart	1.30	1.60	8.31	2.08
ICAPM	1.94	1.68	9.21	3.79
Excess market	0.56	-0.17	7.11	1.30
FF5	-3.33	-2.84	3.99	-5.85
Q-theory	-2.14	-1.58	5.04	-3.72
	Panel C: 25 Size and momentum groups			
CAPM	3.18	5.15	9.67	9.38
FF3	0.30	2.39	6.84	4.24
Carhart	-1.05	1.08	5.39	0.89
ICAPM	-1.04	0.49	5.54	1.19
Excess market	-2.70	-1.32	3.76	-1.11
FF5	-5.59	-3.33	1.20	-7.26
Q-theory	-4.91	-2.61	1.55	-5.78
	Panel D: 25 Value and Q groups			
CAPM	19.25	12.07	19.17	7.41
FF3	17.88	9.77	17.59	0.82
Carhart	17.68	9.25	17.02	-0.45
ICAPM	16.23	10.34	17.04	3.61
Excess market	17.08	8.37	16.08	-0.46
FF5	13.81	3.62	12.23	-8.75
Q-theory	13.83	4.35	12.43	-7.19

This table reports the *t*-statistics associated with γ_1 from the BvB test (equation (14)):

$$\phi(n_{it}) = \gamma_{0t} + \gamma_1(\Delta^c_{it} - \Delta^d_{it}) + \xi_{it}.$$

in comparison of the factor models against the simple market multiples. The sign of equity net issuance $\phi(n)$ is either zero (equity repurchase) or one (positive equity issuance), and observations with zero net equity issuance are excluded. The right-hand variable is the difference in the binary rank of mispricing Δ with respect to asset pricing model c vs. rank of mispricing with respect to a market multiple d. The mispricing with respect to the factor models are estimated based on the post-issuance cumulative abnormal return over 10 years. The mispricing with respect to a market multiple is estimated as the log difference of the firm's market multiple from the average market multiple in the same industry. The last column compares factor models against mispricing inferred from average industry returns. Each panel determines the control sub-groups. In each quarter and within each control sub-group, firms are ranked by estimated mispricing relative to the candidate models. Each cell reports the *t*-statistics from a different regression. A positive number means that the model in the row wins the race against the model in the column and vice versa. All regressions include time fixed effects and the observations are deflated by the number of firms in each quarter. The *t*-statistics are calculated using double clustered standard errors by firm and quarter.

A Appendix: Proofs

Proof of equation (6). Substituting the financing constraint (5) in the objective function (4) gives:

$$\max_{K,n}(1-n)\left(\Pi(K)-\frac{K-n(1+B(n))\Pi(K)}{1-n(1+B(n))}\right)=(1-n)\left(\frac{\Pi(K)-K}{1-n(1+B(n))}\right) \tag{A.1}$$

First order condition with respect to n gives:

$$1-n(1+B(n))=(1-n)(1+B(n)+nB'(n))\Rightarrow B(n)=-B'(n)(1-n)n$$

■

Proof of proposition 1. This proposition directly follows from Assumption 1, considering that the cross-sectional rank of mispricing is increasing in the level of mispricing. ■

Proof of proposition 2. Note that Δ_{it} is equal to 1 for half of the observations and equal to 0 for the other half by construction. Hence, $E[\Delta_{it}]=\frac{1}{2}$ and $Var(\Delta_{it})=\frac{1}{4}$.

$$\begin{aligned}
\beta &= \frac{Cov(\phi(n_{it}),\Delta_{it})}{Var(\Delta_{it})}=4\times\left(E[\phi(n_{it})\Delta_{it}]-E[\phi(n_{it})]E[\Delta_{it}]\right)\\
&=2\times\left(Pr[\phi(n_{it})=1,\Delta_{it}=1]-Pr[\phi(n_{it})=1,\Delta_{it}=0]\right)\\
&=Pr[\phi(n_{it})=1|\Delta_{it}=1]-Pr[\phi(n_{it})=1|\Delta_{it}=0] \qquad\qquad (A.2)\\
&=\sum_{X_{it}}\Big(Pr[\phi(n_{it})=1|\Delta_{it}=1,X_{it}]\frac{Pr[\Delta_{it}=1|X_{it}]Pr[X_{it}]}{Pr[\Delta_{it}=1]}\\
&\qquad\qquad -Pr[\phi(n_{it})=1|\Delta_{it}=0,X_{it}]\frac{Pr[\Delta_{it}=0|X_{it}]Pr[X_{it}]}{Pr[\Delta_{it}=0]}\Big)\\
&=\sum_{X_{it}}Pr[X_{it}]\Big(Pr[\phi(n_{it})=1|\Delta_{it}=1,X_{it}]-Pr[\phi(n_{it})=1|\Delta_{it}=0,X_{it}]\Big) \qquad (A.3)
\end{aligned}$$

The last line comes from the fact that $Pr[\Delta_{it}=1|X_{it}]=Pr[\Delta_{it}=0|X_{it}]=Pr[\Delta_{it}]=\frac{1}{2}$ by construction. Proposition 1 implies that the term in the parenthesis is positive for every X_{it}, hence

$\beta > 0$. ■

In order to prove Proposition 3, we use the following lemma:

Lemma 1. *For any two asset pricing models and within each control group:*

$$Pr[\Delta_{it}^T = 1, \Delta_{it}^F = 0|X_{it}] = Pr[\Delta_{it}^T = 0, \Delta_{it}^F = 1|X_{it}] \tag{A.4}$$

Proof of Lemma 1.

$$Pr[\Delta_{it}^T = 1|X_{it}] = \frac{1}{2} = Pr[\Delta_{it}^T = 1, \Delta_{it}^F = 1|X_{it}] + Pr[\Delta_{it}^T = 1, \Delta_{it}^F = 0|X_{it}] \tag{A.5}$$

$$Pr[\Delta_{it}^F = 1|X_{it}] = \frac{1}{2} = Pr[\Delta_{it}^T = 1, \Delta_{it}^F = 1|X_{it}] + Pr[\Delta_{it}^T = 0, \Delta_{it}^F = 1|X_{it}] \tag{A.6}$$

Comparing above two equations proves the result. ■

Proof of proposition 3. In Proposition 2 we showed that:

$$\beta = 2 \times (Pr[\phi(n_{it}) = 1, \Delta_{it} = 1] - Pr[\phi(n_{it}) = 1, \Delta_{it} = 0]) \tag{A.7}$$

We can write β^T and β^F as follows:

$$\begin{aligned}
\beta^T &= 2 \times (Pr[\phi(n_{it}) = 1, \Delta_{it}^T = 1] - Pr[\phi(n_{it}) = 1, \Delta_{it}^T = 0]) \\
&= 2 \times \Big(Pr[\phi(n_{it}) = 1, \Delta_{it}^T = 1, \Delta_{it}^F = 1] + Pr[\phi(n_{it}) = 1, \Delta_{it}^T = 1, \Delta_{it}^F = 0] \\
&\qquad - Pr[\phi(n_{it}) = 1, \Delta_{it}^T = 0, \Delta_{it}^F = 1] - Pr[\phi(n_{it}) = 1, \Delta_{it}^T = 0, \Delta_{it}^F = 0] \Big) \qquad \text{(A.8)} \\
\beta^F &= 2 \times (Pr[\phi(n_{it}) = 1, \Delta_{it}^F = 1] - Pr[\phi(n_{it}) = 1, \Delta_{it}^F = 0]) \\
&= 2 \times \Big(Pr[\phi(n_{it}) = 1, \Delta_{it}^T = 1, \Delta_{it}^F = 1] + Pr[\phi(n_{it}) = 1, \Delta_{it}^T = 0, \Delta_{it}^F = 1] \\
&\qquad - Pr[\phi(n_{it}) = 1, \Delta_{it}^T = 1, \Delta_{it}^F = 0] - Pr[\phi(n_{it}) = 1, \Delta_{it}^T = 0, \Delta_{it}^F = 0] \Big) \qquad \text{(A.9)}
\end{aligned}$$

Thus,

$$\begin{aligned}
\beta^T - \beta^F &= 4 \times \Big(Pr[\phi(n_{it}) = 1, \Delta^T_{it} = 1, \Delta^F_{it} = 0] - Pr[\phi(n_{it}) = 1, \Delta^T_{it} = 0, \Delta^F_{it} = 1] \Big) \\
&= 4 \sum_{X_{it}} \Big(Pr[\phi(n_{it}) = 1 | \Delta^T_{it} = 1, \Delta^F_{it} = 0, X_{it}] Pr[\Delta^T_{it} = 1, \Delta^F_{it} = 0 | X_{it}] Pr[X_{it}] \\
&\qquad - Pr[\phi(n_{it}) = 1 | \Delta^T_{it} = -1, \Delta^F_{it} = 1, X_{it}] Pr[\Delta^T_{it} = -1, \Delta^F_{it} = 1 | X_{it}] Pr[X_{it}] \Big)
\end{aligned} \tag{A.10}$$

By using Lemma 1, we can simplify above equation:

$$\begin{aligned}
\beta^T - \beta^F &= 4 \sum_{X_{it}} Pr[\Delta^T_{it} = 1, \Delta^F_{it} = 0 | X_{it}] Pr[X_{it}] \\
&\qquad \times \Big(Pr[\phi(n_{it}) = 1 | \Delta^T_{it} = 1, \Delta^F_{it} = 0, X_{it}] - Pr[\phi(n_{it}) = 1 | \Delta^T_{it} = 0, \Delta^F_{it} = 1, X_{it}] \Big) \\
&= 4 \sum_{X_{it}} Pr[\Delta^T_{it} = 1, \Delta^F_{it} = 0 | X_{it}] Pr[X_{it}] \\
&\qquad \times \Big(Pr[\phi(n_{it}) = 1 | \Delta^T_{it} = 1, X_{it}] - Pr[\phi(n_{it}) = 1 | \Delta^T_{it} = 0, X_{it}] \Big)
\end{aligned}$$

The last line comes from the fact that $Pr[\phi(n_{it}) | \Delta^T_{it}, \Delta^F_{it}, X_{it}] = Pr[\phi(n_{it}) | \Delta^T_{it}, X_{it}]$. Proposition 1 implies that the term in the parenthesis is positive for every X_{it}, hence $\beta^T > \beta^F$. ■

Proof of proposition 4. Define:

$$\pi^c = Pr[\Delta_{it} = 1 | \Delta^c_{it} = 1] + Pr[\Delta_{it} = 0 | \Delta^c_{it} = 0] \tag{A.11}$$

By using equation (A.2), we can write:

$$\beta^c = Pr[\phi(n_{it}) = 1 | \Delta^c_{it} = 1] - Pr[\phi(n_{it}) = 1 | \Delta^c_{it} = 0] \tag{A.12}$$

We can write this as:

$$
\begin{aligned}
\beta^c =& Pr[\phi(n_{it}) = 1 | \Delta^c_{it} = 1, \Delta_{it} = 1] Pr[\Delta_{it} = 1 | \Delta^c_{it} = 1] \\
&+ Pr[\phi(n_{it}) = 1 | \Delta^c_{it} = 1, \Delta_{it} = 0] Pr[\Delta_{it} = 0 | \Delta^c_{it} = 1] \\
&- Pr[\phi(n_{it}) = 1 | \Delta^c_{it} = 0, \Delta_{it} = 1] Pr[\Delta_{it} = 1 | \Delta^c_{it} = 0] \\
&- Pr[\phi(n_{it}) = 1 | \Delta^c_{it} = 0, \Delta_{it} = 0] Pr[\Delta_{it} = 0 | \Delta^c_{it} = 0] \\
=& Pr[\phi(n_{it}) = 1 | \Delta_{it} = 1] Pr[\Delta_{it} = 1 | \Delta^c_{it} = 1] + Pr[\phi(n_{it}) = 1 | \Delta_{it} = 0] Pr[\Delta_{it} = 0 | \Delta^c_{it} = 1] \\
&- Pr[\phi(n_{it}) = 1 | \Delta_{it} = 1] Pr[\Delta_{it} = 1 | \Delta^c_{it} = 0] - Pr[\phi(n_{it}) = 1 | \Delta_{it} = 0] Pr[\Delta_{it} = 0 | \Delta^c_{it} = 0] \\
=& \Big(Pr[\phi(n_{it}) = 1 | \Delta_{it} = 1] - Pr[\phi(n_{it}) = 1 | \Delta_{it} = 0] \Big) (\pi^c - 1) \qquad \text{(A.13)}
\end{aligned}
$$

The term in the first parenthesis is positive by Proposition 1, so $\beta^c > \beta^d$ is equivalent to $\pi^c > \pi^d$. ■

Proof of proposition 5.

$$
\gamma_1 = \frac{Cov(\phi(n_{it}), \Delta^c_{it} - \Delta^d_{it})}{Var(\Delta^c_{it} - \Delta^d_{it})} \qquad \text{(A.14)}
$$

and since $Var(\Delta^c_{it}) = Var(\Delta^d_{it}) = \frac{1}{4}$ by construction:

$$
\gamma_1 = \frac{\beta^c - \beta^d}{4 \times Var(\Delta^c_{it} - \Delta^d_{it})} \qquad \text{(A.15)}
$$

Therefore, $\beta^c > \beta^d$ is equivalent to $\gamma_1 > 0$. ■

Proof that our results are identical to Fama-MacBeth. Let $\dot{\phi}_{i,t}$ and $\dot{\Delta}_{i,t}$ be the cross-sectionally demeaned variables for the direction of net issuance and the binary rank of mispricing. Then, the univariate coefficient from a panel regression with time fixed effects is

$$
\frac{4}{TN} \sum_t \sum_i \dot{\phi}_{i,t} \dot{\Delta}_{i,t}, \qquad \text{(A.16)}
$$

where $1/4$ is the sample variance of $\dot{\Delta}_{i,t}$, which is either $-1/2$ or $1/2$. Here, we assume balanced panel. Although in reality our panel data are unbalanced, we use weighted least squares to ensure that different years have the same weight in the regression. Hence, it suffices to analyze the balanced panel case.[13] On the other hand, the Fama-MacBeth coefficient is

$$\frac{1}{T}\sum_t \left(\frac{4}{N}\sum_i \dot{\phi}_{i,t}\dot{\Delta}_{i,t}\right), \tag{A.17}$$

which can be rearranged to be identical to the panel coefficient above. ■

[13]We also ignore the degrees of freedom adjustment in the sample covariance calculation for simplicity.

B Appendix: An alternative measure of mispricing

Our benchmark mispricing in this paper is the compounded alpha (equation (16)). Despite its transparency and simplicity, this estimator does not have a clear interpretation as the deviation of price from the intrinsic value relative to an asset pricing model. The next lemma shows how we can estimate mispricing more accurately by using future realized returns and capital gains.

Definition 2. *Firm i's time-t mispricing with respect to a candidate asset pricing model c is*

$$\delta_{i,t}^{c} = \frac{P_{i,t} - V_{i,t}^{c}}{P_{i,t}}, \tag{B.18}$$

where

$$V_{i,t}^{c} = \sum_{j=1}^{\infty} E_t \left[\frac{D_{i,t+j}}{\prod_{k=1}^{j} \left(1 + R_{i,t+k}^{c}\right)} \right] \tag{B.19}$$

is the intrinsic value of dividends $\{D_{i,t+j}\}$ computed using the firm's rate of return $R_{i,t}^{c}$ implied by an asset pricing model c.

Next, under the mild assumption that the deviation of price from value does not explode, we can use a modified version of the mispricing identity of Cho and Polk (2024) to express $\delta_{i,t}^{c}$ in terms of subsequent returns and capital gains.

Lemma 2. ***(Cho and Polk 2020).*** *Let $V_{i,t}^{c} = \sum_{j=1}^{\infty} E_t \left[\frac{D_{i,t+j}}{\prod_{k=1}^{j}\left(1+R_{i,t+k}^{c}\right)} \right]$ be the intrinsic value of the asset defined as the present value of cash flows with respect to the firm's discount rate $R_{i,t}^{c}$ implied by the asset pricing model. Then,*

$$\delta_{i,t}^{c} \equiv \frac{P_{i,t} - V_{i,t}^{c}}{P_{i,t}} = -\sum_{j=1}^{\infty} E_t \left[\frac{P_{i,t+j-1}}{P_{i,t}} \times \frac{R_{i,t+j} - R_{i,t+j}^{c}}{\prod_{k=1}^{j}(1 + R_{i,t+k}^{c})} \right], \tag{B.20}$$

where P_{t+j-1}/P_t and R_{t+j} are, respectively, the cumulative capital gain and the asset return. This identity holds regardless of whether or not c is the true asset pricing model.

Proof. Let $\delta_{i,t}^{c}$ and $V_{i,t}^{c}$ be mispricing and intrinsic value with respect to a model-implied rate of return R^c. By definition, $V_{i,t}^{c} = E_t \left[\frac{1}{1+R^c} \left(D_{i,t+1} + V_{i,t+1}^{c} \right) \right]$. Use $V_{i,t}^{c} = \left(1 - \delta_{i,t}^{c}\right) P_{i,t}$ to substitute the V's on both sides of the equation:

$$\left(1-\delta_{i,t}^{c}\right)P_{i,t}=E_{t}\left[\frac{1}{1+R^{c}}\left(D_{i,t+1}+\left(1-\delta_{i,t+1}^{c}\right)P_{i,t+1}\right)\right]$$

Rearranging, $\delta_{i,t}^{c}=-E_{t}\left[\frac{1}{1+R^{c}}\left(R_{i,t+1}-R^{c}\right)\right]+E_{t}\left[\frac{1}{1+R^{c}}\frac{P_{i,t+1}}{P_{i,t}}\delta_{i,t+1}^{c}\right]$. Iterating this difference equation for $\delta_{i,t}^{c}$ forward and imposing $\lim_{J\to\infty}\left\{\frac{1}{(1+R^{c})^{J}}E_{t}\left[P_{i,t+J}-V_{i,t+J}^{c}\right]\right\}=0$ gives equation (B.20): $\delta_{i,t}^{c}=-\sum_{j=1}^{\infty}\frac{1}{(1+R^{c})^{j}}E_{t}\left[\frac{P_{i,t+j-1}}{P_{i,t}}(R_{i,t+j}-R^{c})\right]$. ■

Equation (B.20) motivates the sample realization of the right-hand side as the natural estimator of mispricing with respect to model c:

$$\hat{\delta}_{i,t}^{c}=-\sum_{j=1}^{J}\frac{P_{i,t+j-1}}{P_{i,t}}\times\frac{R_{i,t+j}-R_{i,t+j}^{c}}{\prod_{k=1}^{j}(1+R_{i,t+k}^{c})},\tag{B.21}$$

where $J=10$ to 15 years is typically long enough to serve as an accurate approximation of the infinite sum. The finite-sum expression in expectation has the interpretation as the net present value of buying and holding the stock and selling it after J periods with respect to the discount rate $R_{i,t}^{c}$. The result also implies that for short horizons J, a simple cumulation of abnormal returns could proxy for mispricing. This motivates our baseline predictor of mispricing.

C Appendix: Additional Figure and Tables

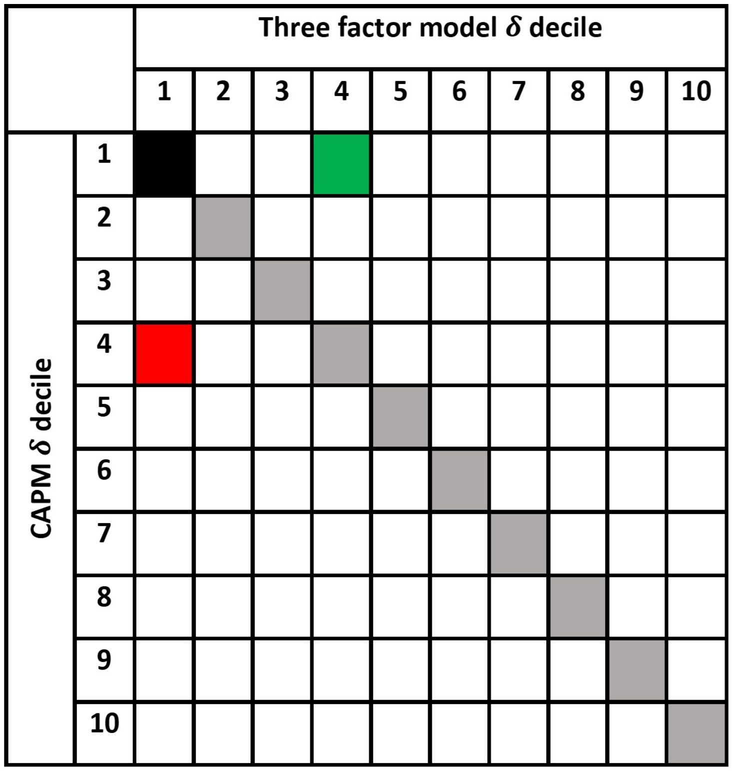

Figure C.1: Horse race dummy variables for pairwise comparison (BHO test)

This figure shows 100 possible dummy variables for the regression that compares mispricing with respect to the CAPM versus mispricing with respect to the Fama French three factor model. In the regression, omitted variable is the dummy with the first decile rank for both models. The gray cells represent firms with similar mispricing ranks from both models. The empirical tests compare the coefficients corresponding to 45 upper off-diagonal and 45 lower off-diagonal cells. For example, we compare the coefficient of dummy variable for firms with CAPM mispricing in the fourth decile and FF3 mispricing in the first decile (red) to the firms with CAPM mispricing in the first decile and FF3 mispricing in the fourth decile (green). CAPM wins the race if firm's issuance decision is more sensitive to the mispricing with respect to the CAPM, i.e. $b_{4,1} > b_{1,4}$.

Table C.1: Pairwise model comparisons, repurchases only

	CAPM	FF3	Carhart	ICAPM	Excess market	FF5	Q-theory
Panel A: 25 Size and value groups							
CAPM	0.00	2.76	3.53	8.58	11.92	10.89	9.88
FF3	-2.76	0.00	1.99	4.48	6.45	12.80	8.29
Carhart	-3.53	-1.99	0.00	3.15	4.99	9.05	8.08
ICAPM	-8.58	-4.48	-3.15	0.00	0.31	2.33	2.38
Excess market	-11.92	-6.45	-4.99	-0.31	0.00	2.13	2.23
FF5	-10.89	-12.80	-9.05	-2.33	-2.13	0.00	0.25
Q-theory	-9.88	-8.29	-8.08	-2.38	-2.23	-0.25	0.00
Panel B: 25 Size and Q groups							
CAPM	0.00	4.83	4.46	7.50	9.48	11.76	9.75
FF3	-4.83	0.00	0.88	2.41	3.31	12.02	7.09
Carhart	-4.46	-0.88	0.00	1.84	2.63	9.39	7.37
ICAPM	-7.50	-2.41	-1.84	0.00	-0.33	3.46	2.80
Excess market	-9.48	-3.31	-2.63	0.33	0.00	4.59	3.55
FF5	-11.76	-12.02	-9.39	-3.46	-4.59	0.00	-1.01
Q-theory	-9.75	-7.09	-7.37	-2.80	-3.55	1.01	0.00
Panel C: 25 Size and momentum groups							
CAPM	0.00	5.04	5.21	9.20	11.38	13.33	11.25
FF3	-5.04	0.00	1.82	2.83	3.86	14.25	8.07
Carhart	-5.21	-1.82	0.00	1.75	2.63	10.15	7.97
ICAPM	-9.20	-2.83	-1.75	0.00	-0.22	4.32	3.42
Excess market	-11.38	-3.86	-2.63	0.22	0.00	4.93	3.98
FF5	-13.33	-14.25	-10.15	-4.32	-4.93	0.00	-0.83
Q-theory	-11.25	-8.07	-7.97	-3.42	-3.98	0.83	0.00
Panel D: 25 Value and Q groups							
CAPM	0.00	2.39	1.15	2.76	6.45	9.59	7.26
FF3	-2.39	0.00	-1.72	-0.06	1.85	15.05	8.30
Carhart	-1.15	1.72	0.00	0.60	2.42	14.66	11.43
ICAPM	-2.76	0.06	-0.60	0.00	1.61	5.36	4.37
Excess market	-6.45	-1.85	-2.42	-1.61	0.00	6.12	4.55
FF5	-9.59	-15.05	-14.66	-5.36	-6.12	0.00	-1.04
Q-theory	-7.26	-8.30	-11.43	-4.37	-4.55	1.04	0.00

This table reports the *t*-statistics associated with γ_1 from the BvB test (equation (14)):

$$\phi(n_{it}) = \gamma_{0t} + \gamma_1(\Delta_{it}^c - \Delta_{it}^d) + \xi_{it}.$$

The sign of equity net issuance $\phi(n)$ is either zero (equity repurchase) or one (positive or zero equity issuance). The right-hand variable is the difference in the binary rank of mispricing Δ with respect to a candidate asset pricing model c. with respect to asset pricing model c vs. d. The models are compared on mispricing estimated by post-issuance cumulative abnormal return over 10 years. Each panel determines the control sub-groups. In each quarter and within each control sub-group, firms are ranked by estimated mispricing relative to a candidate model of risk. Each cell reports the *t*-statistics from a different regression. A positive number means that the model in the row wins the race against the model in the column and vice versa. All regressions include time fixed effects and the observations are deflated by the number of firms in each quarter. The *t*-statistics are calculated using double clustered standard errors by firm and quarter.

Table C.2: Pairwise model comparison, BHO method, Fama Mcbeth regressions

	FF3	Carhart	ICAPM	Excess market	FF5	Q-theory
			Sum of differences			
CAPM	2.112	2.555	3.377	4.348	4.248	3.631
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FF3		1.694	0.789	1.879	3.779	2.756
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Carhart			-0.055	0.822	2.525	1.941
			(0.703)	(0.000)	(0.000)	(0.000)
ICAPM				0.156	1.965	1.188
				(0.293)	(0.000)	(0.000)
Excess market					1.014	0.683
					(0.000)	(0.000)
FF5						-0.261
						(0.051)
			% of differences > 0			
CAPM	95.556	97.778	100.000	95.238	100.000	100.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FF3		95.556	77.778	88.889	100.000	100.000
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Carhart			51.111	77.778	100.000	95.556
			(1.000)	(0.000)	(0.000)	(0.000)
ICAPM				62.222	91.111	80.000
				(0.135)	(0.000)	(0.000)
Excess market					80.000	57.778
					(0.000)	(0.371)
FF5						37.778
						(0.135)

This table presents the results of pairwise horse race between competing risk models using BHO method. In this table, instead of running a panel regression, we estimate the relation between the sign of equity issuance and the decile rank of post-issuance mispricing using a Fama-Macbeth regression. The sign of equity net issuance is either zero (equity repurchase) or one (positive equity issuance). The sample excludes firm-quarter observations with zero net equity issuance. Controls include time and firm fixed effect, lagged equity issuance, lagged logarithm of total assets, lagged market to book ratio, age, profitability, investment, and asset growth. All mispricings are estimated over a 10-year time horizon. We compare off diagonal coefficients of dummy variables as in Figure C.1. Panel A presents the sum of the differences of off-diagonal coefficient estimates and their p-values. A positive number indicates that the model in the row wins the race against the model in the column. Panel B shows the percentage of cases in which the first model (row) beats the second model (column) out of the 45 comparisons and the p-value of the binomial test.. Data is quarterly from 1969 to 2009. All observations are deflated by the number of firms in each quarter and t-statistics are calculated using double clustered standard errors by firm and quarter.

Table C.3: Pairwise model comparisons, alternative measure of mispricing

	CAPM	FF3	Carhart	ICAPM	Excess market	FF5	Q-theory
				Panel A: 25 Size and value groups			
CAPM	0.00	7.66	9.14	9.75	15.04	11.34	10.36
FF3	-7.66	0.00	4.90	1.46	6.13	9.77	5.82
Carhart	-9.14	-4.90	0.00	-1.42	2.77	5.40	3.37
ICAPM	-9.75	-1.46	1.42	0.00	4.22	4.60	4.16
Excess market	-15.04	-6.13	-2.77	-4.22	0.00	1.84	0.96
FF5	-11.34	-9.77	-5.40	-4.60	-1.84	0.00	-1.22
Q-theory	-10.36	-5.82	-3.37	-4.16	-0.96	1.22	0.00
				Panel B: 25 Size and Q groups			
CAPM	0.00	7.91	7.94	8.68	13.89	11.49	9.88
FF3	-7.91	0.00	2.91	0.48	4.31	9.01	5.00
Carhart	-7.94	-2.91	0.00	-1.10	2.10	6.48	3.57
ICAPM	-8.68	-0.48	1.10	0.00	3.49	5.01	4.45
Excess market	-13.89	-4.31	-2.10	-3.49	0.00	3.90	2.73
FF5	-11.49	-9.01	-6.48	-5.01	-3.90	0.00	-1.43
Q-theory	-9.88	-5.00	-3.57	-4.45	-2.73	1.43	0.00
				Panel C: 25 Size and momentum groups			
CAPM	0.00	9.28	9.65	11.45	16.50	12.57	10.84
FF3	-9.28	0.00	3.49	1.10	4.95	9.17	4.67
Carhart	-9.65	-3.49	0.00	-0.95	2.31	6.41	3.05
ICAPM	-11.45	-1.10	0.95	0.00	3.08	4.69	3.58
Excess market	-16.50	-4.95	-2.31	-3.08	0.00	3.59	1.46
FF5	-12.57	-9.17	-6.41	-4.69	-3.59	0.00	-2.16
Q-theory	-10.84	-4.67	-3.05	-3.58	-1.46	2.16	0.00
				Panel D: 25 Value and Q groups			
CAPM	0.00	6.29	7.29	6.18	13.80	10.20	9.95
FF3	-6.29	0.00	3.53	-1.17	4.81	10.19	7.12
Carhart	-7.29	-3.53	0.00	-2.91	2.14	7.57	5.62
ICAPM	-6.18	1.17	2.91	0.00	6.13	6.63	6.88
Excess market	-13.80	-4.81	-2.14	-6.13	0.00	4.23	4.11
FF5	-10.20	-10.19	-7.57	-6.63	-4.23	0.00	-0.40
Q-theory	-9.95	-7.12	-5.62	-6.88	-4.11	0.40	0.00

This table reports the *t*-statistics associated with γ_1 from the BvB test (equation (14)):

$$\phi(n_{it}) = \gamma_{0t} + \gamma_1(\Delta^c_{it} - \Delta^d_{it}) + \xi_{it}.$$

The sign of equity net issuance $\phi(n)$ is either zero (equity repurchase) or one (positive equity issuance), and observations with zero net equity issuance are excluded. The right-hand variable is the difference in the binary rank of mispricing Δ with respect to asset pricing model c vs. d. The models are compared on mispricing estimated using equation (B.21) over 10 years. Each panel determines the control sub-groups. In each quarter and within each control sub-group, firms are ranked by estimated mispricing relative to a candidate model of risk. Each cell reports the *t*-statistics from a different regression. A positive number means that the model in the row wins the race against the model in the column and vice versa. All regressions include time fixed effects and the observations are deflated by the number of firms in each quarter. The *t*-statistics are calculated using double clustered standard errors by firm and quarter.