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Why Do Some Asset Pricing Models Perform Poorly? Evidence from Irrationality, Transaction Costs, and Missing Factors*

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Abstract

We identify and horse race three causes for the underperformance of some asset pricing models: investor irrationality, transaction costs, and missing risk factors. Specifically, we regress the difference of realized over expected returns (pricing error) per various asset pricing models onto proxies for the reasons for explanatory breakdown. First, for the capital asset pricing model (CAPM) and six other models we find that both investor irrationality and transaction costs are significantly related to the pricing error controlling for firm size and valuation. Second, models with more risk factors than the CAPM cannot overcome the shortcoming of the CAPM due to investor irrationality and transaction costs. In conclusion, transaction costs and investor irrationality are shown to be impediments to enhancing

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the prediction power of tested models regardless of additional risk factors.

Keywords: Asset Pricing Model; Transaction Cost; Investor irrationality; Missing Risk Factor; Fama and MacBeth (1973) Regression.

INTRODUCTION

Ever since Sharpe (1964), Lintner (1965), and Mossin (1966) originated the capital asset pricing model (CAPM), many other asset pricing models have been devised to find a better asset pricing model than the CAPM. However, none of other asset pricing models has successfully explained the cross-sectional variation in expected returns. These models have also been criticized because of their theoretical weaknesses or poor empirical performance. For example, the Fama and French three-factor model, which is considered to be successful in explaining the cross-sectional variation of expected returns, has been criticized for its theoretical foundation.[1)]

In this paper, we investigate what reason most appropriately explains the poor performance of various asset pricing models. Our study is different from others reported in the literature so far in that we adopt a *negative* approach: while other studies try to achieve more explanatory power in their models, we focus on the failure, namely, the *lack* of explanatory power of asset pricing models. This negative approach gives a benefit that we can consider the other side of the cross-section of stock returns. Namely, it can show us a direction where we should go into to achieve more explanatory power in asset pricing models.[2)]

Our paper is considered to be adopting synthetic approach since it introduces six other asset pricing models in addition to CAPM. This approach is important in the practice such as calculating the cost of capital and employing a benchmark to evaluate the performance of a fund. For example, if the explanation with missing

1) See, for instance, Lakonishok, Shleifer, and Vishny (1994), MacKinlay (1995), Daniel and Titman (1997), Frankel and Lee (1998), Dechow, Hutton, and Sloan (1999), Piotroski (2000), and Daniel, Titman, and Wei (2001).

2) For example, MacKinlay (1995) classifies the reasons for the violations of the CAPM into two categories of risk-based and non-risk-based explanations and argues that multifactor pricing models do not resolve CAPM deviations by themselves.

risk factors is correct, the calculation of cost of capital using the CAPM should be replaced by another multifactor model with better explanatory power. On the other hand, if the low explanatory power of a model is a result from other explanations, a multifactor model may lead to serious errors because of the same unsolved reason. Recently literature on the multidimensionality of the cross-section of stock returns has improved distinctly. Harvey, Liu and Zhu (2016) identify 316 factors published by academic journals and provide a multiple testing framework that requires a much higher hurdle. Green, Hand and Zhang (2013) investigate more than 330 return predictive signals and conclude that proper combination of these signals can induce large diversification benefits. McLean and Pontiff (2016) implement out-of-sample tests for the post-publication bias of anomalies discovered in the academic journal. The overall result of these studies is that many reported factors seem to be false.

Another innovation in this paper is that we implement a *firm-level analysis* and employ the cross-sectional differences of firms to seek the reason for failure. Some studies try to analyze the specification error of asset pricing models. Most of them, for example, Hodrick and Zhang (2001) and Kan and Robotti (2008), use the Hansen and Jagannathan (1997) distance to compare the specification errors of models. However, these studies do not identify the reason for the failure of asset pricing models, but they only provide a statistical diagnosis. On the other hand, our study provides a simple test of which unrealistic assumptions actually fail asset pricing models in the real world.

Based upon the existing literature, we identify three categories of reasons for the failure of asset pricing models: investor irrationality; transaction costs; and missing risk factors (see, for instance, Fama and French, 2004[3)]; MacKinlay, 1995[4)]). One of the main

3) Fama and French (2004) categorize the reasons for the failure of the CAPM into two kinds: investor irrationality and unrealistic assumptions of the CAPM, such as a single risk factor or transaction costs. In the same vein, we consider the main reasons for the failure of numerous asset pricing models, including the CAPM, to be investor irrationality, transaction costs, and missing risk factors.

4) MacKinlay (1995) classifies the reasons for the violations of the CAPM into two categories: risk-based and non-risk-based explanations. The risk-based explanation includes missing risk factors or the misidentification of the market portfolio, as in Roll (1977). The non-risk-based explanation includes biases that are introduced in the data or empirical methodology, the existence of market frictions, or the presence of irrational investors. Among them, we consider

explanations for the poor record of the CAPM is based on behavioral finance. For example, overreaction has been an important explanation for momentum profits, a famous criticism of the CAPM. Fama and French (1996) also conclude that their three-factor model fails to explain this momentum effect. Lakonishok, Shleifer, and Vishny (1994) argue that investors' incorrect extrapolation of the past performance of stock returns is the main source of the return premium that is associated with high book-to-market stocks. They show that the return premium is too large and that its covariance with macro factors is too low to be considered a compensation for the systemic risk.

Our second consideration is market friction. For example, transaction costs can restrict investors' trading and interrupt the price discovery processes of the market.[5)] Recent studies concentrate on liquidity or transaction costs for the failure of the CAPM and try to supplement them in their model (Mayshar, 1979; Amihud and Mendelson, 1986; Acharya and Pedersen, 2005). Therefore, we consider the effects of transaction costs on the performance of asset pricing models.

Finally, we focus on the assumption of a single risk factor. The development of asset pricing models from the CAPM through to the Fama and French three-factor model or the Carhart four-factor model reflects a continual effort for finding a new risk factor. Therefore, we investigate the effects of missing risk factors on the

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factor-related explanations to use the cross-sectional differences for finding the best reason. In this paper, transaction costs (or liquidity effects) and investor irrationality can be considered as idiosyncratic risks, while missing risk factors are risks that are developed under the assumptions of investor rationality and a perfect capital market.

5) Taxes, short-sale constraints, and information asymmetry also contribute to the restriction on investors' trades. Brennan (1973) and Litzenberger and Ramaswamy (1979) propose an after-tax version of the CAPM that accounts for the taxation of dividends. Short-sale constraints are generally considered to cause overvaluation by keeping more pessimistic investors out of the market (Miller, 1977; Duffie, Galeanu, and Pedersen, 2002). Diamond and Verrecchia (1987) and Hong and Stein (2003) also argue that short-sale constraints reduce the informational efficiency of prices because they keep bad information from being incorporated into prices. Cao, Coval, and Hirshleifer (2002) show that fixed setup costs of trading can cause return patterns that challenge rational theories of securities' pricing. The higher degree of information asymmetry also makes uninformed traders reluctant to participate in trading and thereby requires a higher rate of return on the stock (Easley, Hvidkjaer, and O'Hara, 2002; Easley and O'Hara, 2004). However, we only consider the transaction costs for simplicity.

performance of asset pricing models.

To distinguish these three reasons, we implement the following procedures. First, we focus on the CAPM. We attempt to elucidate which of the two reasons, investor irrationality or transaction costs, explains better the failure of the CAPM. After the differences between the realized returns and the expected returns from the CAPM are computed, the cross-sectional relations between these differences and variables that are related to investor irrationality and transaction costs are analyzed through Fama/MacBeth regression. The results show that both transaction costs and investor irrationality are significantly related to the differences between the realized returns and the expected returns from the CAPM. Strikingly, these relations remain significant even after the size and book-to-market, which are generally considered as the main reasons for the CAPM's failure, are included in the regression. Also, the existence of transaction costs or irrational investors relatively reduces the performance of the CAPM rather than cause the model to collapse altogether. If transaction costs or investor irrationality causes the CAPM to fail totally, we should not observe any monotonic relationship between the pricing errors that result from the CAPM and variables that make the CAPM fail. However, in our results, we observe a strong monotonic relationship.

Second, we investigate whether or not the effects of transaction costs and investor irrationality can be applied to other asset pricing models beyond the CAPM. Even though many other asset pricing models improve upon the CAPM, it is not clear whether a relationship between pricing errors and transaction costs (or investor irrationality) still exists in the models. We examine six asset pricing models to answer this question. The results of Fama/MacBeth regressions show that both transaction costs and investor irrationality are significantly related to the pricing errors.

Finally, we examine the case of missing risk factors. Even if the above tests shed light on the tenacious roles of investor irrationality and transaction costs in the failure of asset pricing models, they cannot resolve the question of whether factors that are missing in the CAPM are also reasons for the failure of the CAPM. To answer this question, we perform two tests. These tests examine the relationship between the CAPM and models with more factors than the CAPM, which show to what extent the explanatory power of asset pricing models is improved by the addition of more factors than are present in the CAPM. First, we compare the regression coefficients from the CAPM with those from the three-factor model by using the Wald test. If a missing factor is the main reason for the failure of the CAPM and if the three-factor model at least improves upon the CAPM, we should observe a different pattern of coefficients.[6)] However, the Wald test reveals the patterns of coefficients from the CAPM and the three-factor model to be very similar. No Wald statistics can reject the null hypothesis that the coefficients of the CAPM and the three-factor model are the same. We also implement this procedure using the Carhart four-factor model, the conditional CAPM, and Campbell (1996)'s model. However, in all models, except for the conditional CAPM, the results do not change.

In the second test, we add the residuals from the Fama/MacBeth regression of the models that comprise more factors than the CAPM into the Fama/MacBeth regression of the CAPM. We know that the residuals contain missing factors though we cannot identify exactly what factors are missing. Thus, these residuals are included in the Fama/MacBeth regression of the CAPM as an explanatory variable. Through this regression, we can determine whether missing factors play a significant role in the poor performance of an asset pricing model and whether variables that are related to transaction costs and investor irrationality still remain significant. The results show that the residuals and the variables that pertain to transaction costs and investor irrationality are all statistically significant. This implies that the poor performance of an asset pricing model that is due to transaction costs and investor irrationality cannot be improved upon by merely adding more factors. However, we cannot exclude the possibility that missing factors may be a cause of the poor performance of an asset pricing model.

This article is organized as follows. In section 2, we develop hypotheses for transaction costs, investor irrationality, and missing risk factors. Data and variables are described in section 3. The main tests are reported in section 4. Finally, section 5 concludes the article.

6) This logic is supported by the appendix, where we show that the same regression coefficients imply that the addition of more risk factors cannot explain the effect of transaction costs and investor irrationality.

HYPOTHESIS

The strength of the CAPM is its theoretical simplicity and its rich insights into economics and finance. However, previous empirical tests have not provided sufficiently favorable results. Fama and French (2004) document two reasons for the empirical poor performance of the CAPM. One reason is investor irrationality and the other comprises unrealistic assumptions, such as transaction costs or a single risk factor.

Daniel, Hirschleifer, and Subrahmanyam (2001) suggest that the degree of investor biases will affect asset prices as do Gervais and Odean (2001). Daniel et al. (2001) offer a model in which arbitrageurs trade against mispricing and both covariance risk and incorrect valuation of investors determine the cross-section of expected returns. As a result, in equilibrium, the expected returns are linearly related to both beta risks and mispricing measures. They argue that if investors' misperceptions are very high, the relationship between mispricing measures and expected returns will be strong and the relationship between beta (β) and the expected return will be weak. Thus, investor biases can decrease the explanatory power of the CAPM.

> **H1 (CAPM & Investor Irrationality)**: A firm that is exposed to greater investor irrationality experiences a wider discrepancy in the risk-return relationship between its beta and its expected return. Consequently, for a firm with greater investor irrationality, the deviation of the firm's actual stock return from the expected return that is estimated by the CAPM will be greater.

Amihud and Mendelson (1986) document that investors should consider liquidity, marketability, or transaction costs when they form their portfolios. They find that investors require a premium for holding illiquid stocks (measured by bid-ask spread). Since then, many studies have shown that liquidity should be considered in an asset pricing model (Brennan and Subrahmanyam, 1996; Pastor and Stambaugh, 2003; Acharya and Pedersen, 2005; Liu, 2006).

Transaction costs also have a restrictive influence on trades. Since trades reflect the information of investors and make asset prices efficient, a large transaction cost can interrupt this process of price discovery. For example, Lesmond, Schill, and Zhou (2004) argue that momentum strategies require frequent trading in securities with higher transaction costs and that such transaction costs prevent the execution of any profitable momentum strategy. Lesmond et al. (1999) also develop a model based on the insight that larger trading costs discourage arbitrageurs from trading and cause returns to tend toward zero. Based on these arguments, we establish the second hypothesis as following:

> **H2 (CAPM & Transaction Costs):** A firm with larger transaction costs is more restricted in the risk-return relationship between its beta and its expected return. Therefore, for a firm with larger transaction costs, the deviation of the firm's actual stock return from the expected return that is estimated by the CAPM will be greater.

Another study argues that investors also care about how their portfolio returns covary with factors other than beta risk in the CAPM. The Fama and French (1993) three-factor model and the Carhart (1997) four-factor model are prominent empirical efforts to include missing risk factors. After Merton (1973) theoretically expanded the one-factor static CAPM to the inter-temporal CAPM that includes another factor for future investment opportunities, many multi-factor models have been developed. However, each model seems to have its own weakness. For example, the Fama and French (1993) three-factor model has been criticized because of its ad hoc features. Again, every asset pricing model cannot be perfect; hence, there necessarily exist differences between the realized return and the expected return from any model. We argue that these differences from multi-factor models are still related to investor irrationality and transaction costs, even when additional risk factors are introduced.

> **H3 (Extension to other Asset Pricing Models beyond the CAPM):** Even if additional risk factors are introduced into an asset pricing model, there will still exist cross-sectional differences in the explanatory power of the model. This cross-sectional difference in the explanatory power will be correlated with either investor irrationality or transaction costs, as described in Hypotheses 1 and 2.

DATA AND DESCRIPTION OF VARIABLES

Data

Monthly stock return data from CRSP are used to estimate the parameters of the CAPM and calculate the differences between the realized returns and the expected returns. The market value and book-to-market ratios (B/M) are calculated from the COMPUSTAT database. To construct a variable that will proxy for investor irrationality, we calculate the churn rate for each company, which is the weighted average of the churn rates of institutions weighted by their respective holding percentages, as in Gaspar, Massa, and Matos (2005). With these initial data, we apply the following selection filters.

1. We use all NYSE, AMEX, and NASDAQ non-financial firms (excluding financial firms and mutual funds with 4-digit SIC codes between 6000 and 6999) that are listed on the CRSP database for 1985-2005. We use the share code to exclude the following categories: certificates; American depository receipts; shares of beneficial interest; units; Americus Trust components; closed-end funds; and real-estate investment trusts. Financial firms, funds, and preferred stocks are removed from the sample because their trading characteristics and accounting rules might differ from those of ordinary equities. After this filtering, 11,198 firms remain.

2. For the 11,198 firms, we calculate four variables: the proportional spread, Roll's spread, the trading cost as per Lesmond et al. (1999) and the institutional churn rate. We obtain the proportional spread from the closing ask and bid prices of the CRSP database. Roll's spread and Lesmond et al.'s (1999) measure of transaction cost are estimated from the CRSP daily stock returns. The institutional churn rate is calculated from the CDA/Spectrum, a database of quarterly 13-F filings of money managers to the U.S. Securities and Exchange Commission. If even one of the four variables for a firm cannot be obtained from the data, that firm is excluded. We also exclude firms for which the number of observations is less than 36 because we need a sufficient period of time for estimating the parameters of asset pricing models. Finally, 8,368 firms remain.

Table 1 shows the distributions of the samples before and after the application of the filter. There are some differences but the

Table 1. Summary statistics of monthly stock returns.

This table reports the cross-sectional distribution of monthly stock returns. We calculate the time-series means of the monthly returns for each firm for the period, 1985-2005, and obtain summary statistics of the means, such as the mean, standard deviation, skewness, and kurtosis. Panel A includes all non-financial firms. Then, we calculate four variables: the proportional spread; Roll's (1984) spread; Lesmond et al.'s (1999) transaction cost; and the institutional churn rate. If all four variables can be obtained from data and the number of monthly stock observations exceeds 36, these firms are included in Panel B. All samples are sorted into quintiles by the firm size, which is ca1culated as the average market capitalization for the period, 1984-2004.

Panel A. All non-financial firms

	No. of firms	Mean	Std. Dev.	Skewness	Kurtosis	Size
	11,192	0.011	0.202	1.096	5.423	806,975
Quintile						
1	2,238	0.001	0.252	1.594	7.538	7,601
2	2,239	0.007	0.223	1.415	6.687	28,840
3	2,238	0.012	0.206	1.164	5.814	83,409
4	2,239	0.016	0.185	0.821	4.065	264,905
5	2,238	0.020	0.142	0.484	3.013	3,650,709

Panel B. Sample firms

	No. of firms	Mean	Std. Dev.	Skewness	Kurtosis	Size
	8,368	0.013	0.191	1.026	5.158	981,705
Quintile						
1	1,673	0.006	0.227	1.609	7.924	14,680
2	1,674	0.010	0.210	1.301	6.159	45,896
3	1,674	0.013	0.198	1.026	5.113	119,462
4	1,674	0.018	0.182	0.763	3.768	344,641
5	1,673	0.019	0.139	0.431	2.826	4,385,301

distributions are almost the same. Therefore, the 8,368 firms in our dataset can appropriately represent the whole cross-section of U.S. stocks.

Description of explanatory variables

Three variables are constructed as proxies for transaction costs: the proportional spread; Roll's spread; and Lesmond et al.'s (1999) measure. Owing to the merits and demerits of each measure of transaction cost, we employ three measures to test our hypotheses. The institutional churn rate for a stock is used as a negative proxy for the degree of investor irrationality.

Proportional bid-ask spread. Proportional bid-ask spread is an immediacy cost because it is paid when investors want to trade immediately. The data of daily bid-ask quotes are obtained from the closing bid and ask prices in the CRSP database. For each stock, we calculate the daily proportional spread using these prices. The proportional spread is defined as in Eq. (1) for firm *i* in day *t*:

$$Proportional\ Spread_{i,t} = \frac{Ask_{i,t} - Bid_{i,t}}{(Ask_{i,t} + Bid_{i,t})/2}. \tag{1}$$

Then, we obtain the quarterly averages of the daily proportional spreads. In this method, we calculate the quarterly proportional spread of the sample firms for the period running from Quarter 4, 1984, to Quarter 3, 2005. In later regression analyses, we use a one-quarter lagged value (quarter *t*-1) as the proportional spread of quarter *t*. Table 2 shows the cross-sectional distribution of the time-series means of the proportional spread for 84 quarters. The mean of the proportional spreads is 4.3% and the standard deviation is 4.4%. The median, 2.9%, is smaller than the mean, which means the distribution of the proportional spread is skewed to the right.

Roll's (1984) spread. Roll's (1984) spread is a measure of the effective spread that depends on the magnitude of the auto-covariance in the return that is produced by bounces between the bid and ask prices. The data for measuring Roll's (1984) spread are obtained from the daily returns in the CRSP database. Roll's spread uses the bid-ask bounce-induced negative auto-covariance in the returns to estimate the effective spread. It is defined as in Eq. (2), where cov_i is the auto-covariance of the returns for stock *i*.

$$Roll\ Spread_i = 2\sqrt{-COV_i}. \tag{2}$$

Table 2. Cross-sectional variation of trading costs.

This table reports the cross-sectional distribution of transaction-cost variables for the 8,368 sample firms. The first measure of transaction costs is the proportional spread that is defined as $Proportional\ Spread_{i,t} = \frac{Ask_{i,t} - Bid_{i,t}}{(Ask_{i,t} + Bid_{i,t})/2}$. We calculate the daily proportional spread of sample firms using the closing bid and ask prices from the CRSP database and obtain quarterly means of the daily proportional spread. We use a one-quarter lagged value (quarter *t*-1) as the proportional spread for quarter *t*. The second measure of transaction costs is Roll's (1984) spread, which is defined as $Roll\ Spread_i = 2\sqrt{-COV_i}$, where Cov_i is the (negative) auto-covariance of daily returns for stock *i*. (In calculating Roll's spread, we adopt the approach of Roll (1984) and Lesmond (2005) and convert all positive auto-covariances to negative values.) We estimate Roll's (1984) spread for quarter *t* by using the daily returns from quarter *t*-4 through to quarter *t*-1 (12 months). The third measure of transaction costs is Lesmond et al. (1999)'s measure, which is calculated as $\alpha 2$-$\alpha 1$ and estimated from Eq. (4). As with Roll's spread, we obtain Lesmond et al.'s measure for quarter *t* by using the daily returns from quarter *t*-4 through to quarter *t*-1 (12 months). For the accurate estimation of Roll's spread and Lesmond et al.'s measure, we exclude estimations when the daily observations in quarter *t*-4 through to *t*-1 number less than 200.

	Mean	Std. Dev.	Min	Q1	Median	Q3	Max
Proportional spread	0.043	0.044	0.000	0.014	0.029	0.056	0.387
Roll's spread	0.033	0.025	0.001	0.016	0.025	0.041	0.345
Lesmond measure	0.030	0.038	0.000	0.008	0.019	0.039	0.397

We calculate Roll's (1984) spread for quarter *t* by using the daily returns from quarters *t*-4 through to *t*-1 (12 months). For accurate estimation of Roll's spread, we exclude firms for which there are fewer than 200 observations in a year. In calculating Roll's spread, we adopt the approach of Roll (1984), Lesmond et al. (1999), and Lesmond (2005), whereby we convert all positive auto-covariances to negative auto-covariances. Table 2 shows the cross-sectional distribution of the time-series means of Roll's spread for 84 quarters. The mean of Roll's spreads is 3.3% and the standard deviation is 2.5%. The median, 2.5%, is smaller than the mean. This means that the distribution of Roll's spread is skewed to the right, as with the proportional spread.

The transaction cost of Lesmond et al. (1999). The measure of Lesmond et al. (1999), which depends on the frequency of zero returns, is a liquidity measure that is based on a limited dependent variable (LDV) model and provides an estimate of liquidity that encapsulates spread effects, price impact effects, and market depth influences. This measure uses only daily stock returns to estimate firm-level transaction costs. The intuition for the approach is that if transaction costs prevent more informed traders from trading, then more zero returns will be observed in a firm with larger transaction costs. Since informed investors trade only when their gains from trading on mispricing exceed the costs of trading, the transaction cost operates as a threshold.

Actually, Lesmond et al. (1999) find that the frequency of daily zero returns is greater for firms with larger trading costs. This is because firms with larger trading costs require a larger accumulation of news to overcome the trading-cost threshold and their returns on nonzero-return days are expected to be larger than for other firms.

The LDV model is characterized by the following equation (Eq. (3)):

$$\begin{aligned} &R(i,t) = R^*(i,t) - \alpha_1(i) && \text{if } R^*(i,t) < \alpha_1(i) \\ &R(i,t) = 0 && \text{if } \alpha_1(i) \le R^*(i,t) \le \alpha_2(i). \\ &R(i,t) = R^*(i,t) - \alpha_2(i) && \text{if } R^*(i,t) > \alpha_2(i) \end{aligned} \tag{3}$$

In Eq. (3), $\alpha_1(i) < 0$ is the sell-side trading cost for asset i, $\alpha_2(i) > 0$ is the buy-side cost, $R(i,t)$ is the return for firm i in day t from the CRSP database, and $R^*(i,t)$ is the unobserved return in a frictionless market. Lesmond et al. (1999) use the market model regression as the return-generating process for the informed trader. The specification is, $R^*(i,t) = b(i)R_M(t) + e(i,t)$ where $R_M(t)$ is the value-weighted CRSP market index return and $e(i,t)$ captures all other information.

We can form an econometric model by using the market model and Eq. (3). The assumption that the return distribution is a normal distribution makes the estimation of α_1 and α_2 possible through the maximization of the following log-likelihood function:

$$\ln L = \sum_{R_1} \ln \frac{1}{(2\pi\sigma(i)^2)^{1/2}} - \sum_{1} \frac{1}{2\sigma(i)^2} (R(i,t) + \alpha_1(i) - b(i)R_M(t))^2$$
$$+\sum_{R_2} \ln \frac{1}{(2\pi\sigma(i)^2)^{1/2}} - \sum_{2} \frac{1}{2\sigma(i)^2} (R(i,t) + \alpha_2(i) - b(i)R_M(t))^2$$
$$+\sum_{R_0} \ln(\Phi_2(i) - \Phi_1(i)). \tag{4}$$

In Eq. (4), R_1, R_2, and R0 respectively represent the regions where the measured return, $R(i,t)$, is in the nonzero negative, nonzero positive, and zero regions. $b(i)$ and $s(i)^2$ are the market risk beta estimate and the variance of the nonzero observed returns. $\Phi j_{(i)}$ represents the cumulative distribution function that is evaluated at region j for firm i. The terms in Eq. (4) respectively correspond to the negative, positive, and zero returns in Eq. (3).

The transaction cost of Lesmond et al. (1999) is the difference between $\alpha_2(i)$ and $\alpha_1(i)$, i.e., $\alpha_2(i) - \alpha_1(i)$, which refers to the implied round-trip transaction cost. As with Roll's spread, we calculate Lesmond et al.'s measure for quarter t by using the daily returns from quarters t-4 through to t-1 (12 months) and exclude estimations for which the number of observations in quarters t-4 through to t-1 is less than 200. Table 2 shows the cross-sectional distribution of the time-series means of Lesmond et al.'s measure for 84 quarters. The mean of Lesmond et al.'s measures is 3.0% and the standard deviation is 3.8%.

Institutional churn rate. We use the institutional churn rate as a negative proxy for the degree of investor irrationality regarding a stock. The literature in behavioral finance argues that individual investors are more irrational than others. They show that many behavioral biases are manifest in trading by individual investors. For example, one behavioral bias is overconfidence. Barber and Odean (2000) and Odean (1999) find that individual investors in the US trade excessively, expose themselves to a high level of risk, and make poor *ex post* investing decisions. They conclude that the stocks that individuals sell outperform those in their holding. These phenomena are also found in the Asian market. Kim and Nofsinger (2002) and Chen et al. (2005) study individual investors in Japan and China respectively. They find that individual investors exhibit behavioral biases and make poor *ex post* trading decisions.

Another behavioral bias we can observe in many individual investors is the disposition effect, which refers to the tendency of investors for holding losers too long and selling winners too soon. Using large samples of individual investors, Odean (1998) reports existence of the disposition effect in the US stock market. There is also plenty of evidence that the magnitude of individual investors' biases is stronger than for sophisticated institutional investors (Glinblatt and Keloharju, 2001, 2000; Shapira and Venezia, 2001; Jin and Scherbina, 2005; Shumway and Wu, 2005; Frazzini, 2006). Some argue that professionalism, discipline, and experience in trading can reduce the disposition effect (Locke and Mann, 2005; Feng and Seasholes, 2005).

As in Gaspar, Massa, and Matos (2005), we obtain the churn rate for each company, which is the weighted average of institutions' churn rates weighted by each institution's holding percentage. This is possible because the CDA/Spectrum database provides information on the positions (of more than 10,000 shares or US$200,000 in value) of all institutions with more than US$100 million dollars under discretionary management.

First, we calculate the churn rate of institution *i* in quarter *t*. The churn rate is a measure of how frequently the institution rotates its positions on all the stocks of its portfolio. It is defined as:

$$CR_{i,t} = \frac{\sum_{j\in Q} | N_{j,i,t}P_{j,t} - N_{j,i,t-1}P_{j,t-1} - N_{j,i,t-1}\Delta P_{j,t} |}{\sum_{j\in Q} \frac{N_{j,i,t}P_{j,t} + N_{j,i,t-1}P_{j,t-1}}{2}}, \tag{5}$$

where Q is the set of companies held by investor i and $P_{j,t}$ and $N_{j,i,t}$ are the price and the number of shares, respectively, of company j held by institutional investor i at quarter t. By construction, the churn rate is in the interval, [0, 2].

Second, we calculate the churn rate for each company. Let S be the set of shareholders in company k and let $w_{k,i,t}$ be the weight in the total percentage that is held by institution i at quarter t. The churn rate of firm k is the weighted average of the institution's churn rate over four quarters:

$$Institutional\ Churn\ Rate = \sum_{i\in S} w_{k,i,t}(\frac{1}{4}\sum_{r=1}^{4} CR_{i,t-r+1}). \tag{6}$$

Table 3. Cross-sectional variation of the institutional churn rate.

This table reports the cross-sectional distribution of the institutional churn rate for 8,368 sample firms. We calculate the time-series means of the quarterly institutional churn rate for each firm and obtain the cross-sectional distribution of these means. We use a one-quarter lagged value (quarter *t*-1) as the institutional churn rate for quarter *t*. Every quarter, all firms are sorted into quintiles by the firm size and B/M. Size is the closing price times the number of shares outstanding at the end of the previous year. B/M is the book value divided by the market capitalization at the end of the previous year. This table contains the 84-quarter time-series averages of the summary statistics for each quintile.

	Mean	Std. Dev.	Min	Q1	Median	Q3	Max
All sample							
	0.140	0.045	0.000	0.115	0.140	0.161	0.646
Quintile by Size							
1	0.130	0.020	0.096	0.114	0.128	0.146	0.176
2	0.133	0.017	0.094	0.118	0.133	0.144	0.175
3	0.133	0.014	0.099	0.126	0.133	0.141	0.164
4	0.141	0.013	0.106	0.132	0.141	0.148	0.172
5	0.152	0.017	0.113	0.141	0.148	0.164	0.193
Quintile by B/M							
1	0.136	0.014	0.096	0.129	0.137	0.144	0.164
2	0.140	0.014	0.106	0.132	0.142	0.148	0.172
3	0.139	0.014	0.101	0.131	0.141	0.146	0.172
4	0.140	0.015	0.105	0.131	0.141	0.148	0.183
5	0.134	0.017	0.100	0.122	0.132	0.146	0.183

In later regression analysis, we use the one-quarter lagged value (quarter *t*-1) as the institutional churn rate at quarter *t*. Table 3 shows the cross-sectional distribution of the time-series means of the institutional churn rate for the 8,368 sample firms. The mean of the institutional churn rates is approximately 14%.

The samples are sorted into quintiles by firm size and B/M every quarter. The size is the closing price times the number of shares outstanding at the end of the previous year. B/M is the book value

Table 4. Correlations between trading costs, the institutional churn rate, and size.

This table reports the correlations between transaction costs (proportional spread, Roll's spread, and Lesmond et al.'s (1999) measure), the institutional churn rate, and firm size during the period, 1985-2005. We pool all quarterly measured variables and calculate correlations.

Panel A. Pearson correlation

	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size
Proportional spread	1.000				
Roll's spread	0.709	1.000			
Lesmond measure	0.752	0.683	1.000		
Institutional churn rate	-0.058	-0.087	-0.105	1.000	
Size	-0.106	-0.103	-0.103	0.059	1.000

Panel B. Spearman correlation

	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size
Proportional spread	1.000				
Roll's spread	0.595	1.000			
Lesmond measure	0.850	0.604	1.000		
Institutional churn rate	-0.128	-0.148	-0.202	1.000	
Size	-0.757	-0.620	-0.797	0.243	1.000

divided by the market capitalization at the end of the previous year. Table 3 reports the 84-quarter time-series averages of a quintile's cross-sectional distribution. The quintile by size shows that institutional investors prefer large firms. The quintile by B/M shows that institutional investors prefer low B/M firms, indicating that individual investors are more likely to hold value stocks than other investors.

Correlations

In this section, we show the correlations between transaction cost, the institutional churn rate, and size. Table 4 reports the correlations between transaction costs (the proportional spread, Roll's spread, and Lesmond et al.'s measure), the institutional churn rate, and the size of a firm during the period, 1985-2005. We pool all the measured variables and obtain correlations.

The transaction costs are positively correlated with each other (Pearson correlations are 0.709, 0.752, and 0.683, while Spearman correlations are 0.595, 0.850, and 0.604). This result again shows that our measures proxy transaction costs in a similar manner to each other.

The correlations between the institutional churn rate and the proportional spread, Roll's spread, and Lesmond et al.'s measure are respectively -0.058, -0.087, and -0.105 as per Pearson's correlation and -0.128, -0.148, and -0.202 as per Spearman's correlation. The size is negatively correlated with the transaction costs and positively correlated with the institutional churn rate. This result shows that we need to be careful when we relate stock returns to the size anomaly since transaction costs can snatch the opportunity of realizing abnormal returns.

EMPIRICAL RESULTS

In section 4.1, we explain how to obtain the absolute pricing errors, namely, the differences between the realized return and the expected return that is estimated by the CAPM. In section 4.2, Fama and MacBeth (1973) regressions are performed. First, we test Hypotheses 1 and 2 for the CAPM. Then, six other asset pricing models are analyzed for testing hypothesis 3. In section 4.3, the case of missing risk factors is examined. Further study and robustness checks are reported in section 4.4 and 4.5 respectively.

Absolute pricing errors as a proxy for the lack of explanatory power

The CAPM states that the expected return of an asset is a function of three variables: Beta; the risk-free rate; and the expected market return. A simple CAPM equation can be written as:

$$E(R_i) = R_f + [E(R_m) - R_f]\beta_i, \tag{7}$$

where $E(R_i)$ is the expected return on stock *i*, R_f is the risk-free rate, $E(R_m)$ is the expected return on the market portfolio, and β_i is the systematic risk (beta) of stock *i*. To estimate the beta of the CAPM, we use the following regression specification:

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_i(R_{m,t} - R_{f,t}) + e_{i,t}, \tag{8}$$

where $R_{i,t}$ is the monthly return of stock *i* in month *t*, $R_{f,t}$ is the one-month T-bill rate, which is taken as the risk-free rate of return, and $R_{m,t}$ is the monthly CRSP value-weighted return. The sample period comprises 252 months between 1985 and 2005. Then, we calculate the pricing error of the CAPM, i.e., the difference between the realized return and the expected return from the CAPM, as:

$$\begin{aligned} Error_{i,t} &= Realized\ Reurn_{i,t} - Expected\ Reurn_{i,t} \\ &= R_{i,t} - E(R_{i,t}) \\ &= (R_{i,t} - R_{f,t}) - \beta_i(R_{m,t} - R_{f,t}). \end{aligned} \tag{9}$$

We take the absolute value of this error and use it as a proxy for the lack of explanatory power of the CAPM.[7] Since it is only a proxy, we implement extensive robustness checks in a subsequent section.

Table 5 reports the cross-sectional distribution of the time-series means of the absolute error. The mean of absolute errors is 11.1% and the median is 7.4%. Several outliers, such as 1,024%, cause this enormous difference between the mean and the median. Therefore, we should be cautious about the interpretation of the results and simultaneously report the means and medians. Also, we again analyze our result in a later section with regard to the robustness check after winsorizing the absolute errors to take care of this outlier problem.

As shown in Table 5, each month we form the quintile portfolios that are sorted by the proportional spread, Roll's spread, the

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7) We also use squared errors as a proxy for the lack of explanatory power. The results are qualitatively similar to those under absolute errors.

Table 5. Cross-sectional variation of the absolute errors from the CAPM. This table reports the cross-sectional distribution of absolute errors that are derived from the CAPM. We calculate the betas (β's) of individual stocks for the period, 1985-2005. Using these betas we obtain monthly errors from the CAPM; $Error_{i,t} = (R_{i,t} - R_{f,t}) - \beta_i (R_{m,t} - R_{f,t})$, where $R_{i,t}$ is the monthly return of stock i in month t, $R_{f,t}$ is the one-month T-bill rate and is taken as the risk-free rate of return, and $R_{m,t}$ is the monthly CRSP value-weighted return. We form quintiles using the proportional spread, Roll's spread, Lesmond et al.'s measure, and the institutional churn rate for the period, 1985-2005. This table contains the 252-month time-series averages of the summary statistics for each quintile.

	Observation	Mean	Std. Dev.	Min	Q1	Median	Q3	Max
All sample								
	625,911	11.133	13.678	0.000	3.280	7.445	14.443	1,024.212
Quintile by Proportional spread								
1		8.597	2.944	4.546	6.636	7.878	9.507	26.823
2		9.365	2.357	6.052	7.802	8.736	10.205	21.420
3		10.260	2.278	6.915	8.750	9.629	11.220	22.572
4		11.400	2.573	6.571	9.791	10.752	12.364	25.749
5		14.099	3.543	8.386	11.938	13.457	15.252	40.961
Quintile by Roll's spread								
1		8.000	1.940	5.094	6.515	7.769	8.944	16.450
2		9.078	2.081	5.677	7.558	8.573	10.091	18.139
3		10.309	2.360	6.735	8.723	9.669	11.529	23.564
4		11.558	3.024	7.368	9.533	10.686	12.985	30.356
5		14.776	4.071	8.144	12.328	13.753	15.855	41.746
Quintile by Lesmond et al.'s measure								
1		7.793	2.150	4.962	6.235	7.311	8.526	17.943
2		9.096	2.228	5.424	7.519	8.426	10.171	19.297
3		10.505	2.610	6.628	8.675	9.785	11.537	26.337
4		11.800	2.805	6.603	10.062	10.973	12.780	30.218
5		14.527	3.688	8.494	12.342	13.724	15.751	35.144
Quintile by Institutional churn rate								
1		12.796	3.425	7.922	10.786	12.048	14.070	36.808
2		10.884	2.571	7.180	9.070	10.193	12.037	25.730
3		9.607	2.244	6.311	7.991	8.945	10.786	21.438
4		9.592	2.194	5.884	8.095	9.004	10.487	19.342
5		10.845	2.688	7.058	8.998	10.333	11.705	25.623

measure of Lesmond et al. (1999), and the institutional churn rate for the period, 1985-2005. Then, we calculate 252-month time-series averages of the summary statistics for each quintile. The quintiles exhibit a trend wherein a portfolio with higher transaction costs has a higher absolute pricing error. For example, the means of the absolute errors are 8.00%, 9.08%, 10.31%, 11.56%, and 14.78%, and the medians are 7.78%, 8.57%, 9.67%, 10.69%, and 13.75%, respectively, for each quintile of Roll's spread. With regard to the institutional churn rate, higher values of portfolios are associated with lower absolute pricing errors. This analysis implies that the cross-sectional deviation of returns from the expected returns from the CAPM is caused by both transaction costs and investors' irrationality. This is a simple check through portfolio formation. More detailed analyses are implemented in the next section.

Test for transaction costs and the investor irrationality hypothesis

The CAPM. In this section, we test Hypotheses 1 and 2 by using Fama and MacBeth (1973) regression analyses. Since stock returns are monthly, each cross-sectional Fama/MacBeth regression is applied to each month. The regression specification is:

$$| Error_{i,t} | = c_0 + c_1 TC_{i,t-1} + c_2 IR_{i,t-1} + c_3 Size_{i,t-1} + c_4 B / M_{i,t-1} + u_{i,t}. \qquad (10)$$

$|Error_i|$ is the absolute pricing error of stock i; TC_i is transaction costs for stock i, such as proportional spread, Roll's spread, and Lesmond et al.'s (1999) measure; IR_i is investor-irrationality measured by the institutional churn rate for stock i; $Size_i$ is the logarithm of the market capitalization for firm i in the previous year; B/M_i is the logarithm of the book-to-market ratio for firm i in the previous year;, and u_i is a random error-term.

Our interest is in the cross-sectional relationship between absolute pricing errors and variables such as transaction costs and investor irrationality. We expect that if our hypotheses are correct, the transaction cost measures will have positive coefficients and the institutional churn rate will have a negative coefficient. The size and book-to-market ratio are used to control the size and book-to-market anomalies in stock returns.

Table 6 shows the results of the regression. In panel A, when calculating the absolute errors for individual stocks, we use betas (β)

Table 6. Fama/MacBeth regression results for the CAPM.

The monthly absolute errors from January 1985 to December 2005 are regressed on explanatory variables, such as the proportional spread, Roll's spread, Lesmond et al.'s (1999) measure, institutional churn rate, size, and B/M. The absolute errors under the CAPM are calculated through Eq. (9). In Panel A, when calculating the absolute errors for individual stocks for the period, 1985-2005, we use the betas (β's) that are estimated for the period, 1985-2005. Thus, one beta is estimated and used for each stock. In Panel B, when calculating the absolute errors for month *t*, we use the betas (β's) that are estimated using the monthly returns from month *t-60* through to month *t*-1. Thus, the betas roll every month for each stock. When the observations number less than 36 months, we exclude the beta for the stability of estimation. Size is the closing price times the number of shares outstanding at the end of the previous year. B/M is the book value divided by the market capitalization at the end of the previous year. We use the logarithms of size and B/M as explanatory variables. This table contains the time-series averages of coefficients that are obtained from monthly cross-sectional regressions; t-statistics are in parentheses.

Panel A. Constant beta.

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
8.698 (53.777)	61.394 (22.884)						0.035
7.679 (65.938)		110.262 (31.045)					0.048
8.866 (60.123)			91.336 (18.170)				0.033
11.980 (58.724)				-8.938 (-15.120)			0.003
9.787 (46.663)	60.657 (22.942)			-7.638 (-14.027)			0.037
8.524 (55.349)		108.683 (30.985)		-5.736 (-11.638)			0.049
9.780 (51.911)			89.553 (18.159)	-6.273 (-12.251)			0.034
13.733 (47.310)	28.481 (14.374)				-1.089 (-33.319)	-1.496 (-24.831)	0.057
11.884 (62.759)		76.695 (27.770)			-0.910 (-35.766)	-1.398 (-25.695)	0.065
13.891 (55.063)			50.596 (15.983)		-1.115 (-37.128)	-1.485 (-24.390)	0.056
17.201 (59.082)				-2.396 (-5.355)	-1.511 (-45.834)	-1.415 (-23.595)	0.050

Table 6. (continued)

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
14.064 (45.404)	29.306 (14.938)			-3.470 (-7.892)	-1.059 (-32.998)	-1.482 (-24.812)	0.058
12.205 (58.832)		76.783 (27.817)		-2.947 (-6.749)	-0.888 (-35.067)	-1.383 (-25.689)	0.065
14.197 (53.284)			50.818 (15.890)	-2.742 (-6.266)	-1.095 (-36.590)	-1.471 (-24.386)	0.057

Panel B. Rolling beta.

Intercept	Proportional spread	Roll's spread	Lesmond easure	Institutional churn rate	Size	B/M	Adj. R2
8.474 (52.862)	64.833 (24.444)						0.040
7.485 (64.338)		115.887 (32.276)					0.053
8.626 (59.452)			96.188 (19.077)				0.038
12.092 (62.441)				-10.433 (-17.154)			0.004
9.625 (47.067)	63.809 (24.400)			-8.040 (-14.463)			0.042
8.368 (55.682)		114.076 (32.086)		-6.009 (-11.870)			0.055
9.593 (53.478)			94.069 (19.110)	-6.658 (-12.987)			0.040
13.599 (46.044)	31.329 (14.798)				-1.076 (-32.520)	-1.455 (-23.903)	0.061
11.785 (62.022)		81.079 (28.309)			-0.903 (-35.505)	-1.357 (-24.376)	0.069
13.690 (54.561)			54.878 (16.679)		-1.092 (-36.110)	-1.437 (-23.285)	0.060
17.380 (63.019)				-2.734 (-5.919)	-1.540 (-47.162)	-1.383 (-22.543)	0.052
13.953 (44.996)	32.069 (15.335)			-3.654 (-8.022)	-1.047 (-32.072)	-1.444 (-23.796)	0.062
12.116 (58.891)		81.098 (28.365)		-3.048 (-6.726)	-0.882 (-34.825)	-1.345 (-24.277)	0.070
14.016 (53.925)			54.884 (16.678)	-2.915 (-6.456)	-1.073 (-35.494)	-1.425 (-23.184)	0.061

that are estimated for the whole period of 1985-2005. In principle, one beta is used for each stock. In panel B, when calculating the absolute errors for month *t*, we use betas that are estimated using monthly returns from month *t*-60 to month *t*-1. Therefore, these betas of any given stock roll every month. By using rolling betas, we can enrich our analysis to accommodate the CAPM with a time-varying property.

In the univariate test shown in panel A, the proportional spread, Roll's spread, Lesmond et al.'s measure, and institutional churn rate are statistically significant with t-statistics of 22.88, 31.05, 18.17, and -15.20, respectively. The time-series averages of the R^2 of each model are 3.5%, 4.8%, 3.3%, and 0.3%, respectively. To compare the significance of transaction costs and the institutional churn rate, we implement bivariate regressions. The results are that both transaction costs and investor irrationality have significant effects. Based upon this evidence, we argue that transaction costs and investor irrationality are both critical reasons for the poor performance of the CAPM.

Size and B/M are included in the regression as control variables because we suspect that the positive relationship of trading costs to absolute pricing errors or the negative relationship of the institutional churn rate are induced by size or book-to-market effects. It is well-known that transaction costs are negatively related to the size, while the institutional churn rate is positively related, and that size is negatively related to pricing errors. When we use the size and B/M as control variables, patterns are still evident. This is striking because the positive and negative relations remain significant even after the size and book-to-market, which are generally considered to be the main reasons for the CAPM's failure, are included in the regression.

The results of panel B are similar with those of panel A. All variables of transaction costs and investor irrationality have significant coefficients with pricing errors from the CAPM. These relations remain significant even after the size and book-to-market are controlled. We can confirm that transaction costs and investor irrationality have significant effects when considering a time-varying property of the beta.

In summary, we conclude that both transaction costs and investor irrationality are the reasons for the poor performance of the CAPM, which supports Hypotheses 1 and 2. However, we do not argue that an asset pricing model fails totally; we note only that the model performs worse (breaks down in a relative sense) as larger transaction costs and/or a greater degree of investor irrationality are involved. This result also sheds light on studies of behavioral finance in the sense that the portion of stock returns that is unexplained by the CAPM cannot result from only investor irrationality but likely arises also from transaction costs.

Fama-French's three-factor model. We regress the difference between the realized return and the expected return from the three-factor model on variables of investor irrationality and transaction costs. First, we calculate the absolute pricing errors from Fama and French's (1993) three-factor model as:

$$Error_{i,t} = (R_{i,t} - R_{f,t}) - (\beta_i (R_{m,t} - R_{f,t}) + \delta_i SMB_t + \kappa_i HML_t), \tag{11}$$

where $(R_{m,t}\text{-}R_f)$ is the excess market return, SMB_t is the return on zero-investment, factor- mimicking portfolios for the size, and HML_t is the return on zero-investment, factor-mimicking portfolios for the book-to-market ratio.

Then, we run a Fama/MacBeth regression again. Table 7 shows that the results are similar to those for the CAPM. In the univariate regression, the proportional spread, Roll's spread, Lesmond et al.'s measure, and institutional churn rate are statistically significant with t-statistics of 25.35, 33.44, 19.62, and -17.85, respectively. In the bivariate regression, both transaction costs and the institutional churn rate have significant effects. Even when we use the size and B/M as control variables, significant relations are maintained.

Carhart's (1997) four-factor model. The preceding procedures are redone using Carhart's (1997) four-factor model. The momentum factor, namely, the return on factor-mimicking portfolios for a one-year momentum in stock returns is added to the three-factor model. We run a Fama/MacBeth regression again. Table 8 shows that the results from the four-factor model are similar to those of the CAPM. In the univariate regression, the proportional spread, Roll's spread, Lesmond et al.'s measure, and institutional churn rate are statistically significant with t-statistics of 25.58, 33.62, 20.04, and -18.22, respectively. In the bivariate regression, all variables of transaction costs and the institutional churn rate have strong

Table 7. Fama/MacBeth regression results for the three-factor, Fama-French model.

The monthly absolute errors from January 1985 to December 2005 are regressed on explanatory variables, such as the proportional spread, Roll's spread, Lesmond et al.'s (1999) measure, institutional churn rate, size, and B/M. The absolute errors from Fama-French's three-factor model are calculated through Eq. (11). When calculating the absolute errors for month *t*, we use beta coefficients that are estimated using the monthly returns from month *t-60* through to month *t*-1. Thus, the betas roll every month for each stock. When the number of monthly observations is less than 36, we exclude the beta coefficients for the stability of estimation. Size is the closing price times the number of shares outstanding at the end of the previous year. B/M is the book value divided by the market capitalization at the end of the previous year. We use the logarithms of size and B/M as explanatory variables. This table contains the time-series averages of coefficients that are obtained from monthly cross-sectional regressions; t-statistics are in parentheses.

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
8.451 (51.903)	67.188 (25.358)						0.042
7.454 (63.910)		118.910 (33.439)					0.056
8.595 (58.516)			99.582 (19.622)				0.041
12.178 (61.338)				-10.644 (-17.846)			0.004
9.619 (46.309)	66.167 (25.331)			-8.145 (-15.026)			0.044
8.347 (55.096)		117.104 (33.272)		-6.067 (-12.344)			0.057
9.567 (52.718)			97.481 (19.670)	-6.680 (-13.431)			0.043
13.784 (44.916)	32.788 (16.045)				-1.115 (-33.349)	-1.480 (-26.569)	0.064
12.015 (60.147)		82.209 (29.257)			-0.949 (-36.811)	-1.377 (-27.422)	0.072
13.824 (54.115)			56.887 (17.911)		-1.121 (-37.765)	-1.461 (-26.140)	0.064
17.680 (62.392)				-2.626 (-5.651)	-1.595 (-50.076)	-1.405 (-25.166)	0.055
14.138 (43.909)	33.496 (16.571)			-3.592 (-7.821)	-1.086 (-32.856)	-1.469 (-26.432)	0.065
12.341 (57.080)		82.208 (29.294)		-2.961 (-6.505)	-0.929 (-35.997)	-1.366 (-27.274)	0.073
14.144 (53.210)			56.881 (17.919)	-2.815 (-6.191)	-1.104 (-37.054)	-1.450 (-26.009)	0.064

Table 8. Fama/MacBeth regression results for Carhart's four-factor model. The monthly absolute errors from January 1985 to December 2005 are regressed on explanatory variables, such as the proportional spread, Roll's spread, Lesmond et al.'s (1999) measure, institutional churn rate, size, and B/M. The absolute errors under Carhart's four-factor model are calculated through Eq. (12). When calculating the absolute errors for month *t*, we use beta coefficients that are estimated using the monthly returns from month *t-60* through to month *t*-1. Thus, the betas roll every month for each stock. When the number of monthly observations is less than 36, we exclude the beta coefficients for the stability of estimation. Size is the closing price times the number of shares outstanding at the end of the previous year. B/M is the book value divided by the market capitalization at the end of the previous year. We use the logarithms of size and B/M as explanatory variables. This table contains the time-series averages of coefficients that are obtained from monthly cross-sectional regressions; t-statistics are in parentheses.

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
8.600 (49.898)	68.399 (25.580)						0.043
7.560 (62.165)		122.060 (33.624)					0.057
8.725 (56.160)			102.148 (20.042)				0.042
12.419 (59.819)				-11.015 (-18.221)			0.004
9.814 (45.120)	67.339 (25.535)			-8.475 (-15.437)			0.045
8.492 (54.153)		120.174 (33.424)		-6.336 (-12.699)			0.058
9.734 (51.467)			99.968 (20.102)	-6.941 (-13.740)			0.044
14.137 (44.220)	32.982 (15.686)				-1.161 (-33.747)	-1.547 (-25.877)	0.066
12.287 (59.799)		83.984 (29.247)			-0.987 (-37.906)	-1.441 (-26.381)	0.074
14.089 (53.676)			58.432 (18.248)		-1.156 (-39.208)	-1.530 (-25.330)	0.066
18.064 (61.597)				-2.733 (-5.821)	-1.643 (-50.753)	-1.472 (-24.447)	0.056
14.497 (43.417)	33.708 (16.220)			-3.694 (-8.002)	-1.131 (-33.217)	-1.536 (-25.746)	0.067
12.622 (57.028)		83.978 (29.296)		-3.072 (-6.697)	-0.965 (-37.070)	-1.429 (-26.251)	0.075
14.416 (53.120)			58.422 (18.274)	-2.916 (-6.345)	-1.137 (-38.371)	-1.519 (-25.215)	0.066

relationship with the degree of mispricing. Overall, the performance of four factor model is almost the same with the three-factor model since their coefficients and t-statistics are not much different from those of the three-factor model.

The conditional CAPM. Some argue that the failure of the CAPM has been attributed to its static nature. They develop a dynamic pricing model and show that this dynamic version of the CAPM can be valid even though the static CAPM does not work (Hansen and Richard, 1987; Jagannathan and Wang, 1996; Lettau and Ludvigson, 2001).

In this section, we adopt the conditional CAPM that has been developed by Jagannathan and Wang (1996). The Jagannathan and Wang (1996) model is derived from the assumption that the CAPM holds in a conditional sense, namely that betas and the market-risk premium vary over time. Their model implies that the unconditional expected return is a linear function of the expected beta and the beta-premium sensitivity. The beta-premium sensitivity incorporates the variation in the market beta and captures the instability of the market beta over the business cycle. Therefore, the unconditional form of the Jagannathan and Wang (1996) model contains two betas. One is the original market beta. The other beta is the beta-premium sensitivity, which is measured by the default premium, R_{PREM}.

In addition, Jagannathan and Wang (1996) argue that the value-weighted index of stocks is an inadequate proxy for aggregate wealth, in accordance with the reasoning of Roll (1977). They extend the proxy for the market return to include a return on human capital, R_{LABOR}. In short, the conditional CAPM of Jagannathan and Wang (1996) has three factors: (R_m-R_f), R_{PREM} and R_{LABOR}.

In the empirical test, we use the return on the value-weighted CRSP index in excess of the one-month, risk-free return, i.e., (R_m-R_f). The default premium, R_{PREM}, is the difference between the yield on *BAA* and *AAA* Moody's Seasoned Corporate Bonds, which are obtained from the Board of Governors of the Federal Reserve and provided by the Federal Reserve Bank of St. Louis. The growth rate in labor income, R_{LABOR}, is computed as $(L_{t-1}+L_{t-2})/(L_{t-2}+L_{t-3})$, where L_{t-1} is the labor income per capita for month t-1. The data are obtained from the Board of Governors of the Federal Reserve and provided by the Federal Reserve Bank of St. Louis. The use of a two-month average is adopted to minimize the influence of measurement errors because the monthly labor income data are typically published with a delay of one month.

The results are summarized in Table 9. In the univariate regression, the proportional spread, Roll's spread, Lesmond et al.'s measure, and the institutional churn rate are statistically significant with t-statistics of 33.85, 33.24, 20.00, and -16.82, respectively. In the bivariate regression, transaction cost variables and the institutional churn rate are also significantly related with absolute pricing errors. Overall, the performance of the conditional model is a bit different from those of the three and four-factor model. It implies that beta-premium sensitivity and human capital could play a significant role in explain the cross-section of stock returns.

Campbell's (1996) intertemporal model. In this section, we use a linear version of Campbell's (1996) log-linear asset pricing model. Campbell (1996) develops a more structured model responding to the critiques of Merton (1973) and Roll (1977). Campbell introduces an intertemporal asset pricing model that allows for changes in investment opportunities and includes an important component of wealth, the human capital. In total, Campbell's model has five factors: (R_m-R_f), *LBR*, *DIV*, *RTB*, and *TRM*. In the original study of Campbell (1996), the pricing proxy is actually defined as $y=exp(-F'b)$ and there are constraints across the parameters. However, we simply adopt a linear model, $y=F'b$, of five factors.

The return on the value-weighted CRSP index in excess of risk free return is used as (R_m-R_f). Unlike in Jagannathan and Wang (1996), however, Campbell (1996) uses the labor income factor, *LBR*, as the monthly growth rate in real labor income. The data are obtained from the Board of Governors of the Federal Reserve and provided by the Federal Reserve Bank of St. Louis. The dividend yield on the return of the value-weighted CRSP index in excess of the one-month, risk-free return, *DIV*, is obtained from the CRSP database. The relative bill rate, *RTB*, is calculated as the difference between the one-month T-bill rate and its one-year backward moving average. The yield spread between long and short-term government bonds, *TRM*, is calculated as the difference in yields on the 30-year government bond and on the one-year government bond. The T-bill rate and the yield of government bond are obtained from the Board of Governors of the Federal Reserve and provided by the Federal

Table 9. Fama/MacBeth regression results for the conditional CAPM.
The monthly absolute errors from January 1985 to December 2005 are regressed on explanatory variables, such as the proportional spread, Roll's spread, Lesmond et al.'s (1999) measure, institutional churn rate, size, and B/M. The absolute errors from the conditional CAPM of Jagannathan and Wang (1996) are calculated. The conditional CAPM of Jagannathan and Wang (1996) has three-factors: (R_m-R_f); R_{PREM}; and R_{LABOR}. We use the return on the value-weighted CRSP index in excess of the one-month, risk-free return, (R_m-R_f), as a proxy for the excess return on the market. The default premium, R_{PREM}, is the difference between the yield on BAA and *AAA* Moody's Seasoned Corporate Bonds; this is obtained from the Board of Governors of the Federal Reserve and provided by the Federal Reserve Bank of St. Louis. The growth rate in the labor income is computed as, $R_{LABOR,t} = (L_{t-1} + L_{t-2})/(L_{t-2} + L_{t-3})$, where L_{t-1} is the per-capita labor income for month *t*-1 and is estimated as the disposal personal income normalized by the total population of the US. The data are obtained from the Board of Governors of the Federal Reserve and provided by the Federal Reserve Bank of St. Louis. When calculating the absolute errors for individual stocks for the period, 1985-2005, we use the betas (β's) that are estimated for the period, 1985-2005. When the number of monthly observations is less than 36, we exclude the beta for the stability of estimation. Size is the closing price times the number of shares outstanding at the end of the previous year. B/M is the book value divided by the market capitalization at the end of the previous year. We use the logarithms of size and B/M as explanatory variables. This table contains the time-series averages of coefficients that are obtained from monthly cross-sectional regressions; t-statistics are in parentheses.

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
124.289 (58.613)	851.813 (33.849)						0.028
103.766 (94.728)		1795.942 (33.247)					0.044
122.532 (71.005)			1517.971 (19.998)				0.033
176.268 (56.357)				-165.964 (-16.881)			0.003
145.600 (45.924)	837.289 (34.496)			-148.758 (-15.827)			0.030
120.215 (58.347)		1765.683 (33.468)		-111.886 (-13.408)			0.046
140.145 (52.805)			1484.584 (20.016)	-120.711 (-13.989)			0.035

Table 9. (continued)

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
242.282 (43.852)	137.496 (4.923)				-25.062 (-38.404)	-32.297 (-29.750)	0.065
199.382 (57.309)		1054.284 (32.715)			-20.429 (-45.028)	-31.135 (-30.318)	0.072
224.528 (51.921)			695.092 (19.018)		-22.727 (-43.942)	-32.418 (-29.733)	0.067
271.905 (57.937)				-33.974 (-4.729)	-28.498 (-54.522)	-31.541 (-29.325)	0.062
246.569 (42.897)	146.645 (5.431)			-41.596 (-5.821)	-24.742 (-37.825)	-32.091 (-29.861)	0.066
204.113 (53.451)		1052.721 (32.971)		-40.699 (-5.875)	-20.178 (-44.562)	-30.920 (-30.423)	0.073
229.194 (49.931)			694.473 (18.936)	-38.585 (-5.495)	-22.517 (-43.671)	-32.192 (-29.796)	0.067

Reserve Bank of St. Louis.

The results are summarized in Table 10. In the univariate regression, the proportional spread, Roll's spread, Lesmond et al.'s measure, and the institutional churn rate are statistically significant with t-statistics of 32.57, 32.66, 27.02 and -16.37 respectively. In the bivariate regression, all variables of the transaction costs and investor irrationality are strongly related with absolute pricing errors. These results are maintained even after the size and B/M are controlled.

The consumption CAPM (CCAPM). The consumption-CAPM (CCAPM) developed by Breeden (1979) seems to be preferable to the CAPM because it takes account of the dynamic nature of portfolio decisions, namely, the inter-temporal consumption portfolio decisions, and integrates other forms of wealth besides financial assets. The standard consumption-based asset pricing model derived from the time-separable power utility framework identifies consumption growth as a pricing factor. Early empirical tests shows that consumption risk alone cannot explain the cross-section of

Table 10. Fama/MacBeth regression results for Campbell's model.

The monthly absolute errors from January 1985 to December 2005 are regressed on explanatory variables, such as the proportional spread, Roll's spread, Lesmond et al.'s (1999) measure, institutional churn rate, size, and B/M. The absolute errors under Campbell's model are calculated. When calculating the absolute errors for individual stocks for the period, 1985-2005, we use the betas (β's) that are estimated for the period, 1985-2005. We use a linear version of Campbell's (1996) log-linear asset pricing model. Campbell's model has five factors: (R_m-R_f); *LBR*; *DIV*; *RTB*; and *TRM*. We use the return on the value-weighted CRSP index in excess of the one-month, risk free return, (R_m-R_f), as a proxy for the excess return on the market. The labor income factor, *LBR*, is the monthly growth rate in real labor income. These data are obtained from the Board of Governors of the Federal Reserve and provided by the Federal Reserve Bank of St. Louis. The dividend yield on the return on the value-weighted CRSP index in excess of the one-month, risk-free return, *DIV*, is obtained from the CRSP database. The relative bill rate, *RTB*, is calculated as the difference between the one-month T-bill rate and its one-year backward moving average. The yield spread between long and short-term government bonds, *TRM*, is calculated as the difference in yields between a 30-year government bond and a one-year government bond. These data are from the Board of Governors of the Federal Reserve and provided by the Federal Reserve Bank of St. Louis. When the number of monthly observations is less than 36, we exclude the beta for the stability of estimation. Size is the closing price times the number of shares outstanding at the end of the previous year. B/M is the book value divided by the market capitalization at the end of the previous year. We use the logarithms of size and B/M as explanatory variables. This table contains the time-series averages of coefficients that are obtained from monthly cross-sectional regressions; t-statistics are in parentheses.

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
9.163 (51.014)	50.102 (32.568)						0.037
8.337 (68.799)		102.825 (32.659)					0.048
9.258 (60.406)			68.774 (27.015)				0.035
12.844 (60.099)				-10.034 (-16.371)			0.003
10.384 (44.962)	49.697 (32.390)			-8.588 (-15.677)			0.039
9.345 (58.739)		101.457 (32.518)		-6.932 (-13.801)			0.049

Table 10. (continued)

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
10.281 (51.303)			67.425 (26.836)	-7.049 (-13.779)			0.036
14.459 (45.770)	27.715 (16.955)				-1.221 (-33.452)	-1.787 (-27.778)	0.061
12.840 (63.346)		70.735 (25.937)			-1.055 (-36.058)	-1.697 (-29.054)	0.067
14.500 (61.918)			39.868 (18.929)		-1.235 (-41.556)	-1.795 (-27.523)	0.060
18.312 (63.187)				-2.989 (-6.491)	-1.693 (-48.932)	-1.708 (-26.241)	0.053
14.872 (44.402)	28.407 (17.387)			-4.222 (-9.272)	-1.187 (-32.727)	-1.770 (-27.677)	0.062
13.255 (60.036)		71.091 (26.025)		-3.817 (-8.492)	-1.029 (-34.982)	-1.679 (-28.971)	0.068
14.879 (58.728)			39.956 (18.947)	-3.307 (-7.398)	-1.214 (-40.863)	-1.779 (-27.473)	0.060

asset returns (e.g. Mankiw and Shapiro (1986), Breeden, Gibbons, and Litzenberger (1989), Campbell (1996)). However, there exists considerable empirical evidence that consumption risk does matter for explaining asset returns. Lettau and Ludvigson (2001) argue that the log consumption–wealth ratio as a conditioning variable performs far better than unconditional version and about as well as the Fama-French three-factor model. Parker and Julliard (2005) use the consumption risk measured by the covariance of an asset's return and consumption growth cumulated over many quarters following the return rather than the contemporaneous covariance of an asset's return and consumption growth. They show that their consumption risk variable at a horizon of three years explains a large fraction of the return variation across the 25 Fama-French portfolios. Kang et al. (2011) also argues that the conditional CCAPM including the conditioning variable from the cointegrating relation among macroeconomic variables performs as well as Fama and French's (1993) three-factor model.

We simply adopt a linear version of the CCAPM as suggested by Hodrick and Zhang (2001) rather than use the original CCAPM, which is nonlinear and requires a particular form of the utility function. Thus, we use the consumption growth rate, Δc, as a factor. The data are obtained from the growth rate in the real consumption of non-durables, as reported in Citibase. In short, the unconditional model of the CCAPM has one factor, Δc.

The results are summarized in Table 11. In the univariate regression, the proportional spread, Roll's spread, Lesmond et al.'s measure, and the institutional churn rate are statistically significant with t-statistics of 32.36, 36.88, 16.68, and -12.72, respectively. In the bivariate regression, both transaction costs and the institutional churn rate are strongly related with the degree of mispricing. Even when we use the size and B/M as control variables, significant relations are maintained.

Cochrane's (1996) production-based model. Cochrane introduces the idea of production-based asset pricing by observing that the returns on firms' investments should equal the financial returns required to the firm. Cochrane (1991) examines a single investment return derived from aggregate investment and shows that expected investment returns are correlated with expected stock returns since firms' investment activity is low when stock prices are depressed. Cochrane (1996) employs two investment returns of aggregate residential and nonresidential investment as factors in a multi-factor model and investigates whether they explain the size effect in stock returns. Kogan (2004) develops of a production-based model in which real investment is irreversible and subject to convex adjustment costs and implement empirical tests by using industry portfolios. Liu, Whited, and Zhang (2009) estimate the production-based model's parameters to minimize the weighted average difference between means and variances of stock returns and levered investment returns by using GMM and stock portfolios. Chen, Novy-Marx, and Zhang (2011) use these ideas to propose an alternative three-factor model using investment-inspired factors. This new factor model consists of the market factor, an investment factor, and a return-on-equity factor and can explains anomalies involving earnings surprises, idiosyncratic volatility, and financial distress. Fama and French (2015) propose a five-factor model including the size, value, profitability, and investment patterns in

Table 11. Fama/MacBeth regression results for the Consumption-CAPM (CCAPM).

The monthly absolute errors from January 1985 to December 2005 are regressed on explanatory variables, such as the proportional spread, Roll's spread, Lesmond et al.'s (1999) measure, institutional churn rate, size, and B/M. The absolute errors under the CCAPM are calculated. We simply adopt a linearized CCAPM as suggested by Hodrick and Zhang (2001) rather than use the original CCAPM, which is nonlinear and requires a particular form for the utility function. Thus, we use the consumption growth rate, Δc, as a factor. The data are from the growth rate in the real consumption of non-durables, as per Citibase. When calculating the absolute errors for individual stocks for the period, 1985-2005, we use the betas (β's) that are estimated for the period, 1985-2005. When the number of monthly observations is less than 36, we exclude the beta for the stability of estimation. Size is the closing price times the number of shares outstanding at the end of the previous year. B/M is the book value divided by the market capitalization at the end of the previous year. We use the logarithms of size and B/M as explanatory variables. This table contains the time-series averages of coefficients that are obtained from monthly cross-sectional regressions; t-statistics are in parentheses.

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
216.987 (102.080)	755.448 (32.360)						0.014
188.778 (196.624)		2077.836 (36.881)					0.034
211.264 (116.820)			1644.928 (16.683)				0.022
267.167 (113.558)				-165.012 (-12.715)			0.003
237.596 (79.218)	738.082 (32.159)			-147.625 (-12.147)			0.017
203.736 (106.393)		2046.064 (36.535)		-105.067 (-9.225)			0.036
228.330 (88.962)			1608.844 (16.579)	-119.870 (-10.517)			0.023
332.302 (60.178)	-52.580 (-0.873)				-26.945 (-46.060)	-48.889 (-46.094)	0.054
258.887 (101.672)		1480.387 (36.389)			-18.774 (-55.979)	-47.867 (-50.098)	0.062
293.647 (68.985)			941.349 (14.002)		-21.833 (-42.768)	-49.501 (-47.611)	0.056

Table 11. (continued)

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
356.175 (121.283)				-31.220 (-2.909)	-29.842 (-102.618)	-48.430 (-44.542)	0.052
335.124 (60.564)	-46.064 (-0.786)			-35.646 (-3.418)	-26.539 (-43.672)	-48.597 (-45.895)	0.055
262.630 (98.867)		1476.801 (36.728)		-39.476 (-3.787)	-18.400 (-50.638)	-47.552 (-49.784)	0.063
297.627 (70.064)			935.724 (14.109)	-38.623 (-3.696)	-21.520 (-39.794)	-49.179 (-47.404)	0.057

average stock returns and verify a better performance than their three-factor model.

In this section, we use a linear version of Cochrane's (1996) production-based asset pricing model, in which he tries to capture the presence of real macroeconomic shocks by observing firms' investment decisions, just as the consumption-based model struggles to infer the presence of systematic shocks by watching the consumption decisions of investors. Cochrane examines whether the cross-sectional and time-series variations in the expected returns can be explained by investment returns, which are estimated from investment data by the means of an adjustment-cost production function. He argues that his model performs substantially better than a simple consumption-based model. In his paper, the investment return is a complicated function of the investment-capital ratio and several parameters, and should be priced in stock returns. During the process of empirical application, however, Cochrane finds that the investment growth rate performs equally well. Following Cochrane's study, we adopt two factors: the growth rate of real, non-residential investment (*GNR*) and the growth rate of real, residential investment (*GR*). The data are obtained from Citibase. We use a quarterly model of real investment, since we cannot obtain monthly data.

The results are summarized in Table 12. In the univariate regression, the proportional spread, Roll's spread, Lesmond et al.'s measure, and the institutional churn rate are statistically significant with t-statistics of 13.35, 18.03, 8.50, and -7.50, respectively.

Table 12. Fama/MacBeth regression results for Cochrane's investment-based model.

The monthly absolute errors from January 1985 to December 2005 are regressed on explanatory variables, such as the proportional spread, Roll's spread, Lesmond et al.'s (1999) measure, institutional churn rate, size, and B/M. The absolute errors under Cochrane's model are calculated. We use a linearized version of Cochrane's (1996) production-based asset pricing model. Following Cochrane, we adopt two factors with regard to the investment growth rate: the growth rate on real, non-residential investment, *GNR*, and the growth rate on real, residential investment, *GR*. These data are obtained from Citibase. We use quarterly data for real investment, since we cannot obtain monthly data for this model. When calculating the absolute errors for individual stocks for the period, 1985-2005, we use the betas (β's) that are estimated for the period, 1985-2005. When the number of observations is less than 36, we exclude the beta for the stability of estimation. Size is the closing price times the number of shares outstanding at the end of the previous year. B/M is the book value divided by the market capitalization at the end of the previous year. We use the logarithms of size and B/M as explanatory variables. This table contains the time-series averages of coefficients that are obtained from monthly cross-sectional regressions; t-statistics are in parentheses.

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
60.687 (40.569)	362.090 (13.354)						0.025
50.472 (65.352)		826.086 (18.030)					0.046
58.595 (48.215)			731.092 (8.501)				0.034
81.506 (45.774)				-67.096 (-7.500)			0.005
69.551 (31.747)	353.877 (13.281)			-63.035 (-7.679)			0.028
57.084 (42.470)		810.956 (18.056)		-45.859 (-6.296)			0.049
65.955 (37.425)			714.883 (8.463)	-51.357 (-6.866)			0.037
117.237 (34.559)	-6.851 (-0.219)				-12.342 (-32.092)	-16.736 (-19.436)	0.076
92.503 (52.344)		481.615 (14.411)			-9.593 (-35.845)	-16.377 (-19.723)	0.084

Table 12. (continued)

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
103.242 (43.531)			380.423 (5.873)		-10.505 (-36.622)	-16.942 (-19.621)	0.080
122.844 (52.241)				-12.615 (-2.058)	-12.929 (-44.455)	-16.742 (-19.192)	0.075
118.225 (34.369)	-4.657 (-0.153)			-13.832 (-2.334)	-12.167 (-31.411)	-16.660 (-19.447)	0.077
93.813 (51.756)		480.693 (14.541)		-15.623 (-2.626)	-9.418 (-34.149)	-16.288 (-19.749)	0.085
104.622 (44.260)			379.807 (5.866)	-15.314 (-2.543)	-10.350 (-34.846)	-16.852 (-19.635)	0.081

In the bivariate regression, transaction cost variables and the institutional churn rate are strongly related with pricing errors even after controlling the firm size and B/M. More detailed comparisons between asset pricing models are implemented and explained in the next section.

Discussion. So far we investigate the traditional CAPM and other six models. In this section, we discuss the performance of asset pricing models. It is meaningful to compare the performance of asset pricing models for selecting a model used in the practice even if all models fail to completely capture the cross-section of stock returns related to transaction cost or irrationality. To compare marginal contribution of asset pricing models we employ the R^2 from regression of absolute pricing errors on variables of transaction cost and investor irrationality. We use the R^2 of univariate regressions reported in the first-fourth rows of the Fama/MacBeth regressions. Higher R^2 means that pricing errors are more closely related to the transaction cost or investor irrationality, thereby asset pricing model fails to explain the cross-section of stock returns. Therefore, we interpret that the lower R^2 is the better asset pricing model.

Panel A of Figure 1 shows that the R^2 from the regression on transaction cost variables. R^2 of the CAPM ranges from 0.04 to 0.06 and those of 3 and 4 factor model are similar. The lowest R^2 corresponds to the consumption CAPM which includes consumption growth rate as a factor. In contrast, Cochrane's production-based asset pricing model, which includes the growth rate of non-residential and residential investment as factors, has higher R^2 than the consumption CAPM. In Panel B of Figure 1, the regression on investor irrationality variable also shows that the consumption CAPM, Campbell model and conditional CAPM have the lowest R^2 while Cochrane's production-based model has the highest. Therefore, we conclude that the consumption CAPM captures the cross-section of stock return the best among seven models and performs better than the production-based model.

Test for a missing risk factor

The results reported in the previous section show that investor irrationality and transaction costs ubiquitously affect asset pricing models; this supports Hypothesis 3 but cannot resolve the question of whether a missing risk factor exists and whether such a factor is the real reason for the failure of the CAPM.[8)] To answer this question, in this section, we implement two tests.

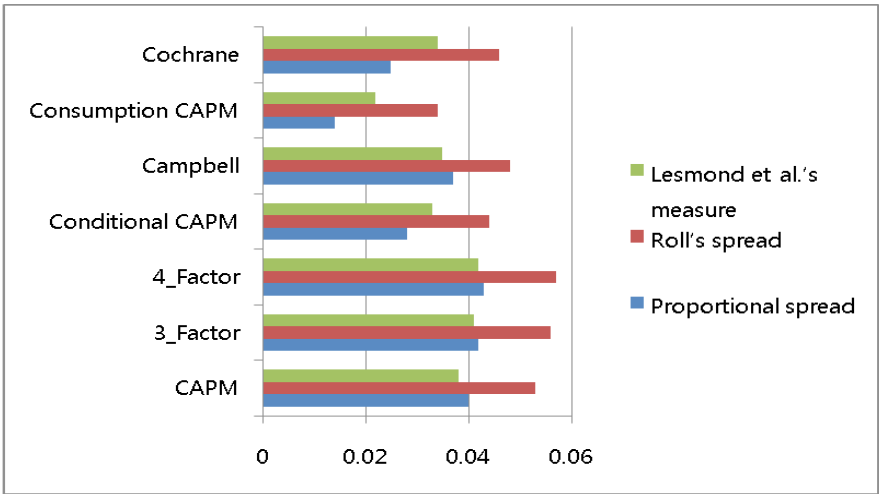
First, using the Wald test, we compare the magnitudes of the coefficients from the CAPM with those from asset pricing models that comprise more factors than the CAPM. If a missing risk factor is the main reason for the failure of the CAPM and the model with more factors at least improves upon the CAPM, we should observe a different pattern of coefficients. On the other hand, a similarity in regression coefficients means that the addition of more risk factors cannot offset the effect of transaction costs and investor irrationality on the poor performance of the CAPM.

Second, we add the residuals from the Fama/Macbeth regression of asset pricing models with more factors than the CAPM into the Fama/Macbeth regression of the CAPM to investigate the effect of missing factors. We know that the residuals contain missing factors though we do not know exactly what factors are missing. Thus, these residuals are included in the Fama/MacBeth regression of the CAPM as an explanatory variable. Through this regression, we can identify whether missing factors play a significant role in the poor performance of an asset pricing model and whether variables that

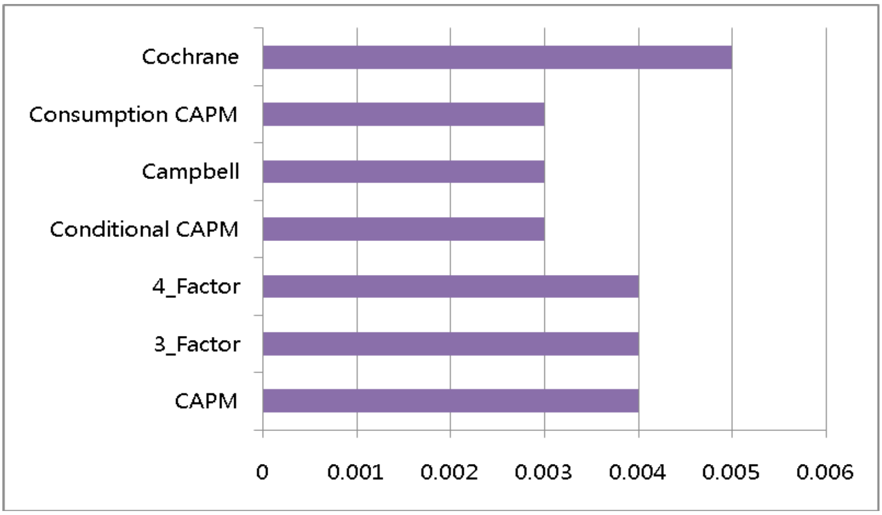
8) MacKinlay (1995) shows that CAPM deviations that result from missing risk factors will be very difficult to detect empirically.

Figure 1. R^2 from regression of pricing error on transaction cost and investor irrationality

This figure shows the R^2 from regression of absolute pricing errors(differences between the realized returns and the expected returns from the model) on variables of transaction cost and investor irrationality. We use the R^2 of univariate regressions reported in the first-fourth rows of the Fama/MacBeth regressions to compare asset pricing models. Panel A is from the regression of pricing errors on transaction costs and Panel B is on institutional churn rate.



(a) Transaction cost variables



(b) Institutional churn rate

are related to transaction costs and investor irrationality remain significant.

For a simple check, we compute the correlations between the absolute pricing errors under the various asset pricing models. Panel A of Table 13 presents the correlations across five asset pricing models. We focus on models with more factors than the CAPM. Thus, the CCAPM is excluded since it does not contain the market factor of the CAPM. Cochrane's model is excluded because it is applicable only for quarterly data. Pearson and Spearman correlations between the CAPM and the three-factor model are 0.944 and 0.858, respectively; between the CAPM and the four-factor model, 0.926 and 0.832; and between the three-factor model and the four-factor model, 0.984 and 0.954. The absolute pricing errors from Campbell's (1996) model are also highly correlated with the errors from the CAPM. However, the conditional CAPM exhibits low correlations with the CAPM (0.158 in terms of the Pearson correlation). We can confirm that the absolute errors under the various asset pricing models are highly correlated and exhibit only small differences, except for the conditional CAPM.

To test the statistical differences between the regression coefficients from the CAPM and those from four other asset pricing models, we implement the Wald test. We perform pair-wise comparisons using the coefficients of univariate regressions that are reported in the first-fourth rows of Fama/MacBeth regressions. Panel B of Table 13 shows that all the Wald statistics of the three-factor and four-factor models are less than 3.84, which is the 95% significance level for the Chi-square statistic with a degree of freedom of 1. This means we cannot reject the null hypothesis that the coefficients of the CAPM and the three-factor model – or for that matter the four-factor model – are the same. Roll's spread and the institutional churn rate in Campbell's model cannot reject the null hypothesis that the coefficients of asset pricing models are the same. With regard to the conditional CAPM, all the tests reject the null hypothesis.

This evidence shows that the inclusion of additional factors, such as the size, book-to-market, and momentum, cannot change the relationship between the explanatory power of the CAPM and transaction costs and/or investor irrationality. However, we do *not* argue that a missing factor cannot be a reason for the failure of asset pricing models; we argue *only that* the addition of more factors

Table 13. Wald test: comparisons of coefficients across asset pricing models.

This table reports the Wald test statistics for comparing coefficients across asset pricing models. We use the coefficients of univariate regressions reported in the first-fourth rows of the Fama/MacBeth regressions to compare asset pricing models. Panel A represents the correlations of pricing errors (differences between the realized returns and the expected returns from the model). The lower-left triangle of the table represents the Pearson correlations and the upper-right triangle represents the Spearman correlations. Panel B compares the Fama/MacBeth regression coefficients of the CAPM to those of other asset pricing models. The Fama-French three-factor model, Carhart's four-factor model, the conditional CAPM of Jagannathan and Wang (JW) (1996), and Campbell's (1996) model are used for comparison with the CAPM. The 95% significance level for a Chi-squared statistic with one degree of freedom is 3.84.

Panel A. Correlations of pricing errors.

	CAPM	3-factor	4-factor	JW	Campbell
CAPM		0.858	0.832	0.172	0.818
3-factor	0.944		0.954	0.173	0.731
4-factor	0.926	0.984		0.173	0.710
JW	0.158	0.159	0.160		0.185
Campbell	0.920	0.869	0.853	0.181	

Panel B. Wald test statistics.

Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate
Panel B.1: Comparison between the CAPM and the three-factor model.			
0.041	0.121	0.005	0.198
Panel B.2: Comparison between the CAPM and the four-factor model.			
0.010	0.233	0.006	0.162
Panel B.3: Comparison between the CAPM and the conditional CAPM.			
975.446	969.635	351.690	254.179
Panel B.4: Comparison between the CAPM and Campbell's model.			
13.332	2.455	16.034	1.658

cannot improve upon the poor performance of the CAPM that is *specifically* related to transaction costs and investors' irrationality. The present results are not enough to rule out the possible effects of missing factors and we restrict our missing-factor hypothesis to the pricing error that specifically stems from transaction costs and investor irrationality. Furthermore, we argue that an asset pricing model does not fail totally but performs worse as transaction costs and investor irrationality increase.

The second test uses the residual terms of Fama/MacBeth regression to investigate the role of missing factors. Though we cannot know exactly what factors are missing in an asset pricing model, we can confirm the presence of missing factors in the residuals from the Fama/MacBeth regression. Therefore, we develop the first regression as follows.

$$| Error_{i,t} \ of \ Model1 | = c_1 TC_{i,t-1} + c_2 IR_{i,t-1} + c_3 Size_{i,t-1} + c_4 B / M_{i,t-1} + u_{i,t}. \quad (12)$$

We know that missing factors other than size, B/M, transaction costs (TC), and investor irrationality (IR) are included in the $\{u_{i,t}\}$ of Eq. (12) though we cannot know exactly what factors are missing from Model 1. In the second regression, we add the residuals from Model 1 into the Fama/MacBeth regression of Model 2 to investigate whether missing factors play a significant role in asset pricing models.

$$| Error_{i,t} \ of \ Model2 | = c_1 TC_{i,t-1} + c_2 IR_{i,t-1} + c_3 Size_{i,t-1} + c_4 B / M_{i,t-1} + c_5 \ u_{i,t} of \ Model1 + \xi_{i,t}. \quad (13)$$

Table 14 shows the results for this second regression. Here, Model 1 is the model with more factors than the CAPM and Model 2 is the CAPM. In Panel A, we obtain the residuals from the Fama/Macbeth regression of the three-factor model. Then, these residuals are included in the Fama/MacBeth regression of the CAPM as an explanatory variable. Through the second regression, we can identify whether missing factors play a significant role in the poor performance of the CAPM and whether variables that are related to transaction costs and investor irrationality remain significant. The results show that the residuals are statistically significant with t-statistics of 171.32, 170.38, and 172.41, respectively. The variables of transaction costs and investor irrationality still remain significant.

We can surmise that the residuals, $u_{i,t}$, of Eq. (12) contain not only missing factors but also noise. This noise will induce the errors-in-variables problem and make the coefficient of the residual, c_5, biased. This measurement error causes the slope of the regression to be closer to zero than the true slope (Johnston and DiNardo, 1997, p.154). Therefore, we confirm that the coefficients of the residuals and their t-values are high enough that the results are reliable.

In Panel B, the conditional CAPM of Jagannathan and Wang (1996) is used. In Panel C, we obtain the residuals using Campbell's model. The results show that the residuals are statistically significant and that the variables of transaction costs and investor irrationality still remain significant in the Fama/MacBeth regression of the CAPM.

In Panels A and C, the coefficients and t-values of residuals are similarly very high when the Fama-French three-factor model and Campbell's model are used. A common feature of the two models is that they incorporate the market factor, $(R_m\text{-}R_f)$. In Panel B, where the conditional CAPM of Jagannathan and Wang is used, the coefficients and t-values of residuals also drop distinctly. This evidence shows that the market factor, $(R_m\text{-}R_f)$, plays a major role in capturing the cross-section of stock returns and that the default premium captures other dimensions of the cross-section of stock returns as well.

Based on the evidence, we argue that the poor performance of an asset pricing model due to transaction costs and investor irrationality cannot be improved upon by only adding more factors as far as we try. However, we cannot exclude the possibility that missing factors may be causes of the poor performance of an asset pricing model.

Further analysis

There has been significant improvement in the literature on transaction cost and investor irrationality. Transaction cost is often used as liquidity measure and recently market liquidity is widely accepted as a systematic risk factor. Specifically, Chordia, Roll, and Subrahmanyam (2000) explain two channels through which liquidity influences stock returns: one is a static channel and the other is a dynamic channel. A static channel argues that liquidity is a kind of tax or cost charged to investors. Namely, transaction costs are cross-sectionally related to expected returns since after-cost returns should be considered by investors in efficient markets. Amihud and Mendelson (1986), Brennan and Subrahmanyam (1996),

Table 14. Fama/MacBeth regression results for missing factors.

This table reports results for missing-factor tests. The first regression is performed as:

$$|\,Error_{i,t}\ of\ Model1\,| = c_1 TC_{i,t-1} + c_2 IR_{i,t-1} + c_3 Size_{i,t-1} + c_4 B/M_{i,t-1} + u_{i,t}.$$

Missing factors, except the size, B/M, transaction costs, and investor irrationality, are included in the $u_{i,t}$ of the above equation. With regard to the second regression, the residuals from Model 1 are included into the Fama/MacBeth regression of Model 2 to investigate whether missing factors exert a significant role in the asset pricing model.

$$|\,Error_{i,t}\ of\ Model2\,| = c_1 TC_{i,t-1} + c_2 IR_{i,t-1} + c_3 Size_{i,t-1} + c_4 B/M_{i,t-1} + c_5 u_{i,t} + \xi_{i,t}.$$

In Panel A, the residuals are obtained from the Fama/Macbeth regression when the Fama-French, three-factor model is used as an asset pricing model for calculating the absolute errors. In Panel B, the residuals are obtained from the Fama/Macbeth regression, when the conditional CAPM of Jagannathan and Wang (1996) is used as an asset pricing model for calculating the absolute errors. In Panel C, the residuals are obtained from the Fama/Macbeth regression when Campbell (1996)'s model is used as an asset pricing model for calculating the absolute errors. Then, these residuals are included in the Fama/MacBeth regression of the CAPM as an explanatory variable.

Panel A. Explanatory power of residuals from the three-factor model with regard to the absolute errors under the CAPM.

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Residuals	Size	B/M	Adj. R^2
13.951 (45.041)	32.083 (15.328)			-3.648 (-8.014)	0.926 (171.317)	-1.047 (-32.100)	-1.444 (-23.784)	0.872
12.115 (58.925)		81.108 (28.358)		-3.044 (-6.719)	0.926 (170.378)	-0.882 (-34.831)	-1.345 (-24.261)	0.872
14.015 (53.953)			54.891 (16.677)	-2.907 (-6.437)	0.927 (172.405)	-1.073 (-35.508)	-1.426 (-23.171)	0.872

Panel B. Explanatory power of residuals from the conditional CAPM with regard to the absolute errors under the CAPM.

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Residuals	Size	B/M	Adj. R^2
14.064 (45.404)	29.306 (14.938)			-3.470 (-7.892)	0.007 (21.267)	-1.059 (-32.998)	-1.482 (-24.812)	0.070
12.205 (58.832)		76.783 (27.817)		-2.947 (-6.749)	0.006 (20.263)	-0.888 (-35.067)	-1.383 (-25.689)	0.076
14.197 (53.284)			50.818 (15.890)	-2.742 (-6.266)	0.007 (21.016)	-1.095 (-36.590)	-1.471 (-24.386)	0.069

Panel C. Explanatory power of residuals from Campbell's model with regard to the absolute errors under the CAPM.

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Residuals	Size	B/M	Adj. R^2
13.543 (37.615)	28.110 (17.298)			-3.530 (-7.204)	0.830 (105.048)	-1.012 (-26.832)	-1.570 (-23.980)	0.767
12.056 (49.380)		68.663 (24.446)		-3.138 (-6.443)	0.830 (104.484)	-0.869 (-29.351)	-1.477 (-25.067)	0.767
13.716 (47.108)			37.670 (17.530)	-2.641 (-5.446)	0.831 (105.197)	-1.062 (-31.710)	-1.574 (-23.603)	0.767

Eleswarapu (1997), Brennan, Chordia, and Subrahmanyam (1998), Chalmers and Kadlec (1998), Amihud (2002) empirically find that liquidity measures, such as spread, depth, volume, and proportion of daily zero return, have significant relation with stock returns.

In contrast, the dynamic channel argues that liquidity has non-diversifiable systematic components. A individual stock's exposure to market liquidity variation leads to non-diversifiable risk and then this liquidity risk will be conceivably priced. There is a tremendous literature supporting this argument (see, for example, Chordia et al. (2000), Huberman and Halka (2001), Amihud (2002), Pastor and Stambaugh (2003), and Acharya and Pedersen (2005)).

Here, we consider liquidity factor when calculating the absolute pricing errors from Carhart's four-factors by adding liquidity factor of Pastor and Stambaugh (2003). Liquidity factor data are downloaded from Pastor's website.[9] Panel A of Table 15 shows the result from the model including liquidity factor. In the univariate regression, the proportional spread, Roll's spread, Lesmond et al.'s measure, and institutional churn rate are statistically significant. In the bivariate regression, both transaction costs and the institutional churn rate are strongly related with the degree of mispricing. Even after the size and B/M are controlled, significant relationships hold. However, liquidity factor seems to reflect transaction costs since R^2 and t-value of coefficient are lower than those from Cahart 4-factor model reported in Table 8. The result is also consistent with Acharya and Pedersen (2005) in that a stock's required return depends on its liquidity level as well as on the liquidity risk, namely, covariances of its liquidity with the market return and liquidity.

In behavioral finance, some researches appear in the opposite of traditional view that deviations in stock prices caused by uninformed investors can be arbitraged away by smart informed traders (Friedman, 1953; Fama, 1965). Many recent studies have confirmed that trading by individual investors can affect stock returns. For example, Kaniel et al. (2008) provide evidence that intense trading by individuals is correlated positively with future stock returns. Barber et al. (2009) show that small trade order imbalances, which are correlated with retail trade imbalances, can forecast future stock returns. Baker and Wurgler (2006) show that investor sentiment can affect the cross-section of stock returns. They consider six proxies

9) http://faculty.chicagobooth.edu/lubos.pastor/research/

Table 15. Further studies for the model including liquidity and sentiment factor

The monthly absolute errors from January 1985 to December 2005 are regressed on explanatory variables, such as the proportional spread, Roll's spread, Lesmond et al.'s (1999) measure, institutional churn rate, size, and B/M. The absolute errors are calculated under Carhart's four-factors including liquidity and investor sentiment factor, respectively. Liquidity factor is from Pastor and Stambaugh (2003) and investor sentiment factor is from Baker and Wurgler (2006). When calculating the absolute errors for month *t*, we use beta coefficients that are estimated using the monthly returns from month *t-60* through to month *t*-1. Thus, the betas roll every month for each stock. When the number of monthly observations is less than 36, we exclude the beta coefficients for the stability of estimation. Size is the closing price times the number of shares outstanding at the end of the previous year. B/M is the book value divided by the market capitalization at the end of the previous year. We use the logarithms of size and B/M as explanatory variables. This table contains the time-series averages of coefficients that are obtained from monthly cross-sectional regressions; t-statistics are in parentheses.

Panel A. Fama/MacBeth regression results for the four-factor model including liquidity factor.

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
9.201 (43.133)	72.345 (22.420)						0.042
7.857 (53.313)		132.719 (31.991)					0.061
9.414 (51.771)			115.837 (18.217)				0.042
13.332 (53.430)				-13.235 (-19.842)			0.005
10.641 (39.236)	70.943 (22.354)			-9.889 (-14.944)			0.045
8.951 (46.025)		130.302 (31.736)		-7.288 (-12.152)			0.063
10.602 (47.346)			112.990 (18.202)	-8.039 (-13.218)			0.044
15.532 (41.570)	30.291 (12.922)				-1.271 (-32.301)	-1.642 (-22.137)	0.069
12.880 (53.881)		91.170 (28.769)			-0.997 (-35.002)	-1.516 (-22.726)	0.079
15.422 (54.815)			63.496 (15.942)		-1.252 (-40.701)	-1.625 (-21.674)	0.069

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
19.230 (55.258)				-3.187 (-5.449)	-1.684 (-44.746)	-1.533 (-20.414)	0.061
15.925 (40.237)	31.165 (13.539)			-4.071 (-7.176)	-1.237 (-31.927)	-1.628 (-22.044)	0.070
13.257 (50.641)		91.116 (28.781)		-3.463 (-6.042)	-0.972 (-34.147)	-1.502 (-22.641)	0.080
15.781 (53.451)			63.452 (15.955)	-3.208 (-5.590)	-1.230 (-39.476)	-1.612 (-21.594)	0.069

Panel B. Fama/MacBeth regression results for the four-factor model including sentiment factor.

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
9.318 (39.571)	72.637 (22.343)						0.042
7.942 (48.427)		134.185 (31.829)					0.061
9.520 (46.085)			117.013 (18.443)				0.042
13.551 (47.227)				-13.761 (-19.834)			0.005
10.840 (35.619)	71.243 (22.254)			-10.383 (-14.957)			0.045
9.115 (41.419)		131.670 (31.603)		-7.757 (-12.421)			0.063
10.788 (41.644)			114.091 (18.421)	-8.522 (-13.450)			0.044
15.717 (39.591)	30.358 (12.735)				-1.286 (-31.712)	-1.671 (-21.028)	0.069
12.994 (50.154)		92.392 (28.899)			-1.005 (-33.962)	-1.541 (-21.575)	0.080
15.551 (49.825)			64.546 (16.092)		-1.260 (-38.141)	-1.656 (-20.673)	0.069
19.486 (50.102)				-3.601 (-6.026)	-1.699 (-42.726)	-1.561 (-19.554)	0.061
16.162 (37.835)	31.291 (13.368)			-4.480 (-7.732)	-1.249 (-31.541)	-1.657 (-20.994)	0.070
13.427 (46.513)		92.356 (28.930)		-3.874 (-6.616)	-0.978 (-33.319)	-1.527 (-21.546)	0.081
15.967 (48.106)			64.512 (16.121)	-3.622 (-6.185)	-1.236 (-37.209)	-1.642 (-20.647)	0.070

suggested in previous literature and develop a composite sentiment index based on their first principal component.

We include this investor sentiment factor into Carhart's four-factors model when calculating the absolute pricing errors. Investor sentiment index data are downloaded from Wurgler's website.[10)] Panel B of Table 15 shows the result from the model including investor sentiment factor. In the univariate and bivariate regression, the proportional spread, Roll's spread, Lesmond et al.'s measure, and institutional churn rate are statistically significant. Even after the size and B/M are controlled, significant relationships are maintained.

In short, our results suggest that the poor performance of an asset pricing model due to transaction costs and investor irrationality survives even after liquidity and investor sentiment factors are added. This supports the important role of transaction cost and investor irrationality as idiosyncratic factors in explaining the cross-section of stock returns.

Robustness checks

Since we make several subjective assumptions in the preceding analyses, we implement robustness checks in this section. The first robustness check uses 1-R^2 as a proxy for the lack of explanatory power, where the R^2 (R-squared) is obtained when we calculate the beta using the time-series of returns. This analysis is based on Roll's (1988) study in which the R^2 values of the time-series regressions are used as the explanatory power of various asset pricing models.

In Panel A.1 of Table 16, we use 1-R^2 as a proxy for the lack of explanatory power for the firm, where the R^2 is obtained when we calculate the beta using the time-series of returns for the period, 1985-2005. Then, we regress the 1-R^2 on the averages of the proportional spread, Roll's spread, Lesmond et al.'s measure, and the institutional churn rate for the period, 1985-2005. Thus, this cross-sectional regression is implemented once for the whole sample period. In the univariate and bivariate regressions, the proportional spread, Roll's spread, Lesmond et al.'s measure, and the institutional churn rate are statistically significant though that is not reported in the table. When the size and B/M are used

10) http://people.stern.nyu.edu/jwurgler/

as control variables in Panel A.1, the statistical significance of the institutional churn rate disappears.

In Panel A.2 of Table 16, we use the 1-R^2 of the rolling CAPM as a proxy for the lack of explanatory power for a firm, where the R^2 is obtained when we calculate rolling betas using the returns from months *t-60* through to *t*-1. In Panel A.3 of Table 10, we use 1-R^2 as a proxy for the lack of explanatory power for a firm, where the R^2 is obtained when we calculate Fama-French's three-factor model in Table 7. Then, we run the Fama/MacBeth regressions. All the results are similar to each other and stronger than those in the previous section. In the univariate and bivariate regressions, all variables are statistically significant though not reported in the table. When the size and B/M are controlled in Panels A.2 and A.3, the statistical significance of Roll's spread decreases distinctly.

The second robustness check is the winsorization of the dependent variables. In Panel B of Table 16, we winsorize the dependent variables each month at 0.05%. The winsorization will dampen the problem whereby outliers in the dependent variables might bias the regression coefficients. The results are similar to those of the preceding sections. In the univariate and bivariate regressions, the proportional spread, Roll's spread, Lesmond et al.'s measure, and the institutional churn rate are statistically significant even after the size and B/M are controlled.

Finally, we remove observations when the positive auto-covariance of daily stock returns is converted to a negative value for obtaining Roll's spread. In Panel C of Table 16, we confirm that the results are similar to those of the preceding sections. In the univariate and bivariate regressions, all variables are statistically significant even after the size and B/M are used as control variables.

This series of robustness checks supports our argument that the poor performance of asset pricing models results from investors' irrationality and transaction costs.

CONCLUSION

The reason for the poor performance of asset pricing models can be divided into the following three categories: investor irrationality; transaction costs; and missing risk factors. The objective of this paper is to find which of these candidates is most responsible for the

Table 16. Robustness checks.

This table reports the results on three kinds of robustness check. In Panel A.1, we use 1-R^2 as a proxy for the lack of explanatory power for a firm, where the R^2 is obtained when we calculate the beta using the time-series of returns for the period, 1985-2005. We regress 1-R^2 on the averages of the proportional spread, Roll's spread, Lesmond et al.'s (1999) measure, and the institutional churn rate for the period, 1985-2005. Thus, this cross-sectional regression is implemented once for the whole sample period. In Panel A.2, we use 1-R^2 as a proxy for the lack of explanatory power for a firm, where the R^2 is obtained when we calculate rolling betas as per panel B of Table 6. Then, we run the Fama and MacBeth (1973) regression. In Panel A.3, we use 1-R^2 as a proxy for the lack of explanatory power for a firm, where the R^2 is obtained when we calculate the Fama-French three-factor model, as in Table 7. Then, we run the Fama and MacBeth (1973) regression. In Panel B, we winsorize the dependent variables each month at 0.05% and run the Fama and MacBeth (1973) regression. In Panel C, we exclude the observations when the positive auto-covariance of daily stock returns are converted to negative values for obtaining Roll's spread and run the Fama and MacBeth (1973) regression.

Panel A.1. 1-R^2 of the CAPM as the dependent variable (constant beta).

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
0.995 (221.623)	0.236 (7.790)				-0.021 (-30.099)	0.001 (0.667)	0.227
1.011 (215.659)		0.157 (3.041)			-0.023 (-33.567)	0.001 (1.154)	0.222
1.013 (248.983)			0.109 (3.258)		-0.023 (-34.812)	0.001 (0.938)	0.223
1.025 (264.934)				-0.020 (-0.886)	-0.025 (-44.848)	0.001 (1.033)	0.222
0.999 (197.001)	0.241 (7.917)			-0.038 (-1.668)	-0.021 (-29.143)	0.001 (0.725)	0.228
1.014 (191.336)		0.161 (3.104)		-0.025 (-1.084)	-0.023 (-32.813)	0.001 (1.199)	0.222
1.016 (211.811)			0.111 (3.315)	-0.024 (-1.076)	-0.023 (-34.047)	0.001 (0.978)	0.223

Panel A.2. 1-R^2 of the CAPM as the dependent variable (rolling beta).

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
0.997 (310.732)	0.289 (10.559)				-0.030 (-31.260)	-0.002 (-3.125)	0.213
1.014 (441.309)		-0.014 (-0.507)			-0.032 (-37.656)	-0.002 (-3.209)	0.214
0.998 (346.260)			0.232 (14.986)		-0.030 (-33.670)	-0.002 (-3.184)	0.213
1.026 (412.861)				-0.073 (-13.526)	-0.033 (-31.939)	-0.002 (-2.491)	0.212
1.004 (315.866)	0.301 (10.947)			-0.082 (-15.155)	-0.029 (-31.583)	-0.002 (-2.850)	0.215
1.021 (470.124)		-0.010 (-0.363)		-0.075 (-13.668)	-0.032 (-38.180)	-0.002 (-2.940)	0.216
1.005 (360.080)			0.237 (15.227)	-0.074 (-13.720)	-0.030 (-33.967)	-0.002 (-2.905)	0.215

Panel A.3. 1-R^2 of the three-factor model as the dependent variable.

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
0.948 (309.290)	0.418 (11.725)				-0.031 (-34.468)	-0.005 (-5.902)	0.212
0.969 (450.652)		0.048 (1.704)			-0.034 (-45.177)	-0.005 (-5.591)	0.211
0.949 (333.742)			0.391 (18.990)		-0.031 (-39.261)	-0.005 (-5.769)	0.212
0.989 (449.690)				-0.104 (-16.588)	-0.035 (-38.438)	-0.005 (-5.192)	0.210
0.959 (317.971)	0.432 (12.078)			-0.115 (-18.608)	-0.030 (-35.140)	-0.005 (-5.797)	0.215
0.980 (516.299)		0.054 (1.915)		-0.107 (-16.833)	-0.033 (-46.325)	-0.005 (-5.482)	0.213
0.960 (362.033)			0.397 (19.158)	-0.105 (-16.689)	-0.031 (-40.032)	-0.005 (-5.669)	0.215

Panel B.1. Winsorizing the dependent variable of the CAPM.

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
13.677 (50.345)	23.585 (13.378)				-1.067 (-35.792)	-1.372 (-24.555)	0.065
11.824 (66.365)		70.084 (29.175)			-0.880 (-38.734)	-1.294 (-25.138)	0.073
13.507 (57.211)			46.413 (16.877)		-1.047 (-37.518)	-1.361 (-23.993)	0.065
16.684 (63.536)				-2.685 (-6.656)	-1.426 (-47.034)	-1.317 (-23.411)	0.057
14.004 (48.764)	24.275 (14.033)			-3.353 (-8.453)	-1.040 (-35.552)	-1.361 (-24.505)	0.065
12.143 (62.651)		70.146 (29.247)		-2.952 (-7.381)	-0.859 (-37.868)	-1.283 (-25.112)	0.074
13.825 (56.283)			46.447 (16.875)	-2.839 (-7.189)	-1.029 (-36.878)	-1.350 (-23.951)	0.065

Panel B.2. Winsorizing the dependent variable of the three-factor model.

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
13.852 (49.344)	25.143 (14.851)				-1.103 (-37.312)	-1.392 (-28.014)	0.068
12.055 (64.061)		71.118 (30.917)			-0.925 (-40.472)	-1.310 (-29.073)	0.077
13.639 (56.588)			48.443 (18.256)		-1.075 (-39.677)	-1.381 (-27.639)	0.069
16.977 (63.001)				-2.576 (-6.332)	-1.479 (-50.552)	-1.334 (-26.816)	0.060
14.179 (47.737)	25.798 (15.517)			-3.292 (-8.234)	-1.077 (-36.964)	-1.382 (-27.939)	0.069
12.370 (60.145)		71.158 (30.975)		-2.864 (-7.129)	-0.905 (-39.342)	-1.299 (-29.009)	0.077
13.951 (55.188)			48.465 (18.262)	-2.739 (-6.869)	-1.058 (-38.887)	-1.371 (-27.573)	0.069

Panel C.1. Roll's spread is excluded when positive auto-covariances are found (the CAPM).

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
13.424 (49.048)	34.588 (16.976)				-1.165 (-35.453)	-1.390 (-20.782)	0.066
11.545 (60.550)		79.855 (27.384)			-0.955 (-33.862)	-1.322 (-21.237)	0.072
13.866 (56.726)			54.743 (17.138)		-1.228 (-36.195)	-1.374 (-20.123)	0.063
17.707 (66.627)				-1.533 (-3.061)	-1.747 (-45.166)	-1.346 (-19.848)	0.054
13.658 (49.174)	34.852 (17.217)			-2.229 (-4.543)	-1.151 (-35.349)	-1.380 (-20.614)	0.066
11.741 (59.355)		79.854 (27.425)		-1.747 (-3.564)	-0.945 (-33.562)	-1.313 (-21.066)	0.073
14.055 (56.839)			54.783 (17.076)	-1.608 (-3.267)	-1.221 (-35.828)	-1.365 (-19.951)	0.064

Panel C.2. Roll's spread is excluded when positive auto-covariances are found (the three-factor model).

Intercept	Proportional spread	Roll's spread	Lesmond measure	Institutional churn rate	Size	B/M	Adj. R^2
13.685 (47.525)	35.476 (17.934)				-1.216 (-36.313)	-1.430 (-22.850)	0.068
11.844 (56.816)		80.351 (29.067)			-1.011 (-34.355)	-1.360 (-23.511)	0.075
14.079 (56.307)			56.150 (18.011)		-1.270 (-38.284)	-1.414 (-22.284)	0.067
18.038 (66.537)				-1.421 (-2.748)	-1.808 (-48.339)	-1.386 (-21.914)	0.057
13.912 (47.584)	35.737 (18.171)			-2.146 (-4.221)	-1.202 (-36.287)	-1.421 (-22.674)	0.069
12.032 (55.571)		80.361 (29.102)		-1.656 (-3.255)	-1.002 (-34.083)	-1.352 (-23.332)	0.076
14.257 (56.464)			56.207 (17.951)	-1.499 (-2.938)	-1.263 (-37.962)	-1.406 (-22.114)	0.067

failure of asset pricing models. To accomplish this, we investigate the relationship between the absolute pricing errors under various asset pricing models and variables that are thought to be related to the failure of asset pricing models.

First, we examine the relationship between variables that are related to investor irrationality (or transaction costs) and the differences between the realized returns and the expected returns, as estimated by the CAPM. The results of Fama-MacBeth regressions show that both transaction costs and investor irrationality are significantly related to the difference, even after the size and book-to-market are included in the regression.

Furthermore, we implement the same testing procedure for six other asset pricing models. The results of Fama-MacBeth regressions for these models are similar to those for the CAPM. Then, we compare the magnitudes of the regression coefficients across different asset pricing models. Most test statistics do not give a reason for rejecting the null hypothesis that the coefficients of asset pricing models are the same except for the conditional CAPM.

This implies that models with more risk factors than the CAPM, such as the Fama-French three-factor model, cannot improve upon the CAPM's poor performance that arises from transaction costs and investor irrationality. Therefore, we argue that asset pricing models are intrinsically limited and cannot be improved upon by the addition of more factors. If transaction costs and investor irrationality are not minimized, any asset pricing model will exhibit various cross-sectional differences in its performance. In a study about an emerging market,[11] the result is similar to that for the US and confirms the conclusion of this study.

The results of this paper are somewhat limited because we use only seven asset pricing models instead of many more models that are reported in the literature. Recently, the liquidity factor, one of the main reasons for the failure of asset pricing models, has been added in the model to improve the explanatory power (see, for instance, Acharya and Pedersen, 2005). However, an examination of this factor lies outside the scope of the present study partly because the literature on liquidity asset pricing itself is quite voluminous. Meanwhile, studies on investor-irrationality factors are only at a nascent stage (see, for instance, Baker and Wurgler, 2006) in

11) See Chae and Yang (2008).

contrast to those on liquidity. More studies are needed in these areas before the findings can be incorporated in an analysis of the present kind.

Appendix: Analysis of the error terms of models

The CAPM specification is:

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_i(R_{m,t} - R_{f,t}) + e_{i,t}. \tag{A1}$$

The Fama-French, three-factor model specification is:

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_i(R_{m,t} - R_{f,t}) + \delta_i SMB_t + \kappa_i HML_t + \xi_i. \tag{A2}$$

From (A1) and (A2), the error term of the CAPM can be rewritten as:

$$e_{i,t} = \delta_i SMB_t + \kappa_i HML_t + \xi_i. \tag{A3}$$

We analyze a cross-sectional regression of the Fama-MaBeth approach for a specific period. We regress the error term of the CAPM, e_i, on X_i, which is the variable that is related to either transaction cost or investor irrationality for firm *i*. The regression specification is:

$$| e_i | = \phi + \gamma X_i + \eta_i. \tag{A4}$$

The coefficient is:

$$\begin{aligned} \gamma &= (X'X)^{-1}X'(|\,\delta SMB + \kappa HML + \xi\,|) \\ &\leq |SMB|\,(X'X)^{-1}X'|\delta| + |HML|\,(X'X)^{-1}X'|\kappa| + (X'X)^{-1}X'|\xi|, \end{aligned} \tag{A5}$$

since all the elements of X are positive in our regression.

In the above, $X = \begin{bmatrix} X_1 \\ \vdots \\ X_i \\ \vdots \\ X_n \end{bmatrix}$, $\delta = \begin{bmatrix} \delta_1 \\ \vdots \\ \delta_i \\ \vdots \\ \delta_n \end{bmatrix}$, $\kappa = \begin{bmatrix} \kappa_1 \\ \vdots \\ \kappa_i \\ \vdots \\ \kappa_n \end{bmatrix}$, and $\xi \quad \begin{bmatrix} \\ \\ \xi \\ \\ \\ \end{bmatrix}$ Further, n is the number of firms in the cross-sectional regression. *SMB* and *HML* are constant in month *t*.

On the other hand, when the error term of the Fama-French three-factor model for firm *i*, ξ_i, is regressed on X_i, the regression specification is:

$$|\xi_i| = \bar{\phi} + \bar{\gamma} X_i + \bar{\eta}_i. \tag{A6}$$

The corresponding coefficient is:

$$\bar{\gamma}_i = (X'X)^{-1} X' |\xi|. \tag{A7}$$

Our empirical result in the article shows that $\gamma = \bar{\gamma}$.

From (A5) and (A7), we derive the conditions that $X'|\delta| = 0$ and $X'|\kappa| = 0$. Since δ and κ are factor loadings in the three-factor model, we may assume that the values for these factor loadings are positive. In that case, $X'|\delta| \approx X'\delta = 0$ and $X'|\kappa| \approx X'\kappa = 0$. This means that the SMB factor loading of firm *i*, δ_i, is orthogonal to X_i and the HML factor loading, κ_i, is also orthogonal to X_i. These imply that SMB and HML fail to explain the effect of transaction costs and investor irrationality and are consistent with our interpretation that transaction costs and investor irrationality are valid reasons for the failure of asset pricing models, quite apart from missing factors.

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