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 the firm's net present value calculation and an asset pricing model of risk most likely to be used in the calculation. We take this insight to develop a test that infers an asset pricing model that firms use. Our market-based test confirms the narrative that the CAPM is the closest risk model to that of firms. Our results are not driven by issuance due to external financing needs and are true even for firms with an extreme size or value characteristic.

JEL classification: G11, G12, G34

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1 Introduction

In the absence of arbitrage, a single asset pricing model of risk describes not only the portfolio decision of investors, but also any profit-maximizing firm's decision under uncertainty. While this observation has led researchers to study asset pricing using firm investments (e.g., Cochrane (1991, 1996)), the literature has not attempted to infer an asset pricing model from firms' trading of their own shares through issuance, repurchase, and dividend payouts ("net issuance"). Our goal in this paper is to infer firms' asset pricing model from the rich data on net issuance decisions and stock prices.

Identifying an asset pricing model that firms use is important. How firms perceive risk affects their decision under uncertainty and equilibrium aggregate output in different states of nature. Moreover, our test based on firm decisions is an out-of-sample test for the finding that flows to mutual funds (Berk and Van Binsbergen (2016); Barber, Huang, and Odean (2016)) and hedge funds (Agarwal, Green, and Ren (2018); Blocher and Molyboga (2017)) are most consistent with investors using the Capital Asset Pricing Model (CAPM). Consistency in the risk model used by different economic agents would bolster the notion that everyone in the economy faces the same state-contingent prices.[1]

We take the revealed preference approach developed in Berk and Van Binsbergen (2016) (BVB) and Barber, Huang, and Odean (2016) (BHO). Since economic agents react to positive net present value (NPV) opportunities, their actions reveal which model of risk they are likely to be using to compute the NPV. Based on this insight, BVB and BHO develop different techniques to infer the risk model investors use to evaluate actively managed mutual funds. We adapt BVB and BHO's techniques to a setting that reveals firms' net present value calculations: market timing through equity issuance. The resulting test identifies firm managers' risk model based on the ability of model-implied NPV estimates to explain the sign of equity net issuance.

Our approach builds on the extensive body of evidence that equity market timing—issuing

[1]Furthermore, as argued in Cochrane (1991), the approach could nicely complement the approach from investors' perspective, since firm managers could be more sophisticated and face less informational barriers than an average investor.

when shares are overvalued and repurchasing when shares are undervalued—is a primary factor in equity issuance decisions.[2] 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.[3] Complementing the survey evidence is that equity issuance is positively related to ex-ante measures of mispricing and predicts subsequent underperformance in stock returns.[4]

We face two main challenges in applying the revealed preference approach to equity net issuance. First, a firm's equity net issuance could be driven by variables other than market timing. In this case, an asset pricing model that generates NPV estimates more correlated with the omitted variables will have an artificial advantage over the competing models. We address this concern in two ways. We first show how the test method developed by BVB can be adapted to incorporate control variables and provide a theoretical framework for the approach. We also repeat our analysis using firms that are unlikely to be financially constrained and therefore are less likely to rely on equity issuance to raise financing if they follow the pecking order.

The second issue is that the firm's *pre*-issuance mispricing that triggers net issuance can be difficult to estimate. While *post*-issuance mispricing can be easier to estimate, one could worry that the equity net issuance issuance could eliminate or change the sign of mispricing such that post-issuance mispricing is a poor indicator of pre-issuance mispricing. However, a simple model based on Gilchrist, Himmelberg, and Huberman (2005) justifies proxying pre-issuance mispricing with post-issuance mispricing. Since a firm is a monopolist in the supply of its own shares, the

[2]A large behavioral corporate finance literature on this topic is surveyed by Baker, Ruback, and Wurgler (2007).

[3]67% of the responses state that misvaluation is a very important or important factor in the decision on issuance. 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.

[4]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.

optimal corporate arbitrage pushes the price towards but not all the way to the intrinsic value. Thus, equity market mispricing persists even after share issuance and has the same sign as the issuance, allowing us to use post-issuance mispricing in our tests.

To proceed, we need to measure post-net-issuance mispricing from the perspective of firm managers. We estimate mispricing with respect to a candidate asset pricing model as the long-horizon cumulative return in excess of the risk-adjusted return implied by the candidate model. In each quarter we sort firms based on the estimated mispricing and test which risk model generates mispricing sortings that best aligns with the direction of net issuance.[5] We estimate mispricing over different time horizons of up to 10 years. We find that mispricing estimated over longer time horizon can better explain direction of equity issuance, consistent with firm managers acting on the interest of long-term shareholders. We show robustness of our results to using an alternative measure of mispricing.

We run a horse race between several well-known single and multifactor models of risk, controlling for firm characteristics such as size, book-to-market, and a proxy for average Q that could proxy for investment opportunity, an important driver of net issuance among financially constrained firms. We find that the CAPM consistently wins the race; that is, firms managers appear to use the CAPM to value the firm and make the issuance decision. Our results are consistent with the survey data that indicates CAPM is by far the most popular risk model used by the firm managers (Bruner et al. (1998); Graham and Harvey (2001)); our results based on actual firm decisions complement this survey-based evidence, which could contain errors due to misreporting and selection bias.

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, since these firms would be making the largest mistake by using the CAPM if the true model of risk includes the size and value factors. Interestingly, CAPM mispricing better explains direction of equity issuance even for these firms in the highest or lowest size or value

[5]By the logic of previous paragraph, direction of net issuance proxies for the true post-issuance mispricing perceived by the firm.

quintiles, with the Fama French three factor model being a close contender.

When interpreting the results, one should be careful that the differences in the estimation errors factor into the comparison among asset pricing models. If, for example, CAPM mispricing has smaller estimation errors, the test is more likely to identify the CAPM as the best model. Therefore, the correct way to interpret our results is that estimated CAPM mispricing best proxies for the firm's true perceived mispricing compared to mispricing estimated using other models.

Our finding is not implied by the notion that anomaly characteristics typically generate the largest spread in abnormal returns with respect to the CAPM. To compare different asset pricing models in their ability to rationalize the net equity issuance decisions, we rely on the cross-sectional *sorting* of firms into high vs. low estimated mispricing groups instead of the *level* of estimated mispricing. There is less reason to expect that the binary sorting based on CAPM abnormal returns would best align with an anomaly characteristic.[6]

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 and point to the time variation in flow-performance sensitivity as the reason. Since our test is not based on investor flows, the same concern does not apply to our results. Still, we take two precautions in response. First, we follow Ben-David et al.'s suggestion to include time fixed effects in all regressions and use weighted least squares to ensure that our test coefficient is a time-series average of the cross-sectional coefficients.[7] Second, we examine if firms follow a simple rule based on market multiples to make the net issuance decision and find that CAPM mispricing outperforms the market multiples in explaining net issuance decisions.

Additional analyses point to the robustness of our findings. Although we control for firm characteristics that may be correlated with investment opportunities—another determinant of net

[6]Indeed, repeating the main analysis with the high vs. low split based on each of the return-predicting signals provided by Chen and Zimmerman (2020) (around 200 signal) as the left-hand side shows that the placebo test selects the CAPM around 1 out of 4 times, which is higher than the odds of 1 out of 7 (the comparison is among 7 asset pricing models) but far from being a dominant choice.

[7]We verify that our results are identical when using a Fama-MacBeth regression, which Ben-David et al. use to draw a different finding from previous studies.

issuance—, we further address this concern by following the literature (Lamont, Polk, and Saaá-Requejo (2001); Baker, Stein, and Wurgler (2003); Polk and Sapienza (2008)) to limit our sample to the firms that are not equity dependent based on the financial constraint measure of Whited and Wu (2006). We find consistent results using alternative measures of financial constraint provided by Kaplan and Zingales (1997), Hadlock and Pierce (2010), and Campello and Graham (2013). We also compare the performance of factor models to the simple market multiples and find that mispricing with respect to the CAPM performs significantly better than market multiples in predicting the direction of equity issuance. Finally, our results are robust to using an alternative measure of mispricing that is arguably closer to the actual mispricing firms use to make net issuance decisions.

Our work contributes to the growing literature that uses revealed preferences to infer 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 the hedge funds. All of these studies reach the same conclusion that fund flows are best explained by CAPM alpha. Ben-David et al. (2021) find, however, that mutual fund investors seem to use a simpler rule based on either raw returns or fund ratings. In contrast, Gormsen (2020) uses firms' own perceived cost of capital to show that large companies in the post-2000 sample appear to also account for the exposure to size and value factors.[8] Dessaint et al. (2019) explores effect of using CAPM on firm's investment decision using M&A data and Baker, Hoeyer, and Wurgler (2019) focus on the effect on financing decisions.

Our work is also related to the literature on stock prices and net issuance. Jung, Kim, and Stulz (1996) and Hovakimian, Opler, and Titman (2001) find strong relationship between stock prices and seasoned equity offerings in the US data. 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,

[8]Restricting our sample to the most recent period shows that the CAPM and the three-factor model that includes size and value perform similarly in explaining net issuance, which could explain the result in Gormsen.

Lakonishok, and Vermaelen (2000) show that repurchasers have higher subsequent average returns and 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 of risk. Section 5 provides the results of robustness checks and additional analysis. Section 6 concludes.

2 Theoretical framework

Our test in subsequent sections build 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 reveal preference test on an asset pricing model 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

We use a stylized model of stock price bubble and equity issuance based on Gilchrist, Himmelberg, and Huberman (2005) to demonstrate 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.[9] 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.

The market value of equity P could deviate from the intrinsic value V and this "bubble" component of the market value, denoted B, is negatively affected 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.[10] 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

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

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

of equilibrium post-net-issuance mispricing matches the sign of net equity issuance:

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

where $-B'\left(n\right) > 0$ because demand curve slopes downward and $\left(1-n\right) > 0$ 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 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 reasons other than mispricing, such as investment opportunities. This leads us to bridge from our stylized theoretical model to the following assumption.[11]

[11] 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.

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.

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 comparing different asset pricing models, we do not want to make any assumptions about the distribution of the estimation error. Therefore, instead of using the level of the estimated mispricing, we use the relative ranking of the mispricing. Let subscript it 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 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 performance of two asset pricing models. The next three propositions establish the foundations for this test. Following BVB, we assume that there exist a true asset pricing model such that in its presence, a false risk model cannot have 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, $\beta^T > \beta^F$.*

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

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

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 an easy test to empirically test competing asset pricing models

Proposition 5. *Consider an OLS regression of $\phi(n_{it})$ on the $\Delta^c_{it} - \Delta^d_{it}$:*

$$\phi(n_{it}) = \gamma_0 + \gamma_1(\Delta^c_{it} - \Delta^d_{it}) + \xi_{it} \tag{14}$$

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 $\hat{\mathbf{b}}$ and realized factor returns $\mathbf{F}$ to estimate the benchmark return R^b:[12]

$$R^b_{i,t} = \hat{\mathbf{b}}'_{i,t}\mathbf{F}_t. \tag{15}$$

[12] We express all vectors as column vectors.

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:

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

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

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 R^b 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 Equity net issuance

Our left-hand side variable is the sign of the equity net issuance. Consistent with the literature of 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. Although not reported, we find the results to be similar when using an alternative measure of equity net issuance that excludes dividend payments:

$$n_{i,t} = \frac{N_{i,t}}{N_{i,t-1}} - 1, \tag{18}$$

where N is the adjusted number of shares outstanding.

3.3 Financial constraint

In Section 5 we use different measures of financial constraint to limit our sample to the firms that are not equity dependent. Whited and Wu (2006) measure is constructed based on a firm's accounting characteristics as follows:

$$\begin{aligned} WW_{it} = &- 0.091 \times CF_{it} + 0.021 \times TLTD_{it} - 0.062 \times DIVPOS_{it} \\ &- 0.044 \times LNTA_{it} + 0.102 \times ISG_{it} - 0.035 \times SG_{it}, \end{aligned} \tag{19}$$

where CF_{it} stands for the 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 previous fiscal year, $LNTA_{it}$ is the logarithm of the total assets, ISG_{it} is the three digit 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 dividend and do not have too much investment opportunities are less likely to be financially constrained.[13]

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:

$$\begin{aligned} KZ_{it} = &- 1.002 \times CF_{it} + 3.139 \times TLTD_{it} \\ &- 39.368 \times TDIV_{it} - 1.314 \times CASH_{it} + 0.283 \times Q_{it} \end{aligned} \tag{20}$$

[13] 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

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:

$$SA_{it} = -0.737 \times SIZE_{it} + 0.043 \times SIZE_{it}^2 - 0.040 \times AGE_{it} \tag{21}$$

3.4 Summary statistics

Table 1 reports summary statistics of our sample between 1969 to 2009. The quarterly issuance has a mean of 1.04 percent and standard deviation of 6.22 percent.[14] The average firm has a size of 5.41 billion dollars and age of 12.83 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 original level. Therefore, our tests are robust to arbitrary shifts in the distribution. 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 estimating the regression coefficient of 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: size and book-to-market (value), size and the Peters and Taylor

[14] We Winsorize equity issuance at 1 and 99 percent in each quarter.

(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.

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 more likely to survive a falsification test.

Table 3 reports the estimates of β 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 the ex-post 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; 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 the 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 γ_1 estimates. 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.

It is interesting to compare performance of the CAPM against 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 which 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

BHO develop a similar technique to run horse races among asset pricing models. One advantage of the BHO method is that we can easily control for other characteristics in a linear regression, although the method has the disadvantage of not being derived form the first principle.

Following the BHO method, we first sort firms based on their estimated 10 year post-issuance mispricing into deciles.[15] 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:

$$D_{jkit} = \begin{cases} 1 & \Delta^c_{it} = j, \Delta^d_{it} = k \qquad \forall j,k = 1,...,10 \\ 0 & otherwise \end{cases} \tag{22}$$

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

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

factor model(green cell, b_{14}). If firm manager uses the CAPM rather than the three factor model, we expect that $b_{41} > b_{14}$. Thus, similar to the BHO, we test the null hypothesis that the sum of difference of 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. The results again show that the CAPM significantly outperforms all other models. This evidence proves 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 appendix 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 8 presents the time-series average of the cross-sectional coefficients.

5.2 Financial constraint

One concern for our tests is that equity issuance can happen for reasons unrelated to market timing, such as the financing of investment projects. To the extent that these other reasons are uncorrelated with mispricing, they would not bias our estimations. Still, we address this concern by following the literature (Lamont, Polk, and Saaá-Requejo (2001); Baker, Stein, and Wurgler (2003); Polk and Sapienza (2008)) to limit our sample to the firms that are not equity dependent. We show that our results are robust to excluding financially constrained firms as identified by alternative measures provided by Whited and Wu (2006), Kaplan and Zingales (1997), Hadlock and Pierce

(2010), and Campello and Graham (2013). Each quarter we sort firms based on their measure of financial constraint and drop top half (most constrained firms). Table 9 presents the results of pairwise model comparison among unconstrained firms identified by the Whited and Wu (2006) measure. As we can see, 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.

5.3 Comparison to market multiples

Although it is not directly related to our question, 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 10 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 11).

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 sheds 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	531,606	5.41	2.18	0.86	10.73
Age	538,560	12.83	11.16	1	49
Estimated mispricing over 120 month					
CAPM	504,812	-0.22	1.28	-6.68	1.00
FF3	504,812	-0.13	1.23	-6.80	1.00
Carhart	504,812	-0.22	1.37	-7.89	1.00
ICAPM	485,385	-1.44	3.40	-20.87	1.00
Excess market	572,685	-0.16	1.24	-6.57	1.00
FF5	504,812	-0.35	1.91	-12.34	1.00
Q-theory	504,812	-0.69	2.85	-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. Estimated mispricing is winsorized at 1 and 99 percent cutoffs.

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	0.779	1					
Carhart	0.678	0.849	1				
ICAPM	0.840	0.699	0.614	1			
Excess market	0.880	0.694	0.612	0.828	1		
FF5	0.502	0.657	0.588	0.479	0.479	1	
Q-theory	0.325	0.360	0.443	0.306	0.298	0.415	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 10-year horizon with respect to different risk models. Data is quarterly from 1969q1 to 2008q2.

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 sign of equity issuance $n_{i,t}$ on the binary rank of post-issuance mispricing Δ_{it}. Ranking is quarterly and within each control sub-group.

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

Each column corresponds to a different time horizon over which mispricing is estimated. Each cell represents a different regression. All observations are weighted by the number of firms in each quarter and *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 of the γ_1 from the BvB test (equation (14)). Each panel determines the control sub-groups. In each quarter and in each characteristic group, firms are sorted into two groups based on the log deviation in the market multiple from the industry average or based on estimated mispricing in which a Fama-French industry average return (based on 49 industries) is the benchmark return. Models are compared based on the estimated 10-year post-issuance mispricing. Each cell reports the *t*-statistics from a different regression. All regressions include time fixed effect and observations are weighted 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 of the γ_1 from the BvB test (equation (14)) for the firms in the highest or the lowest size or value group. In each quarter, firms are sorted based on their estimated mispricing within the 25 sub-group into two bins. Models are compared based on the estimated 10-year post-issuance mispricing. Each cell reports the t-statistics from a different regression. All regressions include time fixed effect and observations are weighted 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 of the γ_1 from the BvB test (equation (14)) of CAPM against other risk models, within each of the 25 size and value sub-groups. In each quarter, firms are sorted within the 25 sub-groups based on their estimated mispricing into two bins. Models are compared based on the estimated 10-year post-issuance mispricing. Each cell reports the *t*-statistics from a different regression. All regressions include time fixed effect and observations are weighted 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 decile rank of post-issuance mispricing as defined by two competing asset pricing models:

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

Controls include time and firm fixed effect, lagged equity issuance, lagged logarithm of size, 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 percent of cases which model in the row wins against the model in the column out of 45 comparisons and the p-value of the binomial test. Data is quarterly from 1969 to 2009. All observations are weighted 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 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 pannel regression, we estimate the relation between the sign of equity issuance and decile rank of post-issuance mispricing using Fama-Macbeth regression. Controls include time and firm fixed effect, lagged equity issuance, lagged logarithm of size, 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 percent of cases which model in the row wins against the model in the column out of 45 comparisons and the p-value of the binomial test. Data is quarterly from 1969 to 2009. All observations are weighted by the number of firms in each quarter and *t*-statistics are calculated using double clustered standard errors by firm and quarter.

Table 9: 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 of the γ_1 from the BvB test (equation (14)) among financially unconstrained firms. Each quarter, we first drop half of the observations based on the Whited and Wu index of financial constraint. Then, within each control sub-group, firms are sorted based on their estimated mispricing into two bins. Models are compared based on the estimated 10-year post-issuance mispricing. Each cell reports the *t*-statistics from a different regression. All regressions include time fixed effect and observations are weighted by the number of firms in each quarter. The *t*-statistics are calculated using double clustered standard errors by firm and quarter.

Table 10: 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 of the γ_1 from the BvB test (equation (14)) in comparison of factor models against simple market multiples. Mispricing with respect to the market multiples is defined as the log difference from the industry average. Last column shows the result of comparison of factor models against mispricing with respect to the average industry returns. Each cell reports the *t*-statistics from a different regression. All regressions include time fixed effect and observations are weighted by the number of firms in each quarter. The *t*-statistics are calculated using double clustered standard errors by firm and quarter.

Table 11: 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 of the γ_1 from the BvB test (equation (14)). Mispricing is estimated using equation (B.21). Each panel determines the control sub-groups. In each quarter, firms are sorted based on their estimated mispricing within the sub-group into two bins. Models are compared based on the estimated 10-year post-issuance mispricing. Each cell reports the *t*-statistics from a different regression. All regressions include time fixed effect and observations are weighted 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 $Var(\Delta_{it})=\frac{1}{4}$.

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

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,

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

By using Lemma 1, we can simplify above equation:

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

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.[16] 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. ■

[16]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

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

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 based on information up to time t.

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 (2020) to express $\delta_{i,t}^{c}$ in terms of subsequent returns and capital gains.

Lemma 2. ***(Cho and Polk 2020).*** *Let $V_{i,t}^{c} = \sum_{j=1}^{\infty} \frac{1}{\left(1+R_{i,t}^{c}\right)^{j}} E_t \left[D_{i,t+j}\right]$ 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,*

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

where P_{t+j-1}/P_t and R_{t+j}^{e} are, respectively, the cumulative capital gain and excess return on the asset. 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 $\lim_{J \rightarrow \infty}\left\{\frac{1}{\left(1+R^{c}\right)^{J}} E_{t}\left[P_{i,t+J}-V_{i,t+J}^{c}\right]\right\}=0$ gives equation (B.20): $\delta_{i,t}^{c}=-\sum_{j=1}^{\infty} \frac{1}{\left(1+R^{c}\right)^{j}} E_{t}\left[\frac{P_{i,t+j-1}}{P_{i,t}}\left(R_{i,t+j}-R^{c}\right)\right]$. ■

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

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

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

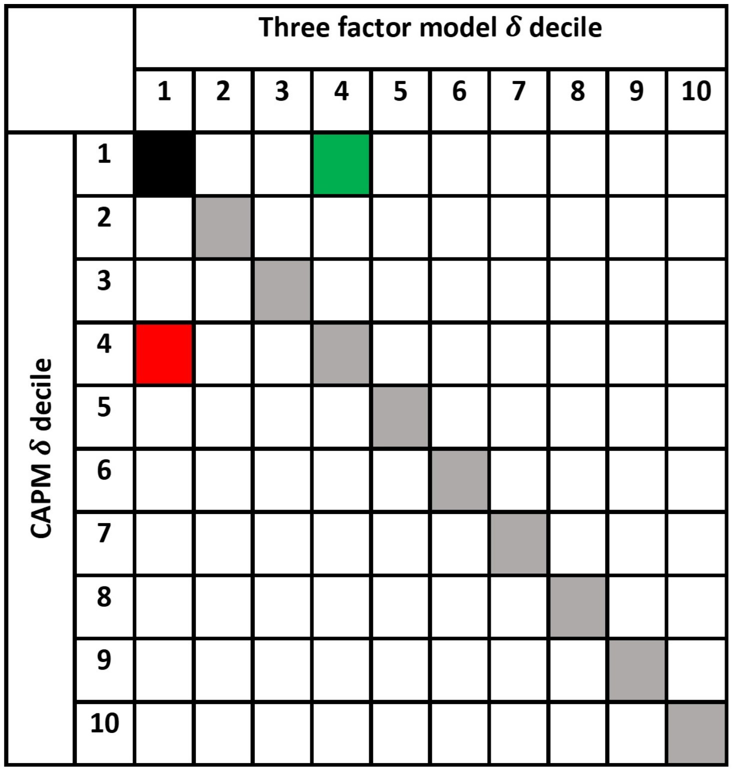

Figure C.1: Horse race dummy variables for pairwise comparison (BHO test)

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. $b_{4,1} > b_{1,4}$.