More Factors Are Needed: Evidence from a Simple Test*

Ai He
Emory University

Dashan Huang
Singapore Management University

Guofu Zhou
Washington University in St. Louis

First Draft: December 2017

Current Version: March 2019

*We are grateful to Tarun Chordia, Johan Hombert, Narasimhan Jegadeesh, Raymond Kan, Yan Liu, Jay Shanken, and seminar and conference participants at Indiana University, Peking University, Renmin University of China, Shanghai University of Finance and Economics, Washington University in St. Louis, and 2018 Conference on Financial Predictability and Data Science for insightful and detailed comments.

Send correspondence to Guofu Zhou, Olin School of Business, Washington University in St. Louis, St. Louis, MO 63130; e-mail: zhou@wustl.edu; phone: 314-935-6384.

More Factors Are Needed: Evidence from a Simple Test

Abstract

How many factors do we need to explain the cross section of expected returns on US stocks? Well-known factor models typically have no more than five factors, such as the Fama-French three-factor model, the Carhart four-factor model, the Fama-French five-factor model, the Hou-Xue-Zhang Q-factor model, and the Stambaugh-Yuan mispricing-factor model. We examine the pricing errors (PEs) of these models, and models with up to 20 factors extracted from a large set of factor proxies or basis portfolios, with and without asset pricing restrictions. We find a systematic PE reversal pattern: a trading strategy that buys low PE decile portfolio and sells high PE decile portfolio earns significant abnormal returns across all the models. Our results show that the required number of factors is much greater than previously thought in the literature. Of the economic forces, the PE reversal is partially driven but cannot be fully explained by limits-to-arbitrage, lottery demand, and expectation extrapolation.

JEL Classification: C53, G11, G12, G17

Keywords: Pricing error, Characteristic, Lottery, Expectation extrapolation, Limits-to-arbitrage

1 Introduction

One of central themes in finance is to explain why different assets have different expected returns. To this end, the capital asset pricing model (CAPM) of Sharpe (1964) and Lintner (1965) has long been the cornerpstone of asset pricing. However, the CAPM is found inadequate and alternative factor models have been proposed, such as the most widely used Fama and French (FF3, 1993) three-factor model and Carhart (FFC, 1997) four-factor model that supplements FF3 with a momentum factor. To better summarize the cross section of expected returns, three new models have been recently proposed: Fama and French (FF5, 2015) five-factor model, Hou, Xue, and Zhang (HXZ, 2015) Q-factor model, and Stambaugh and Yuan (SY, 2017) mispricing-factor model. The common feature of these models is that the number of factors is no greater than five. More recently, Kozak, Nagel, and Santosh (2019) find that only a few principal component analysis (PCA) factors are sufficient for constructing the stochastic discount factor (i.e., representing the opportunity set of investors).

In this paper, we provide a simple test on the number of factors that are needed to explain the cross section of expected returns on US stocks. Unlike the well-known Gibbons, Ross, and Shanken (GRS, 1989) test and the pricing framework of Kozak, Nagel, and Santosh (2019) that can be used at the *portfolio* level with a relatively small number of test assets, our test applies at the individual *stock* level, which does not require the number of observations larger than the number of test assets.

Specifically, we examine the pricing error (PE) of an asset pricing model at the stock level. The simple economic intuition is that, if the model is perfect, its PE should follow a white noise process and there should not exist any profitable trading strategy on individual stocks. However, if we do find an exploitable pattern, it will indicate that the model has systematic mispricing and thus is not adequate for pricing all the stocks. Although this approach is different from the standard and formal parametric tests, it does provide a useful diagnose on the pricing ability of any asset pricing model.

We focus on the PEs of six well-known pre-specified factor models: the CAPM, FF3, FFC, FF5, HXZ, and SY. For all the factor models, we find that there exists a strong PE reversal pattern: stocks with low PE earn significantly higher returns whereas stocks with high PE earn significantly lower returns, and a trading strategy that buys the bottom PE decile portfolio and sells the top PE decile portfolio generates significant abnormal returns (about 0.70% per month with value-weighting). This result indicates that these models do not explain well the cross section of expected returns on US stocks. In addition, the alternative models improve little beyond the CAPM in terpms of the PE reversal.

For robustness, we also study the PEs of PCA factor models extracted from a large set of 70 factor proxies in Huang, Li, and Zhou (2018) or 100 basis portfolios constructed via cluster analysis as Ahn, Conrad, and Dittmar (2009).[1] We consider two types of PCA factors, factors extracted without and with mispricing restrictions, where the latter are in light of Balvers and Stivers (2018). Nevertheless, for all the PCA models with number of factors up to 20, the PE reversal persists: a spread portfolio that buys stocks in the bottom PE decile and sells stocks in the top PE decile earns significant abnormal profits, with magnitude similar as the cases with extant factor models. Hence, alternative PCA factor models are inadequate in explaining the cross section of expected returns either. We need more factors or better factors.

The PE reversal is unlikely driven by data mining. Harvey, Liu, and Zhu (2016) raise a data mining issue concern on anomaly discovery and advocate the use of a t-value greater than 3 in testing whether the average return of a spread portfolio is zero, which is empirically supported by Chordia, Goyal, and Saretto (2018) in evaluating about 2.1 million trading strategies. In this paper, we show that the PE spread portfolios pass this higher hurdle rate with alpha t-values always larger than 3, regardless which well known factor model is used in calculating them.

It appears striking that the six well known factor models perform very similarly in pricing all the stocks as their average absolute pricing errors across the stocks are virtually identical to each other and to that of the CAPM. Moreover, they perform similarly too because none of them is better than the CAPM in terms of having a less PE reversal. The PE spread portfolios are highly correlated with each other, with correlations ranging from 0.75 to 0.93. Moreover, the differences in average return between the spread portfolios are virtually zero. For example, such differences between the CAPM's PE spread portfolio and the HXZ and SY's PE spread portfolios are 0.01% (p-value $= 0.94$) and 0.04% (p-value $= 0.69$). In addition, their differences in FF3 alpha are -0.01% (p-value $= 0.95$) and 0.05% (p-value $= 0.61$), respectively. This result is consistent with Harvey and Liu (2018) that the CAPM is by far the most important factor model in explaining the cross section of stock returns.

The PE reversal is different from the usual short-term reversal portfolio, which is model independent and is constructed by buying stocks in the lowest prior month return decile and selling stocks in the highest

[1] Our results are little changed with 200 basis portfolios

prior month return decile (see, e.g., Lehmann, 1990; Lo and MacKinlay, 1990; Jegadeesh, 1990). Since the PE is almost identical across all the models, we will focus below those based on the CAPM.[2] With a double sort on prior month return and PE, we find that the average return of the PE spread portfolio remains significant within each prior month return quintile. For example, the FF3 alpha ranges from 0.37% (t-value = 2.55) to 0.69% (t-value = 3.98). The PE reversal is not subsumed by the usual long-term reversal either, and continues to exist in a double sort on prior (13-60) return and PE. Moreover, the PE reversal is different from the IVOL effect. Although the PE is normalized by its volatility with past 5-year returns (an alternative estimation of IVOL), its spread portfolio is weakly and negatively related with the Ang, Hodrick, Xing, and Zhang (2006) IVOL spread portfolio, with an insignificant correlation of -0.02. A double sort analysis shows that the PE reversal remains significant within each IVOL quintile.

From an investor's perspective, a natural question is whether the PE spread portfolio has incremental investing value relative to extant risk factors and the short- and long-term reversal portfolios. To examine this question, we carry out six mean-variance spanning tests under different distribution assumptions (see, e.g., Kan and Zhou, 2012), and find that the tests strongly reject the hypothesis that the PE spread portfolio is spanned by these benchmark assets. In another word, the PE spread portfolio lies outside the mean-variance frontier of the benchmark assets.

We attribute the PE reversal to investor mispricing, but it seems unrelated to market-wide sentiment. According to Stambaugh, Yu, and Yuan (2012), if the PE effect is driven by investor sentiment, its spread portfolio should be much stronger and its short-leg portfolio should be much lower when investor sentiment is high. However, we find that these two portfolios do not display such patterns and their average returns and alphas are indistinguishable between high and low sentiment periods, where a month is defined as high if the Baker and Wurgler (2006) sentiment index in the previous month is above the median value and as low otherwise. For example, the PE spread portfolio has an average return of 0.78% (t-value = 3.17) in high sentiment periods and 0.66% (t-value = 2.83) in low sentiment periods, with an insignificant difference of 0.12% (t-value = 0.35). Moreover, the PE long-leg portfolio has significant average returns and alphas in both high and low sentiment periods, suggesting that the PE reversal is due to underpricing in the long-leg and overpricing in the short-leg.

We then explore three possible explanations with cross-sectional analysis. The first is limits-to-arbitrage

[2]Results with other models are reported in Appendix.

(Shleifer and Vishny, 1997), which has been epitomized by Barberis and Thaler (2003) as one of the two building blocks of behavioral finance.[3] In this paper, stocks with extremely PE tend to be those with high IVOL, which typically have high arbitrage costs (Pontiff, 2006). As a results, if arbitrage forces are limited, high PE stocks are likely overvalued whereas low PE stocks are likely undervalued, suggesting a negative relation between PE and subsequent returns. Following Nagel (2005) and Weber (2018), we use institutional ownership as the proxy of limits-to-arbitrage, and find some supporting evidence. The PE spread portfolio has higher alphas in stocks with lower institutional ownership, and its performance is insignificant in the highest institutional ownership quintile. However, across the ownership quintiles, the PE spread portfolio still has significant alphas, in both long- and short-legs. Hence, the PE reversal seems partially driven but beyond the limits-to-arbitrage.

The second explanation is lottery demand. One important implication of prospect theory is that investors overweight the probabilities of extreme returns and mentally represent the stock by the distribution of its past returns (Barberis and Huang, 2008), which induces a strong preference for lottery-like assets. Empirically, Kumar (2009) and Han and Kumar (2013) show that lottery investors generate demand for stocks with high probabilities of large short-term up moves in the stock price. In the spirit of Barberis, Mukherjee, and Wang (2016), with probability overweighing, there would have a disproportionately high lottery demand for high PE stocks and a low lottery demand for low PE stocks, which push the prices of such stocks up and down further, and in turn generate decreasing and increasing future returns. Thus, the PE should be negatively related to future stock returns. Following Bali, Cakici, and Whitelaw (2011), we proxy for lottery demand with MAX, defined as the average of the 5 highest daily returns of the given stock in a given month. A double sort analysis demonstrates that the PE spread portfolio is no longer significant when the portfolio is constrained to be in the top MAX quintile, suggesting that investors' demand for lottery-like stock is also a partial driver of the PE reversal.

The third and last explanation is expectation extrapolation. With survey data, Greenwood and Shleifer (2014) find that investors's return expectations are positively correlated with past returns and the level of the stock market, but negatively correlated with mode-based expected returns. If investors display such an extrapolation bias at the stock level, a high PE stock should have a high subjective expectation of expected returns whereas a low PE stock should have a low subjective expectation of expected returns, which is

[3] The other building block is demand shocks experienced by investors other than arbitrageurs.

consistent with the main finding in this paper.

To test this extrapolation hypothesis, we perform two additional analyses. First, we follow Weber (2018) and look at analysts' implied return expectation (target price scaled by current actual price), which appears overly extrapolated (Asness, Frazzini, and Pedersen, 2017). We find that the PE spread portfolio becomes insignificant in the top implied return expectation quintile, but still significant in other quintiles. Second, we explore expectation extrapolation on fundamentals. Bordalo, Gennaioli, La Porta, and Shleifer (2019) and Weber (2018) show that, financial analysts, as representative investors, forecast fundamentals from observed earnings growth, but tend to overreact to good news, especially on long-term earnings growth forecasts. As stock returns and earnings are generally positively correlated, stocks with extreme PE are more likely to suffer from the extrapolation bias, and therefore are those with extreme forecasts on long-term earnings growth. Empirically, we do find that the PE spread portfolio has insignificant alphas in the top quintile of long-term earnings growth forecasts. Thus, extrapolation can be also a partial driver of the PE reversal.

Finally, to jointly examine these three possible explanations, we perform a series of Fama-MacBeth regressions controlling for all explanatory variables, and find that the PE consistently and negatively predicts future stock returns, which are significant at all standard significance levels. In sum, the PE reversal is partially driven but beyond these three explanations, and calls for a unified framework to understand the cross section of stock returns in future research.

The rest of the paper proceeds as follows. Section 2 introduces the methodology. Section 3 presents the main results. A further analysis and robustness tests of the pricing errors from the well known factor models are conducted in Section 4 and Section 5, respectively. Section 6 explores possible economic mechanisms. Section 7 concludes.

2 Pricing Error Reversal

In this section, we show that the PEs of six well-know factor models display a systematic reversal pattern and a trading strategy that buys stocks with high PE and sell stocks with low PE earns significant average and risk-adjusted returns. Moreover, in terms of average and risk-adjusted returns, the PE spread portfolios of the six factor models are virtually the same, suggesting that the CAPM is by far the most important factor model.

2.1 Methodology

Following Cochrane (2005), we write a general asset pricing model in the stochastic discount factor (SDF) form,

$$\mathrm{E}_{t-1}(M_t R_{i,t}) = 0, \tag{1}$$

where M_t is the SDF, $R_{i,t}$ is the return on stock i in excess of the riskfree rate, and $\mathrm{E}_{t-1}(\cdot)$ is the unconditional expectation operator. The pricing error (PE) of stock i at time t can be defined as:

$$e_{i,t} = R_{i,t} - \mathrm{E}_{t-1}(R_{i,t}), \tag{2}$$

where $E_{t-1}(R_{i,t})$ is the expected return from (1). If the asset pricing model is perfect, the time series $e_{i,t}$ should be a pure white noise overtime for each stock i. Hence, one way to assess how the model performs is to examine the time series properties of e_{it}. If abnormal returns can be made based on e_{it}, the SDF is clearly imperfect.

In this paper, we explore the property of PE in the cross section of stock returns. Specifically, given a factor model, we calculate the PE of each stock in each month with two steps. In the first step, at the end of each month, we run a time-series regression for each stock with its past 60-month returns with a minimum of 50 observations as:

$$R_{i,t-j} = \alpha_{f,i,t} + B_{f,i,t} F_{f,t-j} + \varepsilon_{f,i,t-j}, \quad j = 0, \cdots, 59, \tag{3}$$

where $R_{i,t-j}$ is the excess return of stock i in month $t-j$, $F_{f,t-j}$ is the factor returns of model f, which refers to CAPM, FF3, FFC, FF5, HXZ, or SY. In the second step, we defined PE as the normalized price error:

$$\mathrm{PE}_{f,i,t} = \frac{\varepsilon_{f,i,t}}{\mathrm{Std}(\varepsilon_{f,i,t})}, \tag{4}$$

where $\mathrm{Std}(\varepsilon_{f,i,t})$ is the standard deviation of the residuals from (3) and can be used as an alternative proxy of IVOL. There are two reasons for this normalization. First, econometrically, the normalization makes the pricing error signals stationary ($\alpha_{f,i,t}$ may have a trend). Second, the normalization adjusts the IVOL effect and therefore mitigates the undue impact of high volatile stocks.

2.2 Data and key variables

We obtain monthly stock returns from the Center for Research in Security Prices (CRSP) over the period 1926:12–2016:12. We include all domestic common stocks listed on the NYSE, Amex, and Nasdaq exchanges, and exclude closed-end funds, real estate investment trusts (REITs), unit trusts, American depository receipts (ADRs), and foreign stocks (or stocks that do not have a CRSP share code of 10 or 11). Financial firms and firms with negative book equity are excluded. In addition, every month we exclude stocks without valid previous price (with the CRSP return code of "C"), not trading on the current exchange in that month (with the CRSP return code of "B"), and with missing return due to missing price in that month (with the CRSP return code of "-99.0"). If a stock is delisted with missing delisting return, we assume a return of -30% as Shumway (1997).

In this paper, we also use daily stock returns from the CRSP, with filters similar to the monthly returns. Following Ang, Hodrick, Xing, and Zhang (2006), we measure IVOL by the standard deviation of the residual values from the time-series regression:

$$R_{i,t} = \alpha_i + b_i \text{MKT}_t + s_i \text{SMB}_t + h_i \text{HML}_t + \varepsilon_{i,t}, \tag{5}$$

where $R_{i,t}$ is stock i's daily excess return on date t, and MKT_t, SMB_t, and HML_t are the returns of the market factor, size factor, and value factor on date t, respectively. We estimate (5) for each stock each month using daily returns with a minimum of 15 observations required. Following Bali, Cakici, and Whitelaw (2011), we proxy for lottery demand with MAX, defined as the average of the 5 highest daily returns of the given stock in a given month.

We consider six factor models, CAPM, FF3 (Fama and French, 1993), FFC (Carhart, 1997), FF5 (Fama and French, 2015), HXZ (Hou, Xue, and Zhang, 2015), and SY (Stambaugh and Yuan, 2017). The factor returns of the first four models are from Ken French's website, and the returns of the last two models are from the authors. Due to data availability, CAPM and FF3 start from 1926:12, FFC from 1927:01, FF5 from 1963:07, HXZ from 1967:01, and SY from 1963:01, respectively.

The data on institutional ownership are from the Thomson Reuters 13F database. These data include quarterly observations on long positions of mutual funds, hedge funds, insurance companies, banks, trusts, person funds, and other entities with holdings of more than \$100 million of 13F assets. We calculate the institutional ownership ratio by first summing the holdings of all reporting institutions at the security level and then dividing by the total shares outstanding from CRSP. If a common stock is on CRSP but not in the 13F database, we assign an institutional ownership of 0. We use the CRSP cumulative adjustment factor to account for stocks splits and other distributions between the effective ownership data and the reporting data. The 13F database carries forward institutional reports up to eights quarters. We only keep the holding data as they first appear in the database in calculating the institutional ownership.

Since institutional ownership and size are strongly positively correlated, we follow Nagel (2005) to separate the size effect from the ownership with the following cross-sectional regression,

$$\log \frac{\text{INST}_{i,t}}{1-\text{INST}_{i,t}} = \alpha + \beta_1 \log(\text{ME}_{i,t}) + \beta_2 (\log(\text{ME}_{i,t}))^2 + u_{i,t} \quad (6)$$

and use the residual $u_{i,t}$ as the institutional ownership (IO) measure, where INST represents the institutional holding and ME denotes the market value of equity. We replace the institutional holding ratios below 0.0001 and above 0.9999 with 0.0001 and 0.9999, respectively. Nagel (2005) shows that this method is effective in creating variation in institutional ownership while keeping size largely fixed.

The data on analyst forecasts on long-term growth in earnings (LTG) are from the Institutional Brokers Estimates System (IBES), where LTG is defined as expected annual increase in operating earnings over the company's next full business cycle, a period ranging from three to five years (Weber, 2018).

Target prices are also from the IBES database, which contains the projected price level forecasted by analysts within a specific time horizon. For our analysis, we follow Asness, Frazzini, and Pedersen (2017) and use the monthly mean consensus target price, which is defined over a 12-month time horizon. We measure the expectation of expected returns as analysts' consensus price target scaled by current actual price (PTP).

3 PE portfolios

3.1 Existing factor models

At the end of each month, we form decile portfolios sorted by PE with NYSE breakpoints, where PE1 refers to the portfolio with stocks in the bottom PE decile and PE10 refers to the portfolio with stocks in the top

PE decile. PE1-10 refers to the spread portfolio that goes long PE1 and short PE10. All portfolios are value-weighted and monthly rebalanced throughout the paper. Since the calculation of PE is model dependent, the sample periods start differently, from 1931:02 for the portfolios based on the CAPM and FF3's PEs (PE_{CAPM} and PE_{FF3}), from 1931:03 based on the FFC's PE (PE_{FFC4}), from 1967:09 based on the FF5's PE (PE_{FF5}), from 1971:03 based on the HXZ's PE (PE_{Q4}), and from 1967:03 based on the SY's PE (PE_{M4}), respectively. All portfolios end in 2016:12.

Table 1 reports the results. Consider the decile portfolios based on the CAPM's PE. The average returns monotonically decrease in the PE rank, from 0.98% (t-value = 5.33) for PE1 to 0.25% (t-value = 1.34) for PE10, generating a spread of 0.74% with a 5.90 t-value. The spread portfolio is significant across other factor models too. As shown later, the spread portfolio returns cannot be explained by any known factor models either, suggesting that they are abnormal returns.

3.2 Anomaly factors

Since a stock's PE in month t comes from the residual return which is not able to be priced by factor models, there is a possibility is that the PE reversal is simply a reflection of acknowledged anomalies. To see if this is the case, we, in this section, add anomaly-based factors in calculating PE.

We independently replicate about 120 anomalies from Green, Hand, and Zhang (2017) and Hou, Xue, and Zhang (2015), with data since 1974 and holding period of one month, and find 62 have significant CAPM alpha (vw decile spread). We use principal component analysis (PCA) to extracted factors from the 62 CAPM anomalies. Then following Section 2.1, we can compute PEs from a factor model with the first K anomalies-PCA factors, where K=1, 3, 5, 10, 15, and 20.

The average returns of the decile portfolios based on this new PE are reported in Table 2. Across the six PCA factor models, the average returns of PE deciles show the similar monotonic decreasing pattern as in Table 1, generating a spread ranging from 0.86% with a 4.54 t-value (1-PC factor model) to 1.14% with a 6.85 t-value (15-PC factor model). These results suggest strongly that the PE reversal pattern is still true. The new PE spread portfolios based on anomaly factors still have abnormal returns.

3.3 Extracted exact factors

Consider that there is a given set of target assets. Previous factor models are likely to fail to price the target assets correctly. Then it may not be surprising that they also fail at the stock level. In this section, we ask the question whether a factor model can do much better at the stock level if it can price the target assets exactly (with zero alphas).

Consider a K-factor model for a set of target asset returns,

$$R_{i,t} = \alpha_i + \beta_{i1} f_{1t} + \cdots + \beta_{iK} f_{Kt} + \varepsilon_{it}, \quad i = 1, \cdots, N, \ \ t = 1, \cdots, T, \tag{7}$$

where $R_{i,t}$ is the return on asset i in period t $(1 \le i \le N)$, f_{jt} is the realization of the j-th factor in period t $(1 \le j \le K)$, ε_{it} is the disturbance (i.e., idiosyncratic return) of asset i, and K is the number of factors. Exact linear pricing implies all the alphas are zeros, i.e., $\alpha = 0_N$.

The factors are unknown and have to be estimated from data. It is an open question unaddressed until recently. Balvers and Stivers (2018) provide a novel approach to estimate $f_t = (f_{1t}, \ldots, f_{Kt})'$ under arbitrary conditions on $\alpha'\alpha$, of which $\alpha = 0_N$ is a special case. While Balvers and Stivers (2018) solve the factors only almost analytically for a general constrains on $\alpha'\alpha$, an explicit formula is available for the exact factors, that price the target assets R_i's, as demonstrated below.[4]

Assume that the returns follow a stationary distribution. Denote by Σ the return covariance matrix, $\Sigma = E(R_t - \mu)(R_t - \mu)'$, where μ is the mean of R_t. When α is unrestricted, it is estimated by (7) as

$$\alpha = (I - BQ')\mu, \tag{8}$$

given other parameters. Then, using property of the trace operator, it is easy to see that

$$\min E[e_t' e_t] = min_{B,Q} tr\left[(I - BQ')(I - BQ')\Sigma(I - BQ')\right]. \tag{9}$$

It is well known (see, e.g., Balvers and Stivers (2018)), the above solution to B and Q are the standard PCA

[4] As shown by Huang, Li, and Zhou (2018), one can also solve such factors in the GMM framework.

estimates, and the PCA factors for the target assets are

$$F_t = Q' R_t, \tag{10}$$

where $Q = \Sigma^{-1/2} E$, with E, $N \times K$, as the K standardized eigenvectors of Σ corresponding to the K largest eigenvalues. By design, factors F_t is the best to fit the model or explain the variation of the returns. However, it imposes no restrictions on the alphas, so the PCA factors will not necessarily imply $\alpha = 0$ in the model.

Imposing zero pricing restriction that $\alpha = 0$, we have from (10) that

$$e_t{}^* = (I - BQ')R_t. \tag{11}$$

Hence, minimizing the mean-squared residuals is to

$$\min E[e_t^{*\prime} e_t^*] = min_{B,Q} tr\left[(I - BQ')(I - BQ')(\Sigma + \mu\mu')(I - BQ')\right]. \tag{12}$$

In comparison this with (9), we have now the same objective function as before except now $\Sigma + \mu\mu'$ plays the role of the previous Σ. Hence, the solution can be analytically obtained, and the factors (with zero pricing error constraints) are

$$F_t^* = Q^{*\prime} R_t, \tag{13}$$

where $Q^{*\prime} = (\Sigma + \mu\mu')^{-1/2} E^{*\prime}$, with $E^{*\prime}$, $N \times K$, as the K standardized eigenvectors of $\Sigma + \mu\mu'$ corresponding to the K largest eigenvalues. By design, factors F_t^* is the best to fit the model or to explain the variation of the returns conditional on zero alphas.

It is of interest to the exact factors perform in the real data. To extract them, we need a balance panel of target assets returns or portfolios. Since Fama-French 25 portfolios are well known, it is of interest to consider this set of target assets first. The famous Fama and French (1993) 3 factors can be regarded, intuitively, as extracted factors that explain these 25 portfolios, and then used subsequently to explain all stocks. The 3 extracted factors by using the above procedure is the best extracted factors statistically that implies exactly factor pricing or zero alphas on the 25 target assets.

For comparison, we also extract such factors from targets with more $N > 50$ assets. For this purpose, we need to form such assets or portfolios by certain criteria. To have enough dispersion among the returns, we consider a panel, say $N = 100$ portfolios. To avoid the bias toward it, we do not sort stocks by any firm characteristic. To make our study replicable, we do not use purely randomly sorted portfolios either. Our strategy is quasi-random and replicable. We sort stocks by names alphabetically. To mitigate concerns of similar names in the same portfolio, we put the first 100 firms into 100 groups each of which has one firm, and then put the second 100 firms (names ordered from 101 to 200) into the 100 groups again, each of which now has two firms. Continuing this process, we obtain 100 value-weighted portfolios from the 100 groups, in which the number of firms are either the same or the difference is just one.

Table 3 provides the results. We examine first the average returns of the PE decile portfolios for the 3 extracted factors from the Fama-French 25 size and book-market portfolios. It is interesting that the same PE reversal pattern holds, and the average returns are even slightly greater. However, the return on the spread portfolio is lightly smaller, 0.77 vs 0.8. Now, using the above name-based sorting method, we have extracted factors, its number varying from 5, 10 to 20, and for N=50, 100, or 200, the average returns of PE deciles still show a monotonic decreasing pattern. The return of the spread portfolio ranges from 0.60% with a 4.78 t-value (10-PC factor model from 200 name-based portfolios) to 0.77% with a 6.31 t-value (3-PC factor model of Fama-French 25 book/market portfolios). Amazingly, these results show that, using extracted true statistical factors, the PE spread portfolio still has abnormal returns.

3.4 Better than CAPM?

Besides the reversal pattern, it is important to note that all factors improve little in terms of reducing the abnormal returns of the pricing errors. To see their impact on pricing errors directly, Table 4 reports the average absolute pricing errors across all the factor models. Interesting, they are very close to each other, suggesting strongly that all other factor models do not help much in pricing individual stocks.

4 Further Analysis

For brevity, our focus in what follows analyzes the pricing errors from the well known factor models only, as the pricing errors from other factors behave similar.

4.1 Characteristics of PE spread portfolios

Panel A of Table 6 reports the summary statistics of PE spread portfolios. Interestingly, in addition to have similar means, these portfolios also have similar volatilities, making their monthly Sharpe ratios close to each other. Also, the performance of these portfolios is comparable with, even slightly better than, the market portfolio. Over the sample period 1931:02–2016:12, the market portfolio has a 0.67% average return and a 5.32% volatility, generating a monthly Sharpe ratio of 0.13. As a comparison, the spread portfolio based on the CAPM's PE has a 0.74% average return and a 4.15% volatility, yielding a 0.18 Sharpe ratio.

Panel B of Table 6 reports the pariwise correlations between the PE spread portfolios, which are calculated based on all available data. An interesting pattern in this panel is that these portfolios are high correlated, although they are constructed with different asset pricing models' PEs. The correlations vary from 0.75 between the FF5 and SY's PE spread portfolios to 0.93 between the FF3 and FFC's PE spread portfolios, suggesting that the pricing errors of all the six factor models we consider comove in the same direction.

Panel C of Table 6 shows that the performance of the PE spread portfolios is robust over subsample periods. First, we consider the performance in January and non-January, and find that while the PE spread portfolios seem revealing a January effect (Jegadeesh, 1990), their performance in non-January months is still significant. Actually, the average returns in non-January are similar to their average returns in the whole sample that are shown in Panel A, suggesting that the January effect is not likely the main driver of the PE reversals.

Panel C also reports the average returns in three subsample periods, 1931–1960, 1961–1990, and 1991–2016. Interestingly, there is no downward trend at all. For example, over these three periods, the average returns of the spread portfolios based on the CAPM's PE are 0.74% (t-value = 3.21), 0.72% (t-value = 3.64), and 0.76% (t-value = 3.44), respectively. These results are similar with other PE spread portfolios, and are in stark contrast to McLean and Pontiff (2016) who show that the performance of most of anomalies declines after the publication of research papers that document their discovery. Moreover, the FF3 and FFC's spread portfolio returns monotonically increase in these three subsamples.

Panel D of Table 6 reports the value-weighted firm characteristics of the CAPM's PE decile portfolios. There are several interesting observations. First, the short-term reversal monotonically increases in the PE rank, suggesting that they are highly correlated, which is not surprising as PE is a component of the short-reversal. Second, extreme PE stocks are more likely to be those with extreme high IVOL; the IVOL deceases from PE1 to PE5 and increases thereafter, exhibiting a U shape. Third, the PE seems unrelated with the size effect. Finally, PE is related with MAX, IO, PTP, and LTG, which will be discussed in more detail later. It should be mentioned that the residual institutional ownership, IO, is much higher than that in Nagel (2005). The reason may be that Nagel (2005) use equal weighting whereas we use value weighting, tilting toward large firms. Another reason may be that we extend the sample period of Nagel (2005) from 2003 to 2016, over which institutional ownership increases dramatically. In fact, Lewellen (2011) shows that from 1980 to 2007, the share of US common equity held by institutional investors increased from 32% to 68% of total market value.

4.2 Indifference between PE spread portfolios

A desired asset pricing model should hold for all assets, whether the assets are individual stocks or portfolios. When a new factor model is proposed, it is supposed to better describe the cross section of stock returns, which implies that its PE spread portfolio should have a smaller average return and alpha. To test this necessary condition, we examine the differences of average returns and alphas between the six models' PE spread portfolios in this subsection.

Table 7 reports the differences and the associated *p*-values that test whether the differences are zero. There are two observations, First, all the PE spread portfolios have indistinguishable average returns and alphas, and their differences are not significant at the 5% significant level, which is contrast with Hou, Xue, and Zhang (2015) and Stambaugh and Yuan (2017) who show that the HXZ outperforms the FF3 and the SY outperforms the FF5 and HXZ in explaining extant anomalies at the portfolio level. Second, no model outperforms the CAPM in terms of having a less PE reversal. For example, the differences in average return between the CAPM' PE spread portfolio and the HXZ and SY's PE spread portfolios are 0.01% (p-value $= 0.94$) and 0.04% (p-value $= 0.69$). Their differences in FF3 alpha are -0.01% (p-value $= 0.95$) and 0.05% (p-value $= 0.61$), respectively. This result is surprising as all these models supplement the CAPM with additional factors and are supposed to perform better. These two observations are robust when non-FF3 models are used to calculate the risk-adjusted returns, which are shown in Table A1.

In sum, the CAPM seems by far the most important factor model in explaining the cross section of expected returns, and it performs qualitatively and quantitatively the same as all the well-known multifactor models. For this reason, in the sequel we report the results with the CAPM's PE in the main text and the results with other models' PE in the appendix. That is, unless stated otherwise, PE will refer to the pricing error calculated based on the CAPM.

In summary, this section presents two new empirical facts: 1) there is a systematic PE reversal for all extant risk factor models, and 2) the spread portfolios constructed on PE are virtually the same across factor models.

5 Robustness Tests

5.1 Double sort on prior return and PE

Since a stock's PE in month t is one component of its raw return, one natural question is whether the PE reversal is subsumed by the usually documented short-term reversal, which is based on the raw return (Lehmann, 1990; Lo and MacKinlay, 1990; Jegadeesh, 1990). In this section, we perform a sequential double sort analysis to explore whether the PE reversal is subsumed by the short-term reversal. We first sort all stocks into five groups based on short-term reversal (STR), i.e., current month return, with the NYSE breakpoints, and within each quintile, we sort stocks into five groups based on PE. The intersections produce 25 portfolios.

Panel A of Table 8 reports the FF3 alphas of the 25 valued-valued portfolios. Consistent with Jegadeesh (1990), the usual short-term reversal exists in our sample period, and the FF3 alpha generally deceases in terms of the STR rank. However, the PE reversal continues to exist and is different from the short-term reversal. Within each STR quintile, the PE spread portfolio has a significant FF3 alpha. Across the STR quintiles, the portfolio with the lowest PE has a 0.26% FF3 alpha (t-value = 5.40) and the portfolio with the highest PE has a −0.18% FF3 alpha (t-value = −3.13), making their spread as large as 0.44% (t-value = 4.92). This result suggests that after controlling for the short-term reversal, the PE spread portfolio still generates statistically and economically significant abnormal returns.

De Bondt and Thaler (1985) show that there is a long-term reversal in the stock market; Stocks with high past 3- to 5-year returns earn low returns in the future. Since the PE is estimated with the past 5-year returns, its forecasting power may come from the long-term reversal. Panel B of Table 8 examines this possibility and shows that the PE reversal is not subsumed by the usual long-term reversal. A similar double sort shows that the PE reversal also exists after controlling for the long-term reversal, and the PE spread portfolio across the long-term reversal quintiles has a 0.48% FF3 alpha (t-value $= 4.56$).

5.2 Double sort on IVOL and PE

To mitigate the volatility effect, we normalize PE by its standard deviation when forming the decile portfolios, which is calculated by the residuals of regression (3) and can be an alternative proxy for IVOL. This normalization raises a concern whether the PE reversal is driven by IVOL, which has been shown negatively predicting future stock returns (see, e.g., Ang, Hodrick, Xing, and Zhang, 2006). If the predictive power of PE is from IVOL, stocks with small PE in magnitude are more likely to be the stocks with extremely high IVOL, and therefore are more likely to be mispriced. However, Table 5 does not support this inference and shows opposite results: stocks in the 4th, 5th, and 6th PE deciles are those with least mispricing.

This subsection provides new evidence that the PE reversal is unrelated with IVOL. First, the PE spread portfolio is weakly and negatively related with the Ang, Hodrick, Xing, and Zhang (2006) IVOL spread portfolio, with an insignificant correlation of -0.02. Second, Table 9 reports the alphas of 25 value-weighted portfolios with sequential double sort on IVOL and PE. The results show that the PE reversal is not driven by IVOL, and its spread portfolio remains significant within each IVOL quintile with two exceptions when the factor models are FF5 or HXZ. Controlling for IVOL, the PE spread portfolios across IVOL quintiles have significant alphas, no matter which model is used in calculating the PE and the risk-adjusted returns.

We also perform a battery of other robustness tests and find that the PE reversal continues to hold. First, the PE spread portfolio remains significant in the largest size quintile and therefore does not suffer from the size effect, which seems an issue for a lot of anomalies (Hou, Xue, and Zhang, 2019). Second, we use value-weighting and NYSE breakpoints in constructing portfolios in this paper. We also try equal-weighting and stock universe breakpoints, and find that the results are even stronger. Finally, the mispricing of extreme PE stocks seems unrelated to the mispricing measure in Stambaugh, Yu, and Yuan (2015). A double sort shows that the PE spread portfolio has a significant average return and alpha in each of the Stambaugh, Yu, and Yuan (2015) mispricing score quintile.

5.3 Mean-variance spanning

This section explores whether the PE spread portfolio adds any investing value from the perspective of an investor who holds a well-diversified portfolio, such as the market portfolio or a portfolio spanned by the FF5 factors. The mean-variance spanning test originally proposed by Huberman and Kandel (1987) provides the answer to this question.

The key idea of this test is to show that whether the PE spread portfolio lies outside the mean-variance frontier spanned by a set of benchmark assets. As such, we run a time-series regression of the PE spread portfolio returns on the factor returns in each asset pricing model over the whole sample period as follows:

$$R_t = \alpha + \sum_{j=1}^{K} \beta_j F_{f,j,t} + \varepsilon_t, \tag{14}$$

where $F_{f,j,t}$ is the jth factor return of model f in month t, β_j is the factor loading , and K is the number of risk factors in model f, such as $K = 5$ in the FF5. Huberman and Kandel (1987) show that the spanning test is equivalent to the test of the following restrictions:

$$H_0 : \alpha = 0 \text{ and } \beta_1 + \cdots + \beta_K = 1. \tag{15}$$

We follow Kan and Zhou (2012) and carry out six spanning tests with various distribution assumptions on the spread portfolio return: Wald test under conditional homoscedasticity, Wald test under independent and identically distributed (IID) elliptical distribution, Wald test under conditional heteroscedasticity, Bekerart-Urias spanning test with errors-in-variables (EIV) adjustment, Bekerart-Urias spanning test without the EIV adjustment, and DeSantis spanning test. All these six test statistics have asymptotic chi-squared distribution with 2 degrees of freedom.

Table 10 reports the test statistics and the associated p-values, where the benchmark assets are the risk factors of the six asset pricing models considered in this paper in Panel A, and the risk factors plus the short- and long-term reversal spread portfolios in Panel B. The results are unanimous and all the six tests strongly reject the null hypothesis that the PE spread portfolio is within the mean-variance frontier of these benchmark assets. Therefore, the PE spread portfolio is clearly a unique trading strategy that is unexplained by extant factors and the short- and long-term reversal spread portfolios, thereby providing incremental investing value.

6 Explanations

In this section, we investigate three possible explanations for the PE reversal documented in the previous section. Based on the general asset pricing equation (1), the mispricing of extremely PE stocks may come from three sources, limits-to-arbitrage, exotic preference, and expectation bias, which all deter arbitragers to move the market price toward the fundamental value.

Before exploring the possible explanations, we investigate how the market-wide sentiment affects the PE reversal. According to Stambaugh, Yu, and Yuan (2012), if investor sentiment is the key driver, the PE spread portfolio should display three patterns: 1) the performance of the spread portfolio should be much stronger when sentiment is high, 2) the mispricing of the long-leg is negligible and is insensitive with investor sentiment, and 3) the mispricing of the spread portfolio is mainly from the short-leg.

Following Stambaugh, Yu, and Yuan (2012, 2015), we test the three hypotheses with the following time-series regressions:

$$R_{i,t} = a_H d_{H,t} + a_L d_{L,t} + \sum_{j=1}^{K} \beta_j F_{f,j,t} + \varepsilon_t, \tag{16}$$

where $d_{H,t}$ and $d_{L,t}$ are dummy variables indicating high and low sentiment periods, and $R_{i,t}$ is the PE spread portfolio return or its long- (short-) leg return in month t. We rely on the index of market-wide investor sentiment constructed by Baker and Wurgler (2006) and define a high (low) sentiment month if the value of the index at the end of the previous month is above (below) the median value for the 1967:01–2015:09 sample period, over which all the six factor models' returns are available.

Table 11 presents the results. Panel A considers the PE spread portfolio return as the dependent variable and shows that the performance is insensitive with investor sentiment. The average return is 0.78% (t-value = 3.17) in high sentiment periods and 0.66% (t-value = 2.83) in low sentiment periods, generating a negligible difference of 0.12% (t-value = 0.35). The risk-adjusted returns display similar patterns. For example, over the high and low sentiment periods, the FF3 alphas are 0.73% (t-value = 3.00) and 0.53% (t-value = 2.29), making the difference as small as 0.20% (t-value = 0.61).

Panel B considers the long-leg portfolio and shows a similar pattern as Panel A. The average and risk-adjusted returns are not affected by investor sentiment. However, in contrast with Stambaugh, Yu, and Yuan (2012), the performance of this long-leg portfolio is statistically significant and economic sizeable, which cannot be explained by investor sentiment with impediments to short selling. Panel C considers the short-leg portfolio and again shows that the mispricing from the extremely positive PE stocks seems unrelated with the market-wide sentiment. Although the average and risk-adjusted returns are more pronounced in high sentiment periods, the differences with those in low sentiment periods are not statistically significant. Thus, the PE reversal seems unrelated with the market-wide sentiment, and its driving source appears to be different from those anomalies explored in Stambaugh, Yu, and Yuan (2012).

6.1 Limits-to-arbitrage

This subsection explores whether the PE reversal is driven by limits-to-arbitrage (Shleifer and Vishny, 1997), which has been epitomized by Barberis and Thaler (2003) as one of the two building blocks of behavioral finance. In the literature, limits-to-arbitrage are usually related to institutional ownership, which is often used as a measure of short-sale activities. When a stock's institutional ownership is low, stock loan supply tends to be sparse, and short selling is likely to be expensive. As a result, limits-to-arbitrage are a driver of overpricing. Empirically, D'avolio (2002) shows that institutional ownership is the most important cross-sectional determinant of stock loan supply and Nagel (2005) finds that mispricing is more likely to occur in stocks with lower institutional ownership.

Limits-to-arbitrage can be also a driver of underpricing, especially for stocks with low institutional ownership. When an asset becomes severely underpriced, arbitrageurs incur large losses. To meet investor redemptions and satisfy margin requirements or leverage targets, arbitrageurs are forced to sell the asset because of lack of funding liquidity (Coval and Stafford, 2007), leading to further underpricing. Key to this mechanism is the fact that arbitrageurs cannot raise external funding whey they experience temporary losses. However, Hombert and Thesmar (2014) theoretically and empirically show that, while there are limits-to-arbitrage, institutional investors, such as hedge funds, can attenuate the effects by choosing a stronger capital structure, i.e., they do adjust their ex ante capital structure to avoid liquidating positions when their trades go against them temporarily. Thus, stocks with high institutional ownership are less likely to suffer from underpricing as they are more likely held by institution investors. Instead, stocks with low institutional ownership are more likely held be retail investors and less likely to overcome the limits-to-arbitrage.

In this paper, if the PE reversal is driven by limits-to-arbitrage, there are two implications. First, the most underpricing stocks are those with extremely low institutional ownership and low PE, whereas the most overpricing stocks would be those with extremely high institutional ownership and high PE. Second, the PE spread portfolio performance should be stronger in stocks with low institutional ownership. To test these two implications, we proxy for limits-to-arbitrage with the residual institutional ownership (IO) as in Nagel (2005).

Panel A of Table 12 reports the CAPM alphas of the 25 value-weighted portfolios formed by IO and the CAPM's PE with a sequential double sort. The results provide some support to the two implications. First, within each IO quintile, the alpha of the PE portfolio decreases in general. In the lowest IO quintile, the alpha is 0.43% (t-value $= 2.42$) for the bottom PE portfolio and is -0.15 (t-value $= -1.03$) for the top PE portfolio. In contrast, in the highest IO quintile, the corresponding alphas are -0.00 (t-value $= -0.02$) and -0.28% (t-value $= -2.40$), respectively. These results are consistent with our first implication.

Second, across the five IO quintiles, the alphas of the PE spread portfolios generally decrease, from 0.58% (t-value $= 2.51$) in the lowest IO quintile to 0.28% (t-value $= 1.26$) in the highest IO quintile, suggesting that the mispricing concentrates in the stocks with low IO, and is consistent with our second implication. Panels B to F reports the risk-adjusted returns with the other five factor models, and the results are similar with Panel A. However, across the IO quintiles, the alphas of the extremely high and low PE portfolios are still statistically and economically significant, indicating that IO can be a driver of the PE reversal, but cannot fully explain the mispricing.

6.2 Lottery demand

In behavioral finance, prospect theory is widely viewed as the best available description of how people evaluate risk in decision making, from which one implication is probability weighting. Investors do not weight outcomes by their objective probabilities, but rather by transformed probabilities, which usually overweight low probabilities and underweight high probabilities of events (Barberis, 2013). On the other hand, investors also usually suffer from a mental representation bias. They mentally represent the distribution of a stock's future returns with its past return distribution (Barberis, Mukherjee, and Wang, 2016). Combining probability weighting and mental representation, Barberis and Huang (2008) show that in a financial market where investors evaluate risk according to prospect theory, probability weighting leads to a stronger preference for lottery-like assets. Empirically, Kumar (2009) and Han and Kumar (2013) show that lottery investors generate demand for stocks with high probabilities of large short-term up moves in the stock price. Bali, Cakici, and Whitelaw (2011) show that investors are willing to pay more for stocks that exhibit extreme positive returns and find a negative relation between the maximum daily return over the past one month and expected stock returns.

In terms of this paper, with probability overweighing, there would have a disproportionately high lottery demand for high PE stocks and a low lottery demand for low PE stocks, which push the prices of such stocks up and down further, and in turn generate decreasing and increasing future returns. Thus, the PE should be negatively related to future stock returns.

Following Bali, Cakici, and Whitelaw (2011), we proxy for lottery demand with MAX, defined as the average of the 5 highest daily returns of the given stock in a given month. In Panel D of Table 6, the value-weighted MAX monotonically increases in the PE rank, ranging from 3.95% for PE1 to 7.72% for PE10, suggesting that PE10 is the portfolio with the highest lottery demand whereas PE1 is the portfolio with the lowest lottery demand. As a result, PE1 tends to be the portfolio with the most underpricing and PE10 tends to be the portfolio with the most overpricing, which is confirmed in Table 1.

To examine whether MAX fully subsumes the predictive information in PE, Table 13 reports the risk-adjusted returns of the 25 portfolios sequentially sorted by MAX and the CAPM's PE. The results show that when the benchmark models are the most recently developed factor models, FF5, HXZ, and SY, the PE portfolios are not significant in the top MAX quintile. However, in other MAX quintiles, the PE spread portfolio returns are not affected, suggesting that investors do have a preference for stocks with recent large up moves, but lottery demand seems only a partial driver of the PE reversal.

6.3 Expectation extrapolation

After exploring the non-standard preference on the PE reversal in the previous subsection, this subsection examines the effect of non-standard beliefs, i.e., situations where investors deviate from Bayes' rule in forming their beliefs. Greenwood and Shleifer (2014) study stock market return expectations and find that survey expectations of investors are highly correlated with past overall stock market returns and with the level of the stock market. Andonov and Rauh (2018) show that extrapolating past returns to future expectations exists in institutional investors in a range of asset classes, such as public equity, real assets, private equity, and hedge funds.

If investors display such an extrapolation bias, a high PE stock should have a high subjective expectation of expected returns whereas a low PE stock should have a low subjective expectation of expected returns. To test this hypothesis, we perform two exercises. The first is constructing the expectation of expected return directly. Following Weber (2018), we look at analysts implied return expectation, i.e., target price scaled by current actual price (PTP), which has been shown suffering from the extrapolation bias (Asness, Frazzini, and Pedersen, 2017).

Table 14 presents the risk-adjusted returns of the 25 portfolios sequentially sorted by PTP and the CAPM's PE. The results show that the alphas of the extremely positive PE portfolios are not significant within the bottom and top PTP quintiles. Also within the top PTP quintile, the PE spread portfolios are not significant either. The risk-adjusted returns of the PE spread portfolios decrease in the rank of PTP, providing empirical support to expectation extrapolation.

Our second exercise is about fundamental extrapolation. Bordalo, Gennaioli, La Porta, and Shleifer (2019) and Weber (2018) show that, financial analysts, as representative investors, forecast fundamentals from observed earnings growth, but tend to overreact to good news, especially on long-term earnings growth forecasts. As stock returns and earnings are generally positively correlated, stocks with extreme PE are more likely to suffer from the extrapolation bias, and therefore are those with extreme forecasts on long- term earnings growth.

Table 15 considers a double sort on LTG and PE. Again, the results are consistent with our hypothesis. The performance of the top PE portfolios reduces dramatically after controlling for LTG, and the portfolios in the top LTP quintile are not significant either.

6.4 Fama-MacBeth regressions

In this subsection, we perform Fama-MacBeth regressions to explore the three explanations simultaneously, with controls for firm specific characteristics. If the PE reversal is driven by any of the three interpretations, the regression coefficient on the PE will be not significant while controlling for the variable of interest.

Since the sample periods vary dramatically with different variables, we report the results in Table 16 by restricting the sample period to 1999:04–2016:12, over which all explanatory variables have non-missing observations. The results using all available data regression by regression are reported in Table A10 and quantitatively similar as Table 16.

In general, Table 16 makes two statements. First, the predictive power of the PE cannot be explained by limits-to-arbitrage, lottery demand, and extrapolation, and it is statistically significant and economically sizeable. For example, the coefficient of PE is -0.53% (t-value $= -3.29$) without controlling for explanatory variables weakly drops in magnitude to -0.40% (t-value $= -2.87$) with controlling for all explanatory variables. Economically, the regression coefficients can be interpreted as monthly returns on the long-sort strategy of trading on PE that is orthogonal to other explanatory variables, and are comparable with the spread portfolio returns in Table 1. The t-values are proportional to the Sharpe ratios of the spread portfolio, which equals to the annualized Sharpe ratio times $\sqrt{T}$, the number of years in the sample ($T = 17$ is this table). So the t-value of -2.87 in the last column that controls for all variables suggests that an investor by investing in PE can earn an annualized Sharpe ratio of 0.70 (i.e., $2.87/\sqrt{17}$), more than double of the market Sharpe ratio in this period, 0.33.

Second, the short-term reversal becomes insignificant or even significantly positive after controlling for the PE reversal, suggesting that the PE is actually the driver of the usually documented short-term reversal. In sum, Table 16 confirms the previous subsections that the PE reversal is partially driven but beyond the limits-to-arbitrage, lottery demand, and expectation extrapolation.

7 Conclusions

In this paper, we examine the pricing errors of three types of factor models: a) six well known ones—the CAPM, the Fama-French three-factor model, the Carhart four-factor model, the Fama-French five-factor model, the Hou-Xue-Zhang Q-factor model, and the Stambaugh-Yuan mispricing-factor model; b) principal component factors based on sixty two anomalies; c) K-factor models that price target assets exactly. We find that there is a systematic PE reversal pattern for all of the models. A spread portfolio that buys stocks in the bottom PE decile and sells stocks in the top PE decile earns abnormal profits across the models, implying that none of them is adequate in explaining the cross section of stock returns. Our results suggest that we need more or better factors.

To explain our finding, we explore three channels: limits-to-arbitrage, lottery preference, and expectation extrapolation, and find that they only partially explain the PE reversal patten. The failure of current factor models calls for identifying new factors, with perhaps new methods, for better explaining the cross section of returns.

References

Ahn, D.-H., Conrad, J., Dittmar, R. F., 2009. Basis assets. Review of Financial Studies 22, 5133–5174.

Andonov, A., Rauh, J. D., 2018. The return expectations of institutional investors. Working paper.

Ang, A., Hodrick, R. J., Xing, Y., Zhang, X., 2006. The cross-section of volatility and expected returns. Journal of Finance 61, 259–299.

Asness, C. S., Frazzini, A., Pedersen, L. H., 2017. Quality minus junk. Working paper.

Baker, M., Wurgler, J., 2006. Investor sentiment and the cross-section of stock returns. Journal of Finance 61, 1645–1680.

Bali, T. G., Cakici, N., Whitelaw, R. F., 2011. Maxing out: Stocks as lotteries and the cross-section of expected returns. Journal of Financial Economics 99, 427–446.

Balvers, R. J., Stivers, A., 2018. Efficient factor selection: Explaining risk and mean returns jointly. Working paper.

Barberis, N., Huang, M., 2008. Stocks as lotteries: The implications of probability weighting for security prices. American Economic Review 98, 2066–2100.

Barberis, N., Mukherjee, A., Wang, B., 2016. Prospect theory and stock returns: An empirical test. Review of Financial Studies 29, 3068–3107.

Barberis, N., Thaler, R., 2003. A survey of behavioral finance. Handbook of the Economics of Finance 1, 1053–1128.

Barberis, N. C., 2013. Thirty years of prospect theory in economics: A review and assessment. Journal of Economic Perspectives 27, 173–96.

Bordalo, P., Gennaioli, N., La Porta, R., Shleifer, A., 2019. Diagnostic expectations and stock returns. Journal of Finance, forthcoming.

Carhart, M. M., 1997. On persistence in mutual fund performance. Journal of Finance 52, 57–82.

Chordia, T., Goyal, A., Saretto, A., 2018. p-hacking: Evidence from two million trading strategies. Working paper.

Cochrane, J., 2005. Asset pricing. Princeton University Press.

Coval, J., Stafford, E., 2007. Asset fire sales (and purchases) in equity markets. Journal of Financial Economics 86, 479–512.

D'avolio, G., 2002. The market for borrowing stock. Journal of Financial Economics 66, 271–306.

De Bondt, W. F., Thaler, R., 1985. Does the stock market overreact? Journal of Finance 40, 793–805.

Fama, E. F., French, K. R., 1993. Common risk factors in the returns on stocks and bonds. Journal of Financial Economics 33, 3–56.

Fama, E. F., French, K. R., 2015. A five-factor asset pricing model. Journal of Financial Economics 116, 1–22.

Gibbons, M. R., Ross, S. A., Shanken, J., 1989. A test of the efficiency of a given portfolio. Econometrica 29, 1121–1152.

Green, J., Hand, J. R. M., Zhang, X. F., 2017. The characteristics that provide independent information about average u.s. monthly stock returns. Review of Financial Studies 30, 4389–4436.

Greenwood, R., Shleifer, A., 2014. Expectations of returns and expected returns. Review of Financial Studies 27, 714–746.

Han, B., Kumar, A., 2013. Speculative retail trading and asset prices. Journal of Financial and Quantitative Analysis 48, 377–404.

Harvey, C. R., Liu, Y., 2018. Lucky factors. Working paper.

Harvey, C. R., Liu, Y., Zhu, H., 2016. ... and the cross-section of expected returns. Review of Financial Studies 29, 5–68.

Hombert, J., Thesmar, D., 2014. Overcoming limits of arbitrage: Theory and evidence. Journal of Financial Economics 111, 26–44.

Hou, K., Xue, C., Zhang, L., 2015. Digesting anomalies: An investment approach. Review of Financial Studies 28, 650–705.

Hou, K., Xue, C., Zhang, L., 2019. Replicating anomalies. Review of Financial Studies, forthcoming.

Huang, D., Li, J., Zhou, G., 2018. Shrinking factor dimension: A reduced-rank approach. Working paper.

Huberman, G., Kandel, S., 1987. Mean-variance spanning. Journal of Finance 42, 873–888.

Jegadeesh, N., 1990. Evidence of predictable behavior of security returns. Journal of finance 45, 881–898.

Kan, R., Zhou, G., 2012. Tests of mean-variance spanning. Annals of Economics & Finance 13, 139–187.

Kozak, S., Nagel, S., Santosh, S., 2019. Shrinking the cross section. Journal of Financial Economics, forthcoming.

Kumar, A., 2009. Who gambles in the stock market? Journal of Finance 64, 1889–1933.

Lehmann, B. N., 1990. Fads, martingales, and market efficiency. Quarterly Journal of Economics 105, 1–28.

Lewellen, J., 2011. Institutional investors and the limits of arbitrage. Journal of Financial Economics 102, 62–80.

Lintner, J., 1965. The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets. Review of Economics and Statistics 47, 13–37.

Lo, A. W., MacKinlay, A. C., 1990. When are contrarian profits due to stock market overreaction? Review of Financial Studies 3, 175–205.

McLean, R. D., Pontiff, J., 2016. Does academic research destroy stock return predictability? Journal of Finance 71, 5–32.

Nagel, S., 2005. Short sales, institutional investors and the cross-section of stock returns. Journal of Financial Economics 78, 277–309.

Pontiff, J., 2006. Costly arbitrage and the myth of idiosyncratic risk. Journal of Accounting and Economics 42, 35–52.

Sharpe, W. F., 1964. Capital asset prices: A theory of market equilibrium under conditions of risk. Journal of Finance 19, 425–442.

Shleifer, A., Vishny, R. W., 1997. The limits of arbitrage. Journal of Finance 52, 35–55.

Shumway, T., 1997. The delisting bias in CRSP data. Journal of Finance 52, 327–340.

Stambaugh, R. F., Yu, J., Yuan, Y., 2012. The short of it: Investor sentiment and anomalies. Journal of Financial Economics 104, 288–302.

Stambaugh, R. F., Yu, J., Yuan, Y., 2015. Arbitrage asymmetry and the idiosyncratic volatility puzzle. Journal of Finance 70, 1903–1948.

Stambaugh, R. F., Yuan, Y., 2017. Mispricing factors. Review of Financial Studies 30, 1270–1315.

Weber, M., 2018. Cash flow duration and the term structure of equity returns. Journal of Financial Economics 128, 486–503.

Table 1: Pricing error (PE) decile portfolios of known factor models

This table reports the average returns of the PE decile portfolios (Newey-West t-values in parentheses), where the PE of each stock is calculated based on the CAPM, FF3 (Fama and French, 1993), FFC (Carhart, 1997), FF5 (Fama and French, 2015), HXZ (Hou, Xue, and Zhang, 2015), and SY (Stambaugh and Yuan, 2017) models, respectively. Given a factor model, each month we calculate the PE for each stock using its past 60-month returns with a minimum of 50 observations, and form value-weighted decile portfolios in an ascending order of PE. The sample period ends in 2016:12 for all portfolios, but starts differently, from 1931:02 for the CAPM and FF3's PE portfolios, 1931:03 for the FFC's PE portfolios, 1967:09 for the FF5's PE portfolios, 1971:03 for the HXZ's PE portfolios, and 1967:03 for the SY's PE portfolios, respectively.

Model	PE1	PE2	PE3	PE4	PE5	PE6	PE7	PE8	PE9	PE10	PE1-10
CAPM	0.98	0.85	0.85	0.81	0.73	0.73	0.75	0.60	0.49	0.25	0.74
	(5.33)	(4.65)	(4.65)	(4.37)	(3.92)	(4.18)	(3.99)	(3.13)	(2.64)	(1.34)	(5.90)
FF3	0.97	0.90	0.91	0.89	0.84	0.66	0.60	0.55	0.43	0.17	0.80
	(5.30)	(4.93)	(4.82)	(5.01)	(4.33)	(3.87)	(3.11)	(2.83)	(2.43)	(0.91)	(6.70)
FFC	0.94	0.87	0.91	0.85	0.75	0.69	0.59	0.60	0.46	0.18	0.76
	(5.08)	(4.52)	(5.01)	(4.76)	(3.79)	(3.84)	(3.20)	(3.10)	(2.48)	(0.96)	(6.22)
FF5	0.89	0.83	0.80	0.71	0.56	0.47	0.32	0.28	0.25	0.09	0.80
	(3.94)	(4.13)	(4.13)	(3.45)	(2.77)	(2.22)	(1.56)	(1.37)	(1.29)	(0.45)	(5.17)
HXZ	0.87	0.78	0.78	0.70	0.68	0.49	0.43	0.38	0.36	0.20	0.67
	(3.77)	(3.68)	(3.79)	(3.28)	(3.15)	(2.41)	(2.08)	(1.83)	(1.79)	(1.02)	(4.17)
SY	0.80	0.85	0.76	0.61	0.53	0.48	0.43	0.43	0.26	0.10	0.70
	(3.58)	(4.28)	(3.55)	(2.95)	(2.55)	(2.47)	(2.14)	(2.16)	(1.45)	(0.51)	(4.76)

Table 2: Pricing error (PE) decile portfolios of PCA factors extracted from 70 factor proxies

This table reports the average returns of the PE decile portfolios (Newey-West t-values in parentheses), where the PE of each stock is calculated based on K PCA factors, which are extracted from 70 factor proxies (including the market) in Huang, Li, and Zhou (2018). Given a factor model, each month we calculate the PE for each stock using its past 60-month returns with a minimum of 50 observations, and form value-weighted decile portfolios in an ascending order of PE. The sample period is 1978:03-2016:12.

Model	PE1	PE2	PE3	PE4	PE5	PE6	PE7	PE8	PE9	PE10	PE1-10
$K=1$	1.02	0.98	0.91	0.87	0.70	0.76	0.75	0.56	0.47	0.16	0.86
	(3.95)	(4.32)	(4.15)	(3.96)	(3.28)	(3.50)	(3.50)	(2.67)	(2.14)	(0.71)	(4.54)
$K=3$	1.15	1.09	0.97	0.95	0.69	0.73	0.60	0.42	0.36	0.09	1.06
	(4.75)	(4.96)	(4.60)	(4.27)	(3.14)	(3.35)	(2.78)	(1.81)	(1.60)	(0.44)	(6.64)
$K=5$	1.18	1.13	0.94	0.82	0.78	0.70	0.65	0.36	0.33	0.11	1.07
	(4.88)	(5.12)	(4.33)	(3.72)	(3.51)	(3.34)	(2.82)	(1.60)	(1.54)	(0.49)	(6.85)
$K=10$	1.18	1.13	0.89	0.69	0.83	0.76	0.64	0.51	0.20	0.10	1.09
	(4.88)	(5.19)	(4.12)	(3.29)	(3.79)	(3.57)	(2.90)	(2.30)	(0.88)	(0.43)	(6.60)
$K=15$	1.20	1.09	0.94	0.74	0.85	0.67	0.62	0.46	0.37	0.06	1.14
	(4.98)	(5.02)	(4.59)	(3.31)	(4.09)	(3.13)	(2.94)	(2.13)	(1.61)	(0.26)	(6.85)
$K=20$	1.20	1.02	0.95	0.77	0.70	0.59	0.58	0.63	0.34	0.19	1.00
	(4.98)	(4.70)	(4.27)	(3.65)	(3.47)	(2.46)	(2.67)	(2.90)	(1.62)	(0.86)	(5.76)

Table 3: Pricing error decile portfolios of PCA factors extracted from 100 basis portfolios

This table reports the average returns of the PE decile portfolios (Newey-West t-values in parentheses), where the PE of each stock is calculated based on K PCA factors extracted from 100 basis portfolios constructed via cluster analysis (Ahn et al., 2009). Given a factor model, each month we calculate the PE for each stock using its past 60-month returns with a minimum of 50 observations, and form value-weighted decile portfolios in an ascending order of PE. The sample period is 1931:02-2016:12 for all portfolios.

Model	PE1	PE2	PE3	PE4	PE5	PE6	PE7	PE8	PE9	PE10	PE1-10
$K = 3$	0.95	0.96	0.77	0.75	0.86	0.63	0.70	0.62	0.52	0.20	0.75
	(4.92)	(5.30)	(4.11)	(3.85)	(4.87)	(3.47)	(3.67)	(3.50)	(2.75)	(1.08)	(6.46)
$K = 5$	0.98	0.93	0.92	0.77	0.79	0.61	0.63	0.57	0.47	0.26	0.73
	(5.23)	(5.21)	(4.89)	(4.26)	(4.51)	(3.28)	(3.36)	(3.16)	(2.61)	(1.41)	(6.56)
$K = 10$	0.99	1.00	0.90	0.78	0.72	0.72	0.63	0.49	0.46	0.28	0.71
	(4.80)	(5.54)	(5.20)	(4.31)	(3.86)	(3.77)	(3.59)	(2.88)	(2.53)	(1.53)	(6.32)
$K = 15$	0.90	1.00	0.83	0.80	0.73	0.72	0.76	0.53	0.41	0.30	0.60
	(4.71)	(5.38)	(4.55)	(4.49)	(4.15)	(4.01)	(4.16)	(2.87)	(2.28)	(1.49)	(4.78)
$K = 20$	0.93	0.93	0.91	0.80	0.84	0.70	0.64	0.54	0.46	0.30	0.63
	(4.75)	(4.91)	(5.02)	(4.35)	(4.74)	(3.89)	(3.62)	(2.97)	(2.48)	(1.61)	(6.02)

Table 4: The absolute value of PEs

This table reports the average of the absolute value of PEs in Table 1, Table 2, and Table 3.

known factor models		PCA on factor proxies		PCA on basis portfolios	
Model	average(PE)	Model	average(PE)	Model	average(PE)
CAPM	0.7585	$K = 1$	0.7536	$K = 1$	0.7611
FF3	0.7630	$K = 3$	0.7602	$K = 3$	0.7606
FFC	0.7625	$K = 5$	0.7600	$K = 5$	0.7639
FF5	0.7637	$K = 10$	0.7585	$K = 10$	0.7672
HXZ	0.7606	$K = 15$	0.7579	$K = 15$	0.7606
SY	0.7674	$K = 20$	0.7588	$K = 20$	0.7596

Table 5: Alphas of PE decile portfoliosp

This table reports the alphas of the PE decile portfolios (Newey-West t-values in parentheses), where the factor models include CAPM, FF3 (Fama and French, 1993), FFC (Carhart, 1997), FF5 (Fama and French, 2015), HXZ (Hou, Xue, and Zhang, 2015), and SY (Stambaugh and Yuan, 2017). Given a factor model, each month we calculate the PE for each stock using its past 60-month returns with a minimum of 50 observations, and form value-weighted decile portfolios in an ascending order of PE. PE_{CAPM} refers to the PE of CAPM, and PE_{FF3} to the PE of FF3, etc. The sample period ends in 2016:12 for all portfolios, but starts differently, from 1931:02 for the PE_{CAPM} and PE_{FF3} portfolios, 1931:03 for the PE_{FFC4} portfolios, 1967:09 for the PE_{FF5} portfolios, 1971:03 for the PE_{Q4} portfolios, and 1967:03 for the PE_{M4} portfolios, respectively.

	PE1	PE2	PE3	PE4	PE5	PE6	PE7	PE8	PE9	PE10	PE1-10
Panel A: Portfolios sorted by PE_{CAPM}											
CAPM alpha	0.32	0.16	0.17	0.14	0.06	0.06	0.07	−0.08	−0.19	−0.41	0.72
	(4.19)	(2.57)	(2.90)	(2.31)	(1.11)	(1.10)	(1.25)	(−1.37)	(−3.40)	(−5.10)	(6.12)
FF3 alpha	0.34	0.15	0.15	0.13	0.07	0.05	0.06	−0.11	−0.21	−0.44	0.79
	(4.43)	(2.52)	(2.60)	(2.07)	(1.33)	(0.92)	(1.10)	(−1.86)	(−3.72)	(−5.18)	(6.14)
FFC alpha	0.45	0.20	0.14	0.13	0.02	0.09	0.06	−0.13	−0.22	−0.47	0.92
	(5.50)	(3.09)	(2.10)	(2.25)	(0.34)	(1.37)	(1.01)	(−2.09)	(−3.47)	(−5.74)	(6.93)
FF5 alpha	0.29	0.16	0.19	0.04	0.02	0.04	0.02	−0.07	−0.21	−0.38	0.67
	(2.70)	(1.90)	(2.41)	(0.65)	(0.25)	(0.62)	(0.29)	(−0.90)	(−2.98)	(−4.23)	(4.08)
HXZ alpha	0.37	0.20	0.21	0.04	0.01	0.00	−0.02	−0.08	−0.21	−0.41	0.78
	(3.19)	(2.02)	(2.28)	(0.53)	(0.09)	(0.01)	(−0.22)	(−0.95)	(−2.56)	(−3.98)	(4.20)
SY alpha	0.50	0.29	0.22	0.08	0.02	0.07	−0.01	−0.15	−0.28	−0.50	1.00
	(4.73)	(3.82)	(2.37)	(1.12)	(0.29)	(0.75)	(−0.11)	(−2.08)	(−3.69)	(−5.03)	(5.84)
Panel B: Portfolios sorted by PE_{FF3}											
CAPM alpha	0.31	0.22	0.23	0.23	0.16	0.00	−0.09	−0.15	−0.22	−0.49	0.80
	(4.00)	(3.62)	(3.79)	(4.18)	(2.91)	(0.03)	(−1.69)	(−2.88)	(−4.10)	(−6.50)	(7.02)
FF3 alpha	0.34	0.23	0.23	0.22	0.15	0.01	−0.11	−0.19	−0.24	−0.51	0.85
	(4.41)	(3.83)	(3.55)	(3.90)	(2.56)	(0.12)	(−1.98)	(−3.33)	(−4.63)	(−6.79)	(7.15)
FFC alpha	0.43	0.24	0.21	0.19	0.17	−0.01	−0.14	−0.14	−0.24	−0.54	0.97
	(5.25)	(3.42)	(3.49)	(3.23)	(2.82)	(−0.22)	(−2.37)	(−2.22)	(−4.33)	(−7.25)	(7.93)
FF5 alpha	0.29	0.25	0.18	0.23	0.07	0.01	−0.12	−0.18	−0.29	−0.48	0.77
	(3.03)	(3.24)	(2.48)	(3.71)	(0.87)	(0.13)	(−1.76)	(−2.85)	(−4.68)	(−5.48)	(5.22)
HXZ alpha	0.38	0.29	0.20	0.26	0.04	−0.05	−0.21	−0.17	−0.31	−0.50	0.88
	(3.68)	(3.05)	(2.51)	(3.73)	(0.49)	(−0.64)	(−2.67)	(−2.39)	(−4.26)	(−5.05)	(5.47)
SY alpha	0.52	0.31	0.18	0.22	0.07	0.01	−0.20	−0.20	−0.30	−0.52	1.05
	(5.36)	(3.59)	(2.22)	(3.08)	(0.91)	(0.17)	(−2.53)	(−2.94)	(−4.23)	(−5.30)	(6.24)
Panel C: Portfolios sorted by PE_{FFC4}											
CAPM alpha	0.28	0.18	0.25	0.20	0.06	0.04	−0.07	−0.09	−0.21	−0.47	0.74
	(3.62)	(3.28)	(4.17)	(3.38)	(1.20)	(0.71)	(−1.26)	(−1.59)	(−4.12)	(−6.10)	(6.31)
FF3 alpha	0.30	0.18	0.26	0.21	0.05	0.04	−0.07	−0.14	−0.23	−0.50	0.80
	(3.99)	(3.35)	(4.17)	(3.35)	(0.91)	(0.75)	(−1.33)	(−2.36)	(−4.46)	(−6.56)	(6.52)
FFC alpha	0.37	0.22	0.23	0.17	0.07	0.01	−0.07	−0.07	−0.23	−0.52	0.89
	(4.35)	(3.58)	(3.65)	(2.77)	(1.13)	(0.16)	(−1.17)	(−1.11)	(−4.31)	(−6.95)	(6.96)
FF5 alpha	0.23	0.18	0.27	0.13	0.04	−0.00	−0.11	−0.13	−0.28	−0.46	0.70
	(2.57)	(2.45)	(3.50)	(2.19)	(0.76)	(−0.01)	(−1.71)	(−2.01)	(−4.52)	(−5.34)	(4.71)
HXZ alpha	0.31	0.21	0.28	0.15	0.03	−0.04	−0.17	−0.12	−0.29	−0.48	0.80
	(3.16)	(2.50)	(3.12)	(2.29)	(0.41)	(−0.46)	(−2.38)	(−1.72)	(−4.06)	(−4.84)	(4.89)
SY alpha	0.41	0.26	0.23	0.12	0.09	−0.06	−0.12	−0.13	−0.30	−0.51	0.92
	(4.12)	(3.42)	(2.60)	(1.79)	(1.22)	(−0.73)	(−1.64)	(−1.72)	(−4.04)	(−5.28)	(5.53)

Table 5 (continued)

	PE1	PE2	PE3	PE4	PE5	PE6	PE7	PE8	PE9	PE10	PE1-10
Panel D: Portfolios sorted by PE_{FF5}											
CAPM alpha	0.38	0.33	0.32	0.22	0.08	−0.02	−0.17	−0.19	−0.21	−0.37	0.74
	(3.47)	(3.93)	(5.04)	(3.22)	(1.24)	(−0.27)	(−2.70)	(−2.69)	(−3.53)	(−4.24)	(4.71)
FF3 alpha	0.34	0.30	0.31	0.21	0.05	−0.04	−0.17	−0.20	−0.23	−0.38	0.72
	(3.08)	(3.68)	(4.81)	(3.21)	(0.85)	(−0.71)	(−2.74)	(−2.74)	(−3.69)	(−4.22)	(4.29)
FFC alpha	0.48	0.35	0.32	0.21	0.04	−0.07	−0.17	−0.22	−0.25	−0.43	0.91
	(4.67)	(4.12)	(4.01)	(3.02)	(0.55)	(−1.01)	(−2.74)	(−2.81)	(−3.90)	(−4.50)	(5.36)
FF5 alpha	0.27	0.24	0.27	0.16	0.02	−0.07	−0.20	−0.22	−0.27	−0.40	0.67
	(2.53)	(3.24)	(3.92)	(2.04)	(0.35)	(−1.05)	(−3.10)	(−3.02)	(−4.16)	(−4.59)	(4.36)
HXZ alpha	0.33	0.28	0.30	0.17	−0.02	−0.08	−0.19	−0.22	−0.30	−0.41	0.74
	(3.34)	(3.39)	(3.57)	(1.97)	(−0.24)	(−1.16)	−2.73)	(−2.91)	(−4.29)	(−4.13)	(4.78)
SY alpha	0.48	0.31	0.28	0.13	−0.01	−0.05	−0.21	−0.29	−0.29	−0.41	0.89
	(4.49)	(3.68)	(3.18)	(1.63)	(−0.20)	(−0.73)	(−3.10)	(−3.50)	(−3.84)	(−4.27)	(5.18)
Panel E: Portfolios sorted by PE_{Q4}											
CAPM alpha	0.31	0.24	0.26	0.16	0.14	−0.02	−0.08	−0.13	−0.15	−0.29	0.60
	(2.82)	(2.87)	(3.49)	(2.09)	(2.09)	(−0.32)	(−1.41)	(−1.89)	(−2.35)	(−3.24)	(3.63)
FF3 alpha	0.26	0.22	0.25	0.14	0.13	−0.04	−0.09	−0.13	−0.16	−0.33	0.59
	(2.42)	(2.58)	(3.49)	(1.74)	(1.93)	(−0.66)	(−1.54)	(−1.86)	(−2.53)	(−3.54)	(3.42)
FFC alpha	0.43	0.27	0.23	0.10	0.13	−0.05	−0.12	−0.13	−0.19	−0.39	0.81
	(3.64)	(3.00)	(2.83)	(1.16)	(1.69)	(−0.66)	(−2.02)	(−1.54)	(−2.85)	(−3.70)	(4.18)
FF5 alpha	0.22	0.16	0.24	0.08	0.08	−0.10	−0.13	−0.18	−0.22	−0.36	0.58
	(2.12)	(1.68)	(3.10)	(0.95)	(1.19)	(−1.53)	(−1.96)	(−2.44)	(−3.40)	(−3.72)	(3.39)
HXZ alpha	0.29	0.17	0.28	0.06	0.07	−0.10	−0.14	−0.18	−0.23	−0.38	0.67
	(2.66)	(1.70)	(3.21)	(0.68)	(0.92)	(−1.36)	(−2.19)	(−2.09)	(−3.52)	(−3.65)	(3.71)
SY alpha	0.45	0.27	0.20	0.08	0.05	−0.09	−0.19	−0.16	−0.26	−0.42	0.87
	(3.88)	(2.80)	(2.28)	(0.82)	(0.70)	(−1.12)	(−2.73)	(−1.90)	(−3.63)	(−3.93)	(4.55)
Panel F: Portfolios sorted by PE_{M4}											
CAPM alpha	0.26	0.34	0.24	0.11	0.02	−0.00	−0.06	−0.04	−0.20	−0.37	0.63
	(2.80)	(4.49)	(3.67)	(1.77)	(0.48)	(−0.03)	(−0.91)	(−0.54)	(−3.08)	(−4.24)	(4.25)
FF3 alpha	0.21	0.34	0.22	0.10	0.02	0.01	−0.06	−0.07	−0.24	−0.40	0.61
	(2.06)	(4.40)	(3.45)	(1.48)	(0.37)	(0.11)	(−0.85)	(−0.94)	(−3.45)	(−4.70)	(3.83)
FFC alpha	0.34	0.40	0.23	0.10	−0.02	−0.01	−0.07	−0.08	−0.25	−0.46	0.80
	(2.92)	(5.01)	(3.19)	(1.40)	(−0.27)	(−0.11)	(−1.13)	(−1.06)	(−3.07)	(−5.01)	(4.48)
FF5 alpha	0.21	0.30	0.20	0.04	−0.06	−0.04	−0.07	−0.12	−0.32	−0.42	0.63
	(2.05)	(3.57)	(3.02)	(0.64)	(−0.93)	(−0.65)	(−1.09)	(−1.73)	(−4.78)	(−4.94)	(3.98)
HXZ alpha	0.30	0.35	0.24	0.07	−0.08	−0.07	−0.11	−0.15	−0.35	−0.45	0.75
	(2.55)	(3.63)	(3.11)	(0.87)	(−1.12)	(−0.98)	(−1.54)	(−2.05)	(−4.48)	(−5.01)	(4.48)
SY alpha	0.41	0.37	0.22	0.10	−0.07	−0.04	−0.09	−0.16	−0.37	−0.49	0.90
	(3.83)	(4.43)	(2.73)	(1.24)	(−0.89)	(−0.64)	(−1.33)	(−2.11)	(−4.42)	(−5.18)	(5.26)

Table 6: Characteristics of PE spread portfolios

Panel A reports the descriptive statistics of the PE spread portfolios, Panel B reports their correlations, Panel C reports the subsample average returns and the associated t-values that test whether the average returns are different from zero, and Panel D reports firm characteristics of the CAPM's PE decile portfolios. All portfolios and firm characteristics are value-weighted. PE_{CAPM} refers to the spread portfolio based on the CAPM pricing error, and PE_{FF3} to the spread portfolio based on the FF3 pricing error, etc. STR, MOM, and LTR are the short-term reversal, momentum, and long-term reversal returns at portfolio formation. log(ME) is log market capitalization, IVOL is idiosyncratic volatility, MAX is lottery demand (Bali, Cakici, and Whitelaw, 2011), IO is residual institutional ownership (Nagel, 2005), PTP is analysts' consensus price target scaled by current price, and LTG is analysts' long-term growth forecast on earnings. The sample period is the same as Table 1.

Panel A: Descriptive statistics

Portfolio	Mean	Std	Sharpe ratio	Skew	Kurt	Min	Median	Max
PE_{CAPM}	0.74	4.15	0.18	−0.27	6.92	−30.22	0.70	25.22
PE_{FF3}	0.80	3.93	0.20	−0.13	5.46	−25.18	0.82	22.64
PE_{FFC4}	0.76	3.80	0.20	−0.05	5.83	−24.75	0.73	24.96
PE_{FF5}	0.80	3.73	0.22	0.22	2.99	−16.75	0.72	18.40
PE_{Q4}	0.67	3.84	0.18	0.46	2.23	−13.03	0.48	17.67
PE_{M4}	0.70	3.63	0.19	0.16	1.47	−12.83	0.63	14.63

Panel B: Correlations

Portfolio	PE_{CAPM}	PE_{FF3}	PE_{FFC4}	PE_{FF5}	PE_{Q4}	PE_{M4}
PE_{CAPM}	1.00	0.84	0.79	0.78	0.80	0.79
PE_{FF3}		1.00	0.93	0.91	0.87	0.80
PE_{FFC4}			1.00	0.81	0.81	0.81
PE_{FF5}				1.00	0.88	0.75
PE_{Q4}					1.00	0.82
PE_{M4}						1.00

Panel C: Subsample average returns

Portfolio	January		Non-January		1931–1960		1961–1990		1991–2016	
	Mean	t-stat	Mean	t-stat	Mean	t-stat	Mean	t-stat	Mean	t-stat
PE_{CAPM}	2.00	4.06	0.62	4.94	0.74	3.21	0.72	3.64	0.76	3.44
PE_{FF3}	1.62	3.45	0.73	6.14	0.63	2.90	0.83	4.88	0.97	4.16
PE_{FFC4}	1.36	2.89	0.71	5.97	0.64	2.79	0.74	4.87	0.93	3.70
PE_{FF5}	1.18	1.99	0.77	4.88	–	–	0.75	3.71	0.85	3.65
PE_{Q4}	1.59	2.31	0.59	3.69	–	–	0.60	2.85	0.73	3.10
PE_{M4}	1.75	2.60	0.61	4.08	–	–	0.81	4.23	0.60	2.73

Panel D: PE_{CAPM} firm characteristics at portfolio formation

	PE	STR (%)	MOM (%)	LTR (%)	log(ME)	IVOL (%)	MAX (%)	IO (%)	PTP (%)	LTG (%)
PE1	−1.59	−10.72	1.47	1.48	12.33	1.83	3.95	53.76	11.32	14.08
PE2	−0.94	−6.20	1.55	1.47	12.20	1.63	4.07	53.04	8.02	14.27
PE3	−0.63	−3.80	1.53	1.46	12.14	1.60	4.23	52.50	5.97	14.21
PE4	−0.39	−1.83	1.51	1.41	12.11	1.58	4.35	52.26	9.41	14.17
PE5	−0.17	0.09	1.46	1.38	12.11	1.58	4.52	52.33	10.33	14.03
PE6	0.05	2.01	1.42	1.35	12.14	1.60	4.70	52.53	5.26	13.92
PE7	0.28	4.00	1.40	1.30	12.17	1.63	4.92	52.87	7.85	13.86
PE8	0.57	6.35	1.35	1.24	12.24	1.67	5.22	53.29	5.09	13.69
PE9	0.96	9.53	1.30	1.18	12.28	1.77	5.71	53.55	3.27	13.67
PE10	1.86	17.83	1.10	1.07	12.22	2.22	7.72	52.09	8.68	13.40

Table 7: Difference between PE spread portfolios

This table reports the difference in average return (Panel A) and FF3 alpha (Panel B) between PE spread portfolios, with p-value in parenthesis. The value in (i, j) corresponds to the difference between the PE_i spread portfolio and the PE_j spread portfolio, where i and j denote factor models i and j. PE_{CAPM} refers to the spread portfolio based on the CAPM pricing error, and PE_{FF3} to the spread portfolio based on the FF3 pricing error, etc. The sample period is 1971:03–2016:12 for all portfolios.

Panel A: Difference in average return

	Mean difference					
	PE_{CAPM}	PE_{FF3}	PE_{FFC4}	PE_{FF5}	PE_{Q4}	PE_{M4}
PE_{CAPM}	–	−0.14	−0.09	−0.07	0.01	0.04
		(0.22)	(0.45)	(0.53)	(0.94)	(0.69)
PE_{FF3}		–	0.05	0.06	0.15	0.18
			(0.50)	(0.35)	(0.09)	(0.09)
PE_{FFC4}			–	0.02	0.10	0.13
				(0.86)	(0.33)	(0.19)
PE_{FF5}				–	0.08	0.12
					(0.32)	(0.31)
PE_{Q4}					–	0.03
						(0.72)
PE_{M4}						–

Panel B: Difference in FF3 alpha

	Alpha difference					
	PE_{CAPM}	PE_{FF3}	PE_{FFC4}	PE_{FF5}	PE_{Q4}	PE_{M4}
PE_{CAPM}	–	−0.13	−0.07	−0.08	−0.01	0.05
		(0.23)	(0.58)	(0.49)	(0.95)	(0.61)
PE_{FF3}		–	0.06	0.05	0.12	0.18
			(0.35)	(0.46)	(0.15)	(0.08)
PE_{FFC4}			–	−0.01	0.06	0.12
				(0.88)	(0.56)	(0.23)
PE_{FF5}				–	0.07	0.14
					(0.38)	(0.24)
PE_{Q4}					–	0.06
						(0.51)
PE_{M4}						–

Table 8: FF3 alphas of portfolios sorted by return reversal and PE_{CAPM}

This table reports the FF3 alphas of the 25 value-weighted portfolios sorted by short- or long-term reversal and PE (Newey-West *t*-values in parentheses), where the short-term reversal is measured by the prior (1-1) return (STR), and the long-term reversal is measured by the prior (13-60) return (LTR). PE_{CAPM} is the CAPM pricing error estimated with the past 60-month returns with a minimum of 50 observations. The sample period is 1931:02–2016:12.

Panel A: Sort on STR and PE_{CAPM}

	PE1	PE2	PE3	PE4	PE5	PE1-5
STR1	0.34	0.24	0.00	0.07	−0.10	0.44
	(3.20)	(2.31)	(0.01)	(0.65)	(−0.79)	(3.19)
STR2	0.31	0.12	0.14	−0.14	−0.22	0.53
	(4.01)	(1.74)	(1.55)	(−1.51)	(−1.84)	(3.49)
STR3	0.29	0.09	−0.00	−0.08	−0.15	0.44
	(3.73)	(1.03)	(−0.00)	(−1.19)	(−1.83)	(3.55)
STR4	0.18	0.03	0.10	−0.21	−0.20	0.37
	(1.57)	(0.29)	(1.12)	(−2.56)	(−2.63)	(2.55)
STR5	0.00	−0.19	−0.25	−0.41	−0.69	0.69
	(0.02)	(−1.66)	(−2.68)	(−4.27)	(−6.12)	(3.98)
All stocks	0.26	0.05	0.03	−0.15	−0.18	0.44
	(5.40)	(1.28)	(0.74)	(−3.83)	(−3.13)	(4.92)

Panel B: Sort on LTR and PE_{CAPM}

	PE1	PE2	PE3	PE4	PE5	PE1-5
LTR1	0.19	0.26	0.10	−0.19	−0.30	0.49
	(1.34)	(2.35)	(1.01)	(−1.87)	(−2.67)	(2.84)
LTR2	0.24	0.19	0.20	−0.07	−0.20	0.43
	(2.13)	(2.18)	(2.15)	(−0.83)	(−1.89)	(3.29)
LTR3	0.40	0.10	−0.08	−0.08	−0.18	0.58
	(3.99)	(1.20)	(−1.02)	(−0.93)	(−1.95)	(4.37)
LTR4	0.13	0.19	−0.11	0.07	−0.32	0.46
	(1.29)	(1.78)	(−1.18)	(0.79)	(−3.00)	(2.74)
LTR5	0.07	−0.09	−0.11	−0.07	−0.17	0.24
	(0.60)	(−0.73)	(−1.06)	(−0.62)	(−1.46)	(1.44)
All stocks	0.26	0.15	0.01	−0.04	−0.22	0.48
	(4.30)	(2.62)	(0.31)	(−0.83)	(−3.30)	(4.56)

Table 9: Alphas of portfolios sorted by IVOL and PE_{CAPM}

This table reports the alphas of the 25 value-weighted portfolios sorted by IVOL and PE_{CAPM} (Newey-West t-values in parentheses), where IVOL is estimated as Ang, Hodrick, Xing, and Zhang (2006) and PE_{CAPM} is the CAPM pricing error estimated with the past 60-month returns with a minimum of 50 observations. The factor models include CAPM, FF3, FFC, FF5, HXZ, and SY, respectively. The sample period is the same as Table 1.

	Panel A: CAPM alpha						Panel B: FF3 alpha					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
IVOL1	0.36	0.21	0.23	0.02	−0.07	0.43	0.38	0.23	0.23	0.03	−0.09	0.47
	(5.06)	(3.03)	(3.11)	(0.33)	(−0.91)	(4.07)	(5.79)	(3.58)	(3.38)	(0.51)	(−1.24)	(4.41)
IVOL2	0.41	0.07	0.01	−0.03	−0.19	0.60	0.39	0.05	−0.03	−0.05	−0.22	0.61
	(4.75)	(1.11)	(0.21)	(−0.44)	(−2.54)	(5.34)	(4.71)	(0.71)	(−0.41)	(−0.59)	(−2.97)	(5.27)
IVOL3	0.29	0.25	0.03	0.01	−0.47	0.75	0.24	0.19	−0.03	−0.09	−0.52	0.76
	(3.23)	(3.02)	(0.39)	(0.09)	(−5.07)	(6.20)	(2.91)	(2.43)	(−0.32)	(−1.05)	(−5.84)	(6.24)
IVOL4	0.13	−0.02	−0.06	−0.12	−0.43	0.56	0.07	−0.08	−0.14	−0.24	−0.48	0.55
	(1.32)	(−0.15)	(−0.56)	(−1.24)	(−4.42)	(3.79)	(0.69)	(−0.87)	(−1.33)	(−2.67)	(−4.90)	(3.58)
IVOL5	0.12	−0.27	−0.39	−0.43	−0.70	0.83	−0.03	−0.39	−0.55	−0.54	−0.82	0.79
	(0.72)	(−1.68)	(−2.81)	(−3.41)	(−4.97)	(3.54)	(−0.17)	(−2.92)	(−4.46)	(−4.71)	(−5.66)	(3.35)
All stocks	0.26	0.11	0.08	−0.03	−0.22	0.48	0.27	0.11	0.07	−0.03	−0.24	0.51
	(5.00)	(2.80)	(1.87)	(−0.83)	(−4.07)	(5.59)	(5.21)	(2.90)	(1.62)	(−0.84)	(−4.39)	(5.56)

	Panel C: FFC alpha						Panel D: FF5 alpha					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
IVOL1	0.39	0.18	0.24	0.00	−0.17	0.56	0.40	0.10	0.09	−0.15	−0.39	0.79
	(5.25)	(2.48)	(3.35)	(0.00)	(−2.25)	(4.81)	(5.24)	(1.38)	(1.03)	(−2.01)	(−4.64)	(6.43)
IVOL2	0.45	0.02	−0.02	−0.10	−0.26	0.71	0.30	0.06	−0.10	−0.14	−0.32	0.62
	(5.33)	(0.30)	(−0.24)	(−1.17)	(−3.29)	(5.83)	(3.15)	(0.71)	(−1.09)	(−1.48)	(−3.38)	(4.26)
IVOL3	0.37	0.21	0.04	−0.03	−0.51	0.88	0.22	0.20	−0.01	−0.06	−0.39	0.62
	(4.16)	(2.53)	(0.44)	(−0.31)	(−6.01)	(6.94)	(1.96)	(1.92)	(−0.14)	(−0.67)	(−3.96)	(3.70)
IVOL4	0.22	−0.03	−0.05	−0.11	−0.50	0.73	−0.02	0.16	0.05	0.07	−0.14	0.12
	(1.98)	(−0.31)	(−0.42)	(−1.13)	(−5.02)	(4.43)	(−0.11)	(1.47)	(0.40)	(0.70)	(−1.21)	(0.56)
IVOL5	0.15	−0.29	−0.39	−0.53	−0.75	0.90	−0.14	−0.33	−0.35	−0.11	−0.17	0.04
	(0.98)	(−2.07)	(−3.08)	(−3.87)	(−5.31)	(3.83)	(−0.75)	(−2.01)	(−2.67)	(−0.78)	(−1.08)	(0.14)
All stocks	0.33	0.11	0.10	−0.04	−0.28	0.61	0.24	0.07	0.06	−0.05	−0.31	0.55
	(5.56)	(2.47)	(2.16)	(−1.07)	(−4.92)	(6.02)	(3.40)	(1.19)	(1.11)	(−0.90)	(−5.07)	(4.68)

	Panel E: HXZ alpha						Panel F: SY alpha					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
IVOL1	0.39	0.07	0.09	−0.19	−0.45	0.83	0.43	0.09	0.11	−0.19	−0.51	0.94
	(4.54)	(0.85)	(0.78)	(−2.16)	(−4.79)	(6.49)	(4.75)	(0.92)	(1.03)	(−2.38)	(−6.10)	(7.43)
IVOL2	0.31	0.00	−0.17	−0.16	−0.36	0.67	0.41	0.14	−0.08	−0.15	−0.36	0.76
	(2.67)	(0.00)	(−1.54)	(−1.41)	(−3.46)	(4.28)	(3.61)	(1.31)	(−0.73)	(−1.31)	(−3.69)	(4.88)
IVOL3	0.31	0.20	−0.04	−0.06	−0.39	0.70	0.51	0.27	0.10	−0.07	−0.46	0.96
	(2.12)	(1.73)	(−0.41)	(−0.62)	(−3.63)	(3.49)	(5.08)	(2.61)	(0.90)	(−0.71)	(−4.27)	(5.91)
IVOL4	0.13	0.25	0.08	0.06	−0.16	0.29	0.24	0.26	0.11	0.11	−0.20	0.44
	(0.67)	(1.95)	(0.64)	(0.57)	(−1.20)	(1.09)	(1.50)	(2.11)	(0.89)	(1.10)	(−1.71)	(2.00)
IVOL5	−0.01	−0.23	−0.31	0.05	−0.08	0.07	0.21	−0.16	−0.29	−0.04	−0.24	0.45
	(−0.05)	(−1.24)	(−1.79)	(0.31)	(−0.42)	(0.23)	(1.17)	(−0.98)	(−1.82)	(−0.24)	(−1.44)	(1.82)
All stocks	0.30	0.06	0.04	−0.06	−0.33	0.63	0.38	0.11	0.09	−0.10	−0.39	0.77
	(3.58)	(0.95)	(0.59)	(−0.86)	(−4.83)	(4.70)	(5.16)	(2.04)	(1.41)	(−1.64)	(−6.36)	(6.45)

Table 10: Mean-variance spanning tests

This table reports the Huberman and Kandel (1987) mean-variance spanning test statistics and the associated p-values of the PE_{CAPM} spread portfolio under different distribution assumptions, where W is the Wald test under conditional homoscedasticity, W_e is the Wald test under IID elliptical, W_a is the Wald test under the conditional heteroscedasticity, J_1 is the Bekerart-Urias test with the Errors-in-Variables (EIV) adjustment, J_2 is the Bekerart-Urias test without the EIV adjustment, and J_3 is the DeSantis test. Panel A tests the null hypothesis that the PE_{CAPM} spread portfolio is spanned by risk factors, and Panel B tests the null hypothesis that the PE_{CAPM} spread portfolio is spanned by risk factors plus short- and long-term reversal spread portfolios, where the short-term reversal is measured by the prior (1-1) return (STR), and the long-term reversal is measured by the prior (13-60) return (LTR). The sample period is the same as Table 1.

Benchmark assets	W	W_e	W_a	J_1	J_2	J_3
Panel A: Benchmark assets are risk factors						
CAPM	1636.08	1294.58	257.74	145.44	143.23	926.75
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
FF3	515.67	85.09	99.57	101.20	105.02	133.03
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
FFC	368.38	48.15	153.33	99.30	97.87	121.46
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
FF5	42.63	21.66	19.17	16.08	16.38	19.56
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
HXZ	54.73	29.41	23.87	18.80	19.02	21.77
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
SY	129.32	84.53	46.08	32.81	31.11	59.90
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Panel B: Benchmark assets are risk factors plus short- and long-term reversal portfolios						
STR+LTR	115.74	20.71	18.98	31.58	31.91	34.36
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
CAPM+STR+LTR	122.80	22.64	19.97	33.45	33.87	35.81
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
FF3+STR+LTR	123.00	18.04	14.85	23.32	23.66	22.74
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
FFC3+STR+LTR	88.92	11.34	23.24	32.66	32.58	38.31
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
FF5+STR+LTR	8.93	6.76	7.45	7.63	7.72	7.67
	(0.01)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
HXZ+STR+LTR	11.62	7.85	8.34	8.66	8.78	9.10
	(0.00)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
SY+STR+LTR	12.42	8.46	8.46	9.36	9.32	9.26
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)

Table 11: PE_{CAPM} **portfolios in high and low sentiment periods**

This table reports the average and risk-adjusted returns of the PE_{CAPM} portfolios in high and low sentiment periods, where a month is in high sentiment periods if the Baker and Wurgler (2006) sentiment index in the previous month is above the median value and in low sentiment periods otherwise. The sample period is 1967:01–2015:09.

	High sentiment	*t*-value	Low sentiment	*t*-value	High-Low sentiment	*t*-value
Panel A: PE_{CAPM} long-short spread portfolio						
Average return	0.78	3.17	0.66	2.83	0.12	0.35
CAPM alpha	0.72	2.96	0.55	2.40	0.17	0.52
FF3 alpha	0.73	3.00	0.53	2.29	0.20	0.61
FFC alpha	1.00	4.23	0.76	3.48	0.25	0.81
FF5 alpha	0.77	2.97	0.57	2.34	0.20	0.61
HXZ alpha	0.90	3.36	0.65	2.57	0.26	0.79
SY alpha	1.19	4.43	0.82	3.47	0.37	1.18
Panel B: PE_{CAPM} long-leg portfolio						
Average return	0.68	2.21	1.00	3.07	−0.32	−0.71
CAPM alpha	0.31	2.12	0.30	2.16	0.01	0.06
FF3 alpha	0.26	1.76	0.28	2.00	−0.02	−0.10
FFC alpha	0.44	3.11	0.43	3.27	0.02	0.09
FF5 alpha	0.26	1.58	0.29	1.99	−0.03	−0.15
HXZ alpha	0.38	2.30	0.34	2.20	0.04	0.22
SY alpha	0.52	3.24	0.44	2.99	0.08	0.44
Panel C: PE_{CAPM} short-leg portfolio						
Average return	−0.09	−0.35	0.34	1.21	−0.44	−1.13
CAPM alpha	−0.41	−2.95	−0.25	−1.99	−0.16	−0.86
FF3 alpha	−0.47	−3.54	−0.25	−1.98	−0.21	−1.22
FFC alpha	−0.56	−4.16	−0.33	−2.62	−0.23	−1.34
FF5 alpha	−0.51	−3.79	−0.28	−2.12	−0.23	−1.32
HXZ alpha	−0.52	−3.60	−0.31	−2.27	−0.21	−1.19
SY alpha	−0.66	−4.32	−0.38	−2.93	−0.29	−1.58

Table 12: Alphas of portfolios sorted by IO and PE_{CAPM}

This table reports the alphas of the 25 value-weighted portfolios sorted by institutional ownership (IO) and PE_{CAPM} (Newey-West *t*-values in parentheses), where IO is calculated as Nagel (2005) and PE_{CAPM} is the CAPM pricing error estimated with the past 60-month returns with a minimum of 50 observations. The factor models include CAPM, FF3, FFC, FF5, HXZ, and SY, respectively. The sample period is 1980:03–2015:12.

	Panel A: CAPM alpha						Panel B: FF3 alpha					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
IO1	0.43	−0.01	0.15	0.01	−0.15	0.58	0.34	−0.07	0.06	−0.09	−0.20	0.53
	(2.42)	(−0.08)	(1.04)	(0.11)	(−1.03)	(2.51)	(1.88)	(−0.40)	(0.42)	(−0.70)	(−1.37)	(2.21)
IO2	0.45	0.36	0.07	−0.03	−0.34	0.79	0.37	0.38	0.04	−0.02	−0.43	0.81
	(2.40)	(2.49)	(0.51)	(−0.24)	(−2.23)	(3.46)	(2.02)	(2.62)	(0.33)	(−0.19)	(−3.05)	(3.37)
IO3	0.16	0.28	0.22	0.30	−0.19	0.34	0.09	0.25	0.21	0.27	−0.21	0.30
	(1.18)	(2.42)	(1.87)	(3.23)	(−1.62)	(1.84)	(0.74)	(2.17)	(1.84)	(2.94)	(−1.80)	(1.63)
IO4	0.30	0.21	−0.10	0.01	−0.28	0.58	0.25	0.15	−0.14	−0.04	−0.30	0.55
	(2.26)	(1.99)	(−1.00)	(0.08)	(−2.29)	(3.11)	(1.96)	(1.45)	(−1.39)	(−0.37)	(−2.52)	(2.91)
IO5	−0.00	0.14	−0.14	−0.01	−0.28	0.28	−0.10	0.07	−0.20	−0.08	−0.31	0.21
	(−0.02)	(1.34)	(−1.29)	(−0.12)	(−2.40)	(1.26)	(−0.54)	(0.68)	(−1.73)	(−0.83)	(−2.69)	(0.94)
All stocks	0.25	0.22	0.06	0.04	−0.23	0.48	0.21	0.20	0.05	0.03	−0.25	0.45
	(2.50)	(3.36)	(0.80)	(0.67)	(−2.75)	(3.15)	(2.19)	(3.06)	(0.69)	(0.50)	(−3.05)	(2.94)

	Panel C: FFC alpha						Panel D: FF5 alpha					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
IO1	0.46	−0.05	0.05	−0.17	−0.29	0.75	0.27	−0.06	−0.04	−0.12	−0.2	0.48
	(2.75)	(−0.31)	(0.36)	(−1.40)	(−1.92)	(3.17)	(1.42)	(−0.33)	(−0.29)	(−0.93)	(−1.23)	(1.69)
IO2	0.56	0.44	0.02	−0.00	−0.43	0.99	0.40	0.47	0.04	0.03	−0.4	0.80
	(2.56)	(2.84)	(0.16)	(−0.04)	(−3.00)	(3.41)	(1.98)	(3.07)	(0.29)	(0.20)	(−2.73)	(3.02)
IO3	0.20	0.24	0.18	0.23	−0.24	0.44	0.12	0.14	0.19	0.12	−0.27	0.39
	(1.59)	(2.04)	(1.37)	(2.26)	(−1.93)	(2.24)	(0.90)	(1.18)	(1.66)	(1.38)	(−2.09)	(1.94)
IO4	0.35	0.13	−0.14	−0.03	−0.37	0.72	0.20	0.02	−0.20	−0.07	−0.44	0.64
	(2.85)	(1.21)	(−1.39)	(−0.25)	(−3.02)	(3.76)	(1.36)	(0.19)	(−2.00)	(−0.67)	(−3.47)	(2.96)
IO5	0.02	0.11	−0.22	−0.11	−0.36	0.38	−0.18	0.01	−0.26	−0.12	−0.31	0.13
	(0.11)	(0.95)	(−1.69)	(−1.13)	(−3.20)	(1.94)	(−0.89)	(0.06)	(−2.14)	(−1.19)	(−1.95)	(0.47)
All stocks	0.31	0.21	0.02	0.02	−0.29	0.59	0.18	0.14	−0.00	−0.01	−0.31	0.49
	(3.02)	(2.85)	(0.33)	(0.26)	(−3.13)	(3.45)	(1.69)	(1.87)	(−0.05)	(−0.17)	(−3.34)	(2.74)

	Panel E: HXZ alpha						Panel F: SY alpha					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
IO1	0.36	−0.01	−0.07	−0.20	−0.28	0.65	0.45	−0.00	−0.09	−0.29	−0.42	0.87
	(1.63)	(−0.07)	(−0.51)	(−1.46)	(−1.64)	(1.99)	(2.65)	(−0.01)	(−0.53)	(−1.94)	(−2.54)	(3.48)
IO2	0.54	0.52	0.00	0.04	−0.41	0.94	0.58	0.46	0.03	−0.01	−0.49	1.08
	(2.12)	(3.26)	(0.01)	(0.29)	(−2.74)	(3.12)	(3.00)	(2.68)	(0.20)	(−0.08)	(−2.78)	(3.61)
IO3	0.23	0.08	0.23	0.14	−0.22	0.44	0.27	0.26	0.18	0.14	−0.31	0.57
	(1.67)	(0.62)	(1.67)	(1.59)	(−1.69)	(2.21)	(1.69)	(1.98)	(1.32)	(1.42)	(−2.31)	(2.49)
IO4	0.30	0.04	−0.22	−0.07	−0.48	0.78	0.42	0.10	−0.15	−0.10	−0.45	0.88
	(1.90)	(0.29)	(−2.06)	(−0.64)	(−3.96)	(3.48)	(3.09)	(0.74)	(−1.41)	(−0.92)	(−3.61)	(4.15)
IO5	−0.08	−0.01	−0.33	−0.18	−0.35	0.27	0.10	0.07	−0.23	−0.18	−0.50	0.60
	(−0.41)	(−0.04)	(−2.31)	(−1.58)	(−2.14)	(0.88)	(0.55)	(0.55)	(−1.59)	(−1.80)	(−4.21)	(2.70)
All stocks	0.26	0.13	−0.04	−0.02	−0.32	0.57	0.34	0.20	−0.02	−0.04	−0.39	0.73
	(2.06)	(1.56)	(−0.62)	(−0.26)	(−3.18)	(2.82)	(3.38)	(2.22)	(−0.21)	(−0.66)	(−4.01)	(4.09)

Table 13: Alphas of portfolios sorted by MAX and PE_{CAPM}

This table reports the alphas of the 25 value-weighted portfolios sorted by MAX and PE_{CAPM} (Newey-West t-values in parentheses), where MAX measures the lottery demand and is defined as the average of the 5 highest daily returns in the portfolio formation month (Bali, Cakici, and Whitelaw, 2011), and PE_{CAPM} is the CAPM pricing error estimated with the past 60-month returns with a minimum of 50 observations. The factor models include CAPM, FF3, FFC, FF5, HXZ, and SY, respectively. The sample period is the same as Table 1.

	Panel A: CAPM alpha						Panel B: FF3 alpha					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
MAX1	0.49	0.35	0.19	0.15	−0.13	0.62	0.52	0.35	0.17	0.16	−0.14	0.66
	(6.58)	(4.80)	(2.48)	(2.08)	(−1.68)	(6.09)	(7.11)	(4.96)	(2.21)	(2.31)	(−1.97)	(6.37)
MAX2	0.29	0.19	0.20	0.00	−0.11	0.41	0.27	0.20	0.22	−0.01	−0.15	0.42
	(3.29)	(2.86)	(2.88)	(0.00)	(−1.56)	(3.46)	(3.18)	(2.79)	(3.17)	(−0.11)	(−2.10)	(3.57)
MAX3	0.22	0.12	0.03	0.04	−0.34	0.55	0.19	0.05	−0.02	−0.02	−0.38	0.56
	(2.49)	(1.22)	(0.31)	(0.42)	(−4.03)	(5.05)	(2.21)	(0.48)	(−0.29)	(−0.21)	(−4.52)	(4.98)
MAX4	0.23	−0.09	−0.02	−0.11	−0.37	0.60	0.15	−0.15	−0.13	−0.20	−0.40	0.55
	(1.97)	(−0.86)	(−0.22)	(−1.18)	(−3.46)	(3.58)	(1.31)	(−1.54)	(−1.47)	(−2.23)	(−3.65)	(3.16)
MAX5	−0.22	−0.26	−0.31	−0.29	−0.70	0.48	−0.31	−0.37	−0.45	−0.36	−0.77	0.47
	(−1.26)	(−1.91)	(−2.57)	(−2.57)	(−5.26)	(2.05)	(−2.02)	(−3.13)	(−3.95)	(−3.10)	(−5.78)	(2.05)
All stocks	0.21	0.14	0.12	0.05	−0.23	0.44	0.23	0.13	0.11	0.04	−0.24	0.47
	(3.83)	(2.95)	(3.24)	(1.21)	(−4.21)	(4.75)	(4.03)	(2.79)	(2.90)	(1.11)	(−4.59)	(4.89)

	Panel C: FFC alpha						Panel D: FF5 alpha					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
MAX1	0.51	0.34	0.17	0.11	−0.21	0.72	0.31	0.21	−0.13	−0.07	−0.41	0.72
	(6.70)	(4.25)	(2.09)	(1.55)	(−2.70)	(6.22)	(3.41)	(2.38)	(−1.40)	(−0.76)	(−5.10)	(5.88)
MAX2	0.37	0.16	0.18	−0.02	−0.20	0.56	0.25	0.24	0.07	−0.06	−0.46	0.71
	(4.15)	(2.05)	(2.36)	(−0.25)	(−2.59)	(4.65)	(2.34)	(2.87)	(0.83)	(−0.66)	(−6.07)	(4.80)
MAX3	0.35	0.09	−0.01	−0.01	−0.41	0.75	0.25	0.04	−0.07	0.00	−0.43	0.67
	(3.22)	(1.01)	(−0.14)	(−0.12)	(−5.22)	(6.11)	(1.86)	(0.36)	(−0.83)	(0.04)	(−4.79)	(4.06)
MAX4	0.30	−0.10	−0.03	−0.17	−0.45	0.75	0.25	0.04	0.06	−0.01	−0.19	0.44
	(2.54)	(−0.93)	(−0.27)	(−1.85)	(−4.29)	(4.40)	(1.49)	(0.31)	(0.56)	(−0.14)	(−1.57)	(1.97)
MAX5	−0.19	−0.18	−0.27	−0.27	−0.73	0.53	−0.21	−0.04	−0.04	−0.01	−0.15	−0.06
	(−1.25)	(−1.37)	(−2.24)	(−2.36)	(−5.67)	(2.50)	(−1.07)	(−0.26)	(−0.37)	(−0.11)	(−0.93)	(−0.22)
All stocks	0.30	0.14	0.12	0.04	−0.29	0.60	0.21	0.17	0.04	0.03	−0.35	0.57
	(4.99)	(2.75)	(2.81)	(0.92)	(−5.55)	(5.94)	(2.57)	(3.12)	(0.89)	(0.52)	(−5.70)	(4.29)

	Panel E: HXZ alpha						Panel F: SY alpha					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
MAX1	0.31	0.19	−0.18	−0.10	−0.44	0.75	0.40	0.23	−0.09	−0.12	−0.48	0.89
	(2.87)	(1.76)	(−1.45)	(−0.89)	(−4.33)	(5.55)	(3.70)	(2.08)	(−0.86)	(−1.10)	(−5.18)	(6.44)
MAX2	0.30	0.27	0.07	−0.10	−0.48	0.79	0.34	0.23	0.10	−0.09	−0.55	0.89
	(2.39)	(2.81)	(0.65)	(−0.96)	(−5.66)	(4.72)	(2.71)	(2.58)	(0.84)	(−0.90)	(−6.76)	(5.61)
MAX3	0.42	0.01	−0.13	−0.00	−0.48	0.90	0.52	0.13	−0.02	−0.06	−0.54	1.07
	(2.21)	(0.05)	(−1.37)	(−0.01)	(−4.90)	(4.36)	(4.14)	(1.10)	(−0.26)	(−0.50)	(−5.91)	(6.58)
MAX4	0.34	0.05	−0.01	−0.02	−0.22	0.56	0.53	0.12	0.15	−0.02	−0.26	0.78
	(1.75)	(0.37)	(−0.06)	(−0.19)	(−1.62)	(2.16)	(3.54)	(0.82)	(1.27)	(−0.26)	(−2.05)	(3.73)
MAX5	−0.08	0.04	0.01	0.09	−0.10	0.02	0.11	0.10	0.13	0.06	−0.24	0.35
	(−0.39)	(0.24)	(0.08)	(0.61)	(−0.53)	(0.06)	(0.56)	(0.63)	(0.94)	(0.46)	(−1.52)	(1.37)
All stocks	0.30	0.18	0.00	0.02	−0.38	0.68	0.40	0.20	0.07	−0.02	−0.46	0.86
	(3.17)	(2.75)	(0.01)	(0.37)	(−5.34)	(4.57)	(5.13)	(2.90)	(1.21)	(−0.36)	(−7.22)	(6.71)

Table 14: Alphas of portfolios sorted by PTP and PE_{CAPM}

This table reports the alphas of the 25 value-weighted portfolios sorted by PTP and PE_{CAPM} (Newey-West *t*-values in parentheses), where PTP measures the expectation of expected returns and is defined as analysts' consensus price target scaled by current price (Weber, 2018). PE_{CAPM} is the CAPM pricing error estimated with the past 60-month returns with a minimum of 50 observations. The factor models include CAPM, FF3, FFC, FF5, HXZ, and SY, respectively. The sample period is 1999:03–2016:12.

	Panel A: CAPM alpha						Panel B: FF3 alpha					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
PTP1	1.07	1.17	0.96	0.47	0.35	0.72	1.00	1.07	0.87	0.40	0.22	0.78
	(5.21)	(4.03)	(4.32)	(1.97)	(1.80)	(2.79)	(5.27)	(3.89)	(3.91)	(1.64)	(1.21)	(3.15)
PTP2	0.54	0.64	−0.18	0.10	−0.43	0.97	0.46	0.66	−0.21	0.11	−0.49	0.95
	(2.75)	(3.12)	(−0.73)	(0.61)	(−2.31)	(3.80)	(2.79)	(2.86)	(−0.89)	(0.65)	(−2.73)	(3.75)
PTP3	0.10	0.17	−0.16	0.08	−0.59	0.70	0.05	0.13	−0.18	0.09	−0.59	0.65
	(0.64)	(1.09)	(−1.10)	(0.37)	(−3.39)	(3.13)	(0.37)	(0.87)	(−1.40)	(0.50)	(−3.75)	(2.88)
PTP4	0.35	0.47	−0.38	−0.11	−0.34	0.70	0.35	0.46	−0.34	−0.05	−0.31	0.65
	(1.74)	(1.96)	(−1.83)	(−0.53)	(−1.32)	(2.15)	(1.90)	(1.97)	(−1.58)	(−0.26)	(−1.22)	(2.05)
PTP5	−0.70	−0.29	−0.13	−0.50	−0.42	−0.28	−0.66	−0.34	−0.15	−0.47	−0.51	−0.15
	(−2.46)	(−1.16)	(−0.45)	(−1.85)	(−1.59)	(−0.72)	(−2.32)	(−1.16)	(−0.54)	(−1.70)	(−1.89)	(−0.39)
All stocks	0.30	0.42	−0.10	0.08	−0.41	0.71	0.30	0.39	−0.08	0.12	−0.42	0.71
	(2.42)	(3.45)	(−0.91)	(0.79)	(−3.37)	(3.73)	(2.61)	(3.20)	(−0.77)	(1.14)	(−3.53)	(3.61)
	Panel C: FFC alpha						Panel D: FF5 alpha					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
PTP1	0.94	0.99	0.78	0.30	0.16	0.78	0.78	0.88	0.73	0.14	0.18	0.59
	(4.66)	(3.76)	(3.79)	(1.30)	(0.92)	(3.19)	(4.00)	(3.02)	(2.74)	(0.49)	(0.74)	(2.20)
PTP2	0.43	0.60	−0.21	0.11	−0.53	0.95	0.39	0.58	−0.28	−0.08	−0.62	1.01
	(2.69)	(2.75)	(−0.89)	(0.65)	(−2.94)	(3.78)	(2.10)	(2.45)	(−1.20)	(−0.57)	(−3.41)	(3.76)
PTP3	0.04	0.11	−0.23	0.07	−0.56	0.60	0.01	−0.06	−0.36	−0.11	−0.57	0.59
	(0.29)	(0.73)	(−1.65)	(0.40)	(−3.87)	(2.68)	(0.09)	(−0.33)	(−2.66)	(−0.66)	(−4.15)	(2.91)
PTP4	0.38	0.51	−0.29	0.03	−0.22	0.59	0.21	0.43	−0.33	−0.04	−0.41	0.62
	(2.00)	(2.01)	(−1.35)	(0.16)	(−0.91)	(1.94)	(1.11)	(1.76)	(−1.49)	(−0.22)	(−1.43)	(1.69)
PTP5	−0.49	−0.18	−0.05	−0.36	−0.38	−0.12	−0.47	0.01	−0.06	−0.31	−0.44	−0.03
	(−1.75)	(−0.59)	(−0.20)	(−1.33)	(−1.43)	(−0.29)	(−1.45)	(0.04)	(−0.22)	(−1.07)	(−1.62)	(−0.08)
All stocks	0.30	0.39	−0.09	0.13	−0.41	0.71	0.22	0.33	−0.11	0.02	−0.42	0.64
	(2.59)	(3.18)	(−0.87)	(1.16)	(−3.45)	(3.49)	(1.88)	(2.98)	(−1.07)	(0.14)	(−3.73)	(3.21)
	Panel E: HXZ alpha						Panel F: SY alpha					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
PTP1	0.81	0.88	0.74	0.20	0.11	0.70	0.84	0.82	0.64	0.00	−0.04	0.88
	(4.09)	(3.43)	(2.98)	(0.74)	(0.57)	(2.76)	(3.97)	(2.93)	(2.62)	(0.00)	(−0.24)	(3.40)
PTP2	0.39	0.58	−0.28	0.01	−0.61	0.99	0.44	0.48	−0.23	−0.02	−0.68	1.12
	(2.25)	(2.51)	(−1.13)	(0.05)	(−3.39)	(3.96)	(2.52)	(2.06)	(−0.89)	(−0.13)	(−4.04)	(3.96)
PTP3	−0.07	−0.00	−0.38	−0.06	−0.62	0.55	0.01	0.03	−0.37	−0.08	−0.61	0.62
	(−0.42)	(−0.01)	(−2.51)	(−0.32)	(−4.05)	(2.58)	(0.03)	(0.20)	(−2.24)	(−0.46)	(−4.24)	(2.75)
PTP4	0.31	0.45	−0.34	0.01	−0.33	0.63	0.37	0.58	−0.23	0.17	−0.18	0.55
	(1.53)	(1.64)	(−1.37)	(0.03)	(−1.13)	(1.77)	(1.90)	(1.94)	(−1.02)	(0.79)	(−0.65)	(1.50)
PTP5	−0.40	0.02	0.02	−0.30	−0.36	−0.04	−0.00	0.35	0.12	−0.09	−0.18	0.18
	(−1.30)	(0.05)	(0.07)	(−1.05)	(−1.35)	(−0.09)	(−0.01)	(1.05)	(0.41)	(−0.31)	(−0.63)	(0.42)
All stocks	0.25	0.35	−0.12	0.06	−0.43	0.68	0.34	0.38	−0.10	0.06	−0.49	0.83
	(2.00)	(2.86)	(−0.96)	(0.55)	(−3.66)	(3.29)	(2.60)	(2.70)	(−0.81)	(0.48)	(−3.80)	(3.51)

Table 15: Alphas of portfolios sorted by LTG and PE_{CAPM}

This table reports the alphas of the 25 value-weighted portfolios sorted by LTG and PE_{CAPM} (Newey-West t-values in parentheses), where LTG is analysts' long-term growth forecast on earnings as in Weber (2018) and PE_{CAPM} is the CAPM pricing error estimated with the past 60-month returns with a minimum of 50 observations. The factor models include CAPM, FF3, FFC, FF5, HXZ, and SY, respectively. The sample period is 1982:01–2016:12.

	Panel A: CAPM alpha						Panel B: FF3 alpha					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
LTG1	0.57	0.61	0.41	0.16	0.07	0.50	0.30	0.39	0.20	−0.01	−0.12	0.43
	(3.03)	(3.98)	(2.84)	(1.25)	(0.44)	(2.31)	(2.05)	(3.27)	(1.71)	(−0.04)	(−0.95)	(1.97)
LTG2	0.42	0.32	0.08	0.05	−0.23	0.65	0.25	0.18	−0.05	−0.09	−0.39	0.64
	(2.77)	(2.48)	(0.51)	(0.37)	(−1.38)	(3.00)	(1.84)	(1.94)	(−0.35)	(−0.84)	(−2.61)	(2.84)
LTG3	0.44	0.40	−0.10	−0.00	−0.46	0.90	0.39	0.32	−0.16	−0.06	−0.49	0.89
	(2.85)	(3.09)	(−0.93)	(−0.02)	(−3.65)	(4.83)	(2.88)	(2.57)	(−1.42)	(−0.60)	(−4.31)	(4.96)
LTG4	0.27	0.13	−0.02	−0.03	−0.46	0.74	0.28	0.18	0.04	0.03	−0.42	0.70
	(1.65)	(1.14)	(−0.11)	(−0.19)	(−4.13)	(3.83)	(1.72)	(1.58)	(0.30)	(0.20)	(−3.78)	(3.69)
LTG5	−0.34	0.10	−0.13	0.00	−0.34	0.00	−0.08	0.38	0.15	0.29	−0.09	0.01
	(−1.58)	(0.53)	(−0.61)	(0.01)	(−1.59)	(0.01)	(−0.52)	(2.56)	(0.76)	(1.32)	(−0.50)	(0.04)
All stocks	0.28	0.31	0.08	0.05	−0.31	0.59	0.23	0.29	0.07	0.03	−0.34	0.56
	(2.96)	(4.67)	(1.16)	(0.77)	(−3.45)	(3.89)	(2.58)	(4.44)	(1.00)	(0.46)	(−4.10)	(3.81)
	Panel C: FFC alpha						Panel D: FF5 alpha					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
LTG1	0.43	0.44	0.19	−0.04	−0.16	0.58	0.23	0.25	0.04	−0.16	−0.24	0.47
	(2.59)	(3.60)	(1.61)	(−0.31)	(−1.14)	(2.42)	(1.53)	(2.02)	(0.33)	(−1.37)	(−1.70)	(2.08)
LTG2	0.30	0.14	−0.08	−0.07	−0.34	0.64	0.06	−0.03	−0.29	−0.30	−0.61	0.67
	(2.24)	(1.30)	(−0.61)	(−0.65)	(−2.10)	(2.54)	(0.45)	(−0.32)	(−2.02)	(−3.01)	(−4.15)	(2.97)
LTG3	0.43	0.34	−0.16	−0.07	−0.51	0.94	0.26	0.12	−0.31	−0.22	−0.65	0.92
	(3.33)	(2.80)	(−1.40)	(−0.64)	(−3.88)	(4.98)	(1.90)	(0.99)	(−2.65)	(−2.34)	(−5.44)	(4.65)
LTG4	0.43	0.18	0.03	0.03	−0.43	0.86	0.20	0.12	0.06	0.02	−0.36	0.56
	(2.39)	(1.52)	(0.19)	(0.20)	(−3.53)	(4.07)	(1.16)	(1.03)	(0.44)	(0.18)	(−2.90)	(2.57)
LTG5	0.10	0.41	0.12	0.29	−0.16	0.26	0.09	0.58	0.37	0.59	0.19	−0.10
	(0.61)	(2.57)	(0.66)	(1.51)	(−0.90)	(1.10)	(0.46)	(3.43)	(2.04)	(2.63)	(0.98)	(−0.35)
All stocks	0.32	0.28	0.03	0.02	−0.35	0.67	0.18	0.23	0.03	−0.03	−0.38	0.56
	(3.28)	(3.86)	(0.49)	(0.37)	(−3.81)	(3.99)	(1.96)	(3.26)	(0.44)	(−0.52)	(−4.37)	(3.63)
	Panel E: HXZ alpha						Panel F: SY alpha					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
LTG1	0.32	0.28	0.07	−0.13	−0.18	0.50	0.25	0.32	0.08	−0.12	−0.16	0.41
	(1.67)	(2.02)	(0.53)	(−1.07)	(−1.18)	(2.15)	(1.45)	(2.40)	(0.56)	(−0.97)	(−1.05)	(1.82)
LTG2	0.14	−0.09	−0.33	−0.29	−0.56	0.69	0.25	−0.02	−0.23	−0.26	−0.51	0.76
	(0.92)	(−0.79)	(−1.99)	(−2.77)	(−2.95)	(2.79)	(1.71)	(−0.16)	(−1.58)	(−2.52)	(−2.91)	(2.86)
LTG3	0.29	0.10	−0.37	−0.26	−0.67	0.96	0.32	0.22	−0.30	−0.21	−0.65	0.97
	(2.24)	(0.66)	(−3.17)	(−2.49)	(−5.11)	(4.85)	(2.23)	(1.78)	(−2.30)	(−1.96)	(−4.85)	(4.57)
LTG4	0.30	0.11	−0.03	−0.03	−0.37	0.68	0.35	0.10	−0.01	0.01	−0.50	0.85
	(1.47)	(0.89)	(−0.24)	(−0.25)	(−2.73)	(2.62)	(2.00)	(0.77)	(−0.04)	(0.07)	(−3.57)	(3.72)
LTG5	0.20	0.55	0.35	0.60	0.13	0.07	0.46	0.62	0.31	0.46	−0.03	0.49
	(0.99)	(2.99)	(1.56)	(2.33)	(0.52)	(0.21)	(2.33)	(2.90)	(1.62)	(2.08)	(−0.16)	(1.83)
All stocks	0.25	0.21	−0.02	−0.04	−0.37	0.62	0.30	0.28	−0.01	−0.03	−0.44	0.73
	(2.42)	(2.65)	(−0.24)	(−0.64)	(−3.86)	(3.59)	(3.15)	(3.25)	(−0.10)	(−0.47)	(−4.06)	(4.08)

Table 16: Fama-MacBeth regressions

This table reports the time-series average of the coefficients from Fama-MacBeth regressions of one-month-ahead returns on PE and other variables, where IO refers to institutional ownership, MAX to lottery demand, PTP to analysts' implied return expectation, and LTG to analysts' long-term growth forecast on earnings. Newey-West t-statistics are reported in parentheses. The sample period is 1999:04–2016:12, over which all variables have observations. Intercepts are included in all regressions but not reported here.

	Dependent variable: one-month-ahead return						
PE_{CAPM}	−0.53	−0.47	−0.45	−0.52	−0.52	−0.48	−0.40
	(−3.29)	(−2.94)	(−3.18)	(−3.31)	(−3.47)	(−3.25)	(−2.87)
IO		−0.21					−0.10
		(−0.61)					(−0.34)
MAX			−0.04				−0.03
			(−1.19)				(−0.69)
PTP				−0.00			−0.00
				(−1.66)			(−1.73)
LTG					0.01		0.01
					(0.57)		(1.22)
IVOL						−0.12	−0.04
						(−1.36)	(−0.44)
Log(ME)	−0.11	−0.13	−0.14	−0.12	−0.11	−0.14	−0.12
	(−2.23)	(−2.45)	(−2.69)	(−2.24)	(−2.27)	(−2.77)	(−2.57)
Log(BM)	−0.02	−0.02	−0.02	−0.02	−0.01	−0.00	−0.01
	(−0.21)	(−0.17)	(−0.13)	(−0.16)	(−0.14)	(−0.00)	(−0.09)
STR	0.02	0.02	0.02	0.02	0.02	0.02	0.01
	(1.22)	(0.78)	(1.30)	(1.07)	(1.37)	(1.03)	(0.69)
MOM	0.02	0.03	0.01	0.02	0.01	0.01	0.00
	(0.46)	(0.52)	(0.11)	(0.35)	(0.27)	(0.20)	(0.05)
LTR	−0.06	−0.05	−0.05	−0.07	−0.06	−0.04	−0.10
	(−1.04)	(−0.85)	(−0.89)	(−1.07)	(−1.11)	(−0.70)	(−1.55)
N	229,329	229,329	229,329	229,329	229,329	229,329	229,329

Appendix

Table A1: Alpha difference between PE spread portfolios

This table reports the difference in risk-adjusted return between PE spread portfolios, with p-value in parenthesis. The value in (i, j) corresponds to the difference between the PE_i spread portfolio and the PE_j spread portfolio, where i and j denote factor models i and j. PE_{CAPM} refers to the spread portfolio based on the CAPM pricing error, and PE_{FF3} to the spread portfolio based on the FF3 pricing error, etc. The sample period is 1971:03–2016:12 for all portfolios.

	CAPM alpha difference					FFC alpha difference				
	PE_{FF3}	PE_{FFC4}	PE_{FF5}	PE_{Q4}	PE_{M4}	PE_{FF3}	PE_{FFC4}	PE_{FF5}	PE_{Q4}	PE_{M4}
PE_{CAPM}	−0.16	−0.09	−0.10	−0.01	0.03	−0.01	0.00	−0.02	0.03	0.10
	(0.16)	(0.46)	(0.41)	(0.94)	(0.78)	(0.34)	(0.98)	(0.83)	(0.81)	(0.35)
PE_{FF3}	–	0.06	0.06	0.15	0.19	–	0.10	0.08	0.13	0.20
		(0.33)	(0.38)	(0.09)	(0.08)		(0.11)	(0.23)	(0.13)	(0.06)
PE_{FFC4}		–	−0.01	0.08	0.12		–	−0.03	0.02	0.10
			(0.94)	(.043)	(0.24)			(0.77)	(0.82)	(0.35)
PE_{FF5}			–	0.09	0.13			–	0.05	0.12
				(0.29)	(0.26)				(0.54)	0.29
PE_{Q4}				–	0.04				–	0.07
					(0.68)					(0.45)

	FF5 alpha difference					HXZ alpha difference				
	PE_{FF3}	PE_{FFC4}	PE_{FF5}	PE_{Q4}	PE_{M4}	PE_{FF3}	PE_{FFC4}	PE_{FF5}	PE_{Q4}	PE_{M4}
PE_{CAPM}	−0.06	−0.01	0.02	0.05	0.08	−0.05	0.01	0.06	0.07	0.06
	(0.06)	(0.94)	(0.86)	(0.69)	(0.44)	(0.61)	(0.92)	(0.60)	(0.52)	0.54
PE_{FF3}	–	0.05	0.08	0.10	0.14	–	0.07	0.12	0.13	0.12
		(0.48)	(0.25)	(0.23)	(0.18)		(0.32)	(0.08)	(0.14)	(0.25)
PE_{FFC4}		–	0.03	0.05	0.09		–	0.05	0.06	0.05
			(0.75)	(0.59)	(0.36)			(0.60)	(0.55)	(0.60)
PE_{FF5}			–	0.03	0.06			–	0.01	0.00
				(0.76)	(0.58)				(0.89)	(0.98)
PE_{Q4}				–	0.04				–	−0.01
					(0.70)					(0.92)

	SY alpha difference				
	PE_{FF3}	PE_{FFC4}	PE_{FF5}	PE_{Q4}	PE_{M4}
PE_{CAPM}	−0.01	0.09	0.12	0.09	0.11
	(0.90)	(0.43)	(0.32)	(0.44)	(0.31)
PE_{FF3}	–	0.11	0.13	0.10	0.12
		(0.11)	(0.05)	(0.23)	(0.24)
PE_{FFC4}		–	0.02	−0.01	0.01
			(0.82)	(0.96)	(0.90)
PE_{FF5}			–	−0.03	−0.01
				(0.74)	(0.94)
PE_{Q4}				–	0.02
					(0.85)

Table A2: FF3 alphas of portfolios sorted by short-term reversal and PE

This table reports the FF3 alphas of the 25 value-weighted portfolios sorted by short-term reversal (STR) and pricing error (PE), where STR is measured by the prior (1-1) return and PE is estimated with the past 60-month returns by using the CAPM, FF3, FFC, FF5, HXZ, and SY models, respectively. The sample period is the same as Table 1.

	Panel A: Sort on STR and PE_{CAPM}						Panel B: Sort on STR and PE_{FF3}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
STR1	0.34	0.24	0.01	0.07	−0.10	0.44	0.39	0.24	0.03	0.03	−0.12	0.50
	(3.27)	(2.30)	(0.06)	(0.64)	(−0.77)	(3.21)	(3.72)	(2.31)	(0.28)	(0.26)	(−0.89)	(3.48)
STR2	0.31	0.12	0.15	−0.15	−0.22	0.53	0.32	0.21	0.18	−0.08	−0.28	0.60
	(4.00)	(1.63)	(1.64)	(−1.54)	(−1.81)	(3.46)	(4.07)	(2.77)	(1.98)	(−0.85)	(−2.69)	(4.24)
STR3	0.29	0.09	−0.00	−0.08	−0.15	0.44	0.29	0.23	0.10	−0.03	−0.29	0.59
	(3.73)	(1.06)	(−0.02)	(−1.16)	(−1.80)	(3.54)	(3.64)	(2.75)	(1.27)	(−0.37)	(−3.46)	(4.33)
STR4	0.18	0.02	0.10	−0.21	−0.19	0.37	0.38	0.03	−0.03	−0.11	−0.43	0.81
	(1.59)	(0.24)	(1.14)	(−2.55)	(−2.55)	(2.53)	(3.33)	(0.34)	(−0.37)	(−1.60)	(−5.15)	(5.52)
STR5	0.00	−0.19	−0.25	−0.41	−0.69	0.69	0.08	−0.19	−0.21	−0.47	−0.79	0.86
	(0.01)	(−1.67)	(−2.69)	(−4.28)	(−6.14)	(3.97)	(0.54)	(−1.73)	(−2.33)	(−5.03)	(−7.53)	(4.96)
All stocks	0.26	0.05	0.04	−0.15	−0.17	0.44	0.28	0.12	0.04	−0.10	−0.35	0.63
	(5.40)	(1.26)	(0.82)	(−3.93)	(−3.07)	(4.88)	(5.15)	(2.76)	(0.96)	(−2.43)	(−5.97)	(6.37)
	Panel C: Sort on STR and PE_{FFC4}						Panel D: Sort on STR and PE_{FF5}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
STR1	0.37	0.16	0.11	−0.03	−0.11	0.48	0.34	−0.00	0.08	−0.17	−0.30	0.64
	(3.26)	(1.64)	(1.00)	(−0.25)	(−0.79)	(3.26)	(2.36)	(−0.03)	(0.63)	(−1.16)	(−1.67)	(2.92)
STR2	0.31	0.32	0.18	−0.02	−0.21	0.52	0.47	0.20	0.19	−0.02	−0.35	0.82
	(3.66)	(3.68)	(2.09)	(−0.17)	(−2.05)	(3.81)	(4.22)	(2.01)	(1.90)	(−0.21)	(−2.62)	(4.37)
STR3	0.31	0.25	0.04	−0.05	−0.24	0.55	0.41	0.26	−0.14	−0.13	−0.30	0.71
	(3.90)	(3.04)	(0.51)	(−0.54)	(−2.94)	(4.27)	(4.05)	(2.74)	(−1.28)	(−1.24)	(−3.43)	(4.85)
STR4	0.29	0.06	−0.09	−0.10	−0.43	0.71	0.32	0.21	−0.13	−0.24	−0.28	0.60
	(2.46)	(0.63)	(−0.99)	(−1.35)	(−5.25)	(4.85)	(2.59)	(1.93)	(−1.29)	(−2.35)	(−3.36)	(3.80)
STR5	0.07	−0.26	−0.21	−0.46	−0.74	0.81	0.14	0.07	−0.22	−0.25	−0.65	0.79
	(0.52)	(−2.43)	(−2.15)	(−5.04)	(−7.57)	(5.03)	(0.73)	(0.59)	(−1.98)	(−2.15)	(−5.06)	(3.85)
All stocks	0.25	0.14	0.03	−0.09	−0.32	0.58	0.38	0.14	−0.08	−0.18	−0.34	0.72
	(5.03)	(2.97)	(0.66)	(−2.00)	(−5.42)	(6.07)	(5.35)	(2.67)	(−1.66)	(−3.17)	(−5.00)	(5.70)
	Panel E: Sort on STR and PE_{Q4}						Panel F: Sort on STR and PE_{M4}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
STR1	0.22	0.05	0.14	−0.22	−0.23	0.45	0.27	0.03	0.14	−0.25	−0.27	0.54
	(1.39)	(0.39)	(0.95)	(−1.33)	(−1.22)	(1.97)	(1.70)	(0.21)	(1.11)	(−1.74)	(−1.56)	(2.55)
STR2	0.32	0.44	−0.01	−0.11	−0.23	0.55	0.31	0.26	0.14	−0.20	−0.20	0.51
	(2.97)	(4.29)	(−0.13)	(−1.00)	(−1.76)	(3.21)	(3.10)	(2.44)	(1.27)	(−1.87)	(−1.58)	(3.24)
STR3	0.34	0.07	0.06	−0.18	−0.32	0.66	0.30	0.05	0.04	−0.11	−0.30	0.60
	(3.18)	(0.66)	(0.64)	(−1.64)	(−3.11)	(3.92)	(2.38)	(0.48)	(0.41)	(−1.14)	(−3.01)	(3.17)
STR4	0.32	0.12	−0.15	−0.10	−0.20	0.52	0.34	0.05	−0.05	−0.17	−0.25	0.59
	(2.37)	(1.06)	(−1.58)	(−1.04)	(−2.13)	(3.20)	(2.66)	(0.39)	(−0.59)	(−1.68)	(−2.92)	(3.65)
STR5	0.18	−0.03	−0.04	−0.31	−0.52	0.70	0.22	−0.10	−0.06	−0.33	−0.60	0.82
	(0.98)	(−0.19)	(−0.38)	(−2.74)	(−3.91)	(3.21)	(1.39)	(−0.77)	(−0.47)	(−3.21)	(−4.72)	(4.47)
All stocks	0.30	0.14	0.01	−0.20	−0.29	0.59	0.32	0.05	0.07	−0.20	−0.30	0.62
	(4.19)	(2.28)	(0.28)	(−3.34)	(−3.70)	(4.40)	(4.54)	(0.91)	(1.55)	(−3.59)	(−4.59)	(5.02)

Table A3: FF3 alphas of portfolios sorted by long-term reversal and PE

This table reports the FF3 alphas of the 25 value-weighted portfolios sorted by long-term reversal (LTR) and pricing error (PE), where STR is measured by the prior (13-60) return and PE is estimated with the past 60-month returns by using the CAPM, FF3, FFC, FF5, HXZ, and SY models, respectively. The sample period is the same as Table 1.

	Panel A: Sort on LTR and PE_{CAPM}						Panel B: Sort on LTR and PE_{FF3}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
LTR1	0.20	0.26	0.10	−0.19	−0.29	0.49	0.28	0.30	0.02	−0.03	−0.43	0.70
	(1.35)	(2.38)	(0.94)	(−1.89)	(−2.64)	(2.82)	(1.97)	(2.81)	(0.17)	(−0.33)	(−3.96)	(4.36)
LTR2	0.24	0.19	0.20	−0.07	−0.19	0.43	0.28	0.19	0.20	−0.11	−0.22	0.51
	(2.16)	(2.19)	(2.13)	(−0.82)	(−1.86)	(3.29)	(3.06)	(2.02)	(2.41)	(−1.15)	(−2.24)	(4.03)
LTR3	0.39	0.10	−0.08	−0.08	−0.17	0.57	0.32	0.21	0.05	−0.17	−0.38	0.70
	(3.93)	(1.23)	(−1.05)	(−0.95)	(−1.90)	(4.29)	(3.04)	(2.25)	(0.64)	(−1.98)	(−4.34)	(4.99)
LTR4	0.14	0.19	−0.11	0.06	−0.32	0.46	0.30	0.13	−0.03	−0.15	−0.26	0.56
	(1.34)	(1.77)	(−1.18)	(0.73)	(−3.01)	(2.77)	(2.54)	(1.42)	(−0.36)	(−1.59)	(−2.58)	(3.65)
LTR5	0.07	−0.09	−0.11	−0.06	−0.17	0.25	0.11	0.03	−0.17	−0.15	−0.23	0.34
	(0.62)	(−0.75)	(−1.12)	(−0.60)	(−1.48)	(1.47)	(0.95)	(0.33)	(−1.54)	(−1.54)	(−1.97)	(2.01)
All stocks	0.26	0.15	0.01	−0.04	−0.22	0.48	0.28	0.20	0.03	−0.13	−0.27	0.55
	(4.29)	(2.69)	(0.25)	(−0.88)	(−3.27)	(4.54)	(4.38)	(4.62)	(0.70)	(−2.74)	(−4.89)	(5.38)
	Panel C: Sort on LTR and PE_{FFC4}						Panel D: Sort on LTR and PE_{FF5}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
LTR1	0.22	0.29	0.04	−0.03	−0.39	0.61	0.26	0.44	−0.03	−0.24	−0.38	0.64
	(1.57)	(2.78)	(0.33)	(−0.29)	(−3.55)	(3.69)	(1.80)	(3.06)	(−0.30)	(−2.42)	(−3.62)	(3.93)
LTR2	0.32	0.16	0.27	−0.08	−0.29	0.61	0.42	0.22	−0.05	−0.08	−0.16	0.57
	(3.42)	(1.63)	(2.93)	(−0.85)	(−2.74)	(4.82)	(3.54)	(2.43)	(−0.52)	(−0.94)	(−1.44)	(3.38)
LTR3	0.27	0.24	0.12	−0.20	−0.37	0.64	0.38	0.32	−0.03	−0.20	−0.29	0.67
	(2.76)	(2.68)	(1.53)	(−2.36)	(−4.30)	(4.61)	(3.28)	(3.27)	(−0.33)	(−2.07)	(−2.98)	(4.06)
LTR4	0.19	0.15	−0.01	−0.12	−0.31	0.50	0.36	0.24	0.14	−0.19	−0.27	0.63
	(1.62)	(1.62)	(−0.13)	(−1.28)	(−3.04)	(3.07)	(3.10)	(2.34)	(1.49)	(−1.81)	(−2.18)	(3.71)
LTR5	0.09	−0.01	−0.06	−0.24	−0.18	0.27	0.16	0.23	0.02	−0.10	−0.39	0.55
	(0.74)	(−0.11)	(−0.56)	(−2.34)	(−1.57)	(1.55)	(1.05)	(1.78)	(0.17)	(−0.91)	(−3.30)	(2.83)
All stocks	0.21	0.20	0.08	−0.12	−0.29	0.50	0.34	0.29	−0.03	−0.19	−0.28	0.62
	(3.33)	(4.33)	(2.02)	(−2.64)	(−5.11)	(4.85)	(4.15)	(5.42)	(−0.62)	(−3.64)	(−4.41)	(4.68)
	Panel E: Sort on LTR and PE_{Q4}						Panel F: Sort on LTR and PE_{M4}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
LTR1	0.21	0.36	0.09	−0.20	−0.41	0.62	0.27	0.24	0.08	−0.14	−0.42	0.69
	(1.32)	(2.37)	(0.82)	(−1.80)	(−3.72)	(3.65)	(1.82)	(1.84)	(0.69)	(−1.39)	(−3.88)	(4.27)
LTR2	0.22	0.25	0.08	0.06	−0.23	0.45	0.28	0.07	0.07	0.04	−0.32	0.60
	(1.75)	(2.45)	(0.67)	(0.56)	(−2.07)	(2.48)	(2.22)	(0.71)	(0.66)	(0.36)	(−3.25)	(3.64)
LTR3	0.34	0.26	−0.07	−0.09	−0.31	0.65	0.49	0.04	0.08	−0.09	−0.31	0.80
	(3.04)	(2.60)	(−0.79)	(−0.84)	(−3.04)	(4.13)	(4.40)	(0.41)	(0.85)	(−1.00)	(−3.32)	(5.40)
LTR4	0.38	0.19	0.16	−0.15	−0.26	0.64	0.37	0.30	0.01	−0.10	−0.25	0.62
	(3.12)	(1.87)	(1.46)	(−1.42)	(−2.17)	(3.45)	(3.39)	(3.03)	(0.13)	(−0.92)	(−2.32)	(4.10)
LTR5	0.29	0.20	0.09	−0.01	−0.27	0.56	0.24	0.19	−0.04	−0.03	−0.27	0.51
	(1.84)	(1.42)	(0.79)	(−0.11)	(−2.21)	(2.71)	(1.63)	(1.46)	(−0.35)	(−0.23)	(−2.29)	(2.81)
All stocks	0.27	0.20	0.05	−0.11	−0.28	0.56	0.33	0.15	0.01	−0.08	−0.31	0.63
	(3.26)	(3.79)	(0.85)	(−2.07)	(−4.35)	(4.07)	(4.69)	(2.71)	(0.20)	(−1.39)	(−5.05)	(5.57)

Table A4: FF3 alphas of portfolios sorted by IVOL and PE

This table reports the FF3 alphas of the 25 value-weighted portfolios sorted by IVOL and pricing error (PE), where IVOL is estimated as Ang, Hodrick, Xing, and Zhang (2006) and PE is estimated with the past 60-month returns by using the CAPM, FF3, FFC, FF5, HXZ, and SY models, respectively. The sample period is the same as Table 1.

	Panel A: Sort on IVOL and PE_{CAPM}						Panel B: Sort on IVOL and PE_{FF3}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
IVOL1	0.38	0.23	0.23	0.03	−0.09	0.47	0.43	0.31	0.15	0.07	−0.19	0.62
	(5.79)	(3.58)	(3.38)	(0.51)	(−1.24)	(4.41)	(5.90)	(4.63)	(2.24)	(1.16)	(−2.80)	(5.49)
IVOL2	0.39	0.05	−0.03	−0.05	−0.22	0.61	0.39	0.16	−0.02	−0.10	−0.29	0.67
	(4.71)	(0.71)	(−0.41)	(−0.59)	(−2.97)	(5.27)	(4.56)	(2.42)	(−0.26)	(−1.34)	(−4.13)	(5.62)
IVOL3	0.24	0.19	−0.03	−0.09	−0.52	0.76	0.30	0.22	−0.06	−0.20	−0.54	0.84
	(2.91)	(2.43)	(−0.32)	(−1.05)	(−5.84)	(6.24)	(3.48)	(2.65)	(−0.64)	(−2.53)	(−6.24)	(7.02)
IVOL4	0.07	−0.08	−0.14	−0.24	−0.48	0.55	0.06	−0.02	−0.10	−0.22	−0.57	0.64
	(0.69)	(−0.87)	(−1.33)	(−2.67)	(−4.90)	(3.58)	(0.64)	(−0.21)	(−1.24)	(−2.25)	(−5.45)	(4.36)
IVOL5	−0.03	−0.39	−0.55	−0.54	−0.82	0.79	−0.14	−0.26	−0.44	−0.62	−0.80	0.66
	(−0.17)	(−2.92)	(−4.46)	(−4.71)	(−5.66)	(3.35)	(−0.96)	(−1.80)	(−4.20)	(−5.36)	(−5.68)	(2.98)
All stocks	0.27	0.11	0.07	−0.03	−0.24	0.51	0.30	0.21	0.03	−0.06	−0.32	0.62
	(5.21)	(2.90)	(1.62)	(−0.84)	(−4.39)	(5.56)	(5.40)	(4.95)	(0.77)	(−1.65)	(−7.13)	(6.91)

	Panel C: Sort on IVOL and PE_{FFC4}						Panel D: Sort on IVOL and PE_{FF5}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
IVOL1	0.36	0.33	0.18	0.04	−0.15	0.51	0.54	0.43	0.05	−0.10	−0.27	0.80
	(5.23)	(4.70)	(2.72)	(0.64)	(−2.18)	(4.54)	(6.18)	(4.63)	(0.55)	(−1.06)	(−3.10)	(6.15)
IVOL2	0.37	0.19	−0.02	−0.11	−0.27	0.64	0.45	0.23	−0.01	−0.10	−0.31	0.76
	(4.52)	(2.59)	(−0.31)	(−1.54)	(−3.64)	(5.39)	(4.01)	(2.62)	(−0.16)	(−1.16)	(−3.29)	(4.70)
IVOL3	0.24	0.25	0.06	−0.27	−0.47	0.71	0.36	0.19	0.05	−0.24	−0.34	0.70
	(2.77)	(3.04)	(0.66)	(−3.71)	(−5.55)	(5.98)	(2.99)	(1.79)	(0.48)	(−2.55)	(−2.99)	(3.85)
IVOL4	0.07	0.01	−0.16	−0.18	−0.62	0.68	0.00	0.01	0.05	−0.21	−0.26	0.26
	(0.67)	(0.12)	(−1.86)	(−1.80)	(−5.92)	(4.76)	(0.03)	(0.04)	(0.45)	(−2.21)	(−2.28)	(1.37)
IVOL5	−0.20	−0.26	−0.39	−0.79	−0.72	0.52	−0.41	−0.23	−0.42	−0.46	−0.48	0.06
	(−1.40)	(−1.85)	(−3.05)	(−7.04)	(−5.02)	(2.35)	(−2.46)	(−1.37)	(−3.05)	(−3.67)	(−3.01)	(0.29)
All stocks	0.26	0.21	0.06	−0.09	−0.29	0.55	0.35	0.26	−0.01	−0.16	−0.31	0.67
	(5.07)	(4.61)	(1.72)	(−2.51)	(−5.83)	(6.08)	(4.62)	(5.22)	(−0.29)	(−3.39)	(−5.36)	(5.34)

	Panel E: Sort on IVOL and PE_{Q4}						Panel F: Sort on IVOL and PE_{M4}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
IVOL1	0.44	0.29	0.12	−0.05	−0.28	0.72	0.50	0.32	−0.03	0.01	−0.27	0.77
	(5.12)	(2.92)	(1.28)	(−0.61)	(−3.20)	(5.54)	(6.04)	(3.73)	(−0.28)	(0.07)	(−3.14)	(6.36)
IVOL2	0.38	0.11	0.07	−0.03	−0.24	0.61	0.43	0.17	0.03	−0.09	−0.28	0.71
	(3.17)	(1.15)	(0.89)	(−0.41)	(−2.11)	(3.53)	(4.68)	(1.96)	(0.44)	(−1.08)	(−2.85)	(5.10)
IVOL3	0.39	0.05	0.01	−0.15	−0.26	0.65	0.41	0.17	−0.09	−0.08	−0.31	0.72
	(3.24)	(0.43)	(0.14)	(−1.51)	(−2.16)	(3.55)	(3.37)	(1.87)	(−0.87)	(−0.77)	(−2.90)	(4.23)
IVOL4	−0.12	0.14	0.01	−0.10	−0.27	0.16	−0.03	0.11	−0.10	−0.07	−0.29	0.26
	(−0.65)	(1.03)	(0.08)	(−0.96)	(−2.55)	(0.70)	(−0.19)	(0.95)	(−0.86)	(−0.61)	(−2.78)	(1.39)
IVOL5	−0.31	−0.29	−0.62	−0.27	−0.45	0.14	−0.39	−0.34	−0.43	−0.48	−0.44	0.05
	(−1.56)	(−1.85)	(−4.31)	(−2.04)	(−2.53)	(0.52)	(−2.21)	(−2.11)	(−3.27)	(−3.50)	(−2.51)	(0.20)
All stocks	0.30	0.14	0.02	−0.09	−0.27	0.57	0.32	0.16	−0.02	−0.06	−0.30	0.62
	(3.86)	(2.80)	(0.32)	(−1.99)	(−4.10)	(4.35)	(4.94)	(3.41)	(−0.34)	(−1.13)	(−4.85)	(5.53)

Table A5: Mean-variance spanning tests

This table reports the Huberman and Kandel (1987) mean-variance spanning test statistics and the associated *p*-values of PE spread portfolios, where PE_{CAPM} refers to the spread portfolio based on the CAPM pricing error, and PE_{FF3} to the spread portfolio based on the FF3 pricing error, etc. Panel A tests the null hypothesis that the PE spread portfolios are spanned by risk factors, and Panel B tests the null hypothesis that the PE spread portfolios are spanned by risk factors plus short- and long-term reversal spread portfolios, where the short-term reversal is measured by the prior (1-1) return (STR), and the long-term reversal is measured by the prior (13-60) return (LTR). The sample period is the same as Table 1.

Benchmark assets	PE_{CAPM}	PE_{FF3}	PE_{FFC4}	PE_{FF5}	PE_{Q4}	PE_{M4}
Panel A: Benchmark assets are risk factors						
CAPM	1636.08	1863.70	1917.01	691.83	577.78	711.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
FF3	515.67	558.43	592.01	92.11	75.58	87.85
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
FFC	368.38	396.08	379.12	135.42	123.58	135.37
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
FF5	42.63	37.63	39.62	27.49	28.58	38.67
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
HXZ	54.73	50.24	52.08	39.01	41.65	62.12
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
SY	129.32	112.29	104.69	80.57	96.81	114.67
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Panel B: Benchmark assets are risk factors plus short- and long-term reversal portfolios						
CAPM+STR+LTR	64.98	117.63	125.01	44.50	37.85	39.53
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
FF3+STR+LTR	72.59	123.30	119.62	44.21	37.32	38.23
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
FFC3+STR+LTR	88.92	125.71	120.54	44.71	38.48	38.46
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
FF5+STR+LTR	14.78	24.40	22.50	15.45	12.84	17.68
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
HXZ+STR+LTR	12.90	19.60	19.59	11.91	10.00	18.39
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)
SY+STR+LTR	12.02	21.99	21.49	12.40	15.33	20.11
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Table A6: FF3 alphas of portfolios sorted by IO and PE

This table reports the FF3 alphas of the 25 value-weighted portfolios sorted by institutional ownership (IO) and pricing error (PE), where IO is calculated as Nagel (2005) and PE is estimated with the past 60-month returns by using the CAPM, FF3, FFC, FF5, HXZ, and SY models, respectively. The sample period is 1980:03–2015:12.

	Panel A: Sort on IO and PE_{CAPM}						Panel B: Sort on IO and PE_{FF3}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
IO1	0.34	−0.07	0.06	−0.09	−0.20	0.53	0.32	0.37	−0.06	−0.23	−0.31	0.63
	(1.88)	(−0.40)	(0.42)	(−0.70)	(−1.37)	(2.21)	(1.91)	(2.34)	(−0.48)	(−1.92)	(−2.15)	(2.80)
IO2	0.37	0.38	0.04	−0.02	−0.43	0.81	0.40	0.44	0.05	−0.07	−0.45	0.85
	(2.02)	(2.62)	(0.33)	(−0.19)	(−3.05)	(3.37)	(2.58)	(2.74)	(0.43)	(−0.53)	(−3.35)	(3.71)
IO3	0.09	0.25	0.21	0.27	−0.21	0.30	0.24	0.29	0.17	0.06	−0.27	0.51
	(0.74)	(2.17)	(1.84)	(2.94)	(−1.80)	(1.63)	(1.86)	(2.22)	(1.39)	(0.65)	(−2.56)	(2.86)
IO4	0.25	0.15	−0.14	−0.04	−0.30	0.55	0.24	0.28	−0.02	−0.21	−0.34	0.58
	(1.96)	(1.45)	(−1.39)	(−0.37)	(−2.52)	(2.91)	(1.90)	(2.73)	(−0.19)	(−2.26)	(−2.84)	(3.20)
IO5	−0.10	0.07	−0.20	−0.08	−0.31	0.21	−0.03	−0.08	0.04	−0.15	−0.38	0.35
	(−0.54)	(0.68)	(−1.73)	(−0.83)	(−2.69)	(0.94)	(−0.18)	(−0.69)	(0.39)	(−1.35)	(−3.86)	(1.72)
All stocks	0.21	0.20	0.05	0.03	−0.25	0.45	0.26	0.30	0.05	−0.11	−0.29	0.55
	(2.19)	(3.06)	(0.69)	(0.50)	(−3.05)	(2.94)	(2.89)	(4.17)	(0.84)	(−2.03)	(−3.70)	(3.67)

	Panel C: Sort on IO and PE_{FFC4}						Panel D: Sort on IO and PE_{FF5}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
IO1	0.40	0.12	−0.04	−0.11	−0.35	0.75	0.45	0.28	−0.18	−0.07	−0.39	0.84
	(2.38)	(0.84)	(−0.35)	(−0.92)	(−2.57)	(3.32)	(2.62)	(2.05)	(−1.41)	(−0.57)	(−2.54)	(3.52)
IO2	0.35	0.45	0.12	−0.04	−0.48	0.82	0.39	0.25	0.16	−0.06	−0.41	0.80
	(2.05)	(2.78)	(0.87)	(−0.37)	(−3.48)	(3.53)	(2.43)	(1.77)	(1.39)	(−0.44)	(−3.09)	(3.58)
IO3	0.16	0.35	0.13	0.12	−0.26	0.41	0.28	0.31	0.11	0.02	−0.23	0.51
	(1.15)	(2.77)	(1.11)	(1.16)	(−2.38)	(2.19)	(1.82)	(2.94)	(0.96)	(0.20)	(−2.27)	(2.64)
IO4	0.19	0.18	0.07	−0.24	−0.27	0.46	0.20	0.28	0.06	−0.24	−0.36	0.57
	(1.64)	(1.48)	(0.80)	(−2.72)	(−2.39)	(2.86)	(1.63)	(2.63)	(0.66)	(−2.39)	(−3.39)	(3.26)
IO5	−0.08	0.02	−0.05	−0.11	−0.38	0.29	−0.03	0.06	−0.01	−0.30	−0.32	0.28
	(−0.48)	(0.19)	(−0.54)	(−1.09)	(−3.41)	(1.48)	(−0.19)	(0.50)	(−0.14)	(−2.75)	(−3.13)	(1.40)
All stocks	0.20	0.30	0.05	−0.09	−0.30	0.50	0.29	0.29	−0.01	−0.12	−0.29	0.57
	(2.42)	(4.04)	(0.69)	(−1.46)	(−3.75)	(3.34)	(2.87)	(5.19)	(−0.24)	(−1.94)	(−3.74)	(3.59)

	Panel E: Sort on IO and PE_{Q4}						Panel F: Sort on IO and PE_{M4}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
IO1	0.27	0.24	−0.21	−0.12	−0.24	0.51	0.22	0.00	−0.03	−0.09	−0.23	0.45
	(1.80)	(1.56)	(−1.40)	(−0.87)	(−1.54)	(2.35)	(1.20)	(0.00)	(−0.28)	(−0.65)	(−1.70)	(1.86)
IO2	0.36	0.48	−0.15	−0.01	−0.45	0.81	0.41	0.23	−0.04	0.03	−0.47	0.88
	(2.06)	(2.67)	(−1.37)	(−0.05)	(−2.81)	(3.14)	(2.10)	(1.86)	(−0.29)	(0.25)	(−3.51)	(3.58)
IO3	0.19	0.26	0.20	0.06	−0.20	0.40	0.18	0.21	0.14	0.11	−0.19	0.36
	(1.72)	(2.73)	(1.59)	(0.57)	(−1.91)	(2.40)	(1.68)	(1.92)	(1.39)	(1.07)	(−1.73)	(2.41)
IO4	0.21	0.19	−0.11	−0.18	−0.25	0.46	0.28	0.03	0.01	−0.13	−0.29	0.58
	(1.64)	(1.94)	(−1.02)	(−2.01)	(−2.19)	(2.50)	(2.21)	(0.27)	(0.11)	(−1.27)	(−2.55)	(3.09)
IO5	−0.08	−0.07	0.07	−0.34	−0.27	0.20	0.00	−0.15	0.03	−0.18	−0.35	0.35
	(−0.43)	(−0.61)	(0.63)	(−3.20)	(−2.59)	(0.91)	(0.02)	(−1.28)	(0.31)	(−1.94)	(−3.02)	(1.83)
All stocks	0.21	0.28	0.02	−0.12	−0.24	0.45	0.24	0.16	0.04	−0.02	−0.27	0.50
	(2.25)	(4.09)	(0.30)	(−2.17)	(−3.03)	(2.84)	(2.84)	(3.07)	(0.78)	(−0.38)	(−3.47)	(3.54)

Table A7: FF3 alphas of portfolios sorted by MAX and PE

This table reports the FF3 alphas of the 25 value-weighted portfolios sorted by MAX and pricing error (PE), where MAX measures the lottery demand and is defined as the average of the 5 highest daily returns in the portfolio formation month (Bali, Cakici, and Whitelaw, 2011), and PE is estimated with the past 60-month returns by using the CAPM, FF3, FFC, FF5, HXZ, and SY models, respectively. The sample period is the same as Table 1.

	Panel A: Sort on MAX and PE_{CAPM}						Panel B: Sort on MAX and PE_{FF3}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
MAX1	0.52	0.35	0.17	0.16	−0.14	0.66	0.52	0.35	0.29	0.08	−0.22	0.74
	(7.11)	(4.96)	(2.21)	(2.31)	(−1.97)	(6.37)	(6.98)	(5.03)	(4.01)	(0.96)	(−3.12)	(6.72)
MAX2	0.27	0.20	0.22	−0.01	−0.15	0.42	0.31	0.24	0.19	−0.04	−0.19	0.50
	(3.18)	(2.79)	(3.17)	(−0.11)	(−2.10)	(3.57)	(3.40)	(3.13)	(2.42)	(−0.69)	(−2.81)	(4.19)
MAX3	0.19	0.05	−0.02	−0.02	−0.38	0.56	0.16	0.29	−0.01	−0.08	−0.44	0.60
	(2.21)	(0.48)	(−0.29)	(−0.21)	(−4.52)	(4.98)	(1.73)	(3.14)	(−0.10)	(−1.00)	(−5.38)	(5.15)
MAX4	0.15	−0.15	−0.13	−0.20	−0.40	0.55	0.12	−0.05	−0.00	−0.32	−0.44	0.56
	(1.31)	(−1.54)	(−1.47)	(−2.23)	(−3.65)	(3.16)	(1.10)	(−0.48)	(−0.03)	(−3.51)	(−4.30)	(3.44)
MAX5	−0.31	−0.37	−0.45	−0.36	−0.77	0.47	−0.36	−0.25	−0.39	−0.38	−0.82	0.46
	(−2.02)	(−3.13)	(−3.95)	(−3.10)	(−5.78)	(2.05)	(−2.36)	(−2.19)	(−3.06)	(−3.24)	(−6.65)	(2.17)
All stocks	0.23	0.13	0.11	0.04	−0.24	0.47	0.23	0.22	0.13	−0.06	−0.31	0.54
	(4.03)	(2.79)	(2.90)	(1.11)	(−4.59)	(4.89)	(3.87)	(5.02)	(3.45)	(−1.62)	(−6.46)	(5.63)

	Panel C: Sort on MAX and PE_{FFC4}						Panel D: Sort on MAX and PE_{FF5}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
MAX1	0.52	0.35	0.19	0.13	−0.18	0.69	0.47	0.46	0.07	−0.15	−0.29	0.76
	(7.38)	(4.75)	(2.59)	(1.77)	(−2.41)	(6.38)	(4.75)	(5.74)	(0.80)	(−1.47)	(−2.98)	(5.32)
MAX2	0.30	0.27	0.15	−0.00	−0.18	0.48	0.49	0.42	0.07	−0.03	−0.34	0.84
	(3.21)	(3.31)	(1.90)	(−0.06)	(−2.75)	(4.11)	(4.37)	(4.22)	(0.81)	(−0.35)	(−4.34)	(5.46)
MAX3	0.16	0.21	0.06	−0.16	−0.41	0.57	0.25	0.16	−0.00	−0.17	−0.38	0.62
	(1.78)	(2.38)	(0.65)	(−1.88)	(−5.02)	(4.93)	(2.12)	(1.36)	(−0.04)	(−1.65)	(−3.99)	(4.11)
MAX4	0.17	−0.16	−0.01	−0.34	−0.44	0.61	0.12	0.10	0.17	−0.26	−0.20	0.31
	(1.57)	(−1.72)	(−0.17)	(−3.74)	(−4.30)	(3.79)	(0.70)	(0.89)	(1.45)	(−2.59)	(−1.72)	(1.39)
MAX5	−0.35	−0.34	−0.40	−0.39	−0.79	0.44	−0.38	−0.10	−0.51	−0.17	−0.41	0.02
	(−2.27)	(−2.82)	(−3.19)	(−3.42)	(−6.30)	(2.08)	(−1.93)	(−0.66)	(−3.39)	(−1.18)	(−2.86)	(0.10)
All stocks	0.24	0.19	0.11	−0.03	−0.28	0.52	0.30	0.32	0.03	−0.13	−0.30	0.60
	(4.25)	(4.13)	(3.09)	(−0.77)	(−6.01)	(5.62)	(3.60)	(6.00)	(0.66)	(−2.79)	(−4.71)	(4.47)

	Panel E: Sort on MAX and PE_{Q4}						Panel F: Sort on MAX and PE_{M4}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
MAX1	0.46	0.36	−0.00	−0.00	−0.28	0.74	0.45	0.31	0.17	−0.09	−0.27	0.73
	(4.52)	(3.51)	(−0.02)	(−0.02)	(−2.56)	(4.52)	(5.24)	(3.11)	(1.82)	(−0.86)	(−3.01)	(5.40)
MAX2	0.37	0.36	0.12	−0.01	−0.29	0.66	0.47	0.27	0.20	−0.06	−0.28	0.75
	(3.33)	(3.92)	(1.16)	(−0.14)	(−3.69)	(4.32)	(4.38)	(3.09)	(2.23)	(−0.68)	(−3.73)	(5.28)
MAX3	0.22	0.13	−0.01	−0.25	−0.22	0.44	0.29	0.14	−0.05	−0.15	−0.42	0.71
	(1.80)	(1.07)	(−0.12)	(−2.34)	(−2.33)	(3.03)	(2.10)	(1.26)	(−0.56)	(−1.44)	(−4.44)	(4.27)
MAX4	0.12	0.10	0.03	−0.13	−0.13	0.25	0.19	0.09	0.04	−0.15	−0.19	0.38
	(0.67)	(0.77)	(0.21)	(−1.37)	(−1.08)	(1.09)	(1.18)	(0.75)	(0.38)	(−1.55)	(−1.85)	(1.86)
MAX5	−0.43	−0.26	−0.32	−0.01	−0.38	−0.06	−0.41	−0.31	−0.20	−0.24	−0.35	−0.06
	(−2.01)	(−1.56)	(−2.13)	(−0.09)	(−2.25)	(−0.21)	(−2.01)	(−2.06)	(−1.25)	(−1.64)	(−2.21)	(−0.23)
All stocks	0.24	0.24	0.00	−0.07	−0.25	0.49	0.27	0.18	0.09	−0.07	−0.29	0.55
	(3.06)	(3.99)	(0.01)	(−1.49)	(−3.88)	(3.70)	(3.41)	(3.73)	(2.02)	(−1.53)	(−4.62)	(4.27)

Table A8: FF3 alphas of portfolios sorted by PTP and PE

This table reports the FF3 alphas of the 25 value-weighted portfolios sorted by PTP and PE, where PTP measures the expectation of expected returns and is defined as analysts' consensus price target scaled by the current price Weber (2018), and PE is estimated with the past 60-month returns by using the CAPM, FF3, FFC, FF5, HXZ, and SY models, respectively. The sample period is 1999:03–2016:12.

	Panel A: Sort on PTP and PE_{CAPM}						Panel B: Sort on PTP and PE_{FF3}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
PTP1	1.00	1.07	0.87	0.40	0.22	0.78	70.99	1.28	0.62	0.60	0.15	0.85
	(5.27)	(3.89)	(3.91)	(1.64)	(1.21)	(3.15)	(4.39)	(5.31)	(3.29)	(2.86)	(0.87)	(3.06)
PTP2	0.46	0.66	−0.21	0.11	−0.49	0.95	0.60	0.63	−0.09	−0.09	−0.30	0.90
	(2.79)	(2.86)	(−0.89)	(0.65)	(−2.73)	(3.75)	(2.70)	(2.73)	(−0.48)	(−0.57)	(−1.57)	(2.93)
PTP3	0.05	0.13	−0.18	0.09	−0.59	0.65	0.23	0.25	−0.28	−0.24	−0.42	0.65
	(0.37)	(0.87)	(−1.40)	(0.50)	(−3.75)	(2.88)	(1.71)	(2.12)	(−1.84)	(−1.40)	(−2.48)	(2.74)
PTP4	0.35	0.46	−0.34	−0.05	−0.31	0.65	0.50	0.33	0.02	−0.24	−0.35	0.85
	(1.90)	(1.97)	(−1.58)	(−0.26)	(−1.22)	(2.05)	(2.17)	(1.57)	(0.10)	(−1.16)	(−1.59)	(2.31)
PTP5	−0.66	−0.34	−0.15	−0.47	−0.51	−0.15	−0.12	−0.64	−0.62	−0.21	−0.74	0.61
	(−2.32)	(−1.16)	(−0.54)	(−1.70)	(−1.89)	(−0.39)	(−0.37)	(−2.31)	(−2.27)	(−0.72)	(−2.63)	(1.58)
All stocks	0.30	0.39	−0.08	0.12	−0.42	0.71	0.46	0.44	−0.11	−0.09	−0.35	0.81
	(2.61)	(3.20)	(−0.77)	(1.14)	(−3.53)	(3.61)	(2.98)	(3.80)	(−1.01)	(−1.22)	(−2.68)	(3.14)

	Panel C: Sort on PTP and PE_{FFC4}						Panel D: Sort on PTP and PE_{FF5}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
PTP1	1.00	1.08	0.77	0.56	0.13	0.87	1.15	0.89	0.81	0.52	0.17	0.98
	(4.56)	(4.27)	(4.47)	(2.95)	(0.80)	(3.13)	(4.85)	(4.93)	(3.85)	(2.45)	(1.02)	(3.55)
PTP2	0.54	0.67	−0.05	−0.12	−0.26	0.79	0.69	0.63	−0.15	−0.06	−0.29	0.98
	(2.39)	(2.71)	(−0.29)	(−0.84)	(−1.27)	(2.46)	(2.78)	(2.75)	(−0.92)	(−0.39)	(−1.36)	(2.81)
PTP3	0.17	0.21	−0.12	−0.20	−0.49	0.66	0.28	0.08	−0.36	−0.24	−0.32	0.61
	(1.20)	(1.53)	(−0.71)	(−0.97)	(−2.93)	(2.90)	(2.06)	(0.47)	(−2.35)	(−1.43)	(−1.77)	(2.31)
PTP4	0.40	0.45	0.10	−0.07	−0.54	0.94	0.50	0.36	−0.02	−0.09	−0.40	0.90
	(2.00)	(1.80)	(0.53)	(−0.30)	(−2.26)	(2.60)	(2.20)	(1.81)	(−0.09)	(−0.37)	(−2.01)	(2.56)
PTP5	−0.42	−0.21	−0.39	−0.47	−0.52	0.10	−0.16	−0.63	−0.20	−0.45	−0.71	0.55
	(−1.26)	(−0.82)	(−1.24)	(−1.95)	(−1.78)	(0.22)	(−0.53)	(−2.71)	(−0.72)	(−1.74)	(−2.56)	(1.36)
All stocks	0.40	0.38	0.03	−0.16	−0.36	0.76	0.47	0.31	−0.05	−0.12	−0.36	0.83
	(2.71)	(3.49)	(0.36)	(−1.57)	(−2.99)	(3.07)	(2.98)	(3.77)	(−0.60)	(−1.26)	(−2.56)	(3.02)

	Panel E: Sort on PTP and PE_{Q4}						Panel F: Sort on PTP and PE_{M4}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
PTP1	0.97	1.06	0.95	0.26	0.27	0.69	1.08	0.79	0.69	0.70	0.31	0.77
	(4.59)	(5.49)	(4.18)	(1.13)	(1.53)	(2.80)	(4.79)	(5.14)	(3.55)	(3.39)	(1.70)	(3.20)
PTP2	0.61	0.61	−0.34	0.09	−0.33	0.94	0.69	0.46	−0.13	−0.21	−0.14	0.84
	(2.46)	(2.69)	(−1.65)	(0.43)	(−2.12)	(3.06)	(2.98)	(2.17)	(−0.63)	(−1.28)	(−0.79)	(2.60)
PTP3	0.12	0.26	−0.26	0.01	−0.59	0.71	0.18	−0.04	−0.02	−0.15	−0.46	0.64
	(0.79)	(1.84)	(−1.95)	(0.09)	(−3.12)	(2.57)	(1.36)	(−0.22)	(−0.15)	(−0.75)	(−2.71)	(2.61)
PTP4	0.59	0.16	0.05	−0.18	−0.46	1.05	0.43	0.40	0.07	−0.28	−0.26	0.69
	(2.56)	(0.80)	(0.25)	(−0.73)	(−2.13)	(2.80)	(2.30)	(2.12)	(0.36)	(−1.02)	(−1.13)	(2.24)
PTP5	−0.41	−0.51	0.02	−0.35	−0.65	0.24	−0.64	−0.67	−0.24	−0.27	−0.51	−0.14
	(−1.32)	(−1.72)	(0.05)	(−1.49)	(−2.07)	(0.56)	(−2.08)	(−2.06)	(−0.85)	(−1.15)	(−1.61)	(−0.30)
All stocks	0.37	0.38	0.01	−0.03	−0.40	0.77	0.42	0.16	0.10	−0.08	−0.25	0.67
	(2.81)	(3.82)	(0.11)	(−0.23)	(−3.34)	(3.25)	(3.11)	(1.90)	(1.52)	(−0.73)	(−2.16)	(3.10)

Table A9: FF3 alphas of portfolios sorted by LTG and PE

This table reports the FF3 alphas of the 25 value-weighted portfolios sorted by LTG and PE, where LTG is analysts' long-term growth forecast on earnings as in (Weber, 2018), and PE is estimated with the past 60-month returns by using the CAPM, FF3, FFC, FF5, HXZ, and SY models, respectively. The sample period is 1982:01–2016:12.

	Panel A: Sort on LTG and PE_{CAPM}						Panel B: Sort on LTG and PE_{FF3}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
LTG1	0.30	0.39	0.20	−0.01	−0.12	0.43	0.28	0.32	0.31	−0.00	−0.16	0.44
	(2.05)	(3.27)	(1.71)	(−0.04)	(−0.95)	(1.97)	(2.18)	(2.57)	(2.81)	(−0.01)	(−1.28)	(2.40)
LTG2	0.25	0.18	−0.05	−0.09	−0.39	0.64	0.31	0.11	−0.01	−0.31	−0.27	0.58
	(1.84)	(1.94)	(−0.35)	(−0.84)	(−2.61)	(2.84)	(2.11)	(1.03)	(−0.05)	(−2.35)	(−1.89)	(2.41)
LTG3	0.39	0.32	−0.16	−0.06	−0.49	0.89	0.41	0.27	0.02	−0.11	−0.54	0.95
	(2.88)	(2.57)	(−1.42)	(−0.60)	(−4.31)	(4.96)	(3.04)	(2.22)	(0.18)	(−0.92)	(−5.01)	(4.84)
LTG4	0.28	0.18	0.04	0.03	−0.42	0.70	0.47	0.31	0.10	−0.20	−0.50	0.97
	(1.72)	(1.58)	(0.30)	(0.20)	(−3.78)	(3.69)	(2.82)	(2.13)	(0.82)	(−1.49)	(−4.42)	(4.40)
LTG5	−0.08	0.38	0.15	0.29	−0.09	0.01	0.04	0.29	0.12	0.25	0.01	0.03
	(−0.52)	(2.56)	(0.76)	(1.32)	(−0.50)	(0.04)	(0.23)	(1.74)	(0.79)	(1.09)	(0.05)	(0.13)
All stocks	0.23	0.29	0.07	0.03	−0.34	0.56	0.32	0.26	0.12	−0.11	−0.34	0.66
	(2.58)	(4.44)	(1.00)	(0.46)	(−4.10)	(3.81)	(3.24)	(4.65)	(2.04)	(−2.35)	(−4.03)	(3.95)
	Panel C: Sort on LTG and PE_{FFC4}						Panel D: Sort on LTG and PE_{FF5}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
LTG1	0.19	0.33	0.26	0.01	−0.09	0.27	0.40	0.21	0.28	0.09	−0.12	0.53
	(1.27)	(3.08)	(2.52)	(0.15)	(−0.67)	(1.26)	(2.98)	(1.88)	(2.75)	(0.84)	(−1.04)	(2.63)
LTG2	0.27	0.17	0.03	−0.28	−0.29	0.56	0.27	0.31	−0.09	−0.27	−0.30	0.58
	(1.94)	(1.67)	(0.21)	(−2.09)	(−2.05)	(2.42)	(2.01)	(2.68)	(−0.69)	(−2.25)	(−2.02)	(2.60)
LTG3	0.37	0.22	0.06	−0.15	−0.49	0.86	0.47	0.23	−0.07	−0.12	−0.50	0.97
	(2.99)	(2.21)	(0.52)	(−1.45)	(−4.42)	(4.62)	(3.27)	(2.14)	(−0.63)	(−1.08)	(−4.91)	(5.13)
LTG4	0.42	0.36	−0.02	−0.18	−0.42	0.84	0.46	0.15	0.08	−0.11	−0.55	1.02
	(2.62)	(2.59)	(−0.17)	(−1.53)	(−3.92)	(4.07)	(2.72)	(0.93)	(0.59)	(−0.89)	(−4.48)	(4.44)
LTG5	0.19	0.21	0.09	0.18	0.03	0.16	0.01	0.50	0.09	0.06	−0.03	0.03
	(1.00)	(1.27)	(0.49)	(1.00)	(0.13)	(0.60)	(0.05)	(3.17)	(0.52)	(0.38)	(−0.12)	(0.12)
All stocks	0.29	0.27	0.10	−0.14	−0.29	0.58	0.33	0.27	0.03	−0.11	−0.33	0.66
	(3.23)	(4.36)	(1.44)	(−2.56)	(−3.47)	(3.58)	(3.38)	(4.60)	(0.40)	(−1.85)	(−4.25)	(4.15)
	Panel E: Sort on LTG and PE_{Q4}						Panel F: Sort on LTG and PE_{M4}					
	PE1	PE2	PE3	PE4	PE5	PE1-5	PE1	PE2	PE3	PE4	PE5	PE1-5
LTG1	0.19	0.42	0.23	0.02	−0.10	0.29	0.13	0.33	0.14	0.16	−0.12	0.25
	(1.43)	(3.56)	(2.16)	(0.22)	(−0.81)	(1.42)	(0.67)	(2.74)	(1.19)	(1.70)	(−0.94)	(0.93)
LTG2	0.16	0.26	−0.01	−0.17	−0.30	0.46	0.30	0.15	−0.02	−0.20	−0.31	0.61
	(1.17)	(2.44)	(−0.09)	(−1.52)	(−2.15)	(2.11)	(2.32)	(1.35)	(−0.14)	(−1.38)	(−2.20)	(2.85)
LTG3	0.53	0.20	−0.09	−0.08	−0.45	0.98	0.50	0.14	−0.10	−0.09	−0.49	0.99
	(3.45)	(1.76)	(−0.93)	(−0.70)	(−3.87)	(4.82)	(3.70)	(1.49)	(−0.78)	(−0.75)	(−4.38)	(5.10)
LTG4	0.27	0.31	0.11	−0.15	−0.49	0.76	0.42	0.16	0.10	−0.05	−0.50	0.93
	(1.91)	(2.00)	(0.87)	(−1.23)	(−4.39)	(3.85)	(2.86)	(1.33)	(0.88)	(−0.49)	(−4.54)	(4.63)
LTG5	0.15	0.24	0.16	−0.05	0.01	0.13	0.06	0.14	0.25	−0.00	0.03	0.04
	(0.85)	(1.28)	(0.99)	(−0.29)	(0.08)	(0.55)	(0.35)	(0.83)	(1.31)	(−0.02)	(0.14)	(0.14)
All stocks	0.27	0.28	0.06	−0.13	−0.30	0.57	0.31	0.19	0.05	−0.08	−0.30	0.61
	(2.91)	(4.68)	(1.06)	(−2.42)	(−3.75)	(3.61)	(3.31)	(3.81)	(0.89)	(−1.36)	(−3.61)	(3.80)

Table A10: Fama-MacBeth regressions

This table reports the time-series average of the coefficients from Fama-MacBeth regressions of one-month-ahead returns on PE and other variables, where IO refers to institutional ownership, MAX to lottery demand, PTP to analysts' implied return expectation, and LTG to analysts' long-term growth forecast on earnings. Newey-West t-statistics are reported in parentheses. Each regression uses all available data. Intercepts are included in all regressions but not reported here.

	Dependent variable: one-month-ahead return						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PE_{CAPM}	−0.68	−0.62	−0.63	−0.53	−0.56	−0.63	−0.40
	(−7.86)	(−6.64)	(−7.67)	(−3.50)	(−5.65)	(−7.58)	(−2.87)
IO		0.08					−0.10
		(0.36)					(−0.34)
MAX			−0.04				−0.03
			(−2.59)				(−0.69)
PTP				−0.00			−0.00
				(−1.54)			(−1.73)
LTG					0.01		0.01
					(0.89)		(1.22)
IVOL						−0.21	−0.04
						(−3.99)	(−0.44)
Log(ME)	−0.06	−0.07	−0.08	−0.13	−0.05	−0.10	−0.12
	(−1.65)	(−1.58)	(−2.34)	(−2.46)	(−1.55)	(−3.10)	(−2.57)
Log(BM)	0.12	0.08	0.10	−0.07	0.11	0.09	−0.01
	(1.82)	(1.26)	(1.66)	(−0.68)	(1.58)	(1.41)	(−0.09)
STR	0.03	0.03	0.03	0.02	0.02	0.02	0.01
	(2.83)	(2.41)	(2.69)	(1.10)	(1.59)	(2.35)	(0.69)
MOM	0.08	0.07	0.08	0.02	0.06	0.08	0.00
	(3.09)	(2.68)	(3.24)	(0.42)	(2.27)	(3.25)	(0.05)
LTR	−0.08	−0.03	−0.07	−0.07	−0.03	−0.06	−0.10
	(−1.99)	(−0.68)	(−1.87)	(−1.22)	(−0.74)	(−1.80)	(−1.55)
N	611,310	519,805	611,299	252,447	420,827	611,310	229,329