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SHORT- AND LONG-HORIZON BEHAVIORAL FACTORS

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ABSTRACT

Recent theories suggest that both risk and mispricing are associated with commonality in security returns, and that the loadings on characteristic-based factors can be used to predict future returns. We supplement the market factor with two mispricing factors which capture long- and short-horizon mispricing. Our financing factor is based on evidence that managers exploit long-horizon mispricing by issuing or repurchasing equity. Our earnings surprise factor, which is motivated by evidence of limited attention and short-horizon mispricing, captures short-horizon anomalies. Our three-factor risk-and-behavioral model outperforms both traditional and other prominent factor models in explaining a large set of return anomalies.

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Introduction

In his 2011 Presidential Address to the American Finance Association, John Cochrane asks three questions about what he describes as the "zoo" of new anomalies:

> First, which characteristics really provide independent information about average returns? Second, does each new anomaly variable also correspond to a new factor formed on those same anomalies? Third, how many of these new factors are really important (and can account for many characteristics)?

This paper addresses these questions, and also explores what factors are important for explaining *short-horizon* anomalies (those for which the average returns become statistically insignificant within 1 year after portfolio formation) versus *long-horizon* anomalies (those that earn statistically significant positive abnormal returns for at least 1 year after portfolio formation).

Building on past literature, we propose a factor model that supplements the CAPM with two behaviorally-motivated factors. These factors are constructed using firm characteristics that have been hypothesized to capture misvaluation resulting from psychological biases. The two behavioral factors are complementary, in that they capture distinct short- and long-term components of mispricing. The resulting three-factor model provides a parsimonious description of the return predictability associated with a large set of well-known return anomalies, and provides a generally-better description of the cross-section of expected returns than other factor models proposed in the literature.

Consistent with much of the literature (Fama and French, 1993, 2015), we seek to explain the expected returns of different firms by their factor exposures as opposed to characteristics (Daniel and Titman, 1997). However, we consider behaviorally-motivated factors designed to capture short- or long-term mispricing.

Existing behavioral models motivate the use of factor exposures as proxies for security mispricing. Intuitively, when investors are imperfectly rational and make similar errors about related stocks, the commonality in stock mispricing can be associated with return comovement. For example in the model of Barberis and Shleifer (2003), investors categorize risky assets into different styles and allocate funds at the style level rather than at individual asset level. Sentiment shocks can induce comovement of assets that share the same style, even when news about the assets' underlying cash flows is uncorrelated.

Alternatively, return comovement can result from commonality in investor errors in interpreting signals about fundamental economic factors. In the model of Daniel, Hirshleifer, and Subrahmanyam (2001), overconfident investors overestimate the precision of signals they receive, and accordingly overreact to private information (and underreact to public information) about economic factors that influence profits. (These economic factors, such as industry, are not necessarily priced risk factors in the rational asset pricing sense.) As a result, shocks to these factors lead to comovement among stocks with similar levels of mispricing, as such stocks share similar exposures to the economic factors.

Thus in behavioral models there will be comovement associated with common levels of mispricing, as well as with common exposures to fundamental risk factors. Since mispricing predicts future returns owing to subsequent correction, this implies that behavioral factors can be used to construct a factor model that better describes the cross-section of expected returns.[1] Just as firms which are exposed to systematic risk factors earn an associated risk premium, firms which are heavily exposed to behavioral factors earn a conditional return premium (see, e.g., the model of Hirshleifer and Jiang (2010)). Fama and French (1993, 2015) construct risk factors based on firm characteristics that they argue capture risk exposures; we instead supplement the market factor with two behaviorally-motivated factors. Specifically, some behavioral biases should result in mispricing that will persist a relatively short period of time, and others result in mispricing that will persist longer. We therefore identify a short-horizon and a long-horizon behavioral factor which together capture both short- and long-horizon mispricing.

We expect mispricing resulting from limited attention to higher-frequency information—such as quarterly earnings announcements—to be corrected at reasonably short time horizons. For example, building on insights of Bernard and Thomas (1990), in the models of Hirshleifer and Teoh (2003), DellaVigna and Pollet (2009), and Hirshleifer, Lim, and Teoh (2011), a subset of investors fail to take into account the implications of the latest earnings surprises for future earnings. As a consequence, stock prices underreact to earnings surprises. This results in abnormal returns in the form of post-earnings announcement drift (PEAD) as this mispricing is corrected upon the arrival of the next few earnings announcements (Ball and Brown, 1968).

[1] Several other studies also suggest that behavioral biases systematically affect asset prices. For example, Goetzmann and Massa (2008) construct a behavioral factor from trades of disposition-prone investors and find that exposure to this disposition factor seems to be priced. Similarly, Baker and Wurgler (2006) suggest including investor sentiment in models of prices and expected returns, and Kumar and Lee (2006) find that retail investor sentiment leads to stock return comovement incremental to market, size, value and momentum factors. Stambaugh and Yuan (2017) develop a behavioral factor model based on commonality in mispricing.

In contrast, some biases result in more persistent, longer-horizon mispricing. For example, investors who are overconfident about their private information signals will overreact to these signals, leading to a value effect wherein firms with high stock valuations relative to fundamental measures subsequently experience low returns. Owing to overconfidence in their private signals, investors are relatively unwilling to correct their perceptions as further (public) earnings news arrives. Indeed, in the models of Daniel, Hirshleifer, and Subrahmanyam (1998) and Gervais and Odean (2001), the arrival of new public information can temporarily *increase* overconfidence and mispricing. So in contrast with a limited-attention-driven anomaly, the correction of overconfidence-driven mispricing will take place over a much longer time horizon than mispricing that is solely a result of limited attention.

Furthermore, in the model of Barberis, Shleifer, and Vishny (1998), there are regime shifting beliefs about the nature of the earnings time series. An under-extrapolative belief regime (their "mean-reverting" regime) leads to post-earnings announcement drift and momentum. In this regime the positive returns that follow a positive earnings surprise dissipate rapidly when the next few earnings surprises prove earnings to be higher than expected. In contrast their over-extrapolative ("trending") regime is more persistent, because a brief trend-opposing sequence of earnings surprises does not provide sufficient evidence to overcome the extrapolative expectations investors have formed about more distant earnings.

Overall, then, behavioral theories suggest that different mechanisms can lead to different types of mispricing that correct at either long or short-horizons. We therefore develop distinct long- and short-horizon behavioral factors.[2]

Our long-horizon behavioral factor is based upon security issuance and repurchase. The new issues puzzle, the finding of poor returns after firms issue equity or debt, is well documented, as is the complementary repurchase puzzle, the finding that repurchases positively predict future returns.[3]

[2] A complicating issue is that some behavioral theories also use overconfidence to explain price momentum, which is a short-horizon anomaly (lasting about a year). Empirically, part of the return momentum effect is explained by earnings momentum (Chan, Jegadeesh, and Lakonishok, 1996), which is much like post-earnings announcement drift. The remaining part of the price momentum effect, according to the Daniel, Hirshleifer, and Subrahmanyam (1998) model, derives from dynamic patterns of shifts in overconfidence. This mechanism differs from both the short-run mechanism of the limited attention theory for PEAD, and the long-run static overconfidence mechanism for the value effect and financing anomalies.

[3] See Loughran and Ritter (1995, 2000), Spiess and Affleck-Graves (1995), Brav, Geczy, and Gompers (2000), Bradshaw, Richardson, and Sloan (2006), for post-event underperformance of new issues. See Lakonishok and Vermaelen (1990), Ikenberry, Lakonishok, and Vermaelen (1995), and Bradshaw, Richardson, and Sloan (2006) for post-event outperformance of repurchases. Daniel and Titman (2006) and Pontiff and Woodgate (2008) develop comprehensive measures of a firm's total issuances and repurchases.

Under the market timing hypothesis, managers possess inside information about the true value of their firms and issue or repurchase equity (or debt) to exploit pre-existing mispricing.[4,5] Firms undertaking equity issues will generally be overpriced and repurchasing firms underpriced. Firms can benefit from trading against mispricing that derive from many possible psychological sources. Therefore, issuance and repurchase should be powerful indicators of mispricing.

Furthermore, under this hypothesis, investors hold stubbornly to their mistaken beliefs upon observing the new issue or repurchase, perhaps owing to overconfidence (Daniel, Hirshleifer, and Subrahmanyam, 1998). If investors are overconfident, a few corrective earnings announcements may not be enough to fully eliminate misperceptions, so abnormal performance can persistent for a long period of time.

Building on this intuition, Hirshleifer and Jiang (2010) provide an overconfidence-based model of market timing by firms when there is commonality in misvaluation. In this setting, the loadings on the mispricing factor are proxies for stock-level mispricing. They therefore propose a behavioral factor, the underpriced-minus-overpriced (UMO) factor, based on firms' external financing activities. The UMO factor portfolio takes long positions in firms which repurchased debt or equity over the previous 24 months, and short positions in firms which issued either debt or equity through an IPO or SEO over the same time frame. They find that UMO loadings help predict the cross-section of returns, including even firms that are not engaged in new issues or repurchases. In essence, the argument here is that managers who do not fully share in the market's biased expectations observe mispricing and exploit it in the interest of existing shareholders (who don't participate in either the firm's new issues or repurchases).

Motivated by the same insights, we create a modified financing factor (FIN) based on the 1-year net-share-issuance and 5-year composite-issuance measures of Pontiff and Woodgate (2008) and Daniel and Titman (2006), respectively. Our FIN factor portfolio is based on two-by-three sorts on size and

[4]Ritter (1991) and many others argue that firms may issue and repurchase shares to "time" share mispricing. Stein (1996) develops a theoretical model of market timing. Evidence on market timing suggests that firms issue equity when their price-to-book ratio is high, and repurchase when they are low (Dong, Hirshleifer, and Teoh, 2012; Khan, Kogan, and Serafeim, 2012); that these sales and repurchases forecast the firms' future returns in a way that is consistent with market timing; that earnings surprises tend to be more negative following equity issues (Denis and Sarin, 2001); and, in surveys, that managers state that their issuance and repurchase activity is designed to exploit mispricing (Graham and Harvey, 2001). Baker and Wurgler (2002) provide a good summary of the evidence on market timing.

[5]Alternatively, Eckbo, Masulis, and Norli (2000), Berk, Green, and Naik (1999) and Lyandres, Sun, and Zhang (2008) propose or test risk-based explanations for the new issues anomaly.

financing characteristics (a combination of the 1- and 5-year measures), using methods that are routine in the literature. In untabulated results, we confirm that a financing factor based on the combination of net share issuance and composite issuance exhibits stronger pricing power for the cross-section of stock returns than a factor based solely on external financing events.

FIN is designed to capture long-term mispricing and correction (one year or longer), though it could contain some short-term mispricing as well. Institutional features relating to issuance and repurchase further contribute to the ability of FIN to capture long-term mispricing. Equity issuance and repurchase have disclosure, legal, underwriting, and other costs. There are also informational barriers to high-frequency issuance/repurchase strategies. Owing to such frictions, such corporate events tend to occur only occasionally, rather than as continuously updated responses to even transient changes in market conditions.[6]

Our second behavioral factor is intended to capture short-term mispricing derived from limited attention, such as underreaction to earnings information. Post-earnings announcement drift (PEAD) is the finding that firms that experience positive earnings surprises subsequently earn higher returns than those with negative earnings surprises. Bernard and Thomas (1989) argue that this return differential is not a rational risk premium, and instead reflects delayed price response to information. A recent empirical literature suggests that this delayed response derives from limited investor attention.[7] If the source of PEAD is that some investors neglect the implications of current earnings news for future earnings, any mispricing is likely to be corrected as the next few earnings are announced. Indeed, the evidence indicates that this correction is complete within a year.

We therefore hypothesize that PEAD reflects high-frequency systematic mispricing caused by limited investor attention to earnings-related information, and use a PEAD factor to capture comovement associated with high-frequency mispricing. Earnings announcements are of course not

[6]U.S. regulation potentially creates substantial time lags in registering security issues. Issuance also subjects the firm to possible investor skepticism about the possibility that firms with high value of assets in place are issuing to exploit private information, as modeled by Myers and Majluf (1984). Flexibility in issuance timing can be increased through shelf-registration, allowing firms to exploit even transient private information, but by the same token, investors are likely to be especially skeptical when firms maintain such flexibility.

[7]For example, market reactions to earnings surprises are muted when the earnings announcement is released during low-attention periods such as non-trading hours (Francis, Pagach, and Stephan, 1992; Bagnoli, Clement, and Watts, 2005), Fridays (DellaVigna and Pollet, 2009), days with many same-day earnings announcements by other firms (Hirshleifer, Lim, and Teoh, 2009), and in down market or low trading volume periods (Hou, Peng, and Xiong, 2009). At these times, the immediate price and volume reactions to earnings surprises are weaker and the post-earnings announcement drift is stronger.

the only source of fundamental news that investors might underreact to at a quarterly frequency. However, earnings announcements provide an especially good window into short-term underreaction because they are highly relevant for fundamental value and arrive regularly for every firm each quarter, and because all value-relevant news is ultimately manifested in earnings.

Our PEAD factor is constructed by going long firms with positive earnings surprises and short firms with negative surprises. We are not the first to construct a PEAD factor; our contribution is to use this factor in a theoretically motivated and parsimonious factor pricing model, to show that such a model explains a broad range of both short- and long-horizon anomalies.[8,9]

Our factor model supplements the CAPM with these two behavioral factors to form a three-factor risk-and-behavioral composite model, with behavioral factors designed to capture common mispricing induced by investors' psychological biases. This approach is consistent with theoretical models in which both risk and mispricing proxies predict returns (Daniel, Hirshleifer, and Subrahmanyam, 2001; Barberis and Huang, 2001; Kozak, Nagel, and Santosh, 2017b). By using both long- and short-horizon behavioral factors, we seek to capture both long-term mispricing that takes a few years to correct and short-term mispricing that takes a few quarters to correct.

We empirically assess the incremental ability of behavioral factors to explain expected returns relative to the factors used in other models, including both traditional factors (such as the market, size, value, and return momentum factors) and other recently prominent factors (such as the investment and profitability factors). Barillas and Shanken (2017) suggest that when comparing models with traded factors, "...the models should be compared in terms of their ability to price all returns, both test assets and traded factors." To do this, we first run spanning tests to examine how well other (traded) factors explain the performance of FIN and PEAD and vice versa. We find that a factor model that includes both FIN and PEAD prices many of the traded factors proposed in the literature, including several of the new factors proposed in Fama and French (2015), Hou, Xue, and Zhang (2015), and Stambaugh and Yuan (2017). In sharp contrast, reverse regressions show that most other (traded) factors do *not*

[8]Chordia and Shivakumar (2006) and Novy-Marx (2015a) construct PEAD factors and argue that the predictive power of past returns is subsumed by a zero-investment portfolio based on earnings surprises. Novy-Marx (2015b) uses a PEAD factor to price the ROE factor of Hou, Xue, and Zhang (2015).

[9]Kothari, Lewellen, and Warner (2006) find that the relation between *aggregate* earnings surprises and market returns is negative. This is compatible with our hypothesis. There is likely to be some commonality in factor loadings of the set of firms which experienced both positive and negative earnings surprises. Based on the arguments in Daniel, Hirshleifer, and Subrahmanyam (2001) and Kozak, Nagel, and Santosh (2017a), this will lead to a high return premium for firms that load on the resulting PEAD factor.

fully explain the abnormal returns associated with FIN and PEAD.

We then explore the extent to which FIN and PEAD explain the returns of portfolios constructed by sorting on the characteristics associated with well-known return anomalies. We consider 34 anomalies, closely following the list of anomalies considered in Hou, Xue, and Zhang (2015).[10] Since FIN and PEAD are designed to capture mispricing over different horizons, we are especially interested in how well FIN captures long-horizon anomalies and how well PEAD captures short-horizon anomalies. Therefore, we further categorize the 34 anomalies into two groups: 12 short-horizon anomalies including price momentum, earnings momentum, and short-term profitability, and 22 long-horizon anomalies including long-term profitability, value, investment and financing, and intangibles. We compare the performance of our three-factor composite model built on 3 firm characteristics with recently proposed factor models: the four-factor model of Novy-Marx (2013, NM4) built on 5 characteristics, the five-factor model of Fama and French (2015, FF5) built on 4 characteristics, the four-factor model of Hou, Xue, and Zhang (2015, HXZ4) built on 3 characteristics, and the four-factor model of Stambaugh and Yuan (2017, SY4) built on 12 characteristics.[11]

We find that across the 12 short-horizon anomalies, the composite model fully captures all anomalies at the 5% significance level (i.e., none have significant alphas). In contrast, 11 anomalies have significant FF5 alphas, 2 have significant NM4 alphas, 1 has a significant HXZ4 alpha, and 4 have significant SY4 alphas. The mean $|\hat{\alpha}|$ is lower for the composite model than for any of the four alternative models. Finally, the Gibbons, Ross, and Shanken (1989, GRS) F-test fails to reject the hypothesis that the 12 composite-model alphas are jointly zero, but rejects each of the four alternative models at a 1% significance level.

The composite model also does a good job explaining the 22 long-horizon anomaly portfolios,

[10]McLean and Pontiff (2016), Harvey, Liu, and Zhu (2016) and Linnainmaa and Roberts (2016) each argue that some fraction of the return premia associated with various anomalies is a result of overfitting rather than actual mispricing. In contrast, Lu, Stambaugh, and Yuan (2017) show that anomalies previously identified in U.S. cross-sectional equity data are also significant in five non-U.S. markets, suggesting that the characteristics underlying these anomalies robustly identify mispricing.

[11]Consistent with convention in this literature since Fama and French (1993), both our FIN and PEAD factor portfolios are based on bivariate (3×2) sorts on the relevant characteristic and firm size (i.e., Market Equity). The next step is to go long the high-characteristic portfolios and short the low-characteristic portfolios of both small and large firms (see Section 1.1 for a detailed description). In addition to keeping in mind how many factors are in each model, to assess parsimony it is useful to bear in mind the number of firm characteristics used to construct each factor model. We therefore provide characteristic counts for each model.

but for these portfolios the SY4 and NM4 models also perform well. For the behavioral-composite model, 3 of the 22 alphas are significant at the 5% significance level. For competing models, the numbers of significant alphas are 7 (FF5), 3 (NM4), 5 (HXZ4), 3 (SY4), etc. The GRS F-test that the 22 long-horizon anomaly portfolio alphas are jointly zero is not rejected at a 10% level for the SY4 model, or at a 5% level for our composite model or the NM4 model. The GRS test does, however, reject this null at a 1% significance level for both the FF5 and HXZ4 models. The good performance of the SY4 model appears to result primarily from the inclusion of their MGMT factor, which is constructed from six characteristics associated with investment and financing.

Overall, across all 34 long- and short-horizon anomalies, our three-factor behavioral-composite model performs well. Only 3 anomalies have 5% significant composite-model alphas. In comparison, there are 18 significant FF5 alphas, 5 significant NM4 alphas, 6 significant HXZ4 alphas, and 7 significant SY4 alphas. The composite model also gives the smallest GRS F-statistic. The composite model therefore outperforms both standard and recent enhanced factor models in explaining the large set of anomalies studied in Hou, Xue, and Zhang (2015). This evidence is consistent with the hypothesis that many existing anomalies, such as momentum, profitability, value, investment and financing, and intangibles, can be attributed to systematic mispricing.

Thus, the composite model prices both short- and long-horizon anomalies at a level that is at least comparable with other proposed factor models, and is arguably more parsimonious.[12] Because our composite model is motivated by just two hypotheses—that firm managers time issuance to arbitrage longer horizon mispricing and that shorter-horizon mispricing will result from inattention—our model requires just two behavioral factors in addition to the market. The competing models we examine all use either more factors, more characteristics, or both.

Why do just two proxies for mispricing (external financing and earnings surprises) capture a wide set of anomalies? These proxies can capture misperceptions deriving from multiple behavioral biases, each somewhat different. However, to the extent that each firm's manager is aware of that firm's total mispricing—resulting from this variety of biases—and attempts to arbitrage this

[12] Evaluating parsimony requires care, since it is well known that any pattern of returns can be "explained" ex post by a single-factor model in which the factor is the ex-post mean-variance efficient portfolio (see also the discussion of Novy-Marx (2016)). Still, when factors are built from characteristics, it is likely that the use of more characteristics and/or more factors tends to grant greater freedom to overfit the cross section of returns. Certainly a focus of the empirical factor pricing literature since Fama and French (1992) has been on identifying models that explain the cross-section of returns with a small number of factors, presumably owing to a preference for parsimony.

mispricing via issuance/repurchase activities (the scale of which is proportional to the magnitude of the mispricing), our long-horizon behavioral factor FIN can provide a good summary of the various sources of longer-term mispricing.[13] Similarly, to the extent that short-horizon anomalies derive from psychological biases that induce underreaction to fundamentals, a firm's earnings information may be a good summary of higher-frequency information about firm value that investors misvalue, in which case loadings on the PEAD factor may do a good job of capturing such mispricing.

To further evaluate the performance of our composite factor model, we perform cross-sectional tests. If FIN and PEAD are indeed priced behavioral factors that capture commonality in mispricing, then behavioral models imply that firm loadings on FIN and PEAD should be proxies for underpricing. In particular, FIN loadings are proxies for persistent underpricing and PEAD loadings for transient underpricing. In consequence, these loadings should positively predict the cross-section of stock returns.

The dynamic nature of mispricing implies that any given firm's loadings on these factors will vary substantially over time. We therefore estimate firms' loadings on behavioral factors using daily stock returns over short horizons, e.g., one month.

Using Fama and MacBeth (1973) cross-sectional regressions, we find that FIN loadings significantly predict future stock returns, even after controlling for most of the 34 anomalies that we examine. In contrast, estimated PEAD loadings have no incremental power to forecast future returns. As we discuss in Section 3, the problems are estimation error when PEAD loadings are unstable and the heavy influence in Fama-MacBeth regression tests of small illiquid firms.

The observed premia of the behavioral factors we propose could alternatively be interpreted as rational risk premia. This mirrors the fact that the factors in traditional models (other than the market factor) can instead be interpreted as reflecting mispricing. However, we motivate our two behavioral factors with behavioral/mispricing arguments. Following Daniel, Hirshleifer, and Subrahmanyam (2001) and Kozak, Nagel, and Santosh (2017a), in a setting in which investors with biased expectations co-exist with unbiased (rational) arbitrageurs, the presence of the arbitrageurs ensures that there are no pure arbitrage opportunities. This will necessarily link the covariance

[13] Although models of overconfidence offer a motivation for seeking a factor based on long-horizon mispricing, the market timing motivation for the FIN factor means that it does not directly pinpoint what investor psychological bias is driving mispricing.

structure and the expected returns of the individual assets; that is, *behavioral factors* will be priced, and the Sharpe ratios associated with the behavioral factors will be bounded. The loadings on the behavioral factors will correctly price individual securities, but the factors themselves will not necessarily covary with aggregate fundamental risks, as would the risk factors in a fully rational setting with no biased investors.[14] Furthermore, market frictions constrain rational arbitrage of mispricing. Therefore, the return predictability associated with behavioral factors should be increasing with limits to arbitrage; these implications do not hold for effects in rational frictionless models of risk premia.

We therefore conduct additional tests of the effects of limits to arbitrage, to further evaluate FIN and PEAD as behavioral factors. Behavioral asset pricing suggests two implications. First, owing to short-sale constraints, we expect behavioral factors to be especially good at explaining returns of overpriced stocks in the short-leg of anomaly portfolios (Stambaugh, Yu, and Yuan, 2012). Consistent with this hypothesis, we find the short sides of the anomaly portfolios (i.e., overpriced firms) load far more strongly on the relevant behavioral factors than do the long sides of the portfolios (i.e., underpriced firms).

Second, other market frictions also impede arbitrage, so stocks that are more heavily subject to such frictions should be more heavily mispriced. Sample estimates of mispricing for such stocks should be more accurate owing to a higher signal-to-noise ratio. (For example, sample estimates of mispricing in a pool of stocks that were known to have zero mispricing would be pure noise.) So if behavioral factors truly capture mispricing, we expect the factor-beta/return relation to be stronger for high friction stocks, such as stocks with lower liquidity or institutional ownership. Using both two-way portfolio sorts and cross-sectional regressions, we find that the FIN beta-return relation is indeed stronger among high friction stocks.

A growing literature seeks to explain wide sets of anomalies with a small set of factors. This is the motivation for the tests of Fama and French (1996), and more recently Novy-Marx (2013), Fama and French (2015, 2016b), Hou, Xue, and Zhang (2015), and Stambaugh and Yuan (2017). Our paper goes further in three key ways. First, we identify a strong dichotomy between short- and long-

[14]For example they will not covary with innovations in marginal utility based on aggregate consumption. However, the factors should covary with measures of the innovation in marginal utility for the subset of arbitrageurs in the economy. For example, to the extent that broker-dealers act as rational arbitrageurs, broker-dealer leverage (He and Krishnamurthy, 2013; Adrian, Etula, and Muir, 2014) should price behavioral anomalies, in that it captures "risk" for these agents.

horizon anomalies, with short-horizon anomalies predominantly explained by our PEAD-based factor, and long-horizon anomalies predominantly explained by the financing factor. Second, our behavioral factors are constructed on the basis of three economic characteristics which are not obviously related to many of the anomalies we seek to explain. Finally, as noted earlier, our factor model provides a better fit to a wide set of anomalies and factors.

1 Comparison of Behavioral Factors with Other Factors

1.1 Factor Definitions

We construct the financing-based mispricing factor (FIN) based on the 1-year net share issuance and 5-year composite share issuance measures of Pontiff and Woodgate (2008) and Daniel and Titman (2006), respectively. Daniel and Titman's 5-year composite share issuance (CSI) measures the part of a firm's growth in equity market value that is not explained by stock returns. As such, corporate actions such as splits and stock dividends leave the composite issuance measure unchanged. However, issuance activities such as seasoned issues, the exercise of employee stock options, and equity-financed acquisitions increase the issuance measure. Similarly, equity payout activity such as share repurchases, dividends, and other actions that pay cash out of the firm decreases the issuance measure. Pontiff and Woodgate's net share issuance (NSI) is constructed using the same method as Daniel and Titman, while focusing on an annual horizon. It measures a firm's annual share issuance as change in shares outstanding, adjusted for distribution events such as splits and rights offerings. Both issuance measures earn significant abnormal returns (incremental to each other) during our sample period of 1972 to 2014. Details on variable construction are provided in Appendix A.[15]

The FIN factor is constructed using all NYSE, AMEX, and NASDAQ common stocks with CRSP share codes of 10 or 11, excluding financial firms. At the end of each June, we assign these firms to one of the two size groups (small "S" and big "B") based on whether that firm's market equity is below or above the NYSE median size breakpoint. Independently, we sort firms into one of the three financing groups (low "L", middle "M", or high "H") based on the 1-year net share issuance (NSI) measure of Pontiff and Woodgate (2008) and the corresponding 5-year composite share issuance (CSI)

[15]Pontiff and Woodgate (2008) note that Daniel and Titman's 5-year composite issuance measure, while strong in the post-1968, is weak pre-1970. This is also consistent with the discussion in Daniel and Titman (2016).

measure of Daniel and Titman (2006), respectively. The three financing groups are created based on an index of NSI and CSI rankings.

Specifically, we first sort firms into three CSI groups (low, middle, or high) using 20% and 80% breakpoints for NYSE firms. Special care is needed when sorting firms into NSI groups, since about one quarter of our NSI observations are negative (i.e., are repurchasing firms). If we were to use NYSE 20% and 80% breakpoints to assign NSI groups, then in some formation years we would have all repurchasing firms in the bottom 20% group, without differentiating between firms with high and low repurchases. Similarly, on the issuance side, using a simple NSI sort would cause no distinction between large and small issuances in some formation years. To address this, each June we separately sort all repurchasing firms (with negative NSI) into two groups using the NYSE median breakpoint, and sort all issuing firms (with positive NSI) into three groups using NYSE 30% and 70% breakpoints. We then assign the repurchasing firms with the most negative NSI to the low NSI group, the issuing firms in the top group to the high NSI group, and all other firms to the middle group.

Finally, we assign firms into one of the three financing groups (low "L", middle "M", or high "H") based on an index of NSI and CSI rankings. If a firm belongs to the high group by both NSI and CSI rankings, or to the high group by NSI rankings while missing CSI rankings due to missing data (or vice versa), the firm is assigned to the high financing group ("H"). If a firm belongs to the low group by both NSI and CSI rankings, or to the low group by one ranking while missing the other, it is assigned to the low financing group ("L"). In all other cases, firms are assigned to the middle financing group ("M").

Six portfolios (SL, SM, SH, BL, BM, and BH) are formed based on the intersections of size and financing groups, value-weighted portfolio returns are calculated for each month from July to the next June, and the portfolios are rebalanced at the end of the next June. The FIN factor return each month is calculated as average return of the low financing portfolios (SL and BL) minus average return of the high financing portfolios (SH and BH), that is, $FIN = (r_{SL} + r_{BL})/2 - (r_{SH} + r_{BH})/2$.

PEAD is the post-earnings announcement drift factor, which is intended to capture investor limited attention. It is again constructed in the fashion of Fama and French (1993). Following Chan, Jegadeesh, and Lakonishok (1996), earnings surprise is measured as the four-day cumulative abnormal return ($t-2$, $t+1$) around the most recent quarterly earnings announcement date (COMPUSTAT quarterly item RDQ):

$$CAR_i = \sum_{d=-2}^{d=1} R_{i,d} - R_{m,d}$$

where $R_{i,d}$ is stock $i's$ return on day d and $R_{m,d}$ is the market return on day d relative to the earnings announcement date. We require valid daily returns on at least two trading days during the four-day window. We also require the COMPUSTAT earnings date (RDQ) to be at least two trading days prior to the month end.[16]

The set of firms which are used in calculating the PEAD factor in month t are all NYSE, AMEX, and NASDAQ common stocks with CRSP share codes of 10 or 11, excluding financial firms. At the beginning of each month t, we first assign firms to one of two size groups (small "S" or big "B") based on whether that firm's market equity at the end of month $t-1$ is below or above the NYSE median size breakpoint. Each stock is independently sorted into one of three earnings surprise groups (low "L", middle "M", or high "H") based on its CAR at the end of month $t-1$, using 20% and 80% breakpoints for NYSE firms. Six portfolios (SL, SM, SH, BL, BM, and BH) are formed based on the intersections of the two groups, and value-weighted portfolio returns are calculated for the current month. The month t PEAD factor return is then the average return of the high earnings surprise portfolios (SH and BH) minus the average return of the low earnings surprise portfolios (SL and BL), that is, $PEAD = (r_{SH} + r_{BH})/2 - (r_{SL} + r_{BL})/2$.

1.2 Competing Factor Models

We compare our behavioral factors and the three-factor composite model built on 3 firm characteristics with traditional factor models, such as the CAPM (Sharpe, 1964; Lintner, 1965; Black, 1972), models that include the Mkt-Rf, SMB, HML, and MOM factors proposed by Fama and

[16] If investors underreact to fundamental news by a fixed percentage, then greater news imply greater total underreaction. There is a trade-off in the use of returns versus earnings-based measures of surprises, such as the standardized unexpected earnings (SUE) of Chan, Jegadeesh, and Lakonishok (1996). Returns have major advantages, because analyst forecasts are imperfect proxies for market prior means, and because SUE reflects only imperfectly the precision of the investor prior (which is part of what determines how surprising a given 'surprise' is). Furthermore, the persistence of earnings affects how much news for firm value is contained in the earnings surprise; SUE does not account for this. On the other hand, if investor attention fluctuates over time, then return responses to earnings will sometimes be larger because of higher investor attention. Which measure is a better proxy for total underreaction is therefore an empirical question. Previous literature indicates that PEAD is stronger using return-based measures of earnings surprise (Brandt, Kishore, Santa-Clara, and Venkatachalam, 2008), suggesting that the return measure is a better proxy for total underreaction.

French (1993) and Carhart (1997), as well as a set of recently proposed factors and models.[17] Monthly factor returns are either downloaded from Kenneth French's web site or provided by the relevant authors.[18]

Novy-Marx (2013, NM4) proposes a four-factor model consisting of a market factor, a value factor, a momentum factor, and a profitability factor (PMU). The profitability factor is constructed based on gross profits-to-assets from Compustat annual files. The value, momentum, and profitability characteristics are demeaned by the average characteristic for firms in the same industry, to hedge the factor returns for industry exposure. Thus the model is built on 5 characteristics: value, momentum, gross profits-to-assets, size, and industry. To differentiate from their standard versions, we label the industry-adjusted value and momentum factors as HML(NM4) and MOM(NM4). All factor portfolios are annually rebalanced at the end of each June.

Fama and French (2015, FF5) propose a five-factor model built on 4 characteristics that includes a market factor, a size factor, a value factor, an investment factor (CMA), and a profitability factor (RMW). The investment factor is formed based on annual change in total assets and the profitability factor based on operating profitability. The size, investment, and profitability factors are formed by a triple sort on size, change in total assets, and operating profitability. All factor portfolios are annually rebalanced at the end of each June.

Hou, Xue, and Zhang (2015, HXZ4) propose a q-factor model consisting of four factors built on 3 characteristics: a market factor, a size factor, an investment factor (IVA), and a profitability factor (ROE). The size, investment, and profitability factors are formed by a triple sort on size, change in total assets from Compustat annual files, and ROE from Compustat quarterly files. To differentiate from the standard size factor, we label the size factor in this model as SMB(HXZ4). The size and IVA factor portfolios are rebalanced annually at the end of each June, and the ROE factor is rebalanced each month.

Lastly, Stambaugh and Yuan (2017, SY4) propose a four-factor model built on 12 characteristics that includes a market factor, a size factor, and two mispricing factors (MGMT and PERF). The MGMT factor is constructed based on 6 characteristics related to investment and

[17] The 3 characteristics of our composite model are external financing, earnings surprises, and size. Since firm size is used in forming our FIN and PEAD factors and factors in other models, size is one of the counted characteristics in several factor models.

[18] We are grateful to all these authors for providing their factor return data.

financing: net share issuance, composite issuance, operating accruals, net operating assets, asset growth, and investment-to-assets. The PERF factor is a composite factor based on 5 characteristics including price momentum and profitability: distress, O-Score, momentum, gross profitability, and return on assets. The size factor is formed using only stocks least likely to be mispriced (based on the above eleven characteristics), to reduce the effect of arbitrage asymmetry. We label it SMB(SY4). The SMB(SY4), MGMT and PERF factors are rebalanced each month.

1.3 Summary Statistics

Table 1 reports summary statistics for our zero-investment behavioral factors portfolios, and for a set of factors portfolios proposed in previous literature. Panel A of Table 1 shows that, over our sample period, FIN offers the highest average premium of 0.80% per month and a monthly Sharpe ratio of 0.20. The t-statistic testing whether the FIN premium is zero is 4.6, well above the hurdle of 3.0 for new factors proposed by Harvey, Liu, and Zhu (2016). PEAD offers an average premium of 0.65% per month and the highest monthly Sharpe ratio of 0.35. Consistent with this, the t-statistic testing whether the mean PEAD factor returns is zero is 7.91, the highest among the factors.[19]

Comparing FIN with investment and profitability factors (e.g., CMA, IVA, PMU, RMW) and the composite mispricing factor MGMT shows that FIN offers a substantially higher factor premium, and comparable Sharpe ratio and t-statistic. Comparing PEAD with factors based on short-horizon characteristics (e.g., MOM, ROE) and the composite mispricing factor PERF, PEAD offers comparable factor premium but substantially higher Sharpe ratio and t-statistic.

Panel B reports pairwise correlation coefficients between factor portfolios. We find that different versions of SMB, HML, and MOM are highly correlated, with correlation coefficients (ρ) greater than 0.90 in most cases. The two investment factors (CMA, IVA) are highly correlated with $\rho = 0.90$, and strongly correlated with the value factors (HML, HML(NM4)) with ρ between 0.55 to 0.69. The three profitability factors (PMU, RMW, ROE) are strongly correlated with each other with ρ around 0.60. Also, the correlations of ROE with the two momentum factors (MOM, MOM(NM4)) are about 0.5.

[19] The share issuance effect is slightly stronger among large firms, and the PEAD effect much stronger among small firms. A FIN factor built on large firms, $FIN_B = r_{BL} - r_{BH}$, earns an average premium of 0.83% per month, while FIN built on small firms, $FIN_S = r_{SL} - r_{SH}$, earns 0.77% per month. A PEAD factor built on large firms, $PEAD_B = r_{BH} - r_{BL}$, earns an average premium of 0.38% per month, while PEAD built on small firms, $PEAD_S = r_{SH} - r_{SL}$, earns 0.94% per month. This is consistent with evidence in the literature.

Not surprisingly, the composite MGMT factor, constructed on six investment and financing characteristics, is highly correlated with value factors (HML, HML(NM4)) and investment factors (CMA, IVA), with ρ ranging from 0.59 to 0.76. The PERF factor, which is constructed on five characteristics including price momentum and profitability, is highly correlated with both momentum factors (MOM, MOM(NM4)) and profitability factors (PMU, RMW, ROE), with ρ ranging from 0.48 to 0.72.

Lastly, although FIN is constructed using only external financing, its returns are correlated with both value factors (HML, HML(NM4)) and investment factors (CMA, IVA), with ρ between 0.50 and 0.66, consistent with issuing firms having both high valuation ratios and substantial investment levels. FIN is highly correlated with the composite MGMT factor with $\rho = 0.80$, suggesting that financing characteristics might be a dominant component in the composition of the MGMT factor. FIN is moderately correlated with profitability factors (PMU, RMW, ROE) and the composite PERF factor, with ρ around 0.35. As we would expect, PEAD is strongly correlated with momentum factors (MOM, MOM(NM4)) and the composite PERF factor, with ρ ranging from 0.38 to 0.48, and moderately correlated with the earnings profitability factor ROE, with $\rho = 0.22$. This is consistent with the finding in the literature that earnings momentum, price momentum, and earnings profitability are correlated, apparently driven at least in part by market underreaction to latest earnings news (Chan, Jegadeesh, and Lakonishok, 1996). Finally, the correlation between FIN and PEAD is -0.05, suggesting that the two behavioral factors capture different sources of mispricing.

Panel C summarizes the portfolio weights, returns, and the maximum ex-post Sharpe ratios that can be achieved by combining various factors to form the tangency portfolio. Rows (1) and (2) show that combining the Fama-French three factors achieves a maximum monthly Sharpe ratio of 0.22, and adding the MOM factor increases the Sharpe ratio to 0.31. Rows (3)$-$(6) show that the optimal combination of factors from the Fama and French (2015), Novy-Marx (2013), Hou, Xue, and Zhang (2015), and Stambaugh and Yuan (2017) models achieve realized monthly Sharpe ratios of 0.36, 0.57, 0.43, and 0.50, respectively. In rows (7) and (8), combining two behavioral factors, FIN and PEAD, achieves a Sharpe ratio of 0.41, while adding the MKT factor increases the Sharpe ratio to 0.52. Thus, the three-factor risk-and-behavioral composite model earns a Sharpe ratio higher than standard factor models, and all recently prominent models except for the Novy-Marx (2013) model.

Rows (9)−(12) show that, with the three-factor risk-and-behavioral composite model as a baseline, other recent prominent factors only marginally increase the Sharpe ratio. For example, adding PMU of the Novy-Marx (2013) model or CMA and RMW of the Fama and French (2015) model each increases the Sharpe ratio from 0.52 to 0.54. Adding IVA and ROE of the Hou, Xue, and Zhang (2015) model increases the Sharpe ratio from 0.52 to 0.55, and adding MGMT and PERF of the Stambaugh and Yuan (2017) model increases it to 0.56. Finally, rows (13) and (14) show that combining all factors excluding FIN and PEAD achieves a maximum Sharpe ratio of 0.54. Adding FIN and PEAD results in a very substantial further increase of the Sharpe ratio to 0.65.

1.4 Comparing Behavioral Factors with Other Factors

When comparing models with traded factors, it is important to compare their ability to price all returns, that is both test assets and traded factors (Barillas and Shanken, 2017). Here, using spanning tests, we assess the power of our behavioral factors to price each of the factors from the alternative models, and vice versa. Specifically, we run time-series regressions of the monthly returns of one factor on other proposed factors and examine the regression intercepts (alphas). If a factor is subsumed by a set of other factors, we expect the regression alpha to be close to zero.

In interpreting tests between factors, it is important to keep in mind that winning the horse race is not the only criterion for a good model. It is always possible to construct an overfitted model that will 'beat' all other factors *ex post*. It is therefore crucial for a model to have a strong combination of theoretical motivation, parsimony, and good fit.

Table 2 reports the results of regressions of behavioral factor returns on other sets of factor returns. The significant intercepts from the Fama-French three-factor model, the Carhart model, the Fama and French (2015) five-factor model and the Hou, Xue, and Zhang (2015) q-factor model suggest that the factors in these models do not explain the FIN premium. However, the profitability-based model of Novy-Marx (2013) and the four-factor mispricing model of Stambaugh and Yuan (2017) are able to fully capture the FIN premium. The former model derives its explanatory power from its HML and PMU factors, and the latter from its MGMT factor. Given the high correlation between MGMT and FIN ($\rho = 0.80$, in Panel B of Table 1), it is not surprising that the MGMT factor subsumes FIN. On the other hand, none of those models fully explain the PEAD premium. The 'kitchen sink' regression of the PEAD factor returns on all alternative model factors shows that PEAD continues to earn a significant alpha of 0.58% per month ($t = 6.76$), even after controlling for the exposure to all other proposed factors from the alternative models.

Overall, we confirm that PEAD offers abnormally high returns relative to all other factors, including recently popular investment and profitability factors and the mispricing factors of Stambaugh and Yuan (2017). FIN offers abnormal returns relative to many other factors, except for the profitability factor PMU of Novy-Marx (2013) and the composite MGMT factor of Stambaugh and Yuan (2017).

Table 3 reports the results of regressions of other factors on our two behavioral factors.[20] With just FIN and PEAD, our two-factor behavioral model fully explains 7 out of the 10 factors we examine, such as the value factor HML, the momentum factor MOM, the investment and profitability factors CMA and RMW of Fama and French (2015), the profitability factor ROE of Hou, Xue, and Zhang (2015), and the MGMT and PERF factors of Stambaugh and Yuan (2017). The exceptions are the size factor SMB, the profitability factor PMU of Novy-Marx (2013), and the investment factor IVA of Hou, Xue, and Zhang (2015). Adding the market factor, our three-factor risk-and-behavioral composite model does not explain CMA and MGMT factors either, which load negatively on the market factor and therefore earn significant alphas under the model. However, for the factors other than SMB for which the alphas remain statistically significant, 48% of the premium earned by these factors is explained by exposure to the factors in the the BF3 model.

This significant t-statistic on SMB shows that, at least ex post, the BF3 model could have been improved by the addition of SMB as a fourth factor. However, while statistically significant, the economic improvement that would result from the improvement in the addition of SMB to the model is small. Specifically, the Sharpe ratio of the optimal ex-post combination of the three BF3 factors is 0.52. We find that adding a SMB factor to our BF3 model increases the Sharpe ratio from 0.52 to 0.54.[21]

Also, if managers are timing their issuance and repurchase, then our factor should capture all long horizon mispricing without recourse to a size factor. It is important for a factor model to have

[20] Modified versions of SMB, HML, and MOM factors are not examined here, as Table 1 shows that those modified versions are highly correlated with each other.

[21] The improvement in the squared Sharpe ratio is the Treynor-Black squared Information ratio, which can also be calculated using the t-stat on the SMB coefficient in Table 3.

a theoretical motivation rather than just an ex-post empirical one. As it turns out, the model comes close to pricing all long-horizon anomalies, and additional inclusion of SMB does not help the model get much closer, as evidenced by the small change in the Sharpe ratio when we add in an SMB factor. Overall, we find that FIN and PEAD capture a large fraction of the premia of the factors from the alternative models, but not vice versa. The evidence suggests that FIN and PEAD contain important incremental information about average returns relative to existing factors. This motivates further testing of their ability to explain well-known return anomalies, which we do in the next section.

2 Explaining Anomaly Returns with Behavioral Factors

2.1 Anomaly Magnitudes and Correlations

We next examine whether our behavioral factor model explains the various return anomalies documented in the academic literature. We focus on 34 robust anomalies based upon the list of anomalies considered in Hou, Xue, and Zhang (2015) that earn significant abnormal returns over their sample period of 1972 to 2012. We exclude the systematic volatility (Svol) of Ang, Hodrick, Xing, and Zhang (2006) and the revisions in analysts' earnings forecasts (6-month holding period, RE-6) of Chan, Jegadeesh, and Lakonishok (1996) from the set of anomalies considered by Hou, Xue, and Zhang (2015), as these two portfolios do not earn statistically significant excess returns over our sample period. In addition to the remaining HXZ anomalies, we also consider the cash-based operating profitability (CbOP) of Ball, Gerakos, Linnainmaa, and Nikolaev (2016). We do this based on the evidence in Fama and French (2016a) that an anomaly portfolio based upon cash-based operating profitability dominates one based upon operating profitability.

Since FIN is constructed using a firm's financing activities, and PEAD using the firm's quarterly earnings surprises, we further posit that FIN captures long-term overreaction to firms' growth prospects and the correction of such low-frequency mispricing, and that PEAD captures short-term underreaction to recent earnings news and the correction to such high-frequency mispricing. Given that FIN and PEAD capture mispricing over different horizons, we are especially interested in how well FIN captures long-horizon anomalies and how well PEAD captures short-horizon anomalies.

We define as *long-horizon* those anomalies which continue to earn statistically significant positive abnormal returns for 1 to 3 years after portfolio formation. The trading strategies for each of these long-horizon anomaly portfolios are rebalanced annually. In contrast, *short-horizon* anomalies are those based upon quarterly accounting reports or high-frequency price information. Such anomalies typically have a higher rate of decay of return predictability as the forecast horizon is extended. The premia earned by short-horizon anomaly portfolios generally become statistically insignificant after 1 year, and the trading strategies based on these anomalies are rebalanced monthly.

Based on these criteria, we group the 34 anomalies into 12 short-horizon anomalies, including price momentum, earnings momentum, and short-term profitability, and 22 long-horizon anomalies including long-term profitability, value, investment and financing, and intangibles. Table 4 describes the list of anomalies under each group, as well as the mean returns and Sharpe ratios of those long/short anomaly portfolios. Definitions of anomaly characteristics are provided in Appendix A.

To further validate our classification of long- vs. short-horizon anomalies, Table 5 reports the decay rate of return predictability of each group of anomalies. Short-horizon anomaly portfolios are formed and rebalanced each month, and long-horizon anomaly portfolios are annually rebalanced. Using an event time approach, we examine the buy-and-hold returns of the short-horizon anomaly portfolios in each of the 12 months after portfolio formation. Similarly, for long-horizon anomaly portfolios, we examine the buy-and-hold returns in each of the 12 quarters post-formation. Panel A confirms that the premia earned by short-horizon anomaly portfolios become statistically insignificant after 6 to 9 months. On the other hand, Panel B shows that most long-horizon anomaly portfolios continue to earn statistically significant abnormal returns for 1 to 3 years after portfolio formation.[22]

Table 6 presents the pairwise time series correlations of the anomaly portfolios, grouped by the anomaly horizon. Panel A shows that, among short-horizon anomalies, the L/S portfolio returns of price momentum, earnings momentum, and short-term earnings profitability are strongly positively correlated, consistent with the literature (Chordia and Shivakumar, 2006; Novy-Marx, 2015a,b). Panel B presents the long-horizon anomaly return correlation matrix. Noticeably, the HML portfolio returns are positively correlated with investment and financing, but negatively correlated with long-term profitability. This is consistent with existing evidence that growth firms generally issue

[22]There are a few exceptions. For example, GP/A and CbOP do not earn significant abnormal returns using this event window approach. IvG, IvC, OA, and OC/A earn significant abnormal returns for less than 1 year. Still, we classify these anomalies as long-horizon, as they are based upon annual accounting reports and it makes more sense to form annually rebalanced trading strategies based on them.

more equity and invest more heavily.

2.2 Summary of Comparative Model Performance

To examine how well behavioral factors account for various return anomalies, we run anomaly portfolio regressions of the L/S portfolio returns on FIN alone, PEAD alone, a two-factor model with FIN and PEAD (BF2), and a three-factor risk-and-behavioral composite model with MKT, FIN, and PEAD (BF3). If a model is efficient, the regression alphas of the L/S portfolios should be statistically indistinguishable from zero. We compare the performance of our behavioral-motivated models with standard factor models, such as the CAPM, the Fama-French three-factor model (FF3), and the Carhart four-factor model (Carhart4), and recent prominent models, such as the profitability-based factor model of Novy-Marx (2013, NM4), the five-factor model of Fama and French (2015, FF5), the q-factor model of Hou, Xue, and Zhang (2015, HXZ4), and the four-factor mispricing model of Stambaugh and Yuan (2017, SY4).[23]

Table 7 summarizes the comparative performance of competing factor models in explaining the set of 34 anomalies. We separately compare model performance on the 12 short-horizon anomalies (Panel A), the 22 long-horizon anomalies (Panel B), and all 34 anomalies (Panel C). The column labeled "H-L Ret" reports the monthly average excess return of each L/S anomaly portfolio.[24] The rest of the columns report the regression alphas of each L/S portfolio returns under different factor models. At the bottom of each panel, we summarize model performance by several statistics: (1) the number of significant alphas at the 5% level, (2) the average absolute alphas, (3) the average absolute t-values of alphas, (4) the GRS F-statistics and p-values which test the null hypothesis that all alphas are jointly zero (Gibbons, Ross, and Shanken, 1989), (5) the Hansen and Jagannathan (1997, HJ) distance which measures the maximum pricing error generated by a model on a set of testing portfolios, and (5) the F-statistics and p-values that test whether the average t^2 of alphas

[23]In unreported results, we also check the performance of the liquidity factor model of Pastor and Stambaugh (2003), which adds a traded liquidity factor to the Carhart model. We find that the liquidity factor does not help for explaining most anomalies.

[24]The only anomaly not earning significant excess return is the gross profits-to-assets ratio (GP/A) of Novy-Marx (2013). Novy-Marx (2013) reports significant high-minus-low GP/A excess returns over the sample period of 1963 to 2010, while our sample period is 1972 to 2014. When restricting to the same period as Novy-Marx (2013), we do find significant excess returns associated with GP/A. Still, we include GP/A in our analysis because it serves as the underlying characteristic of the profitability factor (PMU) of the Novy-Marx (2013) model.

under a given model is larger than the average t^2 of the composite-model alphas.[25]

2.2.1 Fitting Short-horizon Anomalies

Panel A of Table 7 compares different models on explaining the list of 12 short-horizon anomalies. We first look at the number of significant alphas at the 5% level. Among standard factor models, the CAPM and FF3 models do not capture most of these anomalies and the Carhart4 model with a momentum factor explains about half of them. Not surprisingly, the FF3 and FF5 models perform poorly, as these models are designed to price only the longer horizon anomalies and not shorter-horizon momentum-like anomalies. The NM4, HXZ4, and SY4 models each miss 2, 1, and 4 anomalies, respectively, owing to the inability of the MOM factor, the ROE factor, and the PERF factor, respectively, to explain the short-horizon anomaly portfolio returns. Among our behaviorally-motivated models, we see that FIN alone captures only a few of these anomalies and PEAD alone captures all of them. Combining the market factor with FIN and PEAD, our BF3 model fully captures all 12 anomalies. Overall, the evidence suggests that the PEAD factor achieves great success in capturing abnormal returns associated with price momentum, earnings momentum, and short-term profitability.

Other statistics confirm the superior performance of the PEAD factor and our BF3 model. The BF3 model gives the smallest average absolute alpha ($|\alpha| = 0.09\%$) and absolute t ($|t| = 0.49\%$) among all models. The F-tests suggest that the average of the squared t-statistics for the estimated alphas (t^2) under all other models are significantly larger than average t^2 of BF3 alphas. Furthermore, the BF3 model gives the smallest GRS F-statistic and does not reject the null hypothesis that all alphas are jointly zero (GRS $F = 1.15$ and $p = 0.32$). It also gives the smallest HJ-distance and does not reject the null hypothesis that the composite model is specified correctly (HJ $= 14.66$ and $p = 0.49$). In contrast, all other models give substantially larger average absolute alphas and t, their GRS F-tests

[25] The HJ-distance is estimated as follows. Consider a portfolio of N assets, with a (gross) return vector R_t at month t. Let 1_N be an N-dimensional vector of ones, and Y_t a K-dimensional vector of (gross) factor returns including one. Following Hansen and Jagannathan (1997), the HJ-distance is estimated by $Dist(\delta_T){=}\sqrt{w'(\delta_T)\ G_T^{-1}\ w(\delta_T)}$, where $\delta_T = (D_T' G_T^{-1} D_T)^{-1} D_T' G_T^{-1} 1_N$ is a GMM estimator that minimizes the distance $Dist(\delta)$, $D_T = \frac{1}{T}\ \sum_{t=1}^{T} R_t Y_t'$, the weighting matrix $G_T = \frac{1}{T} \sum_{t=1}^{T} R_t R_t'$, T is the number of sample months, and the pricing error vector $w(\delta_T) = D_T \delta_T - 1_N$. Jagannathan and Wang (1996) prove that the asymptotic distribution of $T[Dist(\delta_T)]^2$ is a weighted sum of $\chi^2(1)$ distributed random variables. To get the critical value for $T[Dist(\delta_T)]^2$, they suggest an algorithm that first draws $M \times (N - K)$ random variables from $\chi^2(1)$ distribution, and then computes the simulated p-value that tests the null hypothesis that the underlying factor model is specified correctly. We set $M = 5000$ random draws.

reject the null hypotheses at the 1% level, and the HJ tests reject the null hypotheses that these models are specified correctly at the 1% level (except for SY4 model which rejects the null at the 10% level).

Although the PERF factor of the SY4 model is constructed on five characteristics related to price momentum and profitability, our PEAD factor, which is constructed on just two characteristics, earnings surprises and firm size, outperforms the composite PERF factor in capturing the 12 short-horizon anomalies.

2.2.2 Fitting Long-horizon Anomalies

Panel B of Table 7 compares different models on explaining the list of 22 long-horizon anomalies. We first consider the number of significant alphas at the 5% level. Among standard factor models, the CAPM does not capture most of these anomalies, the FF3 model gives 12 significant alphas, and the Carhart4 model gives 8 significant alphas. For competing models, the numbers of significant alphas are 7 (FF5), 3 (NM4), 5 (HXZ4), and 3 (SY4), respectively. Among our behavioral-motivated models, a single FIN factor gives 6 significant alphas, performing as well as the FF5 and HXZ4 models. A single PEAD factor does not capture most of these long-horizon anomalies, which is not surprising as PEAD is designed to capture short-term mispricing. Lastly, our BF3 model (with MKT, FIN, and PEAD) gives 3 significant alphas, outperforming the FF5 and HXZ4 models and performing equally well as the NM4 and SY4 models.

Other statistics confirm the good performance of the NM4, BF3, and SY4 models. The SY4 model gives the smallest average absolute alpha ($|\alpha| = 0.12\%$) and absolute t ($|t| = 0.70\%$) among all models. The F-tests suggest that the average of the squared t-statistics for the estimated alphas (t^2) under FF5, NM4, and HXZ4 models are not significantly different from average t^2 of BF3 alphas, but the average t^2 of SY4 alphas is significantly smaller than that of BF3 alphas. Furthermore, the SY4 model gives the smallest GRS F-statistic and does not reject the null hypothesis that all alphas are jointly zero (GRS $F = 0.74$ and $p = 0.80$). The GRS F-tests cannot reject the null under 5% significance level for NM4 and BF3 models, while rejecting the null at 1% significance level for all other models including the FF5 and HXZ4 models. Lastly, the HJ tests cannot reject the null hypotheses that the FF5, NM4, SY4 and BF3 models are specified correctly, while rejecting the null at 10% significance level for the HXZ4 model.

While the FF5 and HXZ4 models each include an investment factor, both models fail to explain the average returns of several investment-related anomaly portfolios, such as net operating assets (NOA), investment-to-asset ratio (IVA), inventory changes (IvC), and operating accruals (OA). Similarly, the FF5 and HXZ4 models, each with a profitability factor, do not capture the cash-based operating profitability (CbOP) effect, while our BF3 model does, despite the fact that neither FIN nor PEAD is directly constructed on investment or profitability characteristics.

The good performance of the SY4 model appears to result from the inclusion of its MGMT factor, which is constructed on six long-horizon characteristics related to investment and financing, allowing it to price investment-related anomalies. Interestingly our single long-horizon factor (FIN) performs almost as well as the MGMT factor in capturing abnormal returns associated with 22 firm characteristics. This is consistent with the fact that the two factors have a correlation of about 0.8.

2.2.3 Fitting All Anomalies

Panel C of Table 7 summarizes model performance on the whole list of 34 anomalies. Our BF3 model gives just 3 significant alphas at the 5% level, while the FF5, NM4, HXZ4, and SY4 models give 18, 5, 6, and 7 significant alphas, respectively. The SY4 model gives the smallest, and the BF3 model gives the second smallest, average absolute alpha and absolute t among all models. The F-tests suggest that the average of the squared t-statistics for the estimated alphas (t^2) under NM4 and SY4 models are not significantly different from average t^2 of BF3 alphas, but the average t^2 of FF5 and HXZ4 alphas are significantly larger than that of BF3 alphas at 1% and 10% significance levels, respectively. Unlike in Panel A and B, the GRS F-tests reject the null hypotheses of all alphas jointly zero under all models, while the BF3 model achieves the smallest GRS F-statistic. Similarly, the HJ tests reject the null hypotheses under all models, while the BF3 model gives the smallest HJ-distance measure.

Overall, a three-factor risk-and-behavioral composite model (BF3) with a market factor and two behavioral factors outperforms both traditional factor models and recently prominent models in explaining a list of 34 robust anomalies. Our findings suggest that many of the existing anomalies, such as return and earnings momentum, profitability, value, investment and financing, and intangibles, can be attributed to systematic mispricing.

One criticism of characteristic-based factor models is that the factors are built upon the same characteristics as the anomalies to be explained. Such models can have high explanatory power for such anomalies for purely mechanical reasons (Daniel and Titman, 1997). As a robustness check, we therefore rerun our tests where, for each factor model, we exclude the anomalies whose characteristics are used to build the factors of that model. The results are very similar to our main results, and the BF3 model continues to outperform the other models.

Next, we present detailed factor regression results for each anomaly. For brevity, we show statistics only for the long/short (L/S) hedged anomaly portfolios (not for decile portfolios). Definitions of anomaly variables and portfolio constructions are described in Appendix A. Table 8 reports alphas and factor loadings from time-series regressions of each L/S anomaly portfolio returns on recent prominent factor models. We examine factor loadings to gain insights into which factors contribute to explaining which anomalies.

2.2.4 Earnings and Price Momentum

Our test assets include five earnings momentum portfolios (SUE-1, SUE-6, ABR-1, ABR-6, RE-1) and three price momentum portfolios (R6-6, R11-1, I-MOM). Panel A of Table 8 shows that, likely owing to the lack of a momentum factor, the FF5 model does not capture any of these anomalies. Panel B and C show that the momentum factor (MOM) of the NM4 model and the ROE factor of the HXZ4 model help fully explain all anomalies, except for the post-earnings announcement drift (ABR-1). Similarly, Panel D shows that the PERF factor, which is a composite factor formed on five anomaly variables including price momentum, fully explains many of these anomalies but the post-earnings announcement drift (ABR-1, ABR-6). Lastly, Panel E shows that the PEAD factor fully captures all anomalies.

Overall, the PEAD factor, constructed on earnings surprises, exhibits stronger pricing power for price and earnings momentum than does the MOM factor based on past returns, the ROE factor based on earnings profitability, and the composite PERF factor based on momentum, distress, and profitability.

2.2.5 Profitability

Our test assets include six profitability anomaly portfolios. Four are based on short-term profitability metrics from quarterly COMPUSTAT files or based on earnings realizations (ROAQ, ROEQ, NEI, FP), and two are based on longer-term profitability metrics from annual COMPUSTAT files (GP/A, CbOP). The short-term profitability portfolios are rebalanced monthly, and the long-term profitability portfolios are rebalanced annually.

Panel A of Table 8 shows that despite inclusion of the profitability factor RMW, the FF5 model fails to fully explain the premia earned by the profitability portfolios; most of these anomalies have large and significant alphas after controlling for exposure to RMW. Panel B shows that the profitability (PMU) factor of the NM4 model fully explains all but the failure probability effect (FP). Panel C shows that the short-term profitability (ROE) factor of the HXZ4 model fully explains all but the cash-based operating profitability effect (CbOP). Panel D shows that the PERF factor of the SY4 model does not explain the quarterly ROE effect (ROEQ), earnings surprises measured by the number of consecutive quarters with earnings increases (NEI), or the cash-based operating profitability effect (CbOP). Lastly, Panel E shows that the PEAD factor based on earnings surprises fully captures all these profitability anomalies.

Overall, it is notable that the PEAD factor, constructed on earnings surprises, performs better in capturing the profitability effects than the profitability factors of the FF5, NM4, and HXZ4 models and the PERF factor of the SY4 model based on price momentum, distress, and profitability.

2.2.6 Value

Our test assets include five value anomaly portfolios: B/M, E/P, CF/P, NPY, and DUR. Panel A and B of Table 8 show that the FF5 and NM4 models fully explain all these anomalies, owing to the inclusion of a value (HML) factor. In Panel C, without a value factor, the investment (IVA) factor of the HXZ4 model explains all these anomalies except for the net payout yield effect (NPY). In Panel D, the MGMT factor of the SY4 model, constructed on six anomaly variables related to investment and financing, fully captures all these anomalies. Lastly, in Panel E, the FIN factor, constructed on external financing, successfully captures all anomalies as well.

2.2.7 Investment and Financing

Our test assets include nine investment anomaly portfolios (AG, NOA, IVA, IG, IvG, IvC, OA, POA, PTA) and two financing anomaly portfolios (NSI, CSI). Panel A of Table 8 shows that the investment (CMA) factor of the FF5 model fails to explain five anomaly portfolios (NOA, IVA, IvC, OA, NSI). Panel B shows that the NM4 model derives most of its explanatory power from the value (HML) factor and fully explains all but two anomaly portfolios (IvC and OA). In Panel C, the investment (IVA) factor of the HXZ4 model explains all but two anomaly portfolios (OA and NSI). In Panel D, the MGMT factor of the SY4 model explains all but one anomaly portfolio (OA). Lastly, Panel E shows that our FIN factor captures all but one anomaly portfolio (IvC).

Overall, the value factor (HML) and the investment factors (CMA and IVA) all play a role in successfully pricing many, but not all, investment and financing anomaly portfolios. The profitability factors (RMW, PMU, and ROE) to some extent help explain financing anomalies, but go in the wrong direction for many investment anomalies. Not surprisingly, the MGMT factor, constructed on six investment and financing return predictors, delivers the best performance. Interestingly, our FIN factor, constructed on just two return predictors (external financing and firm size), delivers equally good performance as the composite MGMT factor.

2.2.8 Intangibles

Our test assets include four intangibles anomaly portfolios: OC/A, AD/M, RD/M, and OL. Panel A of Table 8 shows that the size (SMB) factor of the FF5 model plays a role in successfully pricing all but one anomaly portfolio (OC/A), which loads negatively on the HML and RMW factors and earns a significant positive FF5 alpha. In Panel B, the HML factor of the NM4 model explains all but one anomaly (OC/A), which loads negatively on the PMU factor. Panel C shows that the SMB factor of the HXZ4 model explains all but one anomaly (RD/M), which loads negatively on the ROE factor. Panel D shows that, with a modified size factor, the SY4 model captures all but one anomaly (OC/A), which loads negatively on the MGMT factor. Lastly, Panel E shows that without a size factor, our BF3 model fails to explain two anomalies (OC/A and RD/M).

The evidence suggests that a size factor contributes greatly to capturing intangibles-related anomalies, whereas profitability factors and financing factors tend to "explain" some of these anomalies, such as OC/A and RD/M, in the wrong direction. Overall, our three-factor risk-and-behavioral composite model has only a limited ability to explain the set of intangibles-related anomalies, perhaps partly as a result of the lack of a size factor in the model.

3 Forecasting Returns with Behavioral Factor Loadings

3.1 Estimation Methods and Results

If FIN and PEAD are behavioral factors that capture return comovement associated with common mispricing, then loadings on FIN and PEAD will be underpricing proxies. As such, these loadings should positively predict the cross-section of future stock returns. We now test this hypothesis.

We expect mispricing to shift over time, owing to correction of past mispricing and innovations to mispricing. Correspondingly, we therefore expect substantial instability in firm-level behavioral factor loadings. This implies substantial error in the estimation of such loadings unless an appropriate conditional estimation technique is used to address the instability. This problem should be especially severe for short-term mispricing, which tends to correct more quickly.

A common presumption for risk factors (such as MKT) in many monthly return tests is that loadings are persistent over periods of 3 to 5 years. As such, when estimating risk factor loadings, the standard method has been to run rolling window regressions over the previous 60 months.[26] However, for our behavioral factors, this presumption is unlikely to apply. Though a firm characteristic (upon which the behavioral factor is constructed) can be indefinitely mispriced by the market, no particular firm is likely to stay over- or underpriced forever, and therefore individual firm loadings on behavioral factors, especially short-horizon factors, should not be stable over longer horizons. We therefore estimate firms' loadings on behavioral factors using daily excess returns over a one month horizon.[27]

Specifically, estimated firm factor loadings at the start of month t come from regressions of each

[26] However, some recent papers have utilitized daily data different horizons for estimating the correlation and volatility components of firm loadings. See, e.g., Frazzini and Pedersen (2014).

[27] The daily FIN and PEAD factor construction is identical to the construction of the corresponding monthly factors: each (value-weighted) component portfolio is rebalanced each year at June month end for FIN, and at the end of each month for PEAD.

firm's daily (excess) returns on daily (excess) market, FIN, and PEAD factor returns over month $t-1$ (a minimum of 15 valid daily returns is required). The estimated coefficients on FIN and PEAD (β_{FIN} and β_{PEAD}) at the end of month $t-1$ are then used to forecast firm level stock returns in month t in a Fama and MacBeth (1973) regression, with standard control variables and a broad set of firm characteristics underlying the list of 34 robust anomalies that we examine. Standard controls include log(ME), log(B/M), and the previous one-month, one-year, and three-year returns to control for short-run contrarian, momentum, and long-term reversal, respectively. All regressors are winsorized at top and bottom 1% and standardized to have zero mean and unit standard deviation, to make the coefficients comparable.

Table 9 reports the regression results. Models (1) and (2) show that estimated firm β_{FIN} loadings positively and significantly forecast the following month's stock returns, with or without standard controls. In models (3)$-$(9), we add one by one earnings momentum and short-term profitability characteristics, and in model (10), we run a horse race between β_{FIN} and all these characteristics, we find that the coefficients on β_{FIN} remain positive and statistically significant in all tests. This suggesting that the return predictive ability of β_{FIN} is incremental to these short-horizon anomaly characteristics.

In models (11)$-$(13), we include two financing characteristics used to construct FIN. We find that the coefficient on β_{FIN} remains statistically significant when controlling for net share issuance (NSI), but is only marginally significant after controlling for composite share issuance (CSI). When including both NSI and CSI, β_{FIN} becomes significant again. In models (14)$-$(22) we add, one by one, a number of investment characteristics, and in model (23) we run a horse race between β_{FIN} and all these characteristics. The coefficients on β_{FIN} remain highly significant in all regressions. In model (24), when controlling for all financing and investment characteristics, the coefficient on β_{FIN} becomes marginally significant, primarily driven by the strong predictive power of composite share issuance (CSI). The evidence suggests that the return predictive ability of β_{FIN} is incremental to both investment and financing characteristics.

In models (25)$-$(38), we control for characteristics related to profitability, value, and intangibles. Consistent with earlier evidence, the return predictive ability of β_{FIN} stays robust and incremental to profitability and value characteristics. When controlling for intangibles, the coefficients on β_{FIN}

become weaker or statistically insignificant. Together the evidence in Tables 7 and 8 indicate that our behavioral factors exhibit weak pricing power for the intangibles-related anomalies, in particular R&D.

Overall, our findings suggest that estimated firm loadings on FIN positively and substantially significantly forecast future stock returns. This predictive power is robust to controls for many well-known return predictors in the literature. The evidence supports our hypothesis that FIN captures return comovement resulting from to common mispricing.

While the predictive power of β_{FIN} for future returns is statistically strong, the coefficients on β_{PEAD} are statistically insignificant in all models. A likely explanation is that the PEAD loadings, β_{PEAD}, are estimated with substantial noise owing to the fact that these are estimates of a transient source of mispricing. PEAD is built on cumulative abnormal returns during the four-day window around earnings announcement (ABR). Table 5 shows that the return predictive ability of ABR portfolios becomes much weaker or insignificant just two quarters after portfolio formation.[28]

3.2 Discussion

These cross-sectional tests generally confirm the predictive power of FIN loadings for future returns, but not PEAD factor loadings. However, for two reasons, we place less weight on the cross-sectional tests than the time series tests. First, each Fama and MacBeth (1973) coefficient is the return of a zero-investment portfolio. However, as discussed by Daniel and Titman (2006) and others, these portfolios can have large and variable weights on microcap stocks, resulting in biases deriving from microstructure noise. Second is the well-known errors-in-variables problem in estimating factor loadings. As discussed above, this is likely to be especially severe for the loadings on short-horizon behavioral factors. We discuss each of these points in turn.

With respect to heavy weights on small illiquid stocks, in a setting where the characteristics (regressors) are fairly stable, the regression coefficient portfolios implicitly place relatively constant weight on high- and low-characteristic securities from month to month, much like an equal-weighted portfolio. In practice, market frictions make it hard to achieve such returns. Maintaining approximate

[28]The correlation between PEAD characteristic (ABR) and estimated PEAD beta is very low−below 0.05. This suggests that the PEAD-beta estimates are too noisy to predict the cross-section of stock returns. Regressions by calendar month show that PEAD betas do not predict stock returns in most months (apart from May and September).

equal-weighting requires rebalancing the portfolio each month, buying firms that fall in value and selling firms that rise. Bid-ask bounce, illiquidity, and transaction costs can tremendously reduce the actual returns from such a strategy, especially for portfolios tilted towards small (and illiquid) firms. This implies upwardly-biased estimates of the returns of illiquid firms.

This can help explain the differences between the Fama-MacBeth tests and the factor regressions tests of Section 2. The ability of factor models to explain anomalies is consistently better in the factor regressions tests than in the Fama-MacBeth tests. A plausible reason is that factor models may do better in explaining implementable anomalies (mispricing of factors that drive return predictability, including larger firms) than non-implementable ones (mispricing of idiosyncratic sources of stock payoffs, especially for smaller firms). For example, in the factor regressions tests the PEAD factor captures short-horizon anomalies extremely well, whereas in the Fama-MacBeth tests it does so poorly. But exploiting short-horizon anomalies requires greater rebalancing, making them more costly to implement. So the model does less well in the Fama-MacBeth tests exactly in the set of anomalies that are harder to implement.

This is what we would expect on theoretical grounds if factor risk is a deterrent to arbitrage. In the frictionless model of mispricing and arbitrage of Daniel, Hirshleifer, and Subrahmanyam (2001), any mispricing of the idiosyncratic components of security payoffs is almost completely arbitraged away, because competitive rational arbitrageurs can diversify away the risk associated with bets on idiosyncratic mispricing, and therefore eliminate this mispricing. In contrast, the only way to arbitrage factor mispricing is to bear substantial non-diversifiable risk, so factor mispricing persists. So in factor regression tests, which focus primarily on liquid stocks, we expect factor-derived mispricing, as reflected in loadings on mispricing factors, to explain the return-prediction ability of characteristics (which reflect both factor-derived and idiosyncratic mispricing). In contrast, in tests that focus on illiquid stocks, we expect characteristics to become more important relative to factor loadings in predicting returns, as idiosyncratic mispricing is not arbitraged away for such stocks.

Consistent with these arguments, in our factor regressions tests, which focus on large liquid stocks, factor loadings (a measure of systematic mispricing) almost completely explain characteristic-based anomalies. This suggests that almost all firm-level mispricing in this universe of stocks is derived from factor mispricing. In contrast, in the Fama-MacBeth tests, which focus heavily on small illiquid stocks, characteristics more often remain incrementally significant in predicting returns. This suggests that among small illiquid stocks, idiosyncratic mispricing remains important.

With respect to the second point, the errors-in-variables problem, the small illiquid stocks that dominate in Fama-MacBeth regressions (again, especially for short-horizon anomalies) are traded by investors less frequently. Owing to asynchronous trading, their factor loadings are estimated poorly. Greater measurement error in estimating PEAD factor loadings would reduce the ability of these loadings to subsume the effect of characteristics in predicting returns.

4 Effects of Limits to Arbitrage

We next conduct additional tests of the effects of limits to arbitrage to refine our understanding of where FIN and PEAD are most effective. We focus on market frictions, which affect arbitrageurs' ability to exploit mispricing. Owing to limits to arbitrage and short-sale constraints, we expect that behavioral factors are especially good at explaining returns of stocks with high arbitrage frictions, such as stocks in the short-leg portfolios and stocks with greater market frictions.

4.1 The Loadings on Behavioral Factors of Long- and Short-leg Portfolios

To exploit anomaly profits, it is standard to form a zero-investment portfolio by going long on underpriced stocks and short on overpriced stocks. Owing to short-sale constraints, overpriced stocks in the short-leg portfolios are harder to correct and therefore more subject to mispricing. If FIN and PEAD capture mispricing, they should explain the returns of the short-leg portfolios particularly well. Generally, we expect the long-leg portfolios (underpriced) to load positively on FIN and PEAD and the short-leg portfolios (overpriced) to load negatively. If FIN and PEAD explain the short legs particularly well, we would expect the negative loadings of the short legs to be larger in absolute magnitude than the positive loadings of the long legs. Moreover, since PEAD primarily captures high-frequency mispricing and FIN captures low-frequency mispricing, we expect the result for PEAD factor loadings to be more pronounced among short-horizon anomalies and the result for FIN factor loadings more pronounced among long-horizon anomalies.

We run time-series regressions of the long- and short-leg portfolio returns on the three-factor risk-and-behavioral composite model. We count how many short-horizon anomalies have more negative (larger in absolute magnitude) PEAD factor loadings in the short legs than the positive loadings in the long legs, and we highlight these cases in boldface. Similarly for long-horizon anomalies, we highlight the cases where the negative loadings on the FIN factor in the short legs are larger (in absolute magnitude) than the positive loadings in the long legs. Table 10 reports the results. Panel A shows that for the 12 short-horizon anomalies, 11 anomalies have larger negative and statistically significant β_{PEAD} in the short legs. In contrast, only 1 anomaly has larger positive and statistically significant β_{PEAD} in the long legs. The average β_{PEAD} is -0.51 for the short legs and 0.31 for the long legs. The evidence is consistent with our hypothesis that PEAD primarily captures high-frequency mispricing embedded in short-horizon anomalies and explains the returns of the short-leg portfolios particularly well.

Similarly, Panel B shows that for the 22 long-horizon anomalies, 15 anomalies have larger negative and statistically significant β_{FIN} in the short legs. In contrast, just 3 anomalies have larger positive and statistically significant β_{FIN} in the long legs. The average β_{FIN} is -0.27 for the short legs and 0.03 for the long legs. Again, the evidence confirms that FIN primarily captures low-frequency mispricing embedded in long-horizon anomalies and explains the returns of the short-leg portfolios particularly well. Overall, the findings support the idea that FIN and PEAD capture commonality in mispricing.

4.2 Market Frictions and the Beta-Return Relation

We have hypothesized that firm loadings or betas on FIN and PEAD are proxies for the degree of mispricing, implying a positive relation between FIN or PEAD betas and future stock returns. In Section 3, we confirmed the strong return predictive ability of FIN betas, but found that PEAD betas have no statistically significant power to forecast future returns, potentially as a result of estimation issues involving betas on transient mispricing among small firms.

In this section, we further propose that market frictions impede arbitrage in mispricing, and thereby affect the *sensitivity* of the FIN-beta/return relation. Owing to limits to arbitrage and short-sale constraints, we expect high friction stocks to have greater mispricing. Mispricing, as proxied by factor betas on FIN, is measured with noise. For stocks with low frictions and with low mispricing (either overpricing or underpricing), most of the variation in the mispricing proxies (factor betas) would be noise. For such stocks, we should observe low sensitivity of expected returns to estimated factor betas. In contrast, for stocks with large frictions and thus greater potential under- or over-pricing, we expect less noise in the mispricing proxies and therefore high sensitivity of expected returns to estimated factor betas. Therefore, we hypothesize that the FIN-beta/return relation should be stronger for high friction stocks.

We first test this hypothesis using two-way portfolio sorts on friction proxies and factor betas. Specifically, at the beginning of each month, we rank firms into 25 portfolios by independent sorts on their FIN betas (from Section 3) and market friction proxies. Portfolios are held for the current month and rebalanced at the beginning of the next month. We calculate value-weighted returns for each portfolio, and corresponding Newey and West (1987) corrected standard errors. Following the literature, we use three friction proxies: the illiquidity measure (ILLIQ) of Amihud (2002), the institutional ownership defined as shares held by institutions divided by shares outstanding (IO), and the residual institutional ownership (RIO) of Nagel (2005), controlling for size. Firms with larger ILLIQ, or smaller IO and RIO, have greater market frictions. Consistent with our hypothesis, Panel A of Table 11 shows that, using ILLIQ and IO as friction proxies, the FIN-beta/return relation is positive and statistically significant *only* for high friction stocks. The results using RIO are consistent with our hypothesis but statistically insignificant.

Next, we run Fama and MacBeth (1973) cross-sectional regressions of monthly stock returns on firms' β_{FIN}, the quintile ranks of their market friction proxies, and the interactions between β_{FIN} and friction ranks, controlling for standard return predictors. All regressors are winsorized at top and bottom 1% and standardized to have zero mean and unit standard deviation, to make the coefficients comparable. Panel B of Table 11 shows the results. We are particularly interested in the interaction terms. The coefficients on the interaction between β_{FIN} and ILLIQ ranks are statistically insignificant. On the other hand, the coefficients on the interactions between β_{FIN} and IO or RIO ranks are both negative and statistically significant, suggesting that high friction stocks (with low IO or RIO ranks) have stronger beta-return sensitivity.

Overall, the evidence from portfolio sorts and cross-sectional regressions is largely consistent with our hypothesis that high friction stocks have stronger sensitivity of expected returns to FIN betas, indicating that FIN betas capture mispricing.

5 Conclusion

We supplement the market factor of the CAPM with behavioral factors intended to capture commonality in mispricing associated with psychological biases. We focus on two psychological biases that are likely to affect asset prices: overconfidence and limited attention. Motivated by the idea that investor overconfidence induces commonality in longer-horizon mispricing, and that managers time share issuance and repurchase to exploit this mispricing (Hirshleifer and Jiang, 2010), we create a financing factor (FIN) based on external financing. Motivated by the theory that limited investor attention induces stock market underreaction to public news arrival, we consider a post-earnings announcement drift factor (PEAD) constructed based upon earnings surprises. We further hypothesize that FIN especially reflects the returns associated with long-term ($>$ 1 year) mispricing, and that PEAD especially reflects returns associated with shorter-term ($<$ 1 year) mispricing.

Our new factor model is designed to capture these complementary aspects of mispricing. We test the ability of our three-factor risk-and-behavioral composite model to explain well-known return anomalies. This composite approach is suggested by theoretical models in which both risk and misvaluation proxies predict returns. We find that the FIN factor is dominant in explaining long-horizon return anomalies, and the PEAD factor is dominant for short-horizon anomalies.

We compare the model performance with standard factor models and recently prominent models, such as the profitability-based model of Novy-Marx (2013), the five-factor model of Fama and French (2015), the q-factor model of Hou, Xue, and Zhang (2015), and the mispricing model of Stambaugh and Yuan (2017). Our composite model outperforms all other models in explaining the returns of 34 anomaly portfolios, based on the list of anomalies considered in Hou, Xue, and Zhang (2015). In addition to its simple conceptual motivation, the composite model is parsimonious in the sense that, along with the market, two behavioral factors built upon only three economic characteristics−size, financing, and earnings surprise−capture a wide range of anomalies.

If FIN and PEAD are indeed priced behavioral factors that capture commonality in mispricing, then behavioral models imply that firm loadings on FIN should be proxies for persistent underpricing, and loadings on PEAD should be proxies for transient underpricing. In consequence, these loadings should positively predict the cross-section of stock returns. Using Fama-MacBeth cross-sectional regressions, we confirm that estimated FIN loadings strongly forecast future returns. Notably, this predictive power remains robust even after controlling for most of the 34 anomaly characteristics that we examine. In contrast, estimated PEAD loadings have no return predictive ability. It is not clear how to interpret the PEAD finding, since there are econometric issues associated with the instability of the PEAD loadings as proxies for transient mispricing and the heavy influence on Fama-MacBeth regression tests of small illiquid firms.

Finally, we conduct several tests related to limits to arbitrage and provide additional evidence suggesting that FIN and PEAD indeed capture mispricing effects. If these are behavioral factors, we expect the mispricing that they identify to be stronger when limits to arbitrage, including short-sale constraints, are more binding. We find that FIN and PEAD are particularly useful for predicting the returns of stocks with high arbitrage frictions, such as over- rather than under-priced stocks, and stocks with greater trading frictions.

The broader message of this study is that it is useful to use behaviorally-motivated factors in explaining asset mispricing, comovement and return predictability at short- versus long-horizons.

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Table 1: Summary Statistics of Factor Portfolios

Panel A reports the mean and standard deviations of monthly factor returns for a set of traded-factor returns. In addition we report the t-statistic testing whether this the mean return is different from zero, the corresponding monthly Sharpe ratio, and the sample period for each return factor. Panel B reports Pearson correlations between factor portfolio returns, and Panel C reports summary statistics for the ex post tangency portfolios of various factor-portfolio combinations. These factors include the Mkt-Rf, SMB, HML, MOM factors proposed by Fama and French (1993) and Carhart (1997), and modified versions of these factors proposed by Novy-Marx (2013, NM4), Fama and French (2015, FF5), Hou, Xue, and Zhang (2015, HXZ4), and Stambaugh and Yuan (2017, SY4). In addition we include: the investment factors CMA and IVA of Fama and French (2015) and Hou, Xue, and Zhang (2015), the profitability factors PMU, RMW, and ROE of Novy-Marx (2013), Fama and French (2015), and Hou, Xue, and Zhang (2015), and the two mispricing factors MGMT and PERF of Stambaugh and Yuan (2017). Monthly factor returns are either from Kenneth French's web page or provided by corresponding authors. FIN and PEAD are our behavioral factors. FIN is the financing-based misvaluation factor constructed based upon two financing characteristics, net share issuance and composite issuance. PEAD is the post-earnings announcement drift factor, constructed based upon earnings surprises (measured as the four-day cumulative abnormal returns around quarterly earnings announcements). In Panel C, we add asterisk after factors SMB, HML and MOM, meaning these factors have modified versions, and asterisk after models NM4, FF5, HXZ4 and SY4, meaning these models use modified factors. The sample period for each factor is indicated in the table.

Panel A: Factor premiums

	Mean	Std	t-value	SR	N	Sample period
MKT	0.53	4.59	2.62	0.12	510	1972:07 – 2014:12
SMB	0.17	3.13	1.19	0.05	510	1972:07 – 2014:12
SMB(HXZ4)	0.29	3.14	2.06	0.09	510	1972:07 – 2014:12
SMB(SY4)	0.41	2.81	3.28	0.15	498	1972:07 – 2013:12
HML	0.41	2.94	3.14	0.14	510	1972:07 – 2014:12
HML(NM4)	0.44	1.49	6.43	0.29	486	1972:07 – 2012:12
MOM	0.68	4.44	3.45	0.15	510	1972:07 – 2014:12
MOM(NM4)	0.61	2.90	4.6	0.21	486	1972:07 – 2012:12
CMA	0.37	1.95	4.27	0.19	510	1972:07 – 2014:12
IVA	0.43	1.86	5.23	0.23	510	1972:07 – 2014:12
PMU	0.27	1.18	5.06	0.23	486	1972:07 – 2012:12
RMW	0.34	2.24	3.44	0.15	510	1972:07 – 2014:12
ROE	0.56	2.59	4.88	0.22	510	1972:07 – 2014:12
MGMT	0.67	2.87	5.24	0.23	498	1972:07 – 2013:12
PERF	0.65	3.90	3.73	0.17	498	1972:07 – 2013:12
FIN	0.80	3.92	4.6	0.20	510	1972:07 – 2014:12
PEAD	0.65	1.85	7.91	0.35	510	1972:07 – 2014:12

Panel B: Correlation matrix

	MKT	SMB	SMB (HXZ4)	SMB (SY4)	HML	HML (NM4)	MOM	MOM (NM4)	CMA	IVA	PMU	RMW	ROE	MGMT	PERF	FIN
SMB	0.26															
SMB(HXZ4)	0.25	**0.95**														
SMB(SY4)	0.21	**0.92**	**0.93**													
HML	-0.28	-0.22	-0.05	-0.05												
HML(NM4)	-0.19	-0.04	0.09	0.10	**0.81**											
MOM	-0.14	0.01	0.01	0.03	-0.17	-0.12										
MOM(NM4)	-0.19	-0.06	-0.07	-0.04	-0.20	-0.18	**0.95**									
CMA	-0.39	-0.12	-0.02	0.01	**0.69**	**0.61**	0.02	-0.01								
IVA	-0.37	-0.23	-0.12	-0.09	**0.68**	**0.55**	0.04	0.02	**0.90**							
PMU	-0.29	-0.27	-0.25	-0.17	-0.10	-0.22	0.25	0.28	-0.03	0.03						
RMW	-0.21	-0.22	-0.16	-0.13	0.01	-0.01	0.21	0.24	-0.03	0.00	**0.57**					
ROE	-0.19	-0.38	-0.31	-0.28	-0.10	-0.21	**0.49**	**0.52**	-0.08	0.06	**0.59**	**0.58**				
MGMT	-0.54	-0.39	-0.29	-0.25	**0.72**	**0.59**	0.06	0.06	**0.76**	**0.76**	0.16	0.16	0.09			
PERF	-0.26	-0.09	-0.12	-0.05	-0.30	-0.24	**0.72**	**0.70**	-0.06	-0.06	**0.59**	**0.48**	**0.63**	0.01		
FIN	-0.50	-0.49	-0.38	-0.30	**0.65**	**0.50**	0.09	0.09	**0.58**	**0.66**	0.35	0.35	0.33	**0.80**	0.15	
PEAD	-0.10	0.03	0.00	0.01	-0.16	-0.13	**0.46**	**0.48**	0.00	-0.04	0.09	0.07	0.22	0.00	**0.38**	-0.05

Panel C: Ex post tangency portfolios

	Portfolio Weights													Tangency Portfolios		
	MKT	SMB*	HML*	MOM*	RMW	CMA	PMU	IVA	ROE	MGMT	PERF	FIN	PEAD	Mean	Std	SR
(1) FF3	0.29	0.15	0.56											0.41	1.86	0.22
(2) Carhart4	0.23	0.09	0.43	0.26										0.49	1.58	0.31
(3) FF5*	0.17	0.06	-0.01		0.31	0.47								0.38	1.06	0.36
(4) NM4*	0.10		0.40	0.11			0.39							0.40	0.70	**0.57**
(5) HXZ4*	0.14	0.13						0.44	0.29					0.46	1.08	0.43
(6) SY4*	0.22	0.17								0.43	0.18			0.59	1.20	0.50
(7) BF2												0.22	0.78	0.68	1.64	0.41
(8) BF3	0.19											0.26	0.55	0.66	1.29	**0.52**
(9) BF3 + PMU	0.16						0.29					0.17	0.39	0.55	1.01	0.54
(10) BF3 + RMW, CMA	0.16				0.10	0.19						0.13	0.41	0.56	1.05	0.54
(11) BF3 + IVA, ROE	0.16							0.25	0.09			0.11	0.40	0.58	1.06	0.55
(12) BF3 + MGMT, PERF	0.20									0.27	0.07	0.06	0.39	0.64	1.15	0.56
(13) All factors ex. BF2	0.15	0.15	-0.01	-0.02	-0.04	-0.09	0.25	0.14	0.13	0.28	0.05			0.47	0.86	0.54
(14) All factors	0.12	0.11	0.01	-0.05	-0.02	-0.13	**0.23**	**0.17**	0.08	**0.20**	0.02	0.00	**0.26**	0.49	0.76	**0.65**

Table 2: Factor Regressions of Behavioral Factors on Other Factors

This table reports time-series regressions of behavioral factors on standard factor models and other recent models: (1) the Fama-French three-factor model (FF3), (2) the Carhart four-factor model (Carhart4), (3) the profitability-based model of Novy-Marx (2013, NM4), (4) the five-factor model of Fama and French (2015, FF5), (5) the q-factor model of Hou, Xue, and Zhang (2015, HXZ4), (6) the four-factor mispricing model of Stambaugh and Yuan (2017, SY4), and (7) the "kitchen sink" model with all factors. The asterisk after factors SMB, HML and MOM means that these factors have modified versions and the asterisk after models NM4, FF5, HXZ4 and SY4 means these models use modified factors. The sample period is from 1972:07 to 2014:12, depending on data availability. Newey-West corrected t-statistics (with 6 lags) are shown in parentheses.

	Mean		α	MKT	SMB*	HML*	MOM*	PMU	RMW	CMA	IVA	ROE	MGMT	PERF	Adj. R^2
FIN	0.80***	(1) FF3	0.71***	-0.24***	-0.38***	0.67***									60.4%
	(4.60)		(5.61)	(-5.55)	(-5.55)	(9.22)									
		(2) Carhart4	0.59***	-0.21***	-0.38***	0.72***	0.13***								63.2%
			(4.64)	(-5.74)	(-4.92)	(10.54)	(2.93)								
		(3) NM4*	-0.02	-0.26***		1.41***	0.04	1.23***							56.4%
			(-0.13)	(-8.29)		(13.29)	(0.27)	(4.10)							
		(4) FF5*	0.34***	-0.13***	-0.19***	0.45***			0.68***	0.56***					73.9%
			(3.59)	(-4.88)	(-3.58)	(9.26)			(9.20)	(7.43)					
		(5) HXZ4*	0.31**	-0.19***	-0.25***						1.14***	0.29***			58.5%
			(2.42)	(-4.32)	(-2.68)						(10.49)	(3.01)			
		(6) SY4*	0.12	-0.05	-0.14								1.02***	0.13**	68.1%
			(1.14)	(-1.22)	(-1.25)								(16.69)	(2.54)	
		(7) All factors	-0.03	-0.06*	-0.14***	0.41***	-0.04	0.35**	0.14	-0.42**	0.54***	0.13	0.58***	0.09	79.1%
			(-0.24)	(-1.77)	(-2.70)	(5.51)	(-0.69)	(2.07)	(0.83)	(-2.22)	(3.07)	(1.49)	(10.12)	(1.51)	
PEAD	0.65***	(1) FF3	0.73***	-0.06***	0.02	-0.12***									3.2%
	(7.91)		(8.47)	(-2.70)	(0.34)	(-2.75)									
		(2) Carhart4	0.56***	-0.03	0.01	-0.06	0.18***								19.2%
			(7.34)	(-1.27)	(0.40)	(-1.47)	(6.31)								
		(3) NM4*	0.54***	-0.02		-0.09	0.31***	-0.11							20.3%
			(6.27)	(-0.66)		(-1.27)	(6.74)	(-1.04)							
		(4) FF5*	0.70***	-0.05**	-0.05	-0.14***			-0.05	0.10					3.8%
			(7.90)	(-2.05)	(-1.31)	(-2.95)			(-0.94)	(1.18)					
		(5) HXZ4*	0.60***	-0.04*	0.05						-0.09	0.16***			7.0%
			(5.78)	(-1.71)	(0.89)						(-1.11)	(2.91)			
		(6) SY4*	0.53***	-0.00	0.02								-0.00	0.18***	13.6%
			(5.61)	(-0.14)	(0.42)								(-0.03)	(5.23)	
		(7) All factors	0.58***	-0.02	-0.01	-0.06	0.15***	-0.15	-0.03	0.25*	-0.27**	0.04	0.03	0.06	23.9%
			(6.76)	(-0.76)	(-0.15)	(-1.24)	(3.38)	(-1.10)	(-0.24)	(1.72)	(-2.11)	(0.41)	(0.41)	(1.17)	

Table 3: Factor Regressions of Other Factors on Behavioral Factors

This table reports time-series regressions of other factors on behavioral factors. SMB, HML, and MOM are the standard size, value, and momentum factors. PMU is the profitability factor of Novy-Marx (2013). RMW and CMA are the investment and profitability factors of Fama and French (2015). IVA and ROE are the investment and profitability factors of Hou, Xue, and Zhang (2015). MGMT and PERF are the two composite mispricing factors of Stambaugh and Yuan (2017). The sample period is from 1972:07 to 2014:12, depending on data availability. Newey-West corrected t-statistics (with 6 lags) are shown in parentheses.

	Mean	α	FIN	PEAD	Adj. R^2	α	MKT	FIN	PEAD	Adj. R^2
SMB	0.17	0.47***	-0.39***	0.01	23.6%	0.45***	0.02	-0.38***	0.02	23.5%
	(1.19)	(3.65)	(-4.56)	(0.10)		(3.09)	(0.25)	(-3.44)	(0.14)	
HML	0.41***	0.15	0.49***	-0.20***	43.9%	0.12	0.03	0.50***	-0.19***	43.9%
	(3.14)	(1.24)	(13.76)	(-3.36)		(0.89)	(0.53)	(11.94)	(-3.43)	
MOM	0.68***	-0.15	0.13	1.12***	22.2%	-0.09	-0.05	0.10	1.11***	22.2%
	(3.45)	(-0.53)	(0.97)	(5.30)		(-0.34)	(-0.66)	(0.68)	(5.62)	
PMU	0.27***	0.14**	0.10***	0.07	12.8%	0.18***	-0.04	0.08***	0.06	14.0%
	(5.06)	(2.28)	(4.04)	(1.43)		(2.96)	(-1.63)	(2.68)	(1.28)	
RMW	0.34***	0.11	0.20***	0.11	12.6%	0.13	-0.02	0.19***	0.10	12.5%
	(3.44)	(1.29)	(2.97)	(0.90)		(1.50)	(-0.63)	(2.65)	(0.89)	
CMA	0.37***	0.12	0.29***	0.03	33.9%	0.18**	-0.06*	0.26***	0.01	35.1%
	(4.27)	(1.36)	(6.47)	(0.53)		(2.02)	(-1.89)	(5.17)	(0.25)	
IVA	0.43***	0.19***	0.31***	-0.01	43.2%	0.22***	-0.02	0.30***	-0.02	43.3%
	(5.23)	(2.65)	(10.25)	(-0.31)		(2.90)	(-0.99)	(9.40)	(-0.51)	
ROE	0.56***	0.17	0.22***	0.33***	16.0%	0.16	0.00	0.23***	0.33***	15.8%
	(4.88)	(1.14)	(3.40)	(2.70)		(1.24)	(0.11)	(3.23)	(2.86)	
MGMT	0.67***	0.16*	0.59***	0.06	64.2%	0.29***	-0.11***	0.52***	0.02	66.2%
	(5.24)	(1.82)	(12.25)	(0.96)		(3.05)	(-3.25)	(9.72)	(0.48)	
PERF	0.65***	-0.02	0.17	0.82***	17.1%	0.17	-0.16**	0.07	0.77***	19.4%
	(3.73)	(-0.09)	(1.54)	(6.21)		(0.87)	(-2.29)	(0.63)	(6.61)	

Table 4: List of Anomalies

This table reports the list of anomalies considered in the paper, closely matching the set of robust anomalies (with significant abnormal returns) considered in Hou, Xue, and Zhang (2015). We classify the total 34 anomalies into two groups: 12 short-horizon anomalies and 22 long-horizon anomalies. Short-horizon anomalies include earning momentum, price momentum, and short-term profitability. Long-horizon anomalies include long-horizon profitability, value, investment and financing, and intangibles. The last two columns report the monthly mean returns (in percent) of the long/short anomaly portfolios and the Sharpe ratios. The sample period runs from 1972:07 to 2014:12, depending on data availability.

Panel A: Short-horizon anomalies (12)

Category	Symbol	List of anomalies	L-S Ret(%)	Sharpe ratio
Earnings momentum	SUE-1	Standardized unexpected earnings (1-month holding period), Foster, Olsen, and Shevlin (1984)	0.40	0.13
	SUE-6	Standardized unexpected earnings (6-month holding period), Foster, Olsen, and Shevlin (1984)	0.19	0.07
	ABR-1	Cumulative abnormal returns around earnings announcements (1-month holding period), Chan, Jegadeesh, and Lakonishok (1996)	0.79	0.25
	ABR-6	Cumulative abnormal returns around earnings announcements (6-month holding period), Chan, Jegadeesh, and Lakonishok (1996)	0.28	0.14
	RE-1	Revisions in analysts' earnings forecasts (1-month holding period), Chan, Jegadeesh, and Lakonishok (1996)	0.60	0.13
Return momentum	R6-6	Return momentum (6-month prior returns, 6-month holding period), Jegadeesh and Titman (1993)	0.72	0.13
	R11-1	Return momentum (11-month prior returns, 1-month holding period), Fama and French (1996)	1.18	0.18
	I-MOM	Industry momentum (6-month prior returns, 6-month holding period), Moskowitz and Grinblatt (1999)	0.62	0.12
Profitability	ROEQ	Quarterly ROE (1-month holding period), Haugen and Baker (1996)	0.75	0.15
	ROAQ	Quarterly ROA (1-month holding period), Balakrishnan, Bartov, and Faurel (2010)	0.53	0.11
	NEI	Number of consecutive quarters with earnings increases (1-month holding period), Barth, Elliott, and Finn (1999)	0.34	0.12
	FP	Failure probability (quarterly updated, 6-month holding period), Campbell, Hilscher, and Szilagyi (2008)	0.58	0.09

Panel B: Long-horizon anomalies (22)

Category	Symbol	List of anomalies	L-S Ret(%)	Sharpe Ratio
Profitability	GP/A	Gross profits-to-assets ratio, Novy-Marx (2013)	0.22	0.06
	CbOP	Cash-based operating profitability, Ball, Gerakos, Linnainmaa, and Nikolaev (2016)	0.42	0.10
Value	B/M	Book-to-market equity, Rosenberg, Reid, and Lanstein (1985)	0.62	0.14
	E/P	Earnings-to-price, Basu (1983)	0.47	0.10
	CF/P	Cash flow-to-price, Lakonishok, Shleifer, and Vishny (1994)	0.45	0.10
	NPY	Net payout yield, Boudoukh, Michaely, Richardson, and Roberts (2007)	0.65	0.17
	DUR	Equity duration, Dechow, Sloan, and Soliman (2004)	0.64	0.15
Investment and financing	AG	Asset growth, Cooper, Gulen, and Schill (2008)	0.43	0.12
	NOA	Net operating assets, Hirshleifer, Hou, Teoh, and Zhang (2004)	0.38	0.12
	IVA	Investment-to-assets, Lyandres, Sun, and Zhang (2008)	0.50	0.17
	IG	Investment growth, Xing (2008)	0.38	0.13
	IvG	Inventory growth, Belo and Lin (2012)	0.33	0.10
	IvC	Inventory changes, Thomas and Zhang (2002)	0.45	0.14
	OA	Operating accruals, Sloan (1996) and Hribar and Collins (2002)	0.24	0.08
	POA	Percent operating accruals, Hafzalla, Lundholm, and Van Winkle (2011)	0.39	0.13
	PTA	Percent total accruals, Hafzalla, Lundholm, and Van Winkle (2011)	0.40	0.12
	NSI	Net share issuance, Pontiff and Woodgate (2008)	0.69	0.22
	CSI	Composite share issuance, Daniel and Titman (2006)	0.56	0.14
Intangibles	OC/A	Organizational capital-to-assets, Eisfeldt and Papanikolaou (2013)	0.40	0.11
	AD/M	Advertisement expense-to-market, Chan, Lakonishok, and Sougiannis (2001)	0.67	0.13
	RD/M	R&D-to-market, Chan, Lakonishok, and Sougiannis (2001)	0.71	0.12
	OL	Operating leverage, Novy-Marx (2011)	0.37	0.09

Table 5: Decay Rate of Anomaly Portfolio Returns

This table reports the decay rate of various anomaly portfolio returns. Short-horizon anomaly portfolios are formed and rebalanced each month. Using an event time approach, we calculate the value-weighted buy-and-hold portfolio returns in each of the 12 months, and in each of the 4 quarters, after portfolio formation (weighted by firm size in the ranking month). Long-horizon anomaly portfolios are formed and rebalanced each June. We calculate value-weighted buy-and-hold portfolio returns in each of the 12 quarters, and in each of the 3 years, after portfolio formation (weighted by firm size in the ranking month). Panel A reports the average long/short portfolio returns of short-horizon anomalies over each return window, and Panel B for long-horizon anomalies, with Newey-West corrected t-statistics (6 lags for monthly or quarterly window, 12 lags for annual window). When a long/short portfolio earns significant returns in predicted direction over a return window, we highlight this case in boldface. The sample period runs from 1972:07 to 2014:12, depending on data availability.

Panel A: Short-horizon anomalies

	SUE	ABR	RE	R6	R11	I-MOM	ROEQ	ROAQ	NEI	FP
	Long/short portfolio returns in each of the 12 months post formation									
Month $t+1$	**0.40*****	**0.78*****	**0.60*****	0.50	**1.18*****	**0.57****	**0.75*****	**0.53****	**0.34*****	-0.63*
	(3.59)	**(6.02)**	**(2.80)**	(1.65)	**(4.06)**	**(2.23)**	**(3.11)**	**(2.35)**	**(3.01)**	(-1.89)
Month $t+2$	0.20	0.15	**0.44****	0.51*	**0.98*****	0.47*	0.46*	0.39*	0.23*	-0.61*
	(1.47)	(1.08)	**(2.08)**	(1.80)	**(3.27)**	(1.88)	(1.86)	(1.65)	(1.95)	(-1.94)
Month $t+3$	0.06	0.01	0.26	**0.68****	**0.78*****	0.41	0.38*	0.31	0.15	-0.43
	(0.48)	(0.10)	(1.28)	**(2.32)**	**(2.69)**	(1.63)	(1.66)	(1.36)	(1.27)	(-1.30)
Month $t+4$	0.16	0.11	0.15	**0.70****	**0.84*****	**0.57****	0.35	0.32	0.18	-0.52
	(1.29)	(0.92)	(0.78)	**(2.16)**	**(2.89)**	**(2.34)**	(1.42)	(1.39)	(1.48)	(-1.62)
Month $t+5$	0.13	**0.33****	-0.09	**0.92*****	0.56*	**0.55****	0.34	0.29	0.17	-0.48
	(1.02)	**(2.16)**	(-0.48)	**(3.11)**	(1.91)	**(2.21)**	(1.42)	(1.28)	(1.40)	(-1.57)
Month $t+6$	0.19	0.26*	0.06	**1.15*****	0.35	**0.92*****	0.29	0.23	0.14	-0.49
	(1.38)	(1.84)	(0.30)	**(4.10)**	(1.30)	**(3.58)**	(1.16)	(1.03)	(1.15)	(-1.58)
Month $t+7$	0.18	0.23*	0.06	**0.88*****	0.38	**1.00*****	0.13	0.14	0.08	-0.41
	(1.31)	(1.83)	(0.33)	**(3.00)**	(1.38)	**(3.57)**	(0.50)	(0.62)	(0.64)	(-1.36)
Month $t+8$	0.17	0.12	0.11	**0.70*****	0.14	**0.78****	0.05	0.05	0.06	-0.28
	(1.12)	(0.78)	(0.51)	**(2.78)**	(0.50)	**(2.44)**	(0.20)	(0.22)	(0.49)	(-0.90)
Month $t+9$	-0.04	0.11	0.15	0.34	-0.02	**0.69****	-0.04	0.00	0.02	-0.18
	(-0.29)	(0.78)	(0.74)	(1.41)	(-0.06)	**(2.52)**	(-0.14)	(0.01)	(0.13)	(-0.58)
Month $t+10$	-0.13	0.08	0.08	0.14	-0.06	0.30	0.14	0.20	0.00	-0.12
	(-0.96)	(0.57)	(0.39)	(0.63)	(-0.20)	(1.30)	(0.57)	(0.93)	(0.01)	(-0.39)
Month $t+11$	-0.17	0.17	0.14	-0.31	-0.19	0.20	0.16	0.22	-0.03	0.01
	(-1.36)	(1.41)	(0.69)	(-1.25)	(-0.71)	(0.79)	(0.62)	(1.01)	(-0.23)	(0.03)
Month $t+12$	-0.14	0.05	0.21	-0.60**	-0.50*	-0.01	-0.04	0.09	-0.02	0.29
	(-1.14)	(0.42)	(0.93)	(-2.23)	(-1.82)	(-0.03)	(-0.14)	(0.43)	(-0.14)	(0.89)
	Long/short portfolio returns in each of the 4 quarters post formation									
Quarter $t+1$	**0.75****	**1.09*****	**1.33****	**1.92****	**3.09*****	**1.61****	**1.54****	1.20*	**0.72****	-1.58*
	(2.34)	**(3.30)**	**(2.42)**	**(2.34)**	**(3.85)**	**(2.35)**	**(2.29)**	(1.85)	**(2.28)**	(-1.73)
Quarter $t+2$	0.42	**0.81****	0.06	**2.88*****	**1.79****	**2.10*****	0.90	0.81	0.45	-1.45*
	(1.24)	**(2.24)**	(0.13)	**(3.46)**	**(2.29)**	**(3.14)**	(1.33)	(1.28)	(1.35)	(-1.67)
Quarter $t+3$	0.32	0.47	0.23	**1.94*****	0.55	**2.51*****	0.10	0.18	0.10	-0.91
	(0.80)	(1.31)	(0.43)	**(2.75)**	(0.73)	**(3.09)**	(0.15)	(0.29)	(0.30)	(-1.04)
Quarter $t+4$	-0.44	0.30	0.39	-0.78	-0.80	0.45	0.31	0.51	-0.09	0.18
	(-1.32)	(0.96)	(0.80)	(-1.19)	(-1.07)	(0.67)	(0.46)	(0.85)	(-0.27)	(0.21)

Panel B: Long-horizon anomalies

	GP/A	CbOP	B/M	E/P	CF/P	NPY	DUR	AG	NOA	IVA	IG
				Long/short portfolio returns in each of the 12 quarters post formation							
Quarter $t+1$	0.58	0.97*	**1.98*** **	**1.51** **	**1.37** **	**1.84*** **	**-1.95*** **	**-1.25** **	**-1.11*** **	**-1.42*** **	**-1.21*** **
	(1.40)	(1.68)	**(3.17)**	**(2.38)**	**(2.27)**	**(3.31)**	**(-3.46)**	**(-2.57)**	**(-2.59)**	**(-3.37)**	**(-3.18)**
Quarter $t+2$	0.47	0.73	**2.34*** **	**1.55*** **	**1.34** **	**1.76*** **	**-2.11*** **	**-1.61*** **	**-1.00** **	**-1.62*** **	**-1.47*** **
	(1.15)	(1.20)	**(3.92)**	**(2.74)**	**(2.37)**	**(3.38)**	**(-3.86)**	**(-3.42)**	**(-2.32)**	**(-3.89)**	**(-3.91)**
Quarter $t+3$	0.40	0.64	**2.36*** **	**1.92*** **	**1.51*** **	**1.63*** **	**-2.07*** **	**-1.40*** **	**-0.82** **	**-1.47*** **	**-1.50*** **
	(0.92)	(1.03)	**(4.22)**	**(3.56)**	**(2.64)**	**(3.35)**	**(-3.79)**	**(-3.14)**	**(-2.01)**	**(-3.59)**	**(-3.93)**
Quarter $t+4$	0.27	0.45	**2.09*** **	**1.81*** **	**1.54*** **	**1.24*** **	**-2.00*** **	**-1.08** **	**-0.86** **	**-1.26*** **	**-1.33*** **
	(0.61)	(0.73)	**(3.85)**	**(3.46)**	**(2.71)**	**(2.91)**	**(-3.50)**	**(-2.35)**	**(-2.14)**	**(-3.21)**	**(-3.58)**
Quarter $t+5$	0.18	0.52	**1.95*** **	**1.65*** **	**1.35** **	**1.43*** **	**-1.83*** **	**-1.11** **	**-1.08*** **	**-1.28*** **	**-1.00*** **
	(0.41)	(0.90)	**(3.43)**	**(3.21)**	**(2.39)**	**(3.58)**	**(-3.14)**	**(-2.51)**	**(-2.78)**	**(-3.22)**	**(-2.85)**
Quarter $t+6$	-0.02	0.39	**1.63*** **	**1.66*** **	**1.36** **	**1.41*** **	**-1.74*** **	**-0.79** **	**-0.92** **	**-0.95** **	**-0.87** **
	(-0.05)	(0.70)	**(2.84)**	**(3.01)**	**(2.40)**	**(3.28)**	**(-3.09)**	**(-2.04)**	**(-2.23)**	**(-2.49)**	**(-2.41)**
Quarter $t+7$	0.05	0.11	**1.27** **	**1.18** **	**1.10** **	**1.07** **	**-1.41*** **	-0.48	-0.82*	-0.65	-0.65*
	(0.10)	(0.19)	(2.24)	(2.22)	**(1.99)**	**(2.32)**	**(-2.60)**	(-1.24)	(-1.88)	(-1.51)	(-1.72)
Quarter $t+8$	0.10	0.15	1.11*	0.89*	0.81	0.75	**-1.45** **	-0.48	-0.64	-0.67	-0.18
	(0.22)	(0.25)	(1.96)	(1.70)	(1.42)	(1.53)	**(-2.38)**	(-1.22)	(-1.39)	(-1.49)	(-0.43)
Quarter $t+9$	0.01	-0.11	0.94*	**1.00** **	0.70	0.54	**-1.18** **	-0.30	-0.38	-0.60	-0.01
	(0.03)	(-0.19)	(1.79)	**(1.99)**	(1.23)	(1.15)	**(-2.00)**	(-0.74)	(-0.79)	(-1.27)	(-0.01)
Quarter $t+10$	-0.06	-0.22	0.99*	0.81	0.71	0.42	-0.97*	-0.25	-0.42	-0.82*	0.04
	(-0.13)	(-0.36)	(1.94)	(1.64)	(1.28)	(0.91)	(-1.72)	(-0.59)	(-0.98)	(-1.72)	(0.08)
Quarter $t+11$	-0.02	-0.20	**1.11** **	0.79	0.64	0.27	-0.99*	-0.16	-0.30	-0.78	0.05
	(-0.04)	(-0.35)	**(2.25)**	(1.59)	(1.15)	(0.58)	(-1.83)	(-0.35)	(-0.75)	(-1.60)	(0.11)
Quarter $t+12$	-0.15	-0.30	**1.30*** **	0.68	0.65	0.32	-0.90*	-0.01	-0.33	-0.87*	-0.32
	(-0.36)	(-0.57)	**(2.70)**	(1.30)	(1.18)	(0.69)	(-1.72)	(-0.03)	(-0.85)	(-1.96)	(-0.72)
				Long/short portfolio returns in each of the 3 years post formation							
Year $t+1$	1.56	2.83	**8.60*** **	**6.32*** **	**5.21** **	**6.58*** **	**-8.09*** **	**-4.39*** **	**-3.67** **	**-5.33*** **	**-5.30*** **
	(0.96)	(1.29)	**(3.58)**	**(2.93)**	**(2.18)**	**(3.46)**	**(-3.55)**	**(-2.62)**	**(-2.06)**	**(-3.23)**	**(-4.39)**
Year $t+2$	-0.13	0.91	**6.15** **	**5.74*** **	**4.57** **	**5.36*** **	**-6.25*** **	-2.35	**-3.31** **	-2.89*	-2.25
	(-0.07)	(0.40)	**(2.55)**	**(2.94)**	**(2.07)**	**(3.50)**	**(-2.66)**	(-1.53)	**(-2.19)**	(-1.77)	(-1.48)
Year $t+3$	-0.51	-1.09	**4.85** **	3.49*	2.94	1.59	**-4.45** **	0.10	-0.93	-2.49	-0.03
	(-0.31)	(-0.47)	**(2.45)**	(1.85)	(1.35)	(0.94)	**(-2.07)**	(0.06)	(-0.58)	(-1.32)	(-0.02)

Panel B: Long-horizon anomalies (*continued*)

	IvG	IvC	OA	POA	PTA	NSI	CSI	OC/A	AD/M	RD/M	OL
Long/short portfolio returns in each of the 12 quarters post formation											
Quarter $t+1$	-0.89**	-1.26***	-0.62*	-1.07***	-1.15***	-1.94***	-1.57***	1.01**	2.11***	2.24***	1.12**
	(-2.35)	(-3.44)	(-1.75)	(-2.63)	(-2.90)	(-4.24)	(-2.99)	(2.28)	(2.96)	(2.92)	(2.09)
Quarter $t+2$	-0.72*	-1.06***	-0.66*	-1.17***	-1.17***	-1.91***	-1.70***	0.66	2.16***	2.40***	1.22**
	(-1.92)	(-2.77)	(-1.78)	(-3.18)	(-3.01)	(-4.23)	(-3.31)	(1.27)	(2.99)	(3.23)	(2.26)
Quarter $t+3$	-0.68**	-0.87**	-0.86**	-1.24***	-1.28***	-1.75***	-1.70***	0.44	2.18***	2.06***	1.33**
	(-1.97)	(-2.26)	(-2.36)	(-3.69)	(-3.51)	(-4.12)	(-3.38)	(0.78)	(3.01)	(3.15)	(2.48)
Quarter $t+4$	-0.45	-0.57	-0.72*	-0.90***	-0.97**	-1.83***	-1.67***	0.43	1.80***	1.72***	1.33**
	(-1.27)	(-1.46)	(-1.84)	(-2.68)	(-2.36)	(-4.73)	(-3.38)	(0.78)	(2.64)	(2.62)	(2.55)
Quarter $t+5$	-0.40	-0.44	-0.65	-0.94***	-1.36***	-1.90***	-1.65***	0.44	1.52**	1.50**	1.23**
	(-1.20)	(-1.13)	(-1.60)	(-2.68)	(-3.29)	(-5.21)	(-3.34)	(0.81)	(2.29)	(2.32)	(2.42)
Quarter $t+6$	0.05	-0.12	-0.23	-0.62*	-1.09**	-1.57***	-1.40***	0.52	1.59**	1.37**	1.03**
	(0.14)	(-0.28)	(-0.58)	(-1.70)	(-2.54)	(-4.13)	(-2.73)	(1.02)	(2.36)	(2.01)	(1.99)
Quarter $t+7$	0.14	0.04	0.21	-0.27	-0.91**	-1.51***	-1.14**	0.70	1.51**	1.24*	0.95*
	(0.36)	(0.09)	(0.54)	(-0.72)	(-2.11)	(-3.66)	(-2.20)	(1.36)	(2.25)	(1.77)	(1.81)
Quarter $t+8$	0.07	-0.14	0.20	-0.37	-0.81**	-1.31***	-1.04**	0.58	1.23*	0.80	0.83
	(0.17)	(-0.35)	(0.53)	(-0.99)	(-2.02)	(-2.90)	(-1.98)	(1.10)	(1.86)	(1.11)	(1.56)
Quarter $t+9$	0.04	0.04	0.33	-0.11	-0.57	-1.22**	-0.91*	0.52	1.19*	0.68	0.76
	(0.10)	(0.11)	(0.89)	(-0.29)	(-1.47)	(-2.52)	(-1.72)	(0.94)	(1.81)	(0.88)	(1.41)
Quarter $t+10$	0.05	0.02	0.29	-0.02	-0.75**	-1.45***	-0.68	0.65	1.06	0.87	0.78
	(0.13)	(0.06)	(0.80)	(-0.04)	(-2.10)	(-2.87)	(-1.28)	(1.24)	(1.62)	(1.18)	(1.39)
Quarter $t+11$	0.07	0.08	0.29	0.07	-0.68*	-1.35***	-0.62	0.87*	0.68	0.84	0.78
	(0.15)	(0.25)	(0.76)	(0.18)	(-1.81)	(-2.85)	(-1.19)	(1.67)	(1.00)	(1.20)	(1.38)
Quarter $t+12$	0.08	0.14	0.01	0.09	-0.88**	-1.17***	-0.76	0.90*	0.85	1.00	0.80
	(0.20)	(0.41)	(0.04)	(0.22)	(-2.42)	(-2.65)	(-1.48)	(1.82)	(1.22)	(1.45)	(1.42)
Long/short portfolio returns in each of the 3 years post formation											
Year $t+1$	-2.49**	-3.38***	-2.76**	-3.69***	-4.26***	-7.30***	-6.71***	3.06	8.08***	8.15***	4.65**
	(-2.13)	(-2.59)	(-2.54)	(-3.00)	(-3.22)	(-4.92)	(-3.82)	(1.58)	(2.87)	(3.13)	(2.28)
Year $t+2$	0.27	-0.14	-0.38	-2.15*	-4.26***	-6.61***	-5.38***	2.70	6.38**	5.71**	3.69**
	(0.21)	(-0.09)	(-0.27)	(-1.88)	(-3.18)	(-4.93)	(-3.02)	(1.38)	(2.20)	(2.25)	(2.01)
Year $t+3$	0.62	0.45	1.03	0.18	-2.96**	-5.00***	-3.07*	3.12	4.28	4.04	2.84
	(0.39)	(0.33)	(0.83)	(0.14)	(-2.06)	(-3.31)	(-1.86)	(1.61)	(1.55)	(1.41)	(1.42)

Table 6: Correlations Between Anomaly Portfolios

This table reports pairwise correlation coefficients between returns of the long/short hedged anomaly portfolios. The signs of L/S portfolios are converted, when necessary, to ensure that the L/S portfolio returns reflect the actual (positive) arbitrage profits. Panel A reports correlations among 12 short-horizon anomalies, and Panel B reports correlations among 22 long-horizon anomalies. Correlation coefficients greater than 0.30 are highlighted in bold. The sample period runs from 1972:07 to 2014:12, depending on data availability.

Panel A: Short-horizon anomalies

	SUE-1	SUE-6	ABR-1	ABR-6	RE-1	R6-6	R11-1	I-MOM	ROEQ	ROAQ	NEI
Earnings momentum											
SUE-6	**0.73**										
ABR-1	0.31	0.24									
ABR-6	0.28	0.20	**0.60**								
RE-1	**0.34**	**0.32**	0.29	0.30							
Return momentum											
R6-6	**0.34**	**0.36**	**0.34**	**0.53**	**0.48**						
R11-1	**0.37**	**0.41**	**0.38**	**0.50**	**0.50**	**0.91**					
I-MOM	**0.34**	**0.35**	**0.33**	**0.44**	**0.36**	**0.78**	**0.77**				
Profitability											
ROEQ	**0.36**	**0.33**	0.16	0.11	**0.35**	0.20	0.25	0.19			
ROAQ	**0.36**	**0.35**	0.16	0.14	**0.32**	0.26	0.29	0.23	**0.91**		
NEI	**0.46**	**0.50**	0.20	0.29	0.27	**0.38**	**0.41**	**0.32**	**0.57**	**0.60**	
FP	**0.38**	**0.41**	0.20	0.20	**0.34**	**0.37**	**0.39**	**0.36**	**0.77**	**0.81**	**0.49**

Panel B: Long-horizon anomalies

	GP/A	CashOP	B/M	E/P	CF/P	NPY	DUR	AG	NOA	IVA	IG	NSI	CSI	IvG	IvC	OA	POA	PTA	OC/A	Ad/M	RD/M
Profitability																					
CashOP	**0.43**																				
Value																					
B/M	-0.45	-0.44																			
E/P	-0.28	-0.11	**0.68**																		
CF/P	-0.35	-0.15	**0.71**	**0.90**																	
NPY	0.07	**0.34**	**0.32**	**0.49**	**0.43**																
DUR	-0.41	-0.30	**0.87**	**0.70**	**0.75**	**0.34**															
Investment and financing																					
AG	-0.14	-0.11	**0.52**	**0.43**	**0.43**	**0.48**	**0.49**														
NOA	**0.32**	**0.30**	-0.24	-0.20	-0.23	0.14	-0.27	0.11													
IVA	-0.14	-0.01	**0.33**	0.21	0.19	**0.32**	**0.31**	**0.57**	0.26												
IG	-0.06	-0.06	**0.32**	0.27	0.23	**0.39**	0.26	**0.52**	0.18	**0.43**											
NSI	0.24	**0.40**	0.20	**0.36**	**0.32**	**0.68**	0.20	**0.39**	**0.31**	**0.38**	**0.33**										
CSI	-0.04	**0.39**	**0.34**	**0.49**	**0.49**	**0.72**	**0.40**	**0.44**	0.09	**0.37**	**0.36**	**0.64**									
IvG	-0.14	0.00	**0.33**	0.24	0.28	**0.36**	**0.29**	**0.51**	0.20	**0.49**	**0.48**	**0.30**	**0.39**								
IvC	-0.22	-0.09	**0.34**	0.22	0.28	0.23	**0.32**	**0.45**	0.14	**0.50**	**0.37**	0.19	0.33	**0.58**							
OA	-0.11	0.11	-0.06	-0.16	-0.02	0.00	-0.10	-0.05	0.22	0.05	-0.02	-0.10	0.10	0.19	0.30						
POA	-0.12	0.09	**0.33**	0.24	**0.35**	**0.40**	**0.33**	**0.45**	0.06	**0.30**	0.30	0.29	**0.45**	**0.46**	**0.40**	**0.36**					
PTA	0.06	0.14	0.28	0.30	0.29	**0.60**	0.28	**0.50**	0.10	**0.37**	**0.37**	**0.46**	**0.47**	**0.41**	**0.36**	0.05	**0.45**				
Intangibles																					
OC/A	-0.08	-0.38	0.04	-0.13	-0.06	-0.41	-0.01	-0.06	0.02	-0.01	-0.03	-0.24	-0.29	-0.10	0.05	0.12	-0.11	-0.26			
Ad/M	-0.03	-0.31	**0.49**	**0.46**	**0.43**	0.27	**0.45**	**0.36**	-0.16	0.18	0.25	0.15	0.20	0.11	0.11	-0.14	0.19	0.24	-0.01		
RD/M	-0.06	-0.40	**0.31**	0.09	0.08	-0.07	0.20	0.12	0.17	0.21	0.08	-0.06	-0.18	-0.02	0.10	0.00	-0.06	-0.05	0.24	**0.32**	
OL	**0.31**	0.18	0.04	0.18	0.06	0.26	0.07	0.11	0.17	0.15	0.19	**0.32**	0.16	0.00	-0.13	-0.33	-0.05	0.15	-0.17	0.25	0.16

Table 7: Comparative Model Performance

This table reports comparative performance of different factor models in explaining anomalies. We compare three sets of factor models. The first set includes standard factor models: the CAPM, Fama-French three-factor model (FF3), and Carhart four-factor model (Carhart4). The second set includes four recent models: the five-factor model of Fama and French (2015, FF5), the profitability-based model of Novy-Marx (2013, NM4), the q-factor model of Hou, Xue, and Zhang (2015, HXZ4), and the four-factor mispricing model of Stambaugh and Yuan (2017, SY4). The last set includes our behavioral-motivated models: a single factor FIN, a single factor PEAD, a two-factor model with FIN and PEAD (BF2), and a three-factor risk-and-behavioral composite model with MKT, FIN, and PEAD (BF3). The table reports the regression alphas from time-series regressions of long/short anomaly portfolio returns on each factor model, with Newey-West corrected t-statistics (6 lags). Panel A compares model performance for short-horizon anomalies, Panel B for long-horizon anomalies, and Panel C for all anomalies. As comparative statistics, we summarize the number of significant alphas at 5% level, the average absolute alphas and t-values, the F-statistics and p-values that test whether the average t^2 of alphas under a given model is significantly larger than the average t^2 of the composite-model alphas, the GRS F-statistics and p-values following Gibbons, Ross, and Shanken (1989), and the HJ-distance following Hansen and Jagannathan (1997). The sample period runs from 1972:07 to 2014:12, depending on data availability.

Panel A: Short-horizon anomalies

	List of Anomalies		H-L Ret	CAPM	FF3	Carhart4	FF5	NM4	HXZ4	SY4	FIN	PEAD	BF2	BF3
Earnings momentum (5)	Standardized Unexpected Earnings	SUE-1	0.40***	0.46***	0.51***	0.30**	0.42***	0.25*	0.13	0.18	0.33***	0.07	-0.01	0.08
		SUE-6	0.19*	0.23**	0.33***	0.12	0.19*	0.07	-0.02	0.03	0.18	-0.07	-0.10	-0.01
	CAR around earnings announcements	ABR-1	0.79***	0.82***	0.91***	0.69***	0.87***	0.69***	0.73***	0.67***	0.83***	-0.08	-0.07	-0.04
		ABR-6	0.28***	0.29***	0.37***	0.18**	0.40***	0.18*	0.23*	0.22**	0.32***	-0.12*	-0.09	-0.06
	Revisions in analysts' earnings forecasts	RE-1	0.60***	0.63***	0.75***	0.31	0.55**	0.23	0.14	0.28	0.61***	0.15	0.14	0.18
Return momentum (3)	Past returns	R6-6	0.72***	0.74***	0.95***	-0.05	0.82***	-0.30*	0.21	0.02	0.77**	-0.12	-0.09	-0.08
		R11-1	1.18***	1.22***	1.43***	0.18	1.15***	-0.21	0.39	0.09	1.20***	0.11	0.10	0.10
	Industry momentum	I-MOM	0.62***	0.66***	0.76***	-0.07	0.58**	-0.42*	0.14	-0.10	0.57**	-0.17	-0.25	-0.26
Profitability (4)	Quarterly ROE	ROEQ	0.75***	0.92***	1.12***	0.82***	0.58***	0.10	0.10	0.48***	0.30	0.51*	0.02	0.12
	Quarterly ROA	ROAQ	0.53**	0.71***	0.94***	0.62***	0.42***	-0.15	0.04	0.25	0.10	0.26	-0.21	-0.07
	N. consecutive qtrs with earnings increases	NEI	0.34***	0.35***	0.57***	0.37***	0.42***	0.18	0.13	0.28**	0.33***	0.07	0.05	0.04
	Failure probability	FP	-0.58*	-1.01***	-1.24***	-0.62***	-0.39**	0.73***	-0.04	0.04	0.07	-0.14	0.64**	0.20
Short-horizon anomalies (12)	N. significant α at 5%		10	12	12	7	11	2	1	4	8	0	0	0
	Average $\lvert\alpha\rvert$		0.58	0.67	0.82	0.41	0.57	0.37	0.26	0.35	0.56	0.17	0.18	0.09
	Average $\lvert t\rvert$		3.11	3.70	4.68	2.40	3.21	1.58	1.08	1.39	2.32	0.78	0.67	0.49
	F-stat $= \frac{Average\ t^2}{Average\ t^2_{BF3}}$		34.84***	47.46***	73.99***	25.28***	37.45***	11.85***	8.75***	11.13***	23.07***	2.54*	2.31*	
	p-value		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.06)	(0.08)	
	GRS F-stat		4.08***	4.73***	5.88***	4.25***	3.44***	4.37***	2.37***	2.70***	4.87***	2.00**	2.38***	1.15
	p-value		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.02)	(0.01)	(0.32)
	HJ-distance			44.20***	43.44***	30.99***	36.50***	32.20***	34.12***	26.73*	44.12***	26.04**	23.39**	14.66
	p-value			(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.09)	(0.00)	(0.02)	(0.03)	(0.49)

Panel B: Long-horizon anomalies

	List of Anomalies		H-L Ret	CAPM	FF3	Carhart4	FF5	NM4	HXZ4	SY4	FIN	PEAD	BF2	BF3
Profitability (2)	Gross profits-to-assets	GP/A	0.22	0.18	0.37**	0.33**	0.01	-0.14	0.03	-0.02	0.20	0.19	0.18	0.06
	Cash-based operating profitability	CashOP	0.42**	0.60***	0.89***	0.71***	0.61***	0.04	0.53***	0.41***	0.14	0.17	-0.14	0.14
Value (5)	Book-to-market	B/M	0.62***	0.69***	0.05	0.06	0.10	0.07	0.26	-0.00	0.30	0.75***	0.41*	0.36
	Earnings-to-price	E/P	0.47**	0.61***	0.01	-0.04	-0.01	-0.27	0.05	-0.02	-0.01	0.74***	0.22	0.22
	Cash flow-to-price	CF/P	0.45**	0.58***	0.01	-0.06	0.02	-0.20	0.12	0.06	0.01	0.66***	0.18	0.21
	Net payout yield	NPY	0.65***	0.85***	0.56***	0.52***	0.24*	-0.03	0.39***	0.09	0.02	0.73***	0.05	0.11
	Equity duration	DUR	-0.64***	-0.75***	-0.16	-0.08	-0.15	0.01	-0.28	-0.03	-0.28	-0.75***	-0.36*	-0.38*
Investment and financing (11)	Asset growth	AG	-0.43**	-0.52***	-0.17	-0.10	0.08	0.07	0.10	0.25	-0.10	-0.48***	-0.13	-0.13
	Net operating assets	NOA	-0.38**	-0.37**	-0.49***	-0.37***	-0.38**	-0.15	-0.36*	-0.03	-0.43**	-0.21	-0.26*	-0.27*
	Investment-to-assets	IVA	-0.50***	-0.58***	-0.40***	-0.34**	-0.31**	-0.30	-0.25*	-0.09	-0.29**	-0.46***	-0.23	-0.27*
	Investment growth	IG	-0.38***	-0.44***	-0.24*	-0.18	-0.08	-0.10	0.02	0.05	-0.18	-0.44***	-0.22*	-0.22
	Inventory growth	IvG	-0.33**	-0.40***	-0.22	-0.11	-0.08	-0.11	0.04	0.02	-0.07	-0.36**	-0.09	-0.09
	Inventory changes	IvC	-0.45***	-0.51***	-0.36***	-0.28**	-0.32**	-0.47**	-0.26*	-0.19	-0.32**	-0.45***	-0.32**	-0.42**
	Operating accruals	OA	-0.24*	-0.26**	-0.29**	-0.27*	-0.48***	-0.51***	-0.52***	-0.37**	-0.25*	-0.21	-0.22	-0.29*
	Percent operating accruals	POA	-0.39***	-0.48***	-0.28**	-0.20	-0.09	-0.13	-0.08	-0.07	-0.11	-0.42***	-0.11	-0.12
	Percent total accruals	PTA	-0.40***	-0.50***	-0.30**	-0.27*	-0.06	-0.06	-0.10	-0.00	-0.01	-0.48***	-0.06	-0.05
	Net share issuance	NSI	-0.69***	-0.80***	-0.67***	-0.58***	-0.28**	-0.10	-0.32**	-0.12	-0.22**	-0.69***	-0.19	-0.11
	Composite issuance	CSI	-0.56***	-0.80***	-0.51***	-0.41***	-0.20*	-0.02	-0.20	-0.07	0.10	-0.60***	0.12	-0.04
Intangibles (4)	Organizational capital-to-assets	OC/A	0.40**	0.28*	0.28**	0.15	0.30**	0.53***	0.20	0.28**	0.73***	0.20	0.56***	0.47***
	Advertisement expense-to-market	Ad/M	0.67***	0.69***	0.10	0.17	-0.05	0.07	0.05	0.03	0.35	1.04***	0.71***	0.52*
	R&D-to-market	RD/M	0.71***	0.53**	0.30	0.37*	0.43*	0.53	0.80***	0.10	1.05***	0.67**	1.05***	0.83***
	Operating leverage	OL	0.37*	0.41**	0.33*	0.29	-0.00	-0.22	-0.11	-0.06	0.17	0.34*	0.12	0.08
Long-horizon anomalies (22)	N. significant α at 5%		19	20	12	8	7	3	5	3	6	16	4	3
	Average $\lvert\alpha\rvert$		0.48	0.55	0.38	0.29	0.23	0.21	0.32	0.12	0.29	0.55	0.32	0.28
	Average $\lvert t\rvert$		2.63	3.09	2.19	1.84	1.38	0.96	1.36	0.70	1.41	2.61	1.48	1.33
	F-stat $= \frac{Average\ t^2}{Average\ t^2_{BF3}}$		3.00***	4.31***	2.86***	2.01*	1.35	0.68	1.20	0.45	1.37	3.17***	1.27	
	p-value		(0.01)	(0.00)	(0.01)	(0.05)	(0.24)	(0.81)	(0.34)	(0.97)	(0.23)	(0.00)	(0.29)	
	GRS F-stat		3.06***	3.91***	3.13***	2.22***	1.97***	1.55*	2.08***	0.74	2.59***	2.29***	1.94***	1.47*
	p-value		(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.05)	(0.00)	(0.80)	(0.00)	(0.00)	(0.01)	(0.08)
	HJ-distance			63.58***	38.76*	16.78	29.49	24.15	34.34*	13.89	57.79***	56.67***	47.96**	35.72
	p-value			(0.00)	(0.07)	(0.90)	(0.16)	(0.73)	(0.05)	(0.90)	(0.00)	(0.00)	(0.01)	(0.35)

Panel C: All anomalies

		H-L Ret	CAPM	FF3	Carhart4	FF5	NM4	HXZ4	SY4	FIN	PEAD	BF2	BF3
All anomalies (34)	N. significant α at 5%	29	32	24	15	18	5	6	7	14	16	4	3
	Average $\lvert\alpha\rvert$	0.52	0.60	0.57	0.33	0.36	0.26	0.31	0.18	0.40	0.45	0.27	0.23
	Average $\lvert t\rvert$	2.80	3.31	3.07	2.04	2.03	1.18	1.26	0.95	1.73	1.96	1.19	1.03
	F-stat $= \frac{Average\ t^2}{Average\ t^2_{BF3}}$	5.08***	7.13***	7.52***	3.54***	3.71***	1.41	1.69*	1.15	2.79***	3.13***	1.34	
	p-value	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.16)	(0.07)	(0.34)	(0.00)	(0.00)	(0.20)	
	GRS F-stat	3.54***	3.95***	3.70***	3.10***	2.60***	2.65***	2.42***	1.71***	3.31***	2.41***	2.12***	1.61**
	p-value	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.02)
	HJ-distance		131.18***	123.65***	105.47***	108.66***	107.69***	103.59***	77.14**	123.13***	102.96***	89.74***	76.39**
	p-value		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	0.00	(0.00)	(0.00)	(0.01)

Table 8: Factor Regressions of Long/Short Anomaly Portfolios

This table reports alphas and factor betas from time-series regressions of long/short anomaly portfolio returns on recent prominent factor models. Panel A, B, C, D report regression alphas and factor betas under the five-factor model of Fama and French (2015), the profitability-based factor model of Novy-Marx (2013), the q-factor model of Hou, Xue, and Zhang (2015), and the four-factor mispricing model of Stambaugh and Yuan (2017), respectively. Panel E reports the alphas and betas under our three-factor risk-and-behavioral composite model (BF3). Newey-West corrected t-statistics (with 6 lags) are shown in parentheses. The sample period runs from 1972:07 to 2014:12, depending on data availability.

	Earnings momentum					Return momentum			Profitability						Value		
	SUE-1	SUE-6	ABR-1	ABR-6	RE-1	R6-6	R11-1	I-MOM	ROEQ	ROAQ	NEI	FP	GP/A	CbOP	B/M	E/P	CF/P
Panel A: The five-factor model of Fama and French (2015, FF5)																	
α	0.42***	0.19*	0.87***	0.40***	0.55**	0.82***	1.15***	0.58**	0.58***	0.41***	0.42***	-0.39**	0.01	0.61***	0.10	-0.01	0.02
β_{MKT}	-0.10**	-0.07*	-0.08**	-0.06**	-0.03	-0.09	-0.10	-0.09	-0.12***	-0.16***	-0.03	0.40***	0.09*	-0.25***	0.01	-0.07	-0.07
β_{SMB}	-0.03	-0.06	-0.08	-0.01	-0.09	-0.03	0.07	0.06	-0.48***	-0.47***	-0.17***	0.71***	0.06	-0.61***	0.46***	0.33***	0.27***
β_{HML}	-0.18	-0.25***	-0.15	-0.14**	-0.28	-0.47**	-0.60**	-0.23	-0.27**	-0.26***	-0.33***	0.35**	-0.47***	-0.34***	1.04***	1.29***	1.23***
β_{RMW}	0.14	0.18**	-0.06	-0.07	0.26*	0.03	0.27	0.17	1.37***	1.32***	0.46***	-1.47***	0.90***	0.73***	-0.32***	0.27***	0.12
β_{CMA}	0.20	0.20	0.06	-0.05	0.22	0.25	0.51	0.19	0.15	0.05	-0.08	-0.49*	0.21	-0.08	0.23*	-0.36**	-0.30**
Panel B: The profitability-based model of Novy-Marx (2013, NM4)																	
α	0.25*	0.07	0.69***	0.18*	0.23	-0.30*	-0.21	-0.42*	0.10	-0.15	0.18	0.73***	-0.14	0.04	0.07	-0.27	-0.20
β_{MKT}	-0.07*	-0.04	-0.04	-0.00	0.01	0.15***	0.18***	0.08**	-0.13***	-0.14***	0.04	0.39***	0.15***	-0.22***	-0.07	-0.14***	-0.15***
β_{HML}	-0.13	-0.15	-0.19*	-0.19**	-0.19	0.13	0.29*	0.51***	-0.08	-0.01	-0.40***	-0.72***	-0.17	-0.15	1.76***	1.89***	1.75***
β_{MOM}	0.32***	0.34***	0.40***	0.33***	0.77***	1.70***	2.10***	1.36***	0.36*	0.43***	0.30***	-0.84***	-0.02	0.32***	-0.10	-0.07	0.01
β_{PMU}	0.18	0.05	-0.17	-0.09	0.02	-0.35**	-0.27	-0.35	2.09***	2.00***	0.63***	-2.36***	1.39***	1.35***	-0.45**	0.20	-0.11
Panel C: The q-factor model of Hou, Xue, and Zhang (2015, HXZ4)																	
α	0.13	-0.02	0.73***	0.23*	0.14	0.21	0.39	0.14	0.10	0.04	0.13	-0.04	0.03	0.53***	0.26	0.05	0.12
β_{MKT}	-0.08*	-0.06	-0.07*	-0.04	0.01	-0.02	-0.03	-0.06	-0.10***	-0.16***	0.02	0.42***	0.07	-0.26***	-0.07	-0.15**	-0.14**
β_{SMB}	0.10*	0.10	0.07	0.07	0.10	0.34*	0.50**	0.37*	-0.37***	-0.35***	-0.08*	0.52***	0.01	-0.51***	0.41***	0.27*	0.18
β_{IVA}	0.01	-0.10	-0.16*	-0.16**	-0.09	-0.16	-0.02	0.01	0.04	-0.13	-0.30***	-0.16	-0.30***	-0.46***	1.26***	1.01***	0.99***
β_{ROE}	0.49***	0.46***	0.26***	0.20***	0.76***	0.88***	1.20***	0.73***	1.42***	1.30***	0.64***	-1.50***	0.50***	0.66***	-0.48***	-0.01	-0.14
Panel D: The four-factor mispricing model of Stambaugh and Yuan (2017, SY4)																	
α	0.18	0.03	0.67***	0.22**	0.28	0.02	0.09	-0.10	0.48***	0.25	0.28**	0.04	-0.02	0.41***	-0.00	-0.02	0.06
β_{MKT}	-0.03	-0.03	-0.03	-0.02	0.06	0.14**	0.21***	0.09	-0.02	-0.05	0.04	0.19**	0.13**	-0.15***	-0.01	-0.08	-0.09
β_{SMB}	0.02	0.01	0.02	0.01	-0.11	0.18	0.31*	0.24	-0.69***	-0.61***	-0.24***	0.75***	-0.03	-0.66***	0.66***	0.36**	0.30**
β_{MGMT}	0.07	-0.01	-0.05	-0.09	-0.10	0.03	0.21	0.12	0.18	0.15	-0.14**	-0.64***	-0.03	0.03	0.81***	0.77***	0.67***
β_{PERF}	0.28***	0.26***	0.24***	0.17***	0.58***	0.85***	1.13***	0.73***	0.70***	0.72***	0.37***	-0.97***	0.33***	0.49***	-0.30***	-0.17*	-0.18*
Panel E: The three-factor composite model (BF3)																	
α	0.08	-0.01	-0.04	-0.06	0.18	-0.08	0.10	-0.26	0.12	-0.07	0.04	0.20	0.06	0.14	0.36	0.22	0.21
β_{MKT}	-0.08	-0.07	-0.02	-0.02	-0.03	-0.00	0.00	0.01	-0.08	-0.12*	0.01	0.37***	0.10**	-0.24***	0.04	-0.01	-0.02
β_{FIN}	0.05	-0.02	-0.02	-0.06*	-0.00	-0.04	0.02	0.10	0.52***	0.47***	0.02	-0.73***	0.08	0.22***	0.42***	0.60***	0.53***
β_{PEAD}	0.49***	0.39***	1.34***	0.61***	0.72***	1.29***	1.65***	1.23***	0.40*	0.44***	0.43***	-0.79***	0.07	0.35***	-0.15	-0.35***	-0.27**

(*Continued*)

	Value		Investment and financing											Intangibles			
	NPY	DUR	AG	NOA	IVA	IG	IvG	IvC	OA	POA	PTA	NSI	CSI	OC/A	AD/M	RD/M	OL
Panel A: The five-factor model of Fama and French (2015, FF5)																	
α	0.24*	-0.15	0.08	-0.38**	-0.31**	-0.08	-0.08	-0.32**	-0.48***	-0.09	-0.06	-0.28**	-0.20*	0.30**	-0.05	0.43*	-0.00
β_{MKT}	-0.10***	0.03	-0.03	-0.02	0.04	-0.00	-0.02	0.04	0.06	-0.03	0.00	0.00	0.18***	0.09**	0.11**	0.21***	-0.01
β_{SMB}	-0.24***	-0.34***	-0.06	0.14*	-0.01	-0.14***	0.15**	0.04	0.26***	0.20***	0.17**	0.10*	0.25***	0.52***	0.67***	0.68***	0.30***
β_{HML}	0.45***	-1.06***	-0.17***	0.41***	0.07	-0.03	-0.03	0.02	-0.04	-0.19***	-0.16	-0.04	-0.38***	-0.28***	0.85***	0.07	0.05
β_{RMW}	0.53***	0.17**	0.06	-0.02	0.25***	-0.06	0.12	0.32***	0.42***	-0.06	-0.22**	-0.69***	-0.42***	-0.25***	0.29**	-0.55***	0.88***
β_{CMA}	0.50***	-0.14	-1.16***	-0.42**	-0.85***	-0.71***	-0.82***	-0.70***	0.12	-0.64***	-0.69***	-0.60***	-0.64***	0.27*	0.25	0.33	0.12
Panel B: The profitability-based model of Novy-Marx (2013, NM4)																	
α	-0.03	0.01	0.07	-0.15	-0.30	-0.10	-0.11	-0.47**	-0.51***	-0.13	-0.06	-0.10	-0.02	0.53***	0.07	0.53	-0.22
β_{MKT}	-0.23***	0.12**	0.11***	-0.05	0.11***	0.05*	0.09**	0.14***	0.09**	0.10***	0.13***	0.07*	0.33***	0.18***	0.05	0.29***	0.04
β_{HML}	1.30***	-1.79***	-1.21***	0.00	-0.58***	-0.67***	-0.66***	-0.35***	0.09	-0.70***	-0.77***	-0.77***	-1.17***	-0.23*	1.76***	0.63***	0.42**
β_{MOM}	-0.06	-0.03	-0.07	-0.21	-0.10	-0.01	-0.11	-0.09	-0.07	-0.05	0.09	-0.03	-0.05	0.31**	-0.27**	-0.05	-0.11
β_{PMU}	1.02***	0.34**	0.11	-0.21	0.15	-0.14	0.08	0.62***	0.70***	-0.12	-0.54**	-1.09***	-0.67***	-0.99***	0.19	-0.89	1.60***
Panel C: The q-factor model of Hou, Xue, and Zhang (2015, HXZ4)																	
α	0.39***	-0.28	0.10	-0.36*	-0.25*	0.02	0.04	-0.26*	-0.52***	-0.08	-0.10	-0.32**	-0.20	0.20	0.05	0.80***	-0.11
β_{MKT}	-0.17***	0.12***	0.01	-0.02	0.05	0.00	-0.02	0.04	0.03	0.01	0.04	0.05	0.23***	0.11**	0.04	0.14**	-0.04
β_{SMB}	-0.32***	-0.34***	-0.11*	0.05	-0.06	-0.15***	0.11**	-0.03	0.28***	0.15***	0.20***	0.16**	0.26***	0.62***	0.55***	0.71***	0.28***
β_{IVA}	0.98***	-1.16***	-1.36***	0.01	-0.80***	-0.81***	-0.95***	-0.70***	0.01	-0.87***	-0.91***	-0.65***	-1.09***	-0.07	1.24***	0.07	0.21
β_{ROE}	0.03	0.31***	0.16**	-0.04	0.14	-0.04	0.04	0.18*	0.31***	0.02	0.04	-0.28***	-0.15*	-0.02	-0.23	-0.72***	0.58***
Panel D: The four-factor mispricing model of Stambaugh and Yuan (2017, SY4)																	
α	0.09	-0.03	0.25	-0.03	-0.09	0.05	0.02	-0.19	-0.37**	-0.07	-0.00	-0.12	-0.07	0.28**	0.03	0.10	-0.06
β_{MKT}	-0.03	0.05	-0.06	-0.13***	-0.00	-0.03	-0.05	0.03	0.02	-0.03	-0.03	-0.07**	0.12***	0.07	0.07	0.25***	0.02
β_{SMB}	-0.18**	-0.53***	-0.27***	0.03	-0.21***	-0.21***	0.03	-0.12*	0.20***	0.08	0.08	0.10	0.20**	0.62***	0.71***	0.92***	0.21*
β_{MGMT}	0.93***	-0.80***	-0.88***	-0.19**	-0.57***	-0.50***	-0.55***	-0.41***	-0.03	-0.54***	-0.67***	-0.67***	-0.88***	-0.23***	0.82***	0.25**	0.25**
β_{PERF}	0.06	0.20***	0.10**	-0.23***	0.08	0.01	0.01	0.10*	0.06	0.01	0.02	-0.21***	-0.06	0.01	-0.32***	-0.16	0.23***
Panel E: The three-factor composite model (BF3)																	
α	0.11	-0.38*	-0.13	-0.27*	-0.27*	-0.22	-0.09	-0.42**	-0.29*	-0.12	-0.05	-0.11	-0.04	0.47***	0.52*	0.83***	0.08
β_{MKT}	-0.05*	0.02	0.01	0.01	0.03	-0.00	0.00	0.08*	0.06	0.01	-0.00	-0.06*	0.13***	0.08	0.16*	0.18*	0.04
β_{FIN}	0.76***	-0.44***	-0.40***	0.07	-0.25***	-0.26***	-0.32***	-0.10	0.05	-0.35***	-0.49***	-0.62***	-0.75***	-0.37***	0.51***	-0.33*	0.27***
β_{PEAD}	-0.05	0.12	0.04	-0.26*	-0.08	0.06	0.02	0.02	-0.02	0.00	0.08	-0.07	0.02	0.28*	-0.49**	0.06	0.08

Table 9: Firm-Level Fama-MacBeth Regressions on Behavioral Factor Loadings

This table reports firm-level Fama-MacBeth regressions of monthly stock returns on factor loadings of FIN and PEAD, while controlling for standard return predictors and firm characteristics. β_{FIN} and β_{PEAD} are estimated by monthly rolling regressions of daily stock returns in the previous month on the three-factor composite model (BF3), which includes a daily market factor, a daily FIN factor, and a daily PEAD factor, with a minimum of 15 daily returns required. Standard return predictors include log(ME) at the end of the previous month, log(B/M) as of the previous fiscal year end, past 1-month return, past 1-year return from month $t-12$ to $t-2$, and past 3-year return from month $t-36$ to $t-13$. All past returns are on monthly basis. Firm characteristics include all short-horizon and long-horizon anomaly characteristics described in Table 4. Intercepts are included in all regressions but not reported here. All regressors are winsorized at top and bottom 1% and standardized to have zero mean and unit standard deviation. Newey-West corrected t-statistics are reported in parentheses (with 6 lags). The sample period runs from 1972:08 to 2014:12 (507 months), depending on data availability.

	(1)	(2)	(3)	(4)	(6)	(7)	(8)	(5)	(9)	(10)
β_{FIN}	0.148**	0.137**	0.146**	0.148***	0.263***	0.144**	0.141**	0.151***	0.114**	0.185***
	(2.04)	(2.38)	(2.54)	(2.67)	(3.88)	(2.55)	(2.52)	(2.66)	(2.22)	(3.39)
β_{PEAD}	-0.019	0.015	0.016	0.009	-0.003	0.016	0.014	0.014	0.012	-0.010
	(-0.33)	(0.34)	(0.36)	(0.21)	(-0.05)	(0.36)	(0.33)	(0.32)	(0.25)	(-0.18)
Earnings momentum characteristics										
ABR			0.513***							0.355***
			(18.37)							(12.13)
SUE				0.452***						0.120***
				(15.49)						(5.32)
RE					0.203***					0.139***
					(5.03)					(3.79)
Short-term profitability characteristics										
$ROEQ$						0.612***				0.258**
						(8.03)				(2.39)
$ROAQ$							0.710***			0.110
							(6.97)			(1.01)
NEI								0.365***		0.110***
								(10.38)		(3.76)
FP									-0.362***	-0.163
									(-3.65)	(-1.61)
$log(ME)$		-0.260**	-0.230**	-0.265**	-0.227*	-0.309***	-0.322***	-0.299***	-0.232***	-0.327***
		(-2.44)	(-2.20)	(-2.54)	(-1.95)	(-3.13)	(-3.39)	(-2.88)	(-3.14)	(-3.62)
$log(B/M)$		0.203**	0.177**	0.198**	0.083	0.191**	0.222***	0.245***	0.208***	0.133*
		(2.50)	(2.19)	(2.49)	(1.06)	(2.45)	(2.87)	(3.06)	(2.80)	(1.74)
$r(t-1)$		-0.969***	-1.055***	-0.999***	-0.646***	-0.983***	-0.998***	-0.975***	-0.830***	-0.737***
		(-11.41)	(-12.14)	(-11.09)	(-8.57)	(-11.20)	(-11.32)	(-10.98)	(-9.55)	(-9.97)
$r(t-12, t-2)$		0.168*	0.188*	0.096	0.361***	0.175*	0.159	0.127	0.250***	0.098
		(1.75)	(1.80)	(0.93)	(2.92)	(1.75)	(1.60)	(1.21)	(2.63)	(0.86)
$r(t-36, t-13)$		-0.271***	-0.246***	-0.237***	-0.176**	-0.308***	-0.307***	-0.297***	-0.224***	-0.208***
		(-3.64)	(-3.19)	(-2.97)	(-2.33)	(-4.23)	(-4.40)	(-3.86)	(-3.74)	(-3.39)
$Adj.R^2$	0.4%	3.8%	4.5%	4.6%	5.1%	4.7%	4.8%	4.5%	4.9%	6.5%
$N.obs$	1,558,118	1,558,118	1,350,525	1,345,932	916,329	1,377,779	1,374,597	1,377,479	1,321,624	848,309

(*Continued*)

	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
β_{FIN}	0.137**	0.100*	0.111**	0.125**	0.135**	0.127**	0.137**	0.132**	0.135**	0.131**	0.132**	0.131**	0.127**	0.103*
	(2.39)	(1.89)	(1.99)	(2.23)	(2.37)	(2.29)	(2.36)	(2.22)	(2.36)	(2.31)	(2.31)	(2.28)	(2.21)	(1.78)
β_{PEAD}	0.023	-0.016	-0.012	0.015	0.013	0.011	0.017	-0.003	0.014	0.017	0.017	0.016	0.001	-0.012
	(0.50)	(-0.38)	(-0.27)	(0.34)	(0.29)	(0.25)	(0.39)	(-0.06)	(0.30)	(0.38)	(0.38)	(0.36)	(0.02)	(-0.26)
Financing characteristics														
NSI	-0.237***		-0.101***											-0.041
	(-6.48)		(-3.20)											(-1.07)
CSI		-0.194***	-0.149***											-0.146***
		(-3.88)	(-3.13)											(-2.77)
Investment characteristics														
AG				-0.273***									-0.070	-0.035
				(-8.43)									(-1.44)	(-0.62)
NOA					-0.290***								-0.213***	-0.112*
					(-6.96)								(-3.62)	(-1.96)
IVA						-0.211***							0.007	-0.003
						(-6.47)							(0.16)	(-0.06)
IG							-0.135***						-0.071***	-0.083***
							(-6.30)						(-3.09)	(-2.90)
IvG								-0.160***					-0.033	-0.031
								(-6.57)					(-1.08)	(-0.92)
IvC									-0.140***				0.005	0.021
									(-4.88)				(0.15)	(0.55)
OA										-0.124***			-0.072**	-0.126***
										(-3.53)			(-2.19)	(-3.49)
POA											-0.046**		-0.002	0.006
											(-2.45)		(-0.09)	(0.29)
PTA												-0.064***	0.005	0.013
												(-3.31)	(0.26)	(0.53)
$log(ME)$	-0.256**	-0.291***	-0.270***	-0.247**	-0.226**	-0.249**	-0.271**	-0.233**	-0.264**	-0.262**	-0.262**	-0.260**	-0.213**	-0.243***
	(-2.46)	(-3.13)	(-2.93)	(-2.32)	(-2.17)	(-2.35)	(-2.55)	(-2.25)	(-2.48)	(-2.49)	(-2.47)	(-2.44)	(-2.13)	(-2.82)
$log(B/M)$	0.203**	0.111	0.130*	0.176**	0.249***	0.181**	0.194**	0.202**	0.193**	0.201**	0.199**	0.203**	0.228***	0.180***
	(2.57)	(1.63)	(1.86)	(2.20)	(3.26)	(2.23)	(2.39)	(2.58)	(2.37)	(2.51)	(2.47)	(2.50)	(3.24)	(2.91)
$r(t-1)$	-0.947***	-0.999***	-0.980***	-0.978***	-0.985***	-0.981***	-0.967***	-0.967***	-0.978***	-0.974***	-0.968***	-0.969***	-0.978***	-0.986***
	(-11.32)	(-12.23)	(-12.24)	(-11.49)	(-11.62)	(-11.49)	(-11.22)	(-11.17)	(-11.42)	(-11.36)	(-11.34)	(-11.32)	(-11.23)	(-12.04)
$r(t-12,t-2)$	0.195**	0.162	0.196*	0.152	0.136	0.148	0.172*	0.174*	0.154	0.157	0.166*	0.166*	0.145	0.177*
	(1.97)	(1.60)	(1.89)	(1.59)	(1.44)	(1.56)	(1.79)	(1.74)	(1.62)	(1.63)	(1.73)	(1.72)	(1.48)	(1.66)
$r(t-36,t-13)$	-0.226***	-0.247***	-0.215***	-0.202***	-0.222***	-0.236***	-0.246***	-0.234***	-0.245***	-0.250***	-0.267***	-0.262***	-0.171**	-0.125*
	(-3.04)	(-3.21)	(-2.82)	(-2.73)	(-3.11)	(-3.19)	(-3.31)	(-3.08)	(-3.32)	(-3.45)	(-3.59)	(-3.52)	(-2.31)	(-1.71)
$Adj.R^2$	4.2%	4.6%	4.9%	3.9%	3.9%	3.9%	3.9%	4.0%	3.9%	3.9%	3.8%	3.8%	4.4%	5.6%
N.obs	1,360,804	1,176,542	1,047,649	1,558,110	1,555,185	1,534,322	1,525,874	1,341,026	1,540,736	1,535,046	1,534,231	1,533,912	1,308,130	901,523

(*Continued*)

	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)
β_{FIN}	0.129**	0.127**	0.122**	0.148**	0.161***	0.132**	0.138**	0.150**	0.127**	0.132*	0.129**	0.125**	0.128	0.134
	(2.27)	(2.21)	(2.15)	(2.45)	(2.67)	(2.20)	(2.44)	(2.52)	(2.17)	(1.93)	(2.14)	(2.16)	(1.65)	(1.57)
β_{PEAD}	0.015	0.016	0.014	-0.022	-0.001	0.053	0.006	-0.016	0.010	0.008	0.029	0.012	-0.014	-0.018
	(0.34)	(0.34)	(0.32)	(-0.45)	(-0.02)	(1.12)	(0.15)	(-0.31)	(0.21)	(0.15)	(0.63)	(0.27)	(-0.25)	(-0.27)
Long-term profitability characteristics														
GP/A	0.142***		0.110**											0.254***
	(2.97)		(2.16)											(2.88)
$CbOP$		0.274***	0.219***											-0.008
		(5.95)	(4.72)											(-0.09)
Value characteristics														
E/P				0.047				-0.107						-0.140
				(1.24)				(-1.60)						(-0.94)
CF/P					0.059			0.164**						0.056
					(1.60)			(2.54)						(0.35)
NPY						0.118***		0.104***						0.027
						(3.23)		(2.79)						(0.38)
DUR							-0.108*	-0.066						-0.106
							(-1.70)	(-1.13)						(-0.76)
Intangibles characteristics														
OC/A									0.053				0.033	0.035
									(1.56)				(0.58)	(0.59)
AD/M										-0.034			-0.003	-0.115
										(-0.69)			(-0.03)	(-0.97)
RD/M											0.242***		0.245**	0.162
											(3.23)		(2.32)	(1.26)
OL												0.069	-0.000	-0.174*
												(1.52)	(-0.00)	(-1.71)
$log(ME)$	-0.252**	-0.320***	-0.294***	-0.192**	-0.216**	-0.227**	-0.266**	-0.185**	-0.234**	-0.250**	-0.239**	-0.232**	-0.239**	-0.156
	(-2.34)	(-3.33)	(-3.04)	(-2.25)	(-2.53)	(-2.27)	(-2.52)	(-2.20)	(-2.37)	(-2.43)	(-2.17)	(-2.20)	(-2.00)	(-1.51)
$log(B/M)$	0.217***	0.221***	0.235***	0.136**	0.131**	0.188**	0.136**	0.063	0.221***	0.136*	0.209**	0.217***	0.124	0.260**
	(2.60)	(2.83)	(2.97)	(2.04)	(1.99)	(2.48)	(2.22)	(1.01)	(2.90)	(1.81)	(2.15)	(2.82)	(1.21)	(2.52)
$r(t-1)$	-0.983***	-0.985***	-0.998***	-0.860***	-0.851***	-0.937***	-0.973***	-0.880***	-0.980***	-0.937***	-1.102***	-0.981***	-1.109***	-1.002***
	(-11.61)	(-11.39)	(-11.51)	(-10.27)	(-10.11)	(-11.14)	(-11.31)	(-10.70)	(-11.37)	(-10.92)	(-12.80)	(-11.20)	(-12.26)	(-10.17)
$r(t-12,t-2)$	0.148	0.172*	0.147	0.348***	0.324***	0.211**	0.174*	0.348***	0.172*	0.096	0.026	0.166*	-0.087	0.106
	(1.57)	(1.77)	(1.54)	(3.22)	(3.05)	(2.16)	(1.80)	(3.19)	(1.74)	(0.98)	(0.29)	(1.70)	(-0.90)	(0.93)
$r(t-36,t-13)$	-0.279***	-0.298***	-0.299***	-0.205***	-0.210***	-0.222***	-0.268***	-0.169***	-0.265***	-0.295***	-0.283***	-0.275***	-0.286***	-0.110
	(-3.85)	(-4.29)	(-4.41)	(-3.28)	(-3.36)	(-2.94)	(-3.76)	(-2.72)	(-3.65)	(-4.13)	(-4.34)	(-3.90)	(-3.70)	(-1.40)
$Adj.R^2$	4.1%	3.9%	4.0%	4.3%	4.3%	4.2%	4.0%	4.9%	3.8%	3.8%	4.4%	3.8%	5.4%	7.6%
$N.obs$	1,556,679	1,420,191	1,420,191	1,167,972	1,221,193	1,280,041	1,531,579	991,025	1,353,450	568,073	719,589	1,375,409	271,606	175,928

Table 10: Behavioral Factor Loadings of the Long- and Short-Leg Portfolios

This table reports time-series regressions of the long- and short-leg portfolio returns on the three-factor composite model. Panel A shows PEAD factor betas of the long- and short-leg portfolios for each of the 12 short-horizon anomalies, and Panel B shows FIN factor betas for long-horizon anomalies. At the bottom of each panel, we summarize the average FIN or PEAD betas, and count how many anomalies have larger (in absolute terms) and significant FIN or PEAD betas in the short legs than in the long legs (highlighted in boldface), and vice versa. The sample period runs from 1972:07 to 2014:12, depending on data availability.

Panel A: β_{PEAD} of short-horizon anomaly portfolios

	Long legs	Short legs		Long legs	Short legs
SUE-1	0.18	**-0.31**	R11-1	0.68	**-0.98**
	(3.73)	**(-3.40)**		(6.15)	**(-6.05)**
SUE-6	0.15	**-0.24**	I-MOM	0.50	**-0.73**
	(3.24)	**(-3.09)**		(4.74)	**(-6.31)**
ABR-1	0.59	**-0.74**	ROEQ	0.14	**-0.25**
	(8.57)	**(-8.78)**		(1.63)	**(-1.95)**
ABR-6	0.17	**-0.44**	ROAQ	**0.26**	-0.19
	(2.87)	**(-6.79)**		**(4.72)**	(-1.69)
RE-1	0.15	**-0.57**	NEI	0.18	**-0.25**
	(1.40)	**(-4.01)**		(3.10)	**(-4.38)**
R6-6	0.45	**-0.84**	FP	0.25	**-0.54**
	(4.39)	**(-5.02)**		(4.70)	**(-3.16)**

Average β_{PEAD} in the long legs: 0.31
Average β_{PEAD} in the short legs: -0.51

N. larger positive and significant β_{PEAD} in the long legs: 1 out of 12
N. larger negative and significant β_{PEAD} in the short legs: 11 out of 12

Panel B: β_{FIN} of long-horizon anomaly portfolios

	Long legs	Short legs		Long legs	Short legs
GP/A	0.01	**-0.07**	IvG	-0.07	**-0.38**
	(0.16)	**(-2.14)**		(-1.30)	**(-7.35)**
CbOP	-0.19	**-0.41**	IvC	-0.13	**-0.23**
	(-6.66)	**(-8.74)**		(-2.56)	**(-4.98)**
B/M	**0.25**	-0.17	OA	-0.38	-0.34
	(3.94)	(-4.70)		(-6.93)	(-8.89)
E/P	0.23	**-0.37**	POA	0.00	**-0.35**
	(4.06)	**(-7.12)**		(0.06)	**(-7.58)**
CF/P	0.24	**-0.29**	PTA	0.03	**-0.46**
	(4.10)	**(-6.71)**		(0.71)	**(-11.01)**
NPY	0.36	**-0.40**	NSI	0.29	**-0.33**
	(5.49)	**(-7.36)**		(6.17)	**(-8.64)**
DUR	**0.23**	-0.21	CSI	**0.38**	-0.37
	(3.39)	(-5.85)		**(13.09)**	(-11.21)
AG	0.04	**-0.36**	OC/A	-0.33	0.03
	(0.83)	**(-7.82)**		(-7.54)	(0.51)
NOA	-0.24	-0.18	AD/M	0.25	**-0.26**
	(-7.70)	(-2.52)		(3.15)	**(-5.18)**
IVA	0.06	**-0.19**	RD/M	-0.31	0.02
	(1.56)	**(-3.62)**		(-2.08)	(0.37)
IG	-0.22	**-0.48**	OL	0.07	**-0.20**
	(-5.04)	**(-14.22)**		(1.25)	**(-3.12)**

Average β_{FIN} in the long legs: 0.03
Average β_{FIN} in the short legs: -0.27

N. larger positive and significant β_{FIN} in the long legs: 3 out of 22
N. larger negative and significant β_{FIN} in the short legs: 15 out of 22

Table 11: Market Frictions and Sensitivity of Beta-Return Relation

Panel A reports returns of double-sorted portfolios by market frictions and FIN factor loadings (β_{FIN}). At the beginning of each month, firms are ranked into 25 portfolios by independent sorts on β_{FIN} and market friction proxies (estimated in the previous month). Value-weighted portfolio returns are calculated for the current month and portfolios are rebalanced at the beginning of the next month. Panel B reports results of Fama-MacBeth cross-sectional regression of monthly stock returns on β_{FIN}, the quintile ranks of market friction proxies, and the interactions between β_{FIN} and friction ranks, with standard control variables. Newey-West corrected t-statistics are shown in the parentheses (with 3 lags). We use three friction proxies: the illiquidity measure (ILLIQ) of Amihud (2002), the institutional ownership defined as shares held by institutions divided by shares outstanding (IO), and the residual institutional ownership (RIO) of Nagel (2005) controlling for size. All regressors are winsorized at top and bottom 1% and standardized to have zero mean and unit standard deviation, to make the coefficients comparable.The sample period runs from 1972:08 to 2014:12 (507 months) using ILLIQ, and from 1980:02 to 2014:12 (417 months) using IO and RIO.

Panel A: Double-sorted portfolios

	Low β	2	3	4	High β	H − L
Low ILLIQ (Low frictions)	0.73	0.86	0.81	1.05	1.05	0.32*
	(2.71)	(4.18)	(4.36)	(5.81)	(5.44)	(1.73)
2	0.94	1.00	1.19	1.09	1.14	0.20
	(3.11)	(4.23)	(5.33)	(5.07)	(4.62)	(1.35)
3	1.08	1.27	1.24	1.25	1.18	0.10
	(3.58)	(4.91)	(5.27)	(5.41)	(4.59)	(0.71)
4	1.08	1.18	1.23	1.13	1.18	0.10
	(3.43)	(4.33)	(4.70)	(4.32)	(4.05)	(0.67)
High ILLIQ (High frictions)	0.80	1.24	1.16	1.17	1.23	0.44***
	(2.47)	(4.19)	(4.35)	(4.16)	(4.18)	(2.84)

	Low β	2	3	4	High β	H − L
Low IO (High frictions)	0.18	1.01	1.10	0.82	1.18	1.00**
	(0.43)	(2.59)	(3.88)	(2.53)	(3.37)	(2.39)
2	0.34	0.94	1.17	0.96	0.95	0.61*
	(0.84)	(3.12)	(5.45)	(4.40)	(3.66)	(1.73)
3	1.02	0.84	0.87	1.15	1.48	0.46*
	(2.91)	(3.16)	(3.51)	(5.44)	(5.71)	(1.77)
4	0.88	1.15	1.14	1.17	1.27	0.39
	(2.62)	(4.11)	(4.62)	(5.09)	(5.33)	(1.59)
High IO (Low frictions)	1.28	1.21	1.13	1.27	1.24	-0.04
	(3.79)	(4.61)	(4.46)	(5.01)	(4.33)	(-0.20)

	Low β	2	3	4	High β	H − L
Low RIO (High frictions)	0.64	1.03	0.95	1.20	1.09	0.45
	(1.69)	(3.66)	(4.23)	(5.72)	(4.69)	(1.32)
2	0.91	1.02	1.06	1.12	1.31	0.40*
	(2.73)	(3.84)	(4.58)	(5.08)	(5.29)	(1.69)
3	1.14	1.14	1.09	1.22	1.05	-0.09
	(3.52)	(4.39)	(4.40)	(5.38)	(4.37)	(-0.39)
4	1.19	1.09	1.17	1.21	1.31	0.11
	(3.14)	(3.98)	(4.54)	(4.77)	(4.40)	(0.45)
High RIO (Low frictions)	1.02	1.02	1.11	1.03	1.27	0.24
	(2.82)	(3.46)	(3.68)	(3.34)	(3.75)	(1.11)

Panel B: Fama-MacBeth cross-sectional regressions

	(1)	(2)	(3)	(4)	(5)	(6)
β_{FIN}	0.200	0.170	0.388***	0.381***	0.407***	0.383***
	(1.28)	(1.28)	(2.82)	(2.98)	(2.86)	(3.03)
$ILLIQ\_rank$	0.074**	-0.080*				
	(1.97)	(-1.87)				
$\beta_{FIN} * ILLIQ\_rank$	-0.026	-0.024				
	(-0.80)	(-0.83)				
IO_rank			0.025	0.152***		
			(0.64)	(4.19)		
$\beta_{FIN} * IO\_rank$			-0.093**	-0.091**		
			(-2.34)	(-2.46)		
RIO_rank					-0.204***	-0.254***
					(-5.72)	(-9.15)
$\beta_{FIN} * RIO\_rank$					-0.089***	-0.079**
					(-2.66)	(-2.50)
$log(ME)$		-0.248**		-0.249**		-0.176*
		(-2.17)		(-2.33)		(-1.83)
$log(B/M)$		0.172***		0.138**		0.171***
		(2.84)		(2.22)		(2.79)
$r(t-1)$		-0.505***		-0.611***		-0.639***
		(-6.77)		(-7.34)		(-7.72)
$r(t-12, t-2)$		0.401***		0.318***		0.288**
		(3.90)		(2.64)		(2.38)
$r(t-36, t-13)$		-0.041		-0.115		-0.118
		(-0.60)		(-1.31)		(-1.35)
$Adj.R^2$	1.9%	5.6%	1.4%	5.0%	1.1%	5.0%
$N.obs$	634,529	634,529	477,847	477,847	477,847	477,847

Appendix

A Definition of Anomaly Variables

A.1 Short-horizon anomalies

Standardized unexpected earnings (SUE-1, SUE-6):

Following Foster, Olsen, and Shevlin (1984), SUE is calculated as the change in quarterly earnings per share (Compustat quarterly item EPSPXQ) from its value four quarters ago divided by the standard deviation of this change over the prior eight quarters (six quarters minimum). To align quarterly SUE with monthly CRSP stock returns, SUE is used in the months immediately following the quarterly earnings announcement date (Compustat quarterly item RDQ) but within 6 months from the fiscal quarter end, to exclude stale earnings. To exclude recording errors, we also require the earnings announcement date to be after the corresponding fiscal quarter end.

At the beginning of each month t, we rank all NYSE, Amex, and NASDAQ stocks into deciles based on their lagged SUE in month $t-1$. Monthly portfolio returns are calculated separately for the current month t (SUE-1) and for the subsequent six months from t to $t+5$ (SUE-6). The portfolios are rebalanced at the beginning of month $t+1$. For SUE-6 portfolios, we calculated the monthly portfolio returns following Hou, Xue, and Zhang (2015). Because of the six-month holding period, in each month, a given SUE-6 decile has six sub-deciles that are initiated in the prior six-month period. We then take the simple average of the six sub-deciles returns as the monthly return of each SUE-6 decile.

Cumulative abnormal return around earnings announcements (ABR-1, ABR-6):

Following Chan, Jegadeesh, and Lakonishok (1996), ABR is calculated as the four-day cumulative abnormal returns $(t-2,\, t+1)$ around the latest quarterly earnings announcement date (Compustat quarterly item RDQ):

$$CAR_i = \sum_{d=-2}^{d=1} R_{id} - R_{md}$$

where R_{id} is stock $i's$ return on day d and R_{md} is the market return on day d. To align quarterly ABR with monthly CRSP stock returns, ABR is used in the months immediately following the quarterly earnings announcement date (Compustat quarterly item RDQ) but within 6 months from the fiscal quarter end, to exclude stale earnings. To exclude recording errors, we also require the earnings announcement date to be after the corresponding fiscal quarter end.

At the beginning of each month t, we rank all NYSE, Amex, and NASDAQ stocks into deciles based on their lagged ABR in month $t-1$. Monthly portfolio returns are calculated separately for the current month t (ABR-1) and for the subsequent six months from t to $t+5$ (ABR-6). The portfolios are rebalanced at the beginning of month $t+1$. For ABR-6 portfolios, we calculated the monthly portfolio returns following Hou, Xue, and Zhang (2015). Because of the six-month holding period, in each month, a given ABR-6 decile has six sub-deciles that are initiated in the prior six-month period. We then take the simple average of the six sub-deciles returns as the monthly return of each ABR-6 decile.

Revisions in analysts' earnings forecasts (RE-1):

Analysts' earnings forecast data are from the Institutional Brokers' Estimate System (IBES). Following Chan, Jegadeesh, and Lakonishok (1996), RE is calculated as the six-month moving average of past changes in analysts' forecasts:

$$RE_{it} = \sum_{j=1}^{6} \frac{f_{it-j} - f_{it-j-1}}{p_{it-j-1}}$$

where f_{it-j} is the consensus mean forecast (IBES unadjusted file, item MEANEST) issued in month $t-j$ for firm i's current fiscal year earnings (IBES unadjusted file, item FPI (fiscal period indicator) =1), and p_{it-j-1} is the prior month's share price (IBES unadjusted file, item PRICE). A minimum of four monthly forecast changes is required.

At the beginning of month t, we rank all NYSE, Amex, and NASDAQ stocks into deciles based on their lagged RE in month $t-1$. Monthly portfolio returns are calculated for the current month t (RE-1) and the portfolios are rebalanced at the beginning of month $t+1$.

Price momentum (R6-6, R11-1):

Following Jegadeesh and Titman (1993), R6 is calculated as a stock's prior 6-month average returns from month $t-7$ to $t-2$. At the beginning of each month t, we rank all stocks into deciles based on R6 and calculate monthly decile returns from month t to $t+5$ (R6-6), skipping month $t-1$. The deciles are rebalanced at the beginning of month $t+1$. Because of the six-month holding period, in each month, a given R6-6 decile has six sub-deciles that are initiated in the prior six-month period. Following Hou, Xue, and Zhang (2015), we take the simple average of the six sub-deciles returns as the monthly return of each R6-6 decile.

The R11-1 deciles are constructed similarly. Following Fama and French (1996), R11 is calculated as a stock's prior 11-month average returns from month $t-12$ to $t-2$. At the beginning of each month t, we rank all stocks into deciles based on R11 and calculate monthly decile returns for month t (R11-1), skipping month $t-1$. The deciles are rebalanced at the beginning of month $t+1$.

Industry momentum (I-MOM):

We start with the Fama-French 49-industry classification. We exclude financial firms, which leaves 45 industries. For each industry, we calculate its prior six-month return from month $t-6$ to $t-1$, by taking a weighted-average of all stocks returns within the industry. Following Moskowitz and Grinblatt (1999), we do not skip month $t-1$ when measuring industry momentum.

At the beginning of each month t, we rank the 45 industries into 9 I-MOM portfolios (each with 5 industries) based on their prior six-month returns from month $t-6$ to $t-1$. Monthly portfolio returns are calculated for the subsequent six months from t to $t+5$, by taking the simple average of the 5 industry returns within each portfolio, and the portfolios are rebalanced at the beginning of month $t+1$. Because of the six-month holding period, in each month, a given I-MOM portfolio has six sub-portfolios that are initiated in the prior six-month period. Following Hou, Xue, and Zhang (2015), we take the simple average of the six sub-portfolios returns as the monthly return of each I-MOM portfolio.

Quarterly ROE and ROA (ROEQ, ROAQ):

ROEQ and ROAQ are calculated using Compustat quarterly files. ROEQ is income before extraordinary items (IBQ) divided by one-quarter lagged book equity. ROAQ is income before extraordinary items (IBQ) divided by one-quarter lagged total assets (ATQ). Book equity is shareholders' equity, plus deferred taxes and investment tax credit (TXDITCQ), minus book value of preferred stocks. Shareholders' equity is shareholders' equity (SEQQ), or common equity (CEQQ) plus the carrying value of preferred stocks(PSTKQ), or total assets (ATQ) minus total liabilities (LTQ), depending on data availability. Book value of preferred stocks equal the redemption value (PSTKRQ) if available, or the carrying value of preferred stocks(PSTKQ).

To align quarterly ROEQ and ROAQ with monthly CRSP stock returns, ROEQ and ROAQ are used in the months immediately following the quarterly earnings announcement date (RDQ) but within 6 months from the fiscal quarter end, to exclude stale earnings. To exclude recording errors, we also require the earnings announcement date to be after the corresponding fiscal quarter end.

At the beginning of each month t, we rank all stocks into deciles based on their lagged ROEQ or ROAQ in month $t-1$. We calculate value-weighted decile returns for month t and rebalance the deciles at the beginning of month $t+1$.

Number of consecutive quarters with earnings increases (NEI):

Following Barth, Elliott, and Finn (1999) and Green, Hand, and Zhang (2013), we measure NEI as the number of consecutive quarters (up to eight quarters) with an increase in earnings (Compustat quarterly item IBQ) over the same quarter in the prior year. NEI takes values from 0 to 8 quarters. To align quarterly NEI with monthly CRSP stock returns, NEI is used in the months immediately following the quarterly earnings announcement date (RDQ) but within 6 months from the fiscal quarter end, to exclude stale earnings. To exclude recording errors, we also require the earnings announcement date to be after the corresponding fiscal quarter end.

At the beginning of each month t, we rank all stocks into nine portfolios, with lagged NEI in month $t-1$ equal to 0, 1, 2, ..., and 8, respectively. We calculate value-weighted portfolio returns for month t and rebalance the portfolios at the beginning of month $t+1$.

Failure probability (FP):

We calculate failure probability (FP) following Campbell, Hilscher, and Szilagyi (2008),

$$\begin{aligned} FP_t = &-9.164 - 20.264\, NIMTAAVG_t + 1.416\, TLMTA_t - 7.129\, EXRETAVG_t \\ &+ 1.411\, SIGMA_t - 0.045\, RSIZE_t - 2.132\, CASHMTA_t + 0.075\, MB_t - 0.058\, PRICE_t \end{aligned}$$

Detailed variable definitions in the above equation follows closely from Hou, Xue, and Zhang (2015).

Quarterly FP is aligned with monthly CRSP stock returns with at least four months gap after the fiscal quarter end, but within six months after the quarterly earnings announcement date (RDQ). We impose the four-month gap between the fiscal quarter end and portfolio formation to ensure that all quarterly data items in the definition of FP are available to public.

At the beginning of each month t, we rank stocks into deciles based on their lagged FP in month $t-1$. We calculate value-weighted decile returns for the subsequent six months from month t to $t+5$ and rebalance the deciles at the beginning of month $t+1$. Because of the six-month holding period, in each month, a given FP decile has six sub-deciles that are initiated in the prior six-month period. Following Hou, Xue, and Zhang (2015), we take the simple average of the six sub-decile returns as the monthly return of each FP decile.

A.2 Long-horizon anomalies

Gross profit-to-asset ratio (GP/A):

Following Novy-Marx (2013), we define GP/A as total revenue (Compustat item REVT) minus cost of goods sold (COGS) for the fiscal year ending in year $t-1$, adjusted by current (not lagged) total asset (AT) of fiscal year ending in year $t-1$. At the end of June of each year t, we sort stocks into deciles based on GP/A for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Cash-based operating profitability (CbOP):

Cash-based operating profitability (CbOP) is defined following Ball, Gerakos, Linnainmaa, and Nikolaev (2016). Operating profitability is measured as revenue (REVT) minus cost of goods sold (COGS) minus reported sales, general, and administrative expenses (XSGA – XRD (zero if missing)). Prior to 1988, we use the balance sheet statement and measure CbOP as operating profitability minus the change in accounts receivable (RECT) minus the change in inventory (INVT) minus the change in prepaid expenses (XPP) plus the change in deferred revenues (DRC + DRLT) plus the change in accounts payable (AP) plus the change in accrued expenses (XACC), deflated by current total assets. Starting from 1988, we use the cash flow statement and measure CbOP as operating profitability plus decrease in accounts receivable (– RECCH) plus decrease in inventory (– INVCH) plus increase in accounts payable and accrued liabilities (APALCH), deflated by current total assets.

At the end of June of each year t, we sort stocks into deciles based on CbOP for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Book-to-market equity (B/M):

B/M is defined as the book equity for the fiscal year ending in year $t-1$ divided by the market equity at the end of December of $t-1$. Following Davis, Fama, and French (2000), book equity is shareholders' equity, plus balance sheet deferred taxes and investment tax credit (TXDITC) if available, minus the book value of preferred stocks. Shareholders' equity is Compustat item SEQ if available, or the book value of common equity (CEQ) plus the carrying value of preferred stocks(PSTK), or total assets (AT) minus total liabilities (LT), depending on data availability. Book value of preferred stocks is the redemption value (PSTKRV), or the liquidating value (PSTKL), or the carrying value of preferred stocks(PSTK), depending on availability.

At the end of June of each year t, we sort stocks into deciles based on B/M for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Earnings-to-price (E/P):

Following Basu (1983), we measure earnings-to-price (E/P) ratio as income before extraordinary items (IB) for the fiscal year ending in year $t-1$ divided by market equity at the end of December of $t-1$. We keep only firms with positive earnings. At the end of June of each year t, we sort stocks into deciles based on E/P for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Cash flow-to-price (CF/P):

We measure cash flow (CF) as income before extraordinary items (IB), plus depreciation and amortization (DP), plus deferred taxes (TXDI, if available). CF/P is calculated as CF for the fiscal year ending in year $t-1$ divided by market equity at the end of December of $t-1$. We keep only firms with positive cash flows. At the end of June of each year t, we sort stocks into deciles based on CF/P for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Net payout yield (NPY):

Following Boudoukh, Michaely, Richardson, and Roberts (2007), total payout (O) is dividend on common stock (DVC) plus repurchase, where repurchase is the purchase of common and preferred stock (PRSTKC) plus any reduction (negative change over the prior year) in the value of the net number of preferred stocks outstanding (PSTKRV). Net payout (NO) is total payout minus equity issuance, which is the sale of common and preferred stock (SSTK) minus any increase (positive change over the prior year) in the value of the net number of preferred stocks outstanding (PSTKRV). Net payout yield (NPY) is calculated as NO for the fiscal year ending in year $t-1$ divided by the market equity at the end of December of year $t-1$.

At the end of June of each year t, we sort stocks into deciles based on NPY for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Equity duration (DUR):

Following Dechow, Sloan, and Soliman (2004), equity duration is calculated as:

$$DUR = \frac{\sum_{t=1}^{T} t \times CD_t/(1+r)^t}{ME} + \left(T + \frac{1+r}{r}\right) \frac{ME - \sum_{t=1}^{T} CD_t/(1+r)^t}{ME}$$

where CD_t is the net cash distribution of year t, ME is the market equity calculated as price per share times shares outstanding of year t ($PRCC\_F \times CSHO$), T is the length of forecasting period, and r is the cost of equity. The construction of CD_t follows closely from Hou, Xue, and Zhang (2015). Also, to be consistent with Hou, Xue, and Zhang (2015), we use a forecasting period of $T = 10$ and a cost of equity of $r = 0.12$.

At the end of June of each year t, we sort stocks into deciles based on DUR for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Asset Growth (AG):

Following Cooper, Gulen, and Schill (2008), asset growth is defined as the percentage change in total asset (Compustat item AT) scaled by beginning total asset. At the end of June of each year t, we sort stocks into deciles based on AG for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Net operating assets (NOA):

Following Hirshleifer, Hou, Teoh, and Zhang (2004), we define net operating assets as NOA = (*Operating Assets* – *Operating Liabilities*)/*Lagged Total Assets*, where *Operating Assets* = *Total Assets*(AT) – *Cash and Short-term Investment* (CHE), and *Operating Liabilities* = *Total Assets* (AT) – *Short-term Debt* (DLC) – *Long-term Debt* (DLTT) – *Minority Interest* (MIB) – *Preferred Stock* (PSTK) – *Common Equity* (CEQ).

At the end of June of each year t, we sort stocks into deciles based on NOA for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Investment-to-asset ratio (IVA):

Following Lyandres, Sun, and Zhang (2008), we measure IVA as the annual change in gross property, plant, and equipment (PPEGT) plus the annual change in inventories (INVT) divided by lagged total assets (AT). At the end of June of each year t, we sort stocks into deciles based on IVA for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Investment growth (IG):

Following Xing (2008), we measure IG as the percentage change in capital expenditure (CAPX). At the end of June of each year t, we sort stocks into deciles based on IG for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Net share issuance (NSI):

Following Pontiff and Woodgate (2008), we measure NSI of fiscal year $t-1$ as the natural log of the ratio of split-adjusted shares outstanding of fiscal year $t-1$ to split-adjusted shares outstanding of fiscal year $t-2$. The split-adjusted shares outstanding is the common share outstanding (CSHO) times the adjustment factor (AJEX).

At the end of June of each year t, we sort stocks into deciles based on NSI for all fiscal years ending in year $t-1$. We notice that about one quarter of our sample observations have negative NSI (repurchasing firms), and three quarters with positive NSI (issuing firms). We separately sort repurchasing firms (with negative NSI) into two groups and issuing firms (with positive NSI) into eight groups using NYSE breakpoints. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Composite share issuance (CSI):

Following Daniel and Titman (2006), we measure CSI as the growth rate in market equity that is not attributable to the stock returns, $CSI_t = log(ME_t/ME_{t-5}) - r(t-5,t)$. Specifically, for CSI in June of year t, ME_t is the market equity at the end of June in year t, ME_{t-5} is the market equity at the end of June in year $t-5$, and $r(t-5,t)$ is the cumulative log return on the stock from end of June in year $t-5$ to end of June in year t.

At the end of June of each year t, we sort stocks into deciles based on CSI measured in June of year t. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Inventory growth (IvG):

Following Belo and Lin (2012), we measure IvG of fiscal year $t-1$ as the ratio of inventory (INVT) of fiscal year ending in year $t-1$ over inventory of the fiscal year ending in $t-2$. At the end of June of each year t, we sort stocks into deciles based on IvG for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Inventory changes (IvC):

Following Thomas and Zhang (2002), we measure IvC of fiscal year $t-1$ as the change in inventory (INVT) from the fiscal year of $t-2$ to the fiscal year of $t-1$, scaled by average total assets (AT) of fiscal years $t-2$ and $t-1$. At the end of June of each year t, we sort stocks into deciles based on IvC for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Operating accruals (OA):

We define operating accruals in a way consistent with Hou, Xue, and Zhang (2015). Prior to 1988, we use the balance sheet approach of Sloan (1996) and measure operating accruals as $OA = [(\Delta \textit{Current Assets} - \Delta \textit{Cash}) - (\Delta \textit{Current Liabilities} - \Delta \textit{Short-term Debt} - \Delta \textit{Taxes Payable}) - \textit{Depreciation and Amortization Expense}]/\textit{Lagged Total Assets}$, where *Current Assets* is Compustat annual item ACT, *Cash* is CHE, *Current Liabilities* is LCT, *Short-term Debt* is DLC (zero if missing), *Taxes Payable* is TXP (zero if missing), *Depreciation and Amortization Expense* is DP (zero if missing), and *Total Assets* is AT.

Starting from 1988, we use the cash flow approach following Hribar and Collins (2002) and measure operating accruals as $OA = [\textit{Net Income} - \textit{Net Cash Flow from Operations}]/\textit{Lagged Total Assets}$, where *Net Income* is NI and *Net Cash Flow from Operations* is OANCF. Data from the statement of cash flows are only available since 1988.

At the end of June of each year t, we sort stocks into deciles based on OA for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Percent operating accruals (POA):

Following Hafzalla, Lundholm, and Van Winkle (2011), we measure POA as operating accruals (OA) scaled by the absolute value of net income (Compustat item NI) for the fiscal year ending in year $t-1$. At the end of June of each year t, we sort stocks into deciles based on POA for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Percent total accruals (PTA):

We first define total accruals (TA) in a way consistent with Hou, Xue, and Zhang (2015). Prior to 1988, we use the balance-sheet approach of Richardson, Sloan, Soliman, and Tuna (2005) and measure TA as ΔWC + ΔNCO + ΔFIN. ΔWC is the change in net non-cash working capital (WC). WC is current operating asset (COA) minus current operating liabilities (COL), with COA = current assets (ACT) minus cash and short-term investments (CHE) and COL = current liabilities (LCT) minus debt in current liabilities (DLC, zero if missing). ΔNCO is the change in net non-current operating assets (NCO). NCO is non-current operating assets (NCOA) minus non-current operating liabilities (NCOL), with NCOA = total assets (AT) minus current assets (ACT) minus investments and advances (IVAO, zero if missing), and NCOL = total liabilities (LT) minus current liabilities (LCT) minus long-term debt (DLTT, zero if missing). ΔFIN is the change in net financial assets (FIN). FIN is financial assets (FINA) minus financial liabilities (FINL), with FINA = short-term investments (IVST, zero if missing) plus long-term investments (IVAO, zero if missing), and FINL= long-term debt (DLTT, zero if missing) plus debt in current liabilities (DLC, zero if missing) plus preferred stock (PSTK, zero if missing).

Starting from 1988, we use the cash flow approach following Hribar and Collins (2002) and measure TA as net income (NI) minus total operating, investing, and financing cash flows (OANCF, IVNCF, and FINCF) plus sales of stocks (SSTK, zero if missing) minus stock repurchases and dividends (PRSTKC and DV, zero if missing). Data from the statement of cash flows are only available since 1988.

Following Hafzalla, Lundholm, and Van Winkle (2011), we measure PTA as total accruals (TA) scaled by the absolute value of net income (NI) for the fiscal year ending in year $t-1$. At the end of June of each year t, we sort stocks into deciles based on PTA for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Organizational capital-to-assets (OC/A):

Following Eisfeldt and Papanikolaou (2013), OC/A is measured using the perpetual inventory method:

$$OC_{it} = (1-\delta)OC_{it-1} + SG\&A_{it}/CPI_t$$

where SG&A is Selling, General, and Administrative expenses (Compustat item XSGA), CPI is the consumer price index during year t, and δ is the annual depreciation rate of OC. For detailed definition of each variable, we follow closely Hou, Xue, and Zhang (2015).

At the end of June of each year t, we sort stocks into deciles based on OC/A for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Advertisement expense-to-market (AD/M):

Following Chan, Lakonishok, and Sougiannis (2001), we measure AD/M as advertising expenses (Compustat item XAD) for the fiscal year ending in year $t-1$ divided by the market equity at the end of December of year $t-1$. We keep only firms with positive advertising expenses. At the end of June of each year t, we sort stocks into deciles based on AD/M for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

R&D-to-market (RD/M):

Following Chan, Lakonishok, and Sougiannis (2001), we measure RD/M as R&D expenses (Compustat item XRD) for the fiscal year ending in year $t-1$ divided by the market equity at the end of December of year $t-1$. We keep only firms with positive R&D expenses. At the end of June of each year t, we sort stocks into deciles based on RD/M for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.

Operating leverage (OL):

Following Novy-Marx (2011), OL is measured as cost of goods sold (Compustat item COGS) plus selling, general, and administrative expenses (Compustat item XSGA) for the fiscal year ending in year $t-1$, adjusted by current (not lagged) total assets (Compustat item AT). At the end of June of each year t, we sort stocks into deciles based on OL for all fiscal years ending in year $t-1$. Monthly decile returns are calculated from July of year t to June of year $t+1$ and the deciles are rebalanced at the end of June of year $t+1$.