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Two Essays on Investment

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Two Essays on Investment

A Dissertation

Submitted to the graduate Faculty of the
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Doctor of Philosophy
in
Financial Economics

by

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Dedication:

This dissertation is dedicated to my parents, Liancun Zheng and Ai Tao, and my husband Eric.

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Abstract

This dissertation consists of two essays: one looks at the time-varying relationship between earnings and price momentum, and the other looks at how liquidity and transparency affect the pricing differential between Chinese A-and Hong Kong H-share.

The first essay presented in Chapter I investigates the time varying relationship between earnings momentum and price momentum. Using a Markov-switching framework, allowing for variation between high volatility and low volatility states, I find that price momentum is significantly more influenced by earnings momentum in the high volatility state. Further for price momentum I find that loser firms display a higher degree of differential response to earnings momentum across the low and high volatility states than winner firms. Limited financing and investor's sensitivity to future investment opportunities might explain these two results. A further analysis indeed indicates that loser firms tend to be more financially constrained. Additionally, I investigate the relationship between investor sentiment and the two momentums and find that sentiment only has predictive power for price momentum profits in the low volatility state. Finally, the results are robust regardless of instrument variables.

The second essay presented in Chapter 2 examines the impact of liquidity and transparency on the discount attached to H-shares from 2003 to 2011. The higher the relative illiquidity of an H-share, the more the H-share is discounted relative to the underlying A-share price. In addition, more actively traded A-shares and infrequently traded H-shares are associated with a higher H-share discount. Further, increases in the number of analysts following a firm, both in the A-and H- market, are accompanied by a lower H-share discount. Also, a firm with a higher percentage of A-share holdings by mutual funds is associated with a smaller H-share discount. Overall, the results provide support for the notion that liquidity and transparency affect the relative pricing of A- and H-shares.

Keywords: earnings momentum, price momentum, regime-switching, discount, illiquidity, transparency

Chapter 1

The Relation between Earnings and Price Momentum: Does It Vary across Regimes?

1. Introduction

Earnings momentum and price momentum are well-known market anomalies. Each has been intensely studied in the empirical finance literature; however, there are relatively few studies investigating the relation between the two. Chordia and Shivakumar (2006) show a linear relationship between the two anomalies and conclude that price momentum can be captured by systematic earnings momentum. On the other hand Chan, Jegadeesh and Lakonishok (1996) argue that although there is a correlation between earnings momentum and price momentum one effect cannot be subsumed by the other. This mixed evidence may be partly the result of the time varying relation between the two momentums. Consequently, this paper attempts to model a nonlinear relationship between the two using a Markov regime-switching framework incorporating macroeconomic information into the state transition probabilities. This framework is helpful in that it allows for variation in the relation between high volatility and low volatility states.

In order to examine the relationship between these two anomalies, I first sort firms into decile portfolios based on the most recent standardized earnings surprise (or standardized unexpected earnings, SUE) to create an investment portfolio (PMN) that is long in the highest earnings surprise decile and is short in the lowest earnings surprise decile. Similarly, sorting firms into decile portfolios using past returns, I create a second investment portfolio (WML) that is long in past winners and short in past losers. I use each of these portfolios as the fourth factor in a regime-switching Fama-French model. The results from these models indicate that price momentum is significantly more influenced by earnings momentum in the high volatility state.

There are two possible explanations for this finding. First, from a financing perspective, the discount rate in the low volatility state has a large impact on stock prices but not necessarily on companies' earnings. However in the high volatility state, when financing is more constrained, the discount rate makes a bigger difference on earnings. Therefore, the co-movement of price momentum and earnings momentum becomes stronger when volatility is higher. Second, from an investing perspective, PMN captures future aggregate investment opportunities and its predictive content becomes more important for investors in the high volatility state. Therefore, investors pay more attention to earnings information in the high volatility state, which could also result in a stronger relation between earnings and price momentum.

No less important, I extend the analysis to allow firms with different degrees of SUE to respond differently to factors across volatility states. Likewise, I examine whether winner and loser firms display similar responses to earnings momentum across volatility states. This analysis is motivated by two observations. First, as argued above, financing and investment considerations might be important in explaining momentum. It is further argued that the importance of these considerations likely differs across firms. More specifically, firms with constraints on financing and investments likely are more vulnerable in more volatile conditions. Second, by comparing the firm characteristics of firms in the two extreme SUE portfolios, P10 and P1, I find that that firms in the lowest SUE portfolio generally have high book-to-market ratios and small market value, (Chordia and Shivakumar (2006)) [1], as well as higher debt ratio and more constraints on financing. Similarly, by comparing the firm characteristics of firms in the two extreme price momentum portfolios, loser and winner, I find that firms in the loser portfolio generally have small market value, low book-to-market ratio, higher debt ratio and are

[1] Chordia and Shivakumar (2006) find the highest earnings surprise decile is generally composed of firms with large size, high book-to-market ratio and thus behaves more like a growth portfolio, whereas the lowest earnings surprise decile is composed of firms with small size, low book-to-market ratio and thus behaves like a value portfolio.

significantly more financially constrained than firms in the winner portfolio (Baytas and Cakici (1999), Lesmond, Schill and Zhou (2004))[2]. Previous literature also suggests that firms in the lowest SUE or loser portfolios also tend to be more sensitive to changes in the state of the economy (Perez-Quiros & Timmermann (2000), Gulen, Xing and Zhang (2011))[3]. I find that loser firms display a stronger differential response to both the market risk premium and earnings momentum (PMN) across low and high volatility states. In contrast, lowest SUE firms display a higher degree of asymmetry only to the market risk premium, but not to price momentum (WML). One explanation for this is that PMN captures future macroeconomic activities such as aggregate investment opportunities. Loser firms are generally small firms with high book-to-market ratios that have limited financing access, higher financing costs and are potentially associated with higher credit risk. These properties make loser firms more sensitive to PMN than winner firms across states. In contrast, WML does not contain information about future economic or investment opportunities;[4] therefore, lowest SUE and highest SUE firms do not react to WML asymmetrically.

Finally, since momentum generally implies some degree of market inefficiency and thus might be caused by investor sentiment or return chasing behavior, whose strength may vary with economic conditions, I adopt two sentiment measures constructed by Baker and Wurgler (2006) to investigate the relationship between sentiment and the two momentums. I find that profits from earnings momentum are positive and do not vary with investor sentiment. In contrast, profits for price momentum exist only when investor sentiment is optimistic. When pessimistic,

[2] Baytas and Cakici (1999) provide evidence that in the U.S. the market value for loser firms is almost ten times smaller than that of winner firms, which is also confirmed by Lesmond, Schill and Zhou (2004).

[3] Perez-Quiros & Timmermann (2000) find strong evidence that small firms display a higher asymmetry in their factor loadings than large firms across recession and expansion states. Gulen, Xing and Zhang (2011) find that when conditional volatilities are high, the expected excess returns of value stocks are more sensitive to aggregate economic conditions than the expected excess returns of growth stocks.

[4] Chordia and Shivakumar (2006) and Liew and Vassalou (2000)

price momentum results in losses. This suggests a high correlation between price momentum and investor sentiment. Overall, the results indicate that sentiment has predictive power for price momentum profits, but not for earnings momentum profits. Moreover, this predictive power for price momentum profits is only pronounced in the low volatility state.

The rest of the paper is as follows: Section 2 examines the literature for price and earnings momentum, Section 3 describes data and how the portfolios and the sentiment measures are constructed, Section 4 presents the general econometric framework for incorporating asymmetries in the conditional distribution of stock returns, Section 5 applies this framework to a univariate regime-switching model for single decile regressions, Section 6 applies this framework to a bivariate model for the 1^{st} and 10^{th} deciles , Section 7 examines the relationship between investor sentiment and the two momentums, Section 8 is the robustness check and Section 9 concludes.

2. Literature Review

Jegadeesh and Titman (1993) are the first to document price momentum profits. The momentum strategy involves a portfolio that takes a long position in winner stocks and a short position in loser stocks. The stocks are first ranked monthly according to their performance, over the past six months, and then assigned to decile portfolios. These in turn are then held for a six month period. The authors report that a price momentum strategy earns more than 1% above the risk-free rate per month and that this return cannot be fully explained by size or market exposure. Jegadeesh and Titman (2001) further confirm that the profits of price momentum strategies, of about 1% per month, continue through the 1990s suggesting that their initial results were not due to data mining. In addition, the robustness of this strategy has been confirmed using data from stock markets other than the U.S., where the profitability of this strategy was initially identified.

In particular, Rouwenhorst (1998) examines international markets and finds momentum payoffs to be significantly positive in twelve countries. More recently Cooper, Gutierrez and Hameed (2004) test overreaction theories of short-run momentum and long-run reversal in the cross section of stock returns. They find that momentum profits depend on the state (regime) of the market and that up-market momentum reverses in the long run. They also suggest that models of asset pricing, both rational and behavioral, need to incorporate such regime switches.

Besides momentum strategies that utilize past returns, there is also a large body of literature on momentum strategies that utilize past earnings. Ball and Brown (1968) are the first to document earnings momentum or the post-earnings announcement drift, which encompasses the tendency of stock prices to move in the direction suggested by recent earnings surprises. Further Foster, Olsen and Shevlin (1984) are able to calculate a 25% annual profit from earnings momentum strategies. Bernard and Thomas (1989) link post-earnings announcement drift to behavioral finance on the assumption that investors fail to fully appreciate the earnings information, resulting in delayed price responses. In addition Hew, Skerratt, Strong and Walker (1996) investigate earnings momentum in the U.K. The authors find that earnings momentum is not statistically significant for larger companies and conclude that earnings momentum might be explained by trading costs, trading volumes and the amount of information available to investors before the announcement date.

Additionally, there is a growing body of literature investigating the interaction between earnings and price momentum. Chan, Jegadeesh and Lakonishok (1996) find that the profitability of earnings momentum strategies is still evident among large capitalization stocks, even after controlling for Fama-French factors. They further argue that although there is a correlation between the earnings momentum and price momentum, however, one effect cannot absorb the other. Conversely Chordia and Shivakumar (2006) examine whether earnings momentum and price momentum are related and find that price momentum is captured by the systematic component of earnings momentum. They argue that the predictive power of past returns is subsumed by a zero investment portfolio that is long on stocks with high earnings surprises and short on stocks with low earnings surprises. More recently Leippold and Lohre (2009) find that price and earnings momentum are pervasive features of international equity markets, even when controlling for data snooping biases. For European markets, they find that price momentum is subsumed by earnings momentum on an aggregate level. However, this conclusion does not apply to each and every country. While the above explanation is confined to certain time periods in the U.S., earnings momentum nevertheless appears to be a crucial driver of the price momentum anomaly in many markets.

The mixed results from these various studies may be due to the time varying relation between the two momentums. Therefore, I attempt to model a nonlinear relationship between price momentum and earnings momentum using a Markov regime-switching framework, incorporating macroeconomic information in the state transition probabilities. The Markov regime-switching framework has been widely applied in the area of nonlinear modeling. For example, Perez-Quiros and Timmermann (2000) adopt a flexible two-state regime-switching model to analyze the presence of asymmetries in the variation of small and large firm risk over the economic cycle. Their model shows that small firms display higher sensitivity to variables that measure credit market conditions. Another example is Gulen, Xing and Zhang (2011) which study time variations of the expected value premium using a two-state Markov-switching model. They find that when conditional volatilities are high the expected excess returns of value stocks are more sensitive to aggregate economic conditions than the expected excess returns of growth stocks. As a result, the expected value premium is time varying. In fact, the value premium tends to go up in the high volatility state only to decline more gradually in subsequent periods. Further, momentum portfolios, as mentioned in Chordia and Shivakumar (2002), are highly influenced by the state of macroeconomic conditions. Because of these studies, it makes sense to examine earnings momentum and price momentum in a regime-based framework.

In recent years, more empirical studies emerge focusing on the impact of investor sentiment on the profitability of momentum strategies. Hou, Peng and Xiong (2009) find that price momentum profits are higher in up-market, but that earnings momentum profits are higher among low volume stock and down-market. In the long run, price momentum profits reverse but earnings momentum profits do not. Antoniou, Doukas and Subrahmanyam (2011) show that momentum profits arise only under optimism and are driven principally by strong momentum in losing stocks. They also show that momentum-based hedge portfolios formed during optimistic periods experience long run reversals. In conclusion, this literature provides a theoretical and economic foundation to study earning and price momentum in a non-linear framework.

3. Data

The paper focuses on excess returns of earning and price momentum portfolios. Excess returns are calculated as portfolio returns in excess of the one-month Treasury bill rate. The data for one-month Treasury bill rates was obtained from Kenneth French's website. Following Chordia and Shivakumar (2006), I create earnings portfolios that capture the post-earnings-announcement-drift phenomenon. Each month, all NYSE-AMEX firms on the monthly CRSP files, along with data from COMPUSTAT, are sorted into deciles based on their standardized unexpected earnings (SUE) from the most recent earnings announcement. The firms are sorted each month into deciles based on the earnings in this quarter less earnings from four quarters ago.

In order to make a cross-sectional comparison, earnings are standardized[5] using the standard deviation of the earnings changes in the prior eight quarters. Decile portfolios, which are also referred to as SUE portfolios, are formed by weighting equally all firms in the decile rankings. The positions are held for six months, *t* through *t+5*, which is designated as the holding period. I form price momentum decile portfolios on the basis of past returns. Portfolio returns are average monthly returns that are rebalanced monthly. The ten price momentum portfolios are formed on the basis of the prior six-month returns, where decile 1 comprises past "losers" and decile 10 comprises past "winners." Thus, for each month *t*, all NYSE and AMEX stocks are ranked into deciles based on their formation period returns, *t – 6* through *t – 1*. The momentum portfolios are formed by equally weighting all firms in the decile rankings. The positions are then held for a six-month period, *t* through *t+5*.

The sample period is from January 1972 to December 2010, for a total of 468 monthly observations. Table I Panel A presents the returns on the earnings momentum portfolios. Over the entire sample period, the mean monthly returns range from -0.79%, for the lowest SUE portfolio, to 1.92% for the highest SUE portfolio. The return from shorting the lowest SUE portfolio and holding the highest SUE portfolio (PMN) is a statistically and economically significant 2.71% per month with over 87% of the months being positive. Similarly, Table I Panel B presents the returns on the price momentum portfolios. The mean monthly returns range is from 0.80% for the loser portfolio to 1.23% for the winner portfolio. The return from shorting

[5] Using stock price, market capitalization, total assets, or sales variables might unintentionally proxy for size or expected returns; therefore, standardizing earnings is preferred. In other words by sorting firms on earnings changes, scaled by the above variables, this might bias towards capturing cross-sectional differences in expected returns associated with those variables.

Table I. Summary Statistics of Monthly Excess Returns to Earnings and Price Momentum Portfolios (January 1972 to December 2010)

Each month, firms are sorted into deciles based on their standardized change in earnings from the most recent earnings announcement (SUE portfolios) or on their returns over the past 6-months (Momentum portfolios). In each month, SUE portfolios are computed using all earnings announcements made in the prior 4-month period. The standardized unexpected earnings (SUE) for month $t = (E_{it} - E_{it-4})/\sigma_{it}$, where E_{it} is the most recently announced earnings and σ_{it} is the standard deviation of $(E_{it} - E_{it-4})$ over the prior 8 quarters. Momentum portfolios are sorted based on the returns of the prior 6-month period. The portfolios are then held for the following 6-month period. The table reports the returns to these portfolios as well as the payoffs from a strategy of being long on the highest portfolio (P10) and short on the lowest portfolio (P1). PMN is the profit from earnings momentum portfolios and WML is the profit from price momentum portfolios. P-values are reported in the parenthesis. Panel A reports results for SUE portfolios, while Panel B reports the results for momentum portfolios.

Panel A. Earnings Momentum Portfolios

	Lowest SUE	**Decile 2**	**Decile 3**	**Decile 4**	**Decile 5**	**Decile 6**	**Decile 7**	**Decile 8**	**Decile 9**	**Highest SUE**	**PMN=P10-P1**
Mean	-0.0079	-0.0023	0.0671	0.0022	0.0052	0.0099	0.0107	0.0146	0.0160	0.0192	0.0271
t-Statistic	-2.46	-0.79	0.04	0.74	1.79	3.41	3.84	5.14	5.76	7.14	15.52
(Mean=0)	(0.01)	(0.43)	(0.97)	(0.46)	(0.07)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
% > 0	41.88	50.64	50.43	52.14	55.34	57.48	57.48	61.32	62.61	62.82	86.97

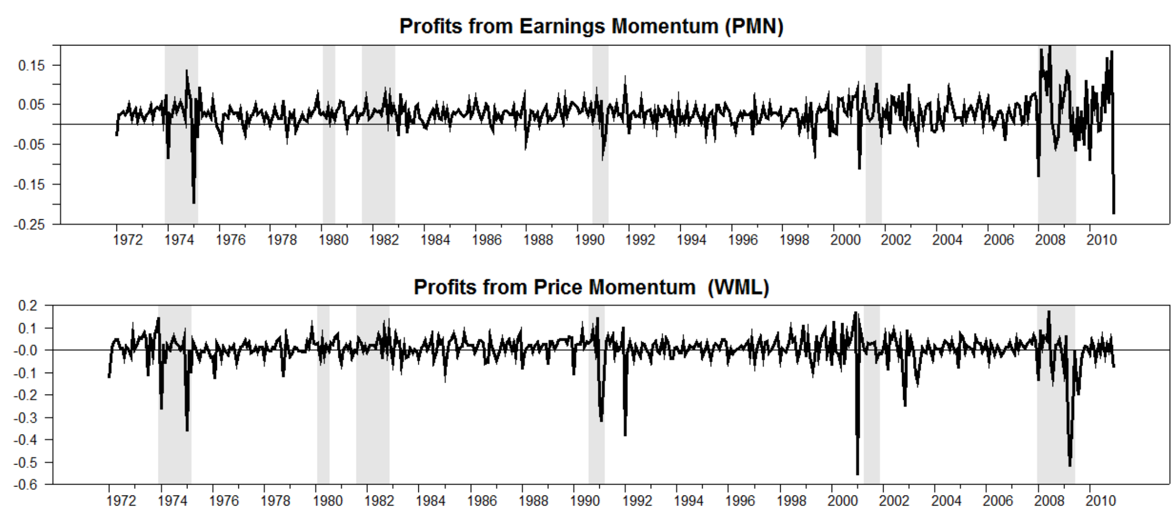
Panel B. Price Momentum Portfolios

	Loser	**Decile 2**	**Decile 3**	**Decile 4**	**Decile 5**	**Decile 6**	**Decile 7**	**Decile 8**	**Decile 9**	**Winner**	**WML=P10-P1**
Mean	0.0080	0.0080	0.0094	0.0094	0.0097	0.0098	0.0099	0.0100	0.0106	0.01225	0.0043
t-Statistic	1.74	2.47	3.27	3.60	3.97	4.13	4.24	4.19	4.22	4.17	1.31
(Mean=0)	(0.08)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.19)
% > 0	51.82	52.99	57.05	60.04	60.90	60.26	61.75	60.90	61.11	60.26	64.53

the loser portfolio and holding the winner portfolio (WML) is 0.43% per month with over 64.53% of the months being positive. This is largely due to the disappearance of momentum profits since the late 1990s.[6] This suggests that the profit from earnings momentum (PMN) seems to be more persistent than that of price momentum (WML). Figure I(a) plots the profits of PMN and WML portfolios over time and Figure I(b) plots the excess returns of the lowest SUE portfolio, the highest SUE portfolio, loser's portfolio, and winner's portfolio. It appears from both figures that PMN and WML is correlated over time, but that this correlation is certainly less than perfect. Therefore the relation between the two factors calls for a thorough investigation.

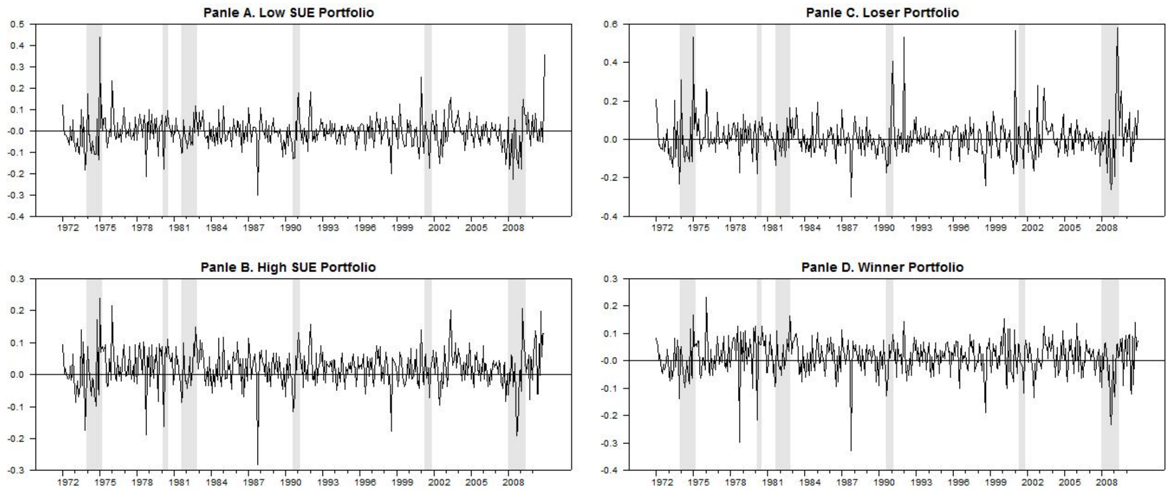
Figure I(a) Plots of Profits from Earnings Momentum and Price Momentum

Figure I(a) plots the expected returns on a strategy that is long on stocks with high earnings surprises and short on stocks with low earnings surprises (PMN) and a strategy of buying winners and selling losers (WML). Figure I(b) plots the expected excess returns for the lowest SUE portfolio (Panel A), the highest portfolio (Panel B), the loser's portfolio (Panel C), and the winner's portfolio (Panel D).



[6]There are numerous studies documenting how price momentum profits have been disappearing since the late 1990s, such as Bhattacharya, Kumar and Sonaer (2011). In my unreported sub-sample study from January 1972 to December 1999, the return on the WML portfolio is statistically and economically significant (t-stat= 2.62) with a return of 0.82% per month.

Figure I(b) Plots of Excess Returns from Four Portfolios



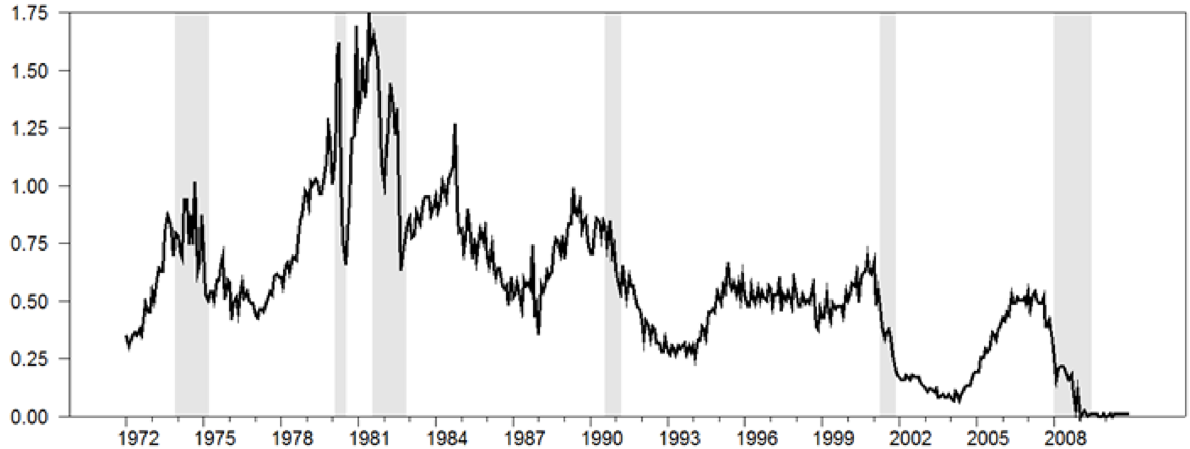
The excess returns are first explained for each of the earnings and price momentum portfolios using a Fama-French three-factor model. Following Gray (1996) and Gulen, Xing and Zhang (2011) framework, the one-month Treasury bill rate (TB) is used as a state variable proxy to model the unobserved expectations of investors on future economic conditions. Using the one-month Treasury bill rate as a state variable allows me to incorporate the time varying discount rate into the regime-switching model. The one-month Treasury bill rate is used frequently in past literature (Fama, 1981; Campbell, 1987) to predict stock market returns. Figure II Panels A and B plot monthly returns of the one-month Treasury bill rate and the one-month Treasury bill rate changes.

To examine the relationship of investor sentiment and the two momentums, I need a measure of sentiment that best captures the different facets of investor sentiments. Therefore, I decide to use the sentiment measure developed by Baker and Wurgler (2006). This measure is available through Jeffrey Wurgler's website.

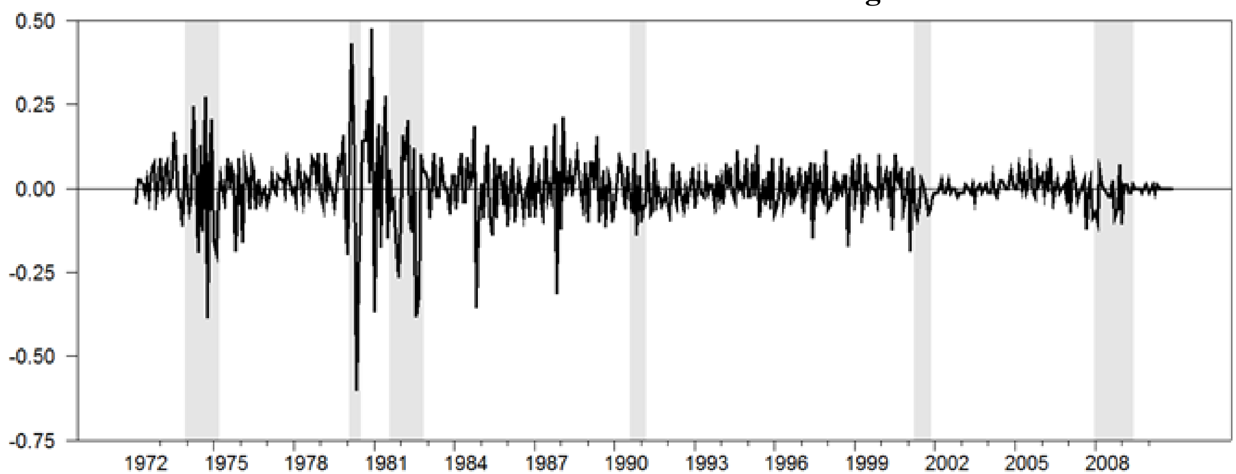
Figure II Plot of Monthly Return of One-Month Treasury Bill Rates

The figure contains a time series plot of monthly one-month Treasury bill rates, reported in annualized percentage terms. The sample period is January 1972 to December 2010, a total of 468 observations.

Panel A. One Month T-Bill Rate Change



Panel B. One Month T-Bill Rate Change



4. General Econometric Frame work:

This section discusses the general methodology I employ in this paper. First, I state the nature of the empirical topic and the choices of the model. Second, I describe the framework details and how I empirically estimate the model. Additionally, I outline various applications of the model in order to test several hypotheses the paper examines.

A potentially useful approach to modeling nonlinearities in time series is to assume different behavior (structural breaks) in different subsamples (or regimes). If the dates in which the regime switches have taken place are known, then modeling can be worked out simply with dummy variables. In practice, however, the prevailing regime is not always directly observable. Therefore, the Markov-switching frame work is a preferable choice since it does not require exact dates to be known when estimating the underlying regimes. It is a latent state approach that does not require conditioning on predefined state indicators. The state transition probability obtained through estimation reveals important information about the directions in which variations in the conditional distribution of stock return occurs.

Let r_t denote the excess return of an earnings or price momentum portfolio over period t and X_t be a vector of conditioning variables used to explain the excess return r_t. The Markov-switching specification follows a general framework and allows the intercept, regression coefficients, and variance/volatility of excess returns to depend on a single, latent state variable, S_t :

$$r_t = \alpha_{S_t} + \beta_{S_t}' X_t + \varepsilon_t \qquad with \qquad \varepsilon_t \sim N(0, \sigma_{S_t}^2), \qquad (1)$$

in which $N(0, \sigma_{S_t}^2)$ is a normal distribution with zero mean and a variance of $\sigma_{S_t}^2$. I allow the parameters to differ across two states. This methodology allows for the interpretation of the nature of the state from the data without presumption or restrictions. Later in the paper, the estimation shows that state 1 represents the low volatility state, and is denoted as $S_t = 1$, whereas state 2 ($S_t = 2$) represents the high volatility state. The regression coefficients and variance are either $\left(\alpha_1, \beta_1^{'}, \sigma_1^2\right)$ or $\left(\alpha_2, \beta_2^{'}, \sigma_2^2\right)$, depending on the state.

To specify how the underlying state evolves over time, I make the general assumption that the state transition probabilities follow a first-order Markov chain:

$$p_t = P(S_t = 1 | S_{t-1} = 1, Y_{t-1}) = p(Y_{t-1}) \quad (2)$$

$$1 - p_t = P(S_t = 2 | S_{t-1} = 1, Y_{t-1}) = 1 - p(Y_{t-1}) \quad (3)$$

$$q_t = P(S_t = 2 | S_{t-1} = 2, Y_{t-1}) = q(Y_{t-1}) \quad (4)$$

$$1 - q_t = P(S_t = 1 | S_{t-1} = 2, Y_{t-1}) = 1 - q(Y_{t-1}) \quad (5)$$

in which Y_{t-1} is a vector of information variables that are publicly known at time $t-1$ and affects the state transition probabilities between time $t-1$ and t. Traditional formulations of Markov-switching models generally assume that state transition probabilities are constant over time. However, recent literature suggests that the state transition probabilities are time varying and depend on prior information such as interest rates (Gray, 1996) or economic leading indicators (Filardo, 1994). Time-varying transition probabilities allow me to capture important economic behavior that may be missed using constant (or fixed) transition probabilities.

The parameters of the model are estimated using a maximum likelihood estimation, with some assumptions made regarding the conditional density function of the innovations, ε_t, $\varepsilon_t \sim N(0, \sigma_{S_t}^2)$. Let θ denote the vector of parameters entering the likelihood function for the data.

Suppose the density of the of the innovations, ε_t , conditional on being in state j ,

$f(r_t \mid S_t = j, X_t; \theta)$, is Gaussian:

$$f(r_t \mid \Omega_{t-1}, S_t = j, X_t; \theta) = \frac{1}{\sqrt{2\pi\sigma_j}} \exp\left(\frac{-\left(r_t - \alpha_j - \beta_j^{'} X_t\right)^2}{2\sigma_j} \right) \qquad (6)$$

for $j = 1,\ 2,\ \Omega_{t-1}$ denotes the information set $X_{t-1},\ r_{t-1},\ Y_{t-1}$, and also the lagged values of these variables. We assume that the relationship between the conditioning factors, X_t, and excess returns, r_t, is constant within each state, but allow these coefficients to vary across states. The log-likelihood function is given by:

$$L\left(r_t \mid \Omega_{t-1}; \theta\right) = \sum_{t=1}^{T} \log\left(\phi\left(r_t \mid \Omega_{t-1}; \theta\right)\right), \qquad (7)$$

where the density, $\phi\left(r_t \mid \Omega_{t-1}; \theta\right)$, is obtained by summing the probability-weighted state densities, $f\left(\bullet\right)$ across two possible states:

$$\phi\left(r_t \mid \Omega_{t-1}; \theta\right) = \sum_{j=1}^{2} f\left(r_t \mid \Omega_{t-1},\ S_t = j; \theta\right) P\left(S_t = j \mid \Omega_{t-1}; \theta\right), \qquad (8)$$

and $P\left(S_t = j \mid \Omega_{t-1}; \theta\right)$ is the conditional probability of state j at time t given information at time $t-1$. The conditional transition probabilities depend on lagged conditioning information and reflect the perception of investors on the conditional likelihood of being in the low volatility state for the next period.

I then obtain the conditional state probabilities recursively based on the total probability theorem:

$$P\left(S_t = i \mid \Omega_{t-1};\theta\right) = \sum_{j=1}^{2} P\left(S_t = i \mid S_{t-1} = j,\ \Omega_{t-1};\theta\right) P\left(S_{t-1} = j \mid \Omega_{t-1};\theta\right), \qquad (9)$$

Then, using Bayes' rule, the conditional state probabilities can be obtained as

$$P\left(S_{t-1} = j \mid \Omega_{t-1};\theta\right) = P(S_{t-1} = j \mid r_{t-1}, X_{t-1}, Y_{t-1}, \Omega_{t-2};\theta)$$

$$= \frac{f\left(r_{t-1} \mid S_{t-1} = j, X_{t-1}, Y_{t-1}, \Omega_{t-2};\theta\right) P\left(S_{t-1} = j \mid X_{t-1}, Y_{t-1}, \Omega_{t-2};\theta\right)}{\sum_{j=1}^{2} f\left(r_{t-1} \mid S_{t-1} = j, X_{t-1}, Y_{t-1}, \Omega_{t-2};\theta\right) P\left(S_{t-1} = j \mid X_{t-1}, Y_{t-1}, \Omega_{t-2};\theta\right)}. \qquad (10)$$

Following Gray (1996), Perez-Quiros and Timmermann (2000) and Gulen, Xing and Zhang (2011) I iterate on Equations (9) and (10) recursively to derive the state probabilities $P\left(S_t = j \mid \Omega_{t-1};\theta\right)$ and obtain the parameter estimates of the likelihood function. Thus, the inferred state probabilities are driven by variation in the distribution of excess returns conditional on the included regressors.

This general framework will be applied in later sections. I first apply the framework to a single portfolio Fama-French three-factor and then again to an extended four-factor regression, with WML or PMN as the additional factor. Next, I apply the framework to jointly estimate the 1st and 10th portfolios to test whether (1) loser firms display symmetric response in their risk across volatility states as winner firms and (2) lowest SUE firms display symmetric response in their risk across volatility states as highest SUE firms.

5. Univariate Markov-switching Model –An Application of General Econometric Frame Work

5.1. Single Portfolio Regression Specifications

For each earnings and price momentum decile, indexed by i, I first estimate the following model:

$$r_t^i = \alpha_{S_t}^i + \beta_{1,S_t}^i MKT_t + \beta_{2,S_t}^i SMB_t + \beta_{3,S_t}^i HML_t + \varepsilon_t^i \qquad (11)$$

in which r_t^i is the monthly excess return for the ith earnings and price momentum decile, MKT, SMB and HML are Fama-French Factors obtained from Kenneth French Website.

$\varepsilon_t^i \sim N\left(0, \sigma_{i,S_t}^2\right)$, $S_t = \{1, 2\}$.

The conditional variance of excess returns, σ_{i,S_t}^2, is allowed to depend on the state. To model investors' conditional beliefs, I follow Gray (1996) and Gulen, Xing and Zheng (2011) and model the state transition probabilities to be a linear function of the one-month Treasury bill rate. This choice allows the model to capture the currently available information regarding future economic conditions. The state transition probabilities are thus defined as follows:

$$p_t^i = P\left(S_t^i = 1 \mid S_{t-1}^i = 1, Y_{t-1}\right) = \Phi\left(\mu_0^i + \mu_1^i TB_{t-1}\right); \qquad (12)$$

$$1 - p_t^i = P\left(S_t^i = 2 \mid S_{t-1}^i = 1\right); \qquad (13)$$

$$q_t^i = P\left(S_t^i = 2 \mid S_{t-1}^i = 2, Y_{t-1}\right) = \Phi\left(\mu_0^i + \mu_2^i TB_{t-1}\right); \qquad (14)$$

$$1 - q_t^i = P\left(S_t^i = 2 \mid S_{t-1}^i = 2\right); \qquad (15)$$

in which S_t^i indicate the state for ith portfolio and Φ is the cumulative density function of a standard normal variable. This specification is similar to Gray (1996). The information of investors on state transition probabilities is captured parsimoniously through the use of the one-month Treasury bill rate. The above model is estimated using maximum likelihood estimation.

5.2. Estimation Results and Interpretation of States

Table II reports the parameter estimates for the single-regime Fama-French three-factor model of excess returns for earnings and momentum portfolios. These parameter estimates are similar to those reported in Chordia and Shivakumar (2006). For earnings momentum portfolios, I find that the intercepts increase monotonically from a significant -1.74% per month for the lowest SUE portfolio to a significant 1.15% per month for the highest SUE portfolio. For the price momentum portfolio, the intercepts increase monotonically from a significant -0.49% per month for the loser's portfolio to a significant 0.42% per month for the winner's portfolio. Thus, even after for controlling for the Fama-French factors, a strategy that is long on stocks with high earnings surprises and short on stocks with low earnings surprises generates a payoff of 2.89% per month; a strategy of buying winners and selling losers generates a payoff of 0.91% per month. Therefore, empirical results confirm the existence of momentum profits.

Table II. **Parameter Estimates for Single-Regime Fama-French Three-Factor Model of Excess Returns to Momentum Portfolios (January 1972 to December 2010)**

This table reports the estimates for the time-series regression of excess portfolio returns on the Fama-French three-factor model. In Panel A the portfolios are sorted based on the most recent standardized unexpected earnings; in Panel B the portfolios are sorted into deciles based on past six-month return (***, ** and * denote significance level of 1%, 5%, and 10%).

Panel A. Parameters for Earnings Momentum Portfolios

	Low Sue	**Decile 2**	**Decile 3**	**Decile 4**	**Decile 5**	**Decile 6**	**Decile 7**	**Decile 8**	**Decile 9**	**High SUE**
Intercept	-0.0174***	-0.0111***	-0.0096***	-0.0069***	-0.0037**	0.0011	0.0021*	0.0061***	0.0076***	0.0115***
MKT	1.0797***	1.0464***	1.1497***	1.0416***	1.0284***	1.038***	1.0421***	1.044***	1.0318***	1.0057***
SMB	0.8445***	0.7358***	0.7817***	0.8311***	0.7758***	0.7531***	0.6997***	0.7106***	0.6916***	0.6193***
HML	0.5421***	0.4754***	0.553***	0.4809***	0.495***	0.4742***	0.4598***	0.4194***	0.4252***	0.3265***
Log likelihood	894.38	1013.08	1026.75	1044.48	1005.97	1012.11	1097.86	1060.15	1087.29	1095.50
	T-stat	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**
Intercept	-10.63	-7.85	-7.48	-5.60	-2.53	0.86	1.68	4.49	6.26	9.90
MKT	17.91	26.76	24.54	28.25	25.69	26.04	22.40	23.99	26.08	26.30
SMB	9.28	8.49	10.16	10.38	9.48	9.04	9.79	9.98	10.51	8.98
HML	5.48	6.41	7.04	6.48	6.71	6.18	5.46	4.90	5.39	4.69

Panel B. Parameters for Price Momentum Portfolios

	Loser's	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Winner's
Intercept	-0.0049*	-0.0023	-0.0001	0.0007	0.0016**	0.002***	0.0023***	0.0024***	0.0029***	0.0042***
MKT	1.3665***	1.1562***	1.0935***	1.0368***	0.9934***	0.9832***	0.9666***	0.9763***	0.9996***	1.0594***
SMB	1.2953***	0.8583***	0.6974***	0.5962***	0.5449***	0.5001***	0.4939***	0.5082***	0.5598***	0.7893***
HML	0.7305***	0.6275***	0.6095***	0.5717***	0.5129***	0.4854***	0.4615***	0.4255***	0.3748***	0.2514***
Log likelihood	669.14	976.60	1096.58	1197.03	1276.06	1313.17	1323.42	1309.40	1253.44	1099.83
	T-stat	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**
Intercept	-1.94	-1.61	-0.06	0.74	2.05	2.74	3.10	3.24	3.65	4.06
MKT	15.27	20.78	25.04	30.46	36.94	40.85	39.29	41.13	36.67	30.53
SMB	7.28	8.49	8.42	8.60	8.75	9.08	9.50	10.41	12.68	14.96
HML	4.44	6.30	7.57	8.49	9.03	9.66	9.46	9.52	8.37	4.33

Table III extends Table II by incorporating the two regimes. First it is important to interpret the state estimate from the model. Estimates of the state transition probabilities are reported in Table III, along with all the parameters obtained from estimating the Markov-switching Fama-French model. For the earnings momentum portfolios 8 out of 10 state transition probability estimates of the coefficients on the one-month Treasury bill rate are negative for state 2, whereas 10 out of 10 estimates are positive for state 1. For the price momentum portfolios 6 out of 10 estimates of the coefficients on the one-month Treasury bill rate are negative in state 2, whereas 7 out of 10 are positive in state 1, with the remaining estimates for state 1 being significantly larger than those for state 2. The time variation in the transition probabilities therefore indicates that the effect of an increase in the one-month Treasury bill is to decrease the probability of staying in state 2 and to increase the probability of staying in state 1. This suggests that state 1 is likely an expansion state while state 2 is likely a recession state.

Table III. Parameter Estimates for the Univariate Markov-Switching Fama-French Three-Factor Model of Excess Returns (January 1972 to December 2010)

For each earnings and price momentum portfolio i, I estimate the following two-state Markov-switching model:
$r_t^i = \beta_{0,S_t}^i + \beta_{1,S_t}^i MKT + \beta_{2,S_t}^i SMB + \beta_{3,S_t}^i HML + \varepsilon_t^i \qquad \varepsilon_t^i \sim N(0, \sigma_{i,S_t}^2)\ , \qquad S_t^i = (1,2)$ in
$p_t^i = P(S_t^i = 1 \mid S_{t-1}^i = 1) = \Phi\left(\mu_0^i + \mu_1^i TB_{t-1}\right);\ 1 - p_t^i = P(S_t^i = 2 \mid S_{t-1}^i = 1)\ \ q_t^i = P(S_t^i = 2 \mid S_{t-1}^i = 2) = \Phi\left(\mu_0^i + \mu_2^i TB_{t-1}\right);\ 1 - q_t^i = P(S_t^i = 1 \mid S_{t-1}^i = 2)$
which r_t^t is the monthly excess return for a given decile portfolio and $S_t^i$is the regime indicator. MKT, SMB and HML are obtained from the Kenneth French Website (***, ** and * denote significance level of 1%, 5%, and 10%).

Panel A. Parameters for Earnings Momentum Portfolios

	Low Sue	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	High SUE
Intercept, State 1	-0.0172***	-0.0100***	-0.0096***	-0.0067***	-0.0032***	0.0008	0.0026***	0.0053***	0.0078***	0.0111***
Intercept, State 2	-0.0159**	-0.0119**	-0.0025	-0.0035	-0.0005	0.0051	0.0027	0.0106***	0.0106***	0.0157***
MKT, State 1	1.0570***	1.0010***	1.0149***	1.0343***	1.0327***	1.0550***	1.0714***	1.0485***	1.0466***	1.0441***
MKT, State 2	1.0431***	1.0718***	1.3441***	0.9881***	0.9689***	0.9538***	0.9546***	0.9977***	0.9377***	0.8743***
SMB, State 1	0.8509***	0.8396***	0.8806***	0.9492***	0.9513***	0.9193***	0.9503***	0.8702***	0.8482***	0.7797***
SMB, State 2	0.8174***	0.6096***	0.5605***	0.6608***	0.5786***	0.5588***	0.4453***	0.5324***	0.5264***	0.4343***
HML, State 1	0.3763***	0.3427***	0.3358***	0.3594***	0.3714***	0.3663***	0.3882***	0.2950***	0.2618***	0.1682***
HML, State 2	0.6879***	0.6013***	0.7061***	0.6101***	0.6106***	0.5686***	0.4854***	0.5191***	0.5692***	0.4627***
Standard Deviation										
σ, State 1	0.0160***	0.0137***	0.0138***	0.0137***	0.0130***	0.0129***	0.0116***	0.0110***	0.0118***	0.0117***
σ, State 2	0.0667***	0.0561***	0.0499***	0.0498***	0.0504***	0.0477***	0.0332***	0.0416***	0.0381***	0.0358***
Transition Probability Parameters										
Constant	1.6344***	1.8344***	1.2504***	0.9397***	1.5160***	1.9902***	2.6838***	0.6110	1.5710***	1.9125***
TB, State 1	0.3086	0.4219	0.9637*	1.7743***	0.8620***	0.5487*	0.2596	2.5480***	0.9129	0.7070
TB, State 2	-1.1958***	-1.1819	-0.8814	0.2725	-0.3789***	-0.3340	-0.3284	2.2000**	-0.0437	-0.1644***
Log likelihood value	1061.52	1186.68	1172.09	1182.25	1176.53	1190.21	1255.32	1226.77	1234.21	1252.30

	T-stat	T-stat	T-stat	T-stat	T-stat	T-stat	T-stat	T-stat	T-stat	T-stat
Intercept, State 1	-19.53	-14.48	-12.61	-10.30	-4.49	1.11	4.16	8.69	11.53	14.44
Intercept, State 2	-2.48	-1.99	-0.42	-0.67	-0.10	1.17	0.99	2.86	3.06	4.92
MKT, State 1	60.96	59.94	51.87	72.30	82.51	66.12	87.98	72.88	73.26	64.39
MKT, State 2	10.88	9.82	15.12	10.01	12.05	12.25	25.83	17.71	15.25	14.97
SMB, State 1	28.38	32.31	35.66	39.32	34.43	40.88	54.65	46.40	35.00	31.38
SMB, State 2	7.35	6.30	4.90	7.42	6.39	7.05	6.34	6.78	7.19	6.66
HML, State 1	12.63	12.23	11.16	15.28	14.46	14.31	20.95	13.36	10.54	6.12
HML, State 2	5.16	4.82	6.97	5.80	5.57	5.68	9.01	7.39	9.10	7.18
σ, State 1	27.34	23.63	26.58	28.51	26.46	28.84	31.16	24.34	22.99	19.84
σ, State 2	21.49	18.19	19.05	17.42	31.39	26.56	34.90	29.66	17.95	22.68
Constant	10.74	5.90	3.76	6.26	9.23	12.18	13.79	1.40	4.12	4.58
TB, State 1	1.20	0.69	1.67	6.36	2.94	1.71	0.40	2.91	1.25	0.79
TB, State 2	-2.75	-1.50	-1.03	0.53	-0.84	-0.45	-0.51	1.99	-0.04	-0.12

Panel B. Parameters for Price Momentum Portfolios

	Loser's	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Winner's
Intercept, State 1	-0.0107***	-0.0029***	0.0006	0.0018**	0.0023***	0.0033***	0.0035***	0.0036***	0.0041***	0.0043***
Intercept, State 2	0.0402**	0.0068	0.0027	-0.0015**	0.0007	0.0009	0.0019***	0.0001	0.0008	0.001
MKT, State 1	1.1727***	1.0269***	0.9646***	1.0565***	0.9686***	1.0353***	1.0054***	0.9964***	1.0884***	1.1466***
MKT, State 2	1.7968***	1.2787***	1.2384***	0.794***	1.0784***	0.8681***	0.8346***	0.7575***	0.8513***	0.8997***
SMB, State 1	1.0975***	0.8412***	0.6679***	0.8248***	0.5657***	0.7571***	0.7304***	0.6525***	0.795***	1.071***
SMB, State 2	1.1564***	0.7844***	0.6786***	0.2723***	0.5131***	0.3433***	0.3351***	0.3667***	0.4524***	0.5683***
HML, State 1	0.3787***	0.351***	0.2996***	0.4801***	0.2104***	0.3316***	0.2987***	0.2493***	0.1886***	0.2031***
HML, State 2	1.1682***	0.8858***	0.8577***	0.639***	0.8409***	0.5674***	0.5513***	0.5952***	0.4591***	0.2444***
Standard Deviation										
σ, State 1	0.0267***	0.0138***	0.0112***	0.0152***	0.0084***	0.0088***	0.0088***	0.0103***	0.0113***	0.0164***
σ, State 2	0.1236***	0.0557***	0.0414***	0.0115***	0.0221***	0.0126***	0.0124***	0.0125***	0.015***	0.0286***
Transition Probability Parameters										
Constant	1.2786***	1.7598***	1.93***	1.4951***	1.9095***	3.9885***	1.8186***	1.1929***	1.1401***	1.5384***
TB, State 1	0.4623**	-0.269	-0.2425	0.6202	0.0554	-1.9301***	1.2935***	3.5086***	1.5957***	1.4548
TB, State 2	-1.9585***	-1.5963***	-1.3945***	-0.9088	-0.7225**	-3.0802***	0.8983***	2.7195***	1.1634**	0.805
Log Likelihood value	861.81	1140.85	1260.53	1288.77	1427.81	1467.14	1479.23	1450.80	1358.07	1175.23

	T-stat	T-stat	T-stat	T-stat	T-stat	T-stat	T-stat	T-stat	T-stat	T-stat
Intercept, State 1	-7.51	-4.01	1.02	2.32	4.94	6.94	7.27	6.99	5.92	4.89
Intercept, State 2	1.92	1.09	0.61	-1.17	0.28	1.00	1.63	0.09	0.60	0.38
MKT, State 1	43.08	57.53	77.61	99.40	114.63	115.19	132.61	128.30	66.74	54.60
MKT, State 2	6.07	16.60	21.80	27.09	34.14	52.15	55.14	27.15	52.91	19.63
SMB, State 1	23.61	29.55	33.51	51.85	35.96	63.02	64.51	57.55	47.78	34.91
SMB, State 2	3.83	10.55	9.81	14.41	20.51	27.75	24.31	14.40	18.90	9.46
HML, State 1	7.51	12.74	12.41	28.48	16.31	23.82	20.19	17.57	8.02	6.16
HML, State 2	4.03	9.74	12.83	28.27	23.02	26.39	38.88	19.93	19.28	4.20
σ, State 1	19.92	22.88	27.58	61.00	27.35	28.66	32.00	38.78	29.84	27.37
σ, State 2	11.86	18.66	15.74	12.54	18.58	32.37	30.07	10.86	28.78	19.08
Constant	10.02	12.93	12.92	5.12	11.87	19.26	7.74	5.62	5.94	3.89
TB, State 1	2.34	-1.45	-1.11	1.30	0.23	-7.39	2.50	6.56	4.31	1.46
TB, State 2	-4.18	-5.02	-4.05	-1.50	-1.96	-5.47	1.17	2.46	2.35	0.79

Table III also indicates that state 1 is associated with low volatilities, whereas state 2 is associated with high volatilities. Therefore, we can interpret state 1 as a low volatility state and state 2 as a high volatility state. For example, the standard deviation[7] estimation for the lowest SUE decile is 0.016 in state1 and 0.067 in state 2, and for the highest SUE decile is 0.012 in state 1 and 0.036 in state 2. For the price momentum portfolios, the standard deviation estimation for the loser decile is 0.027 in state1 and 0.124 in state 2, and for the winner decile is 0.016 in state 1 and 0.029 in state 2. These results in general support that state1 is a low volatility state and state 2 is a high volatility state.

Table III reports the parameter estimates for the univariate Markov-switching Fama-French three-factor models of excess returns for the earnings and price momentum portfolios. In state 1, the low volatility state for the earnings momentum portfolios, the intercepts increase from -1.72% per month for the lowest SUE portfolio to 1.11% per month for the highest SUE portfolio. For the price momentum portfolio, the intercepts increase from -1.07% per month for the loser's portfolio to 0.43% per month for the winner's portfolio. Thus, even after controlling for the Fama-French factors, a strategy that is long on stocks with high earnings surprises and short on stocks with low earnings surprises generates a payoff of 2.83% per month in state 1; a strategy of buying winners and selling losers generates a payoff of 1.50% per month in state 1. These results are similar to those of the single-regime Fama-French model.

In state 2, the high volatility state for the earnings momentum portfolios, the intercepts are also found to increase. They range from -1.59% per month, for the lowest SUE portfolio, to 1.57% per month for the highest SUE portfolio. For the price momentum portfolio the intercepts range from 4.02% per month for the loser's portfolio to 0.10% per month for the winner's portfolio. Thus, a strategy that is long on stocks with high earnings surprises and short on stocks with low earnings surprises generates a payoff of 3.16% per month in state 2, 0.33% more than in state 1; a strategy of buying winners and selling losers generates a payoff of -3.92% per month

[7] The standard deviation here is the square root of the volatility.

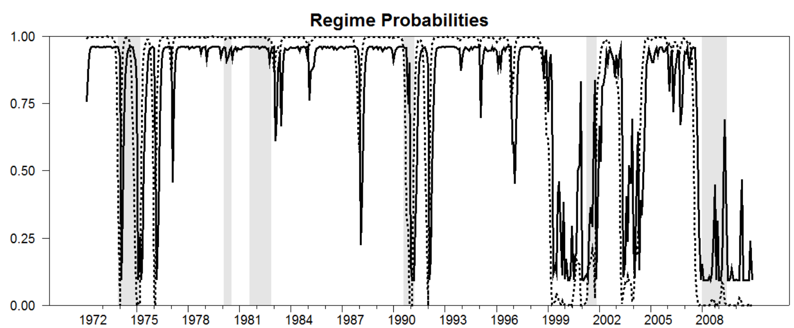
in state 2. The results for price momentum are quite different from those estimated from the single regime Fama-French model where price momentum strategy generates positive profit. In particular, the profit for price momentum strategy is only positive in state 1 but negative in state 2. However, these results are similar to the literature regarding the profitability of price momentum, which only generates a positive profit in good economic conditions (Chordia and Shivakumar, 2002). To sum up, Table III shows the profitability of the price momentum disappears during the high volatility state. However, the profitability of earnings momentum is quite persistent regardless of the underlying state.

In addition to Table III, I also plot several figures to further demonstrate the transition of the states. Figure III Panels A and B plot the conditional transition probabilities of being in the low volatility state at time *t*, conditional on the information set at time $t-1$, $P(S_t = 1 | \Omega_{t-1}; \theta)$ for the lowest and highest SUE portfolios, respectively. Similarly, Figure III Panels C and D plot the conditional transition probabilities of being in the low volatility state at time *t* conditional on the information set at time $t-1$, $P(S_t = 1 | \Omega_{t-1}; \theta)$ for the loser's and winner's portfolios, respectively. The transition probabilities are overlaid with historical NBER recession dates. From looking at Figure III one can see that the transitional probabilities of being in the high volatility state are all moderately high during the eight postwar recessions. In addition, the evidence indicates that the high volatility state is more likely during recessions while the low volatility state is more likely during expansions. The relationship between stock volatilities and business cycles is consistent with the findings of Schwert (1989) and Campbell ,Lettau, Malkiel and Xu (2001).

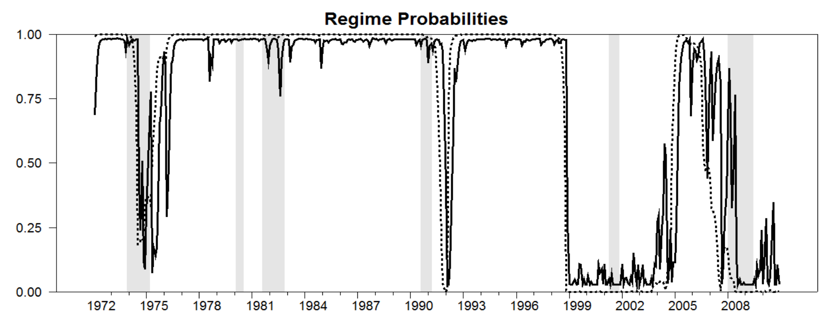
Figure III Plot of Regime-Switching Probabilities
(January 1972 to December 2010)

For each portfolio, I plot a time-series scheme of the ex-ante and smoothed probabilities for regime 1 (the low-volatility / variance) at time *t*. The ex-ante probability is based on the information available at time *t* (Pr $[S_t = 1|\Phi_{t-1}]$), while the smoothed probability is based on the entire sample (Pr $[S_t = 1|\Phi_T]$). The solid lines are for the ex-ante probabilities and the dotted lines are for the smoothed probabilities. Panel A examines the Low SUE portfolio, Panel B the High SUE portfolio, Panel C the Loser's portfolio, while Panel D examines the Winner's portfolio. Shaded areas indicate NBER recession periods.

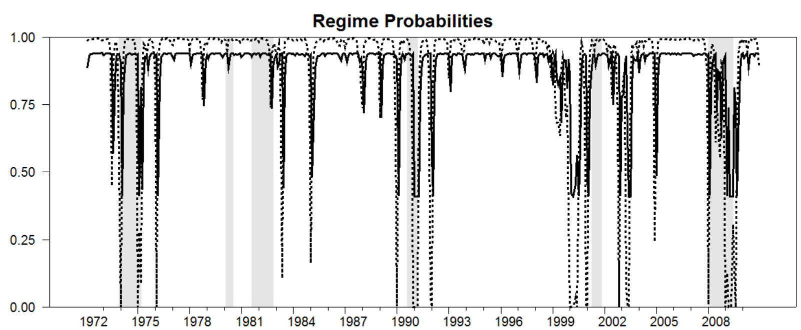
Panel A. Low SUE Portfolio



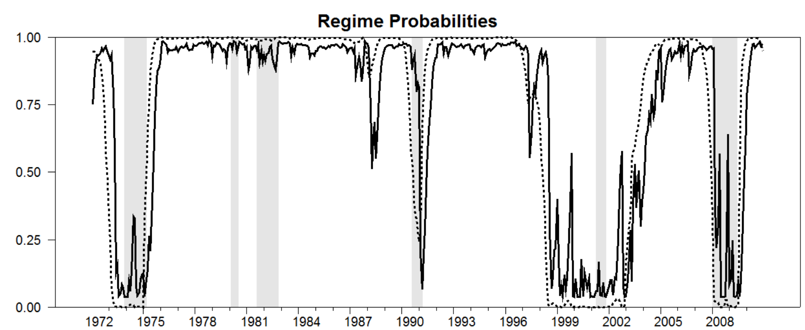
Panel B. High SUE Portfolio



Panel C. Loser's Portfolio



Panel D. Winner's Portfolio



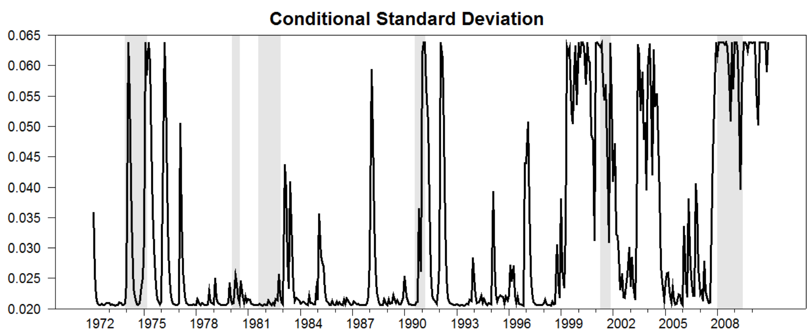
Furthermore, Figure III indicates that the frequency of the probability of being in state 2 is higher than the frequency of the aggregate economy entering a recession. In particular, state 2 also captures incidents of high stock return volatilities yet is not officially in a recession, such as October 1987. In Panels A and B, the univariate Markov-switching model classifies 1992 as a recession for the earnings momentum portfolio, but not for the price momentum portfolios. Similarly, in Panels B and D, the univariate Markov-switching model classifies the period 1999 to the first half of 2003 as a recession for the highest SUE portfolio and winner's portfolio, but not for lowest SUE portfolio and loser's portfolio. In view of these differences, I interpret state 1 as the low volatility state (as opposed to the expansion state) and state 2 as the high volatility state (as opposed to the recession state).

Time variations in expected returns can be driven by variations in conditional volatilities, variations in conditional Sharpe ratios, or both. Figure IV Panels A and B plot the conditional volatilities for the lowest SUE and highest SUE portfolios, while Figure IV Panels C and D plot the conditional volatilities for the loser's and winner's portfolios. Because these volatilities are conditional volatilities, they therefore incorporate the switching probabilities, not just the volatilities of returns in a given state. Figure IV reports that the upward spikes appear during most recessions for both (1) loser and winner firms and (2) lowest SUE and highest SUE firms. The conditional volatilities spike upward much more frequently for loser firms and lowest SUE firms than for winner firms and highest SUE firms. Additionally, the conditional volatilities spike upward much more frequently than the NBER recession dates.

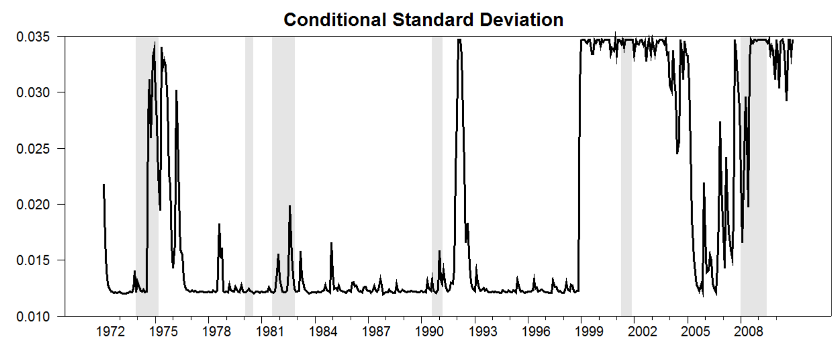
Figure IV Plot of Conditional Standard Deviation (January 1972 to December 2010)

These plots contain time-series plot of conditional standard deviation for the lowest SUE (Panel A), highest SUE (Panel B), loser's (Panel C), and winner's portfolios (Panel D). Shaded areas indicate NBER recession periods.

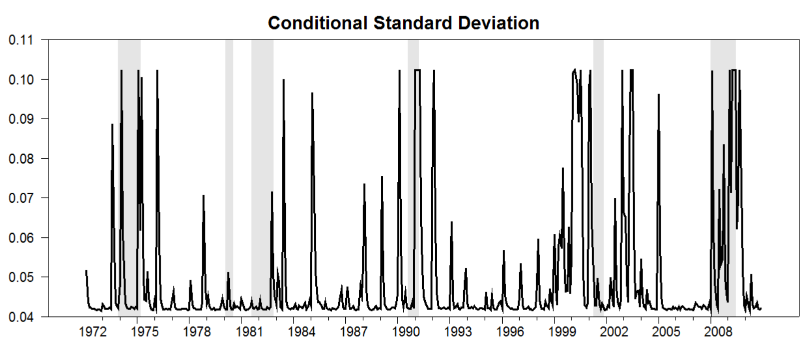
Panel A. Low SUE Portfolio



Panel B. High SUE Portfolio



Panel C. Loser's Portfolio



Panel D. Winner's Portfolio

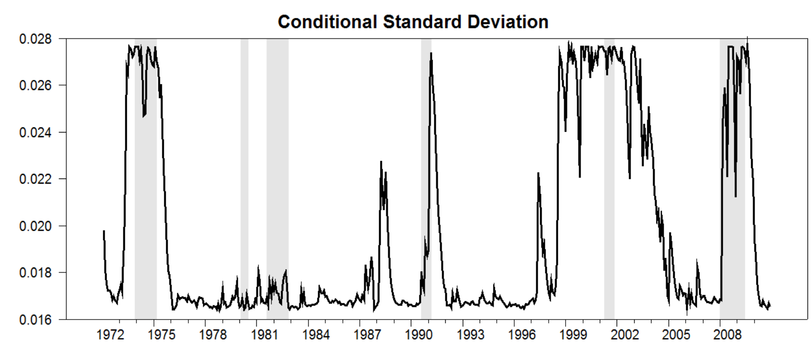
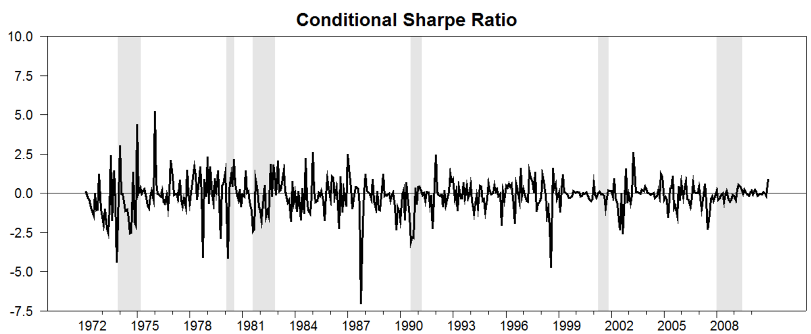


Figure V Panels A and B plot the conditional Sharpe ratios for lowest SUE and highest SUE portfolios from the univariate model while Figure V Panels C and D plot the conditional Sharpe ratios for loser's and winner's portfolios . The Sharpe ratio dynamics are similar for the lowest SUE and highest SUE portfolios, as well as for the loser's and winner's portfolios. Both display substantial time variations. The Sharpe ratios for the highest SUE and winner's portfolios are almost double what the lowest SUE and loser's portfolio are in the 1987 stock market crash. The Sharpe ratios tend to increase rapidly during recessions and to decline more gradually in expansions. The time variations in expected excess returns for earnings and momentum portfolios in Figure V Panel B appear to be correlated with variations in both conditional volatilities and conditional Sharpe ratios.

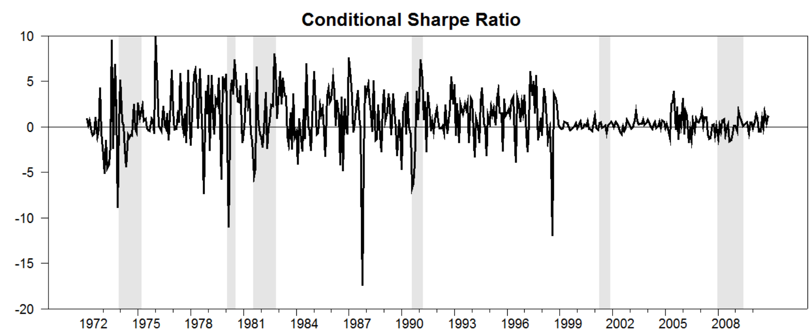
Figure V Plot of Conditional Sharpe Ratio
(January 1972 to December 2010)

These plots are of conditional Sharpe ratios, defined as expected excess returns divided by conditional volatilities. Panel A, B, C, and D plot the conditional Sharpe ratio for the lowest SUE, highest SUE, loser's, and winner's portfolios, respectively. Shaded areas indicate NBER recession periods.

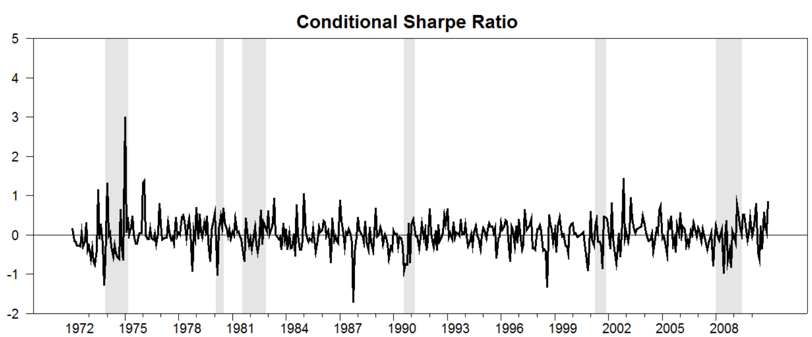
Panel A. Low SUE Portfolio



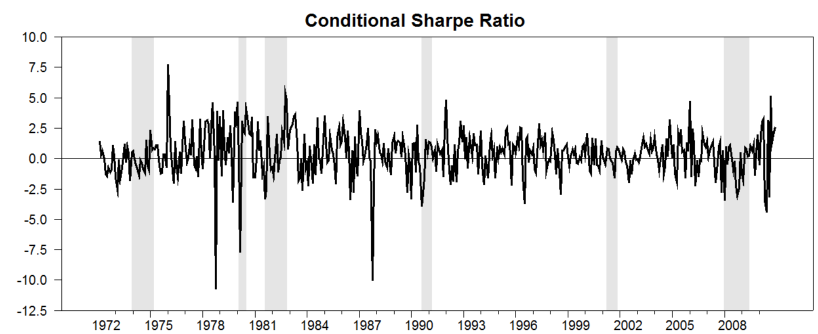
Panel B. High SUE Portfolio



Panel C. Loser's Portfolio



Panel D. Winner's Portfolio



5.3.Extended Four Factor Model

In this part, I follow Chordia and Shivakumar (2006) adding PMN and WML as an additional factor. Specifically, they extend the Fama-French model by including the earnings-based zero-investment portfolio, PMN (positive minus negative), and price-based zero-investment portfolio, WML (winners minus losers) as additional factors. They run the following regression for each of earnings momentum portfolios:

$$R_i - R_f = \alpha_i + b_i * (R_M - R_F) + s_i * SMB + h_i * HML + w_i * WML + e_i$$

and the following regression for each of price momentum portfolios:

$$R_i - R_f = \alpha_i + b_i * (R_M - R_F) + s_i * SMB + h_i * HML + p_i * PMN + e_i$$

I then extend the earlier model for each of the earnings and price momentum deciles:

Earnings Momentum:

$$r_t^i = \alpha_{S_t}^i + \beta_{1,S_t}^i MKT + \beta_{2,S_t}^i SMB + \beta_{3,S_t}^i HML + \beta_{4,S_t}^i WML + \varepsilon_t^i \qquad (16)$$

Price Momentum:

$$r_t^i = \alpha_{S_t}^i + \beta_{1,S_t}^i MKT + \beta_{2,S_t}^i SMB + \beta_{3,S_t}^i HML + \beta_{4,S_t}^i PMN + \varepsilon_t^i \qquad (17)$$

in which r_t is the monthly excess return for the earnings and price momentum deciles. The conditional variance of excess returns, σ_{i,S_t}^2, is allowed to depend on the state of economy. The state transition probabilities are specified in Equations (12) to (15).

Chordia and Shivakumar (2006) suggest that earnings momentum subsumes price momentum and Chan, Jegadeesh and Lakonishok (1996) argue that although earnings and price momentum are correlated, one effect does not subsume the other. To examine the interaction between earnings and price momentums, I first run regressions for Equations (16) and (17) in a linear fashion without incorporating regime switching. The results are reported in Table IV Panels A and B for earning and price momentum deciles, respectively. The results for earnings

Table IV. Parameter Estimates for Single-Regime Extended Four-Factor Models of Excess Returns to Earnings and Price Momentum Portfolios (January 1972 to December 2010)

This table reports the coefficient estimates from the time-series regression of excess portfolio returns on a four-factor model that extends the Fama-French model. The fourth factor is either PMN or WML. In Panel A the portfolios are sorted based on the most recent standardized unexpected earnings; in Panel B the portfolios are sorted into deciles based on past six-month return. (***, ** and * denote significance level of 1%, 5%, and 10%).

Panel A. Parameters for Earnings Momentum Portfolios

	Low Sue	**Decile 2**	**Decile 3**	**Decile 4**	**Decile 5**	**Decile 6**	**Decile 7**	**Decile 8**	**Decile 9**	**High SUE**
Intercept	-0.0146***	-0.0092***	-0.0075***	-0.0053***	-0.0025*	0.0025**	0.0029**	0.0074***	0.0084***	0.0120***
MKT	0.9853***	0.9823***	1.0815***	0.9902***	0.988***	0.9919***	1.0163***	1.0003***	1.0062***	0.9898***
SMB	0.689***	0.6301***	0.6692***	0.7463***	0.7091***	0.6771***	0.6572***	0.6386***	0.6495***	0.5931***
HML	0.3949***	0.3753***	0.4465***	0.4007***	0.4318***	0.4023***	0.4196***	0.3512***	0.3852***	0.3017***
WML	-0.3074***	-0.2089***	-0.2223***	-0.1674***	-0.1318***	-0.1501***	-0.084**	-0.1424***	-0.0833**	-0.0518*
Log likelihood	987.12	1080.72	1110.61	1092.16	1029.83	1044.41	1111.91	1096.12	1100.49	1100.69
	T-stat	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**
Intercept	-10.40	-6.82	-6.32	-4.49	-1.67	1.95	2.16	5.38	6.54	9.90
MKT	20.34	28.72	27.78	31.45	27.02	26.22	21.92	22.97	25.38	26.71
SMB	12.44	9.46	11.78	11.37	9.64	9.57	9.61	10.66	10.27	8.59
HML	5.60	6.51	7.48	6.79	6.85	6.16	5.23	4.34	5.15	4.51
WML	-6.73	-5.69	-6.36	-4.41	-3.46	-4.21	-2.27	-4.41	-2.37	-1.69

Panel B. Parameters for Price Momentum Portfolios

	Loser's	**Decile 2**	**Decile 3**	**Decile 4**	**Decile 5**	**Decile 6**	**Decile 7**	**Decile 8**	**Decile 9**	**Winner's**
Intercept	0.0131***	0.0065***	0.0055***	0.0036***	0.0029***	0.0020**	0.0011	-0.0002	-0.0013	-0.0024
MKT	1.3204***	1.1338***	1.0792***	1.0293***	0.9900***	0.9831***	0.9695***	0.9830***	1.0104***	1.0763***
SMB	1.1551***	0.7902***	0.6540***	0.5734***	0.5346***	0.4998***	0.5030***	0.5286***	0.5928***	0.8406***
HML	0.5962***	0.5623***	0.5679***	0.5499***	0.5030***	0.4851***	0.4702***	0.4450***	0.4063***	0.3006***
PMN	-0.6227***	-0.3023***	-0.1929***	-0.1009***	-0.0458	-0.0011	0.0401*	0.0906***	0.1464***	0.2279***
Log likelihood	708.30	1010.56	1119.14	1206.24	1278.69	1313.17	1325.88	1321.48	1278.98	1132.42
	T-stat	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**
Intercept	2.66	2.51	2.94	2.51	2.45	1.91	1.12	-0.23	-1.26	-1.60
MKT	15.12	20.98	25.85	31.11	37.79	41.42	39.52	41.75	38.81	34.68
SMB	7.41	8.62	8.50	8.70	8.89	9.31	9.88	11.03	13.83	15.91
HML	3.75	5.97	7.50	8.51	9.07	9.78	9.65	9.96	9.31	5.74
PMN	-4.81	-4.78	-4.05	-2.84	-1.57	-0.04	1.71	4.43	6.50	6.08

momentum, reported in Table IV Panel A, show that the estimated intercepts increase monotonically from a low of –1.46% to a 1.20% per month, which suggests that even after controlling for price momentum, a strategy of buying the highest SUE portfolio and selling the lowest SUE portfolio would earn a significant payoff of 2.66 % per month. The coefficient on WML is highly significant for most of the portfolios and increases monotonically from –0.3074 for the lowest SUE portfolio to -0.0518 for the highest SUE portfolio. This suggests that although price momentum is related with earnings momentum, it cannot subsume the profits of earnings momentum.

In Table IV Panel B, I estimate the single-regime four-factor model with PMN as an additional factor. The coefficient on PMN is highly significant for most of the portfolios and increases monotonically from –0.6227 for the loser portfolio to 0.2279 for the winner portfolio. This indicates that exposure of firms to PMN systematically varies across the momentum portfolios. The estimated intercepts decrease from 1.31% for the loser portfolio to –0.24% for the winner portfolio, suggesting that price momentum strategy has a negative payoff, after controlling for the portfolios' exposures to PMN. The results seem to suggest that price momentum can be dominated by earnings momentum.

Next, I incorporate regime switching in estimation of Equations (16) and (17). The state transition probabilities are specified in Equations (12) to (15). The corresponding results are reported in Table V Panels A and B, for earning and price momentum deciles, respectively. For the Markov-switching, four-factor model with WML as an additional factor, the coefficient on WML is highly significant for most of the portfolios and increases from -0.3201 for the lowest SUE portfolio to 0.0070 for the winner portfolio in state 1 and from -0.3344 for the lowest SUE portfolio to -0.1013 for the highest SUE portfolio in state 2, as reported in Table V Panel A. The

Table V. Parameter Estimates for the Univariate Markov-Switching Extended Four - Factor Model of Excess Returns to Momentum Portfolios (January 1972 to December 2010)

For each earnings and price momentum portfolio *i*, I estimate the following two-state Markov-switching model:

$$r_t^i = \beta_{0,S_t}^i + \beta_{1,S_t}^i MKT + \beta_{2,S_t}^i SMB + \beta_{3,S_t}^i HML + \beta_{4,S_t}^i WML \ or \ PMN + \varepsilon_t^i \qquad \varepsilon_t^i \sim N(0,\sigma_{i,S_t}^2)\ , \qquad S_t^i = (1,2)$$

$$p_t^i = P(S_t^i = 1 \mid S_{t-1}^i = 1) = \Phi\left(\mu_0^i + \mu_1^i TB_{t-1}\right);\ 1 - p_t^i = P(S_t^i = 2 \mid S_{t-1}^i = 1) \quad q_t^i = P(S_t^i = 2 \mid S_{t-1}^i = 2) = \Phi\left(\mu_0^i + \mu_2^i TB_{t-1}\right);\ 1 - q_t^i = P(S_t^i = 1 \mid S_{t-1}^i = 2)$$

(***, ** and * denote significance level of 1%, 5%, and 10%).

Panel A. Parameters for Earnings Momentum Portfolios

	Low Sue	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	High SUE
Intercept, State 1	-0.0131***	-0.0078***	-0.0054***	-0.0044***	-0.0012*	0.0031***	0.0038***	0.0065***	0.0086***	0.0111***
Intercept, State 2	-0.0262***	-0.0128***	-0.0137***	-0.0065	-0.0032	0.0021	0.0018	0.0087***	0.0093***	0.0152***
MKT, State 1	1.0867***	1.0035***	1.1358***	1.0148***	1.042***	1.0245***	1.0562***	1.0532***	1.0674***	1.0453***
MKT, State 2	0.6421***	0.8767***	0.7441***	0.8906***	0.847***	0.8406***	0.9037***	0.875***	0.898***	0.8014***
SMB, State 1	0.82***	0.7895***	0.8343***	0.8624***	0.9169***	0.8513***	0.8673***	0.8457***	0.8645***	0.7834***
SMB, State 2	0.4915***	0.5069***	0.3481***	0.6077***	0.4692***	0.4686***	0.4233***	0.4806***	0.4278***	0.408***
HML, State 1	0.4539***	0.261***	0.4905***	0.3238***	0.3557***	0.3042***	0.3299***	0.2887***	0.302***	0.1701***
HML, State 2	0.285***	0.4559***	0.2311***	0.4562***	0.4625***	0.4792***	0.4602***	0.4005***	0.4486***	0.4203***
WML, State 1	-0.3201***	-0.1614***	-0.2546***	-0.1818***	-0.16***	-0.1516***	-0.1019***	-0.0815***	-0.0891***	0.007
WML, State 2	-0.3344***	-0.2581***	-0.2039***	-0.1501***	-0.1172***	-0.1539***	-0.068***	-0.1801***	-0.0965***	-0.1013***
σ, State 1	0.015***	0.0111***	0.0188***	0.0114***	0.012***	0.0124***	0.0105***	0.0107***	0.012***	0.0117***
σ, State 2	0.0574***	0.0403***	0.0185***	0.0441***	0.044***	0.0476***	0.0337***	0.0338***	0.0344***	0.0343***
Transition Probability Parameters										
Constant	1.3788***	2.2786***	-0.149	0.7218***	1.679***	2.0291***	1.786***	2.247***	2.2014***	1.8451***
TB, State 1	2.0572**	0.1118	3.8786***	2.473***	1.3584***	0.9721**	1.464**	0.412	0.257	0.8388
TB, State 2	0.8785	-0.8207	2.3404***	1.0751**	0.6188	0.3931	0.999*	-0.1717	-0.5407	-0.0239
Log Likelihood value	1178.68	1261.64	1156.28	1254.94	1225.72	1243.73	1292.32	1255.38	1244.11	1257.46
	T-stat	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**
Intercept, State 1	-17.54	-12.52	-5.14	-6.86	-1.81	4.40	6.63	11.52	10.86	17.17
Intercept, State 2	-3.87	-3.40	-5.12	-1.42	-0.77	0.45	0.65	3.27	3.20	5.01
MKT, State 1	71.88	80.21	59.59	76.51	98.85	64.65	88.45	90.75	83.90	81.13
MKT, State 2	5.58	14.78	13.16	11.33	12.44	11.53	25.66	23.61	20.62	17.27
SMB, State 1	41.81	42.44	23.21	46.68	48.03	35.90	48.53	41.13	37.79	32.05
SMB, State 2	3.23	6.29	6.53	7.13	4.48	4.11	6.03	7.17	5.79	5.61
HML, State 1	19.24	12.33	15.11	13.26	16.10	11.64	18.60	14.63	13.14	8.04
HML, State 2	1.92	4.70	4.41	4.03	3.74	4.00	8.74	8.12	8.03	6.56
WML, State 1	-37.55	-15.40	-32.10	-22.48	-15.87	-13.93	-11.97	-7.90	-7.11	0.64
WML, State 2	-6.56	-12.80	-8.18	-5.43	-3.91	-5.15	-3.81	-9.02	-5.17	-4.27
σ, State 1	29.41	26.62	45.16	27.74	29.42	29.26	26.65	27.39	27.67	25.89
σ, State 2	21.61	37.51	12.62	23.04	25.23	18.03	31.01	38.68	27.10	15.64
Constant	4.13	13.12	-0.50	3.68	8.91	9.56	8.88	13.96	11.67	4.22
TB, State 1	2.33	0.32	5.09	5.72	2.98	2.12	1.98	1.05	0.70	0.99
TB, State 2	0.71	-1.02	2.92	2.03	0.93	0.42	1.65	-0.30	-0.86	-0.02

Panel B. Parameters for Price Momentum Portfolios

	Loser's	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Winner's
Intercept, State 1	0.0031***	0.0166***	0.0115***	0.0062***	0.0045***	0.004***	0.0034***	0.0027***	0.0018*	0.0009
Intercept, State 2	0.0641***	0.0014	0.0021**	0.0014	0.0052***	0.0038***	0.0018	-0.001	-0.0034**	-0.0074***
MKT, State 1	1.1463***	1.2826***	1.1568***	1.0472***	0.9727***	0.9824***	0.9651***	0.998***	1.0773***	1.1453***
MKT, State 2	1.6401***	1.0162***	0.9766***	0.8982***	0.9412***	0.8992***	0.9804***	0.7677***	0.8858***	0.9462***
SMB, State 1	1.0569***	1.4834***	1.0733***	0.7879***	0.6759***	0.6326***	0.6018***	0.6603***	0.8293***	1.081***
SMB, State 2	0.8143***	0.5798***	0.4538***	0.3601***	0.3736***	0.373***	0.3889***	0.3731***	0.4739***	0.6564***
HML, State 1	0.2619***	0.2727***	0.3387***	0.3312***	0.2209***	0.2125***	0.1803***	0.264***	0.1974***	0.2365***
HML, State 2	1.0386***	0.4886***	0.6369***	0.7395***	0.8326***	0.7772***	0.795***	0.5916***	0.4691***	0.2963***
PMN, State 1	-0.4383***	-0.3645***	-0.2905***	-0.1493***	-0.0609***	-0.0312***	-0.0018***	0.0329**	0.1035***	0.1287***
PMN, State 2	-0.9358***	-0.1686***	-0.0997***	-0.1204***	-0.2182***	-0.1646***	-0.022***	0.0389	0.1318***	0.2526***
σ, State 1	0.0235***	0.0385***	0.0197***	0.0138***	0.0088***	0.0088***	0.0089***	0.0102***	0.011***	0.016***
σ, State 2	0.1143***	0.0174***	0.0148***	0.0149***	0.0155***	0.0124***	0.0125***	0.0124***	0.0136***	0.0256***
Transition Probability Parameters										
Constant	1.0848***	1.4559***	1.7504***	3.0927***	2.1424***	3.0049***	2.112***	1.1129***	0.7261	1.4606***
TB, State 1	0.8175***	-0.6132	0.3195	-1.1132*	-0.3187	-1.4075***	0.247	3.6996***	2.0222**	1.7159***
TB, State 2	-1.6196***	0.6055***	0.2155	-2.6872***	-1.7234***	-2.9991***	-0.7299	2.911***	1.6594	1.0936
Log Likelihood value	917.51	1126.25	1218.66	1310.97	1441.94	1477.67	1487.83	1453.53	1373.54	1196.46

	T-stat	T-stat	T-stat	T-stat	T-stat	T-stat	T-stat	T-stat	T-stat	T-stat
Intercept, State 1	4.26	3.47	8.16	8.19	9.99	8.04	7.84	4.14	1.78	0.96
Intercept, State 2	2.48	1.57	2.36	0.82	3.27	3.48	1.29	-0.67	-2.09	-3.02
MKT, State 1	6.99	22.89	63.83	101.23	104.66	107.61	140.58	128.55	82.01	58.64
MKT, State 2	45.81	47.52	52.57	32.09	42.43	44.92	52.25	28.72	48.72	25.12
SMB, State 1	3.71	12.87	28.12	30.41	42.93	41.61	47.90	59.40	25.09	33.38
SMB, State 2	25.41	38.77	38.70	18.38	17.09	19.17	17.27	15.94	19.31	13.56
HML, State 1	4.06	2.95	9.38	21.61	11.80	15.72	12.52	17.25	6.66	7.76
HML, State 2	6.01	13.14	37.84	24.07	30.63	37.48	35.38	19.99	18.16	6.20
PMN, State 1	-5.04	-4.85	-10.89	-11.72	-7.54	-3.25	-0.17	2.14	3.93	5.89
PMN, State 2	-19.36	-9.63	-6.79	-2.90	-7.13	-7.42	-1.19	1.35	4.22	6.61
σ, State 1	12.76	22.57	56.71	68.87	27.61	29.62	31.04	39.94	29.38	26.76
σ, State 2	24.83	47.78	35.20	14.83	18.31	15.26	15.52	10.39	22.31	14.48
Constant	8.31	9.82	10.68	6.08	7.44	18.16	8.80	5.18	1.26	6.74
TB, State 1	-3.47	-1.61	0.98	-1.67	-0.68	-6.12	0.64	6.37	2.31	3.38
TB, State 2	3.98	2.44	0.63	-2.52	-2.56	-5.91	-1.40	2.58	1.61	1.57

estimated intercepts decrease from -1.31% for the lowest portfolio to 1.11% for the highest SUE portfolio in state, 1 and from -2.62% for the loser portfolio to 1.52 % for the highest SUE portfolio in state 2. Again, the results suggest that earnings momentum cannot be subsumed by price momentum. For the highest SUE portfolio, the coefficient of WML is positive and extremely small, 0.007 for the low volatility state (state 1), and is not statistically significant. Thus, the ability of WML as an additional factor to explain earnings momentum is limited.

Table V Panel B reports the estimation results for the Markov-switching four-factor model with PMN as an additional factor. The coefficient on PMN is highly significant for most of the portfolios and increases monotonically from -0.4383 for the loser portfolio to 0.1287 for the winner portfolio in state 1 and from -0.9358 for the loser portfolio to 0.2526 for the winner portfolio in state 2. This indicates that exposure of firms to PMN varies across the momentum portfolios and is much more pronounced in state 2, the high volatility state. In other words, earnings momentum influences price momentum more in the high volatility than in the low volatility state. From a financing perspective, the discount rate in the low volatility state has a large impact on stock prices but not on companies' earnings. However, in the high volatility state, when financing is more constrained, the discount rate makes a bigger difference on earnings. Therefore, the co-movement of price momentum and earnings momentum becomes stronger. From an investing perspective, PMN captures future aggregate investment opportunities and its predictive content becomes more important for investors in the high volatility state. Therefore, investors pay more attention and place higher weights on earnings. The results also show that exposure of firms to PMN varies across the price momentum portfolios, and is more pronounced than the exposure of firms to WML which vary across earnings momentum portfolios. The estimated intercepts decrease from 0.31% for the loser portfolio to 0.09% for the winner portfolio in state 1 and from 6.41% for the loser portfolio to -0.74% for the winner portfolio in state 2. However, the statistical significance of the intercept for most price momentum deciles indicates that although earnings momentum seems to dominate price momentum, it does not appear to fully subsume price momentum.

These results show that there is strong evidence of asymmetries in stock returns. However, they do not prove that the asymmetries are statistically significant. Therefore, a set of likelihood ratio tests are performed regarding the existence of the two states in the conditional mean and variance for each of the earnings and price momentum deciles.[8] It is important to understand that the likelihood ratio test is testing whether there is asymmetry in the coefficients across two different states rather than testing the existence of the two states. The test I perform here, after already establishing there are two regimes, is to examine whether the coefficients are symmetric in the two mean equations. When testing for asymmetry of the coefficients across the two states, I cannot use the standard likelihood ratio test for multiple states since the state transition probability parameters are not identified under the null hypothesis of a single-regime, as Hansen (1992) discusses. Therefore, the regression coefficients from the Markov regime-switching model are restricted by setting the coefficients equal to one another across the two states. The resulting likelihood ratio statistic follows a standard chi-squared distribution. Specifically, I test the null hypothesis that the regression coefficients on the MKT, SMB, HML, and WML or PMN are equal across the two states for each of the testing deciles.

Table VI Panel A shows that the state dependence in the conditional mean equations is indeed statistically significant. The p-values for the likelihood ratio tests are equal or smaller

[8] The likelihood ratio test here is not testing whether single or two regime models are appropriate. It is testing that, given two regimes and allowing the intercept to vary, whether coefficients are statistically different across regimes. The existence of two states (the choice of two regime models) is confirmed in the unreported tests which are based on the standard likelihood ratio test.

than 1% for 8 out of 10, and smaller than 5% for 1 out of 10 of earnings momentum deciles, meaning that the null hypothesis is strongly rejected. In particular, the null hypothesis is rejected at the 1% significance level for the lowest SUE and highest SUE deciles. Similarly, Table VI Panel B shows that the state dependence on the conditional mean equations is statistically significant as well. The p-values for the likelihood ratio tests are equal or smaller than 1% for 6 out of 10 and smaller than 5% for 1 out of 10 of price momentum deciles, meaning that the null hypothesis is strongly rejected. In particular, the null hypothesis is rejected for the loser's and winner's deciles.

Table VI. Tests for Identical Slope Coefficients across States in the Markov-Switching Model (January 1972 to December 2010)

For each earnings and price momentum portfolio i, I estimate the following two-state Markov-switching model:

$$\text{Earnings Momentum:} \quad r_t^i = \beta_{0,S_t}^i + \beta_{1,S_t}^i MKT + \beta_{2,S_t}^i SMB + \beta_{3,S_t}^i HML + \beta_{4,S_t}^i WML + \varepsilon_t^i$$

$$\text{Price Momentum:} \quad r_t^i = \beta_{0,S_t}^i + \beta_{1,S_t}^i MKT + \beta_{2,S_t}^i SMB + \beta_{3,S_t}^i HML + \beta_{4,S_t}^i PMN + \varepsilon_t^i$$

$$\varepsilon_t^i \sim N(0, \sigma_{i,S_t}^2) \ , \qquad S_t^i = (1,2)$$

$$p_t^i = P(S_t^i = 1 \mid S_{t-1}^i = 1) = \Phi\left(\mu_0^i + \mu_i^i TB_{t-1}\right); \ 1 - p_t^i = P(S_t^i = 2 \mid S_{t-1}^i = 1)$$

$$q_t^i = P(S_t^i = 2 \mid S_{t-1}^i = 2) = \Phi\left(\mu_0^i + \mu_2^i TB_{t-1}\right); \ 1 - q_t^i = P(S_t^i = 1 \mid S_{t-1}^i = 2)$$

in which r_t^t is the monthly excess return for a given decile portfolio and $S_t^i$is the regime indicator.. I conduct likelihood ratio tests on the null hypothesis that the coefficients are equal across states, that is $\beta_{k,S_t=1}^i = \beta_{k,S_t=2}^i \ , k = \{1, \ 2, \ 3, \ 4\}$, for earnings and price momentum decile i. The p-value is the probability that the null hypothesis is not rejected. When testing the null hypothesis, the model conditions on the existence of two states for the conditional volatility.

Panel A. Earnings Momentum Portfolios

	Low SUE	Decile 2	Decile 3	Decile 4	Decile 5
Unrestricted log-likelihood value	1178.68	1261.64	1156.28	1254.94	1225.72
Restricted log-likelihood with $\beta_{k,S_t=1}^i = \beta_{k,S_t=2}^i \ , k = \{1, \ 2, \ 3, \ 4\}$	1173.35	1251.29	1229.33	1247.66	1211.10
Chi-square	10.67	20.70	20.29	-146.10	29.23
p-value	0.03	0.00	NA	0.01	0.00

	Decile 6	Decile 7	Decile 8	Decile 9	High SUE
Unrestricted log-likelihood value	1243.73	1292.32	1255.38	1244.11	1257.46
Restricted log-likelihood with $\beta^i_{k,S_t=1} = \beta^i_{k,S_t=2}$, $k = \{1, \ 2, \ 3, \ 4\}$	1231.90	1267.96	1237.14	1223.37	1229.76
Chi-square	23.66	48.72	36.46	41.48	55.41
p-value	0.00	0.00	0.00	0.00	0.00

Panel B. Price Momentum Portfolios

	Loser's	Decile 2	Decile 3	Decile 4	Decile 5
Unrestricted log-likelihood value	917.51	1126.25	1218.66	1310.97	1441.94
Restricted log-likelihood with $\beta^i_{k,S_t=1} = \beta^i_{k,S_t=2}$, $k = \{1, \ 2, \ 3, \ 4\}$	911.86	1168.73	1269.81	1348.94	1400.90
Chi-square	11.30	-84.95	-102.30	-75.95	82.07
p-value	0.02	NA	NA	NA	0.00

	Decile 6	Decile 7	Decile 8	Decile 9	Winner's
Unrestricted log-likelihood value	1477.67	1487.83	1453.53	1373.54	1196.46
Restricted log-likelihood with $\beta^i_{k,S_t=1} = \beta^i_{k,S_t=2}$, $k = \{1, \ 2, \ 3, \ 4\}$	1414.45	1429.79	1424.30	1348.30	1173.43
Chi-square	126.44	116.07	58.46	50.48	46.06
p-value	0.00	0.00	0.00	0.00	0.00

6. Bivariate Markov-switching Models for 1st and 10th Decile–A Further Application of General Econometric Frame Work

I now study the characteristics of firms in the two extreme SUE portfolios P10 andP1. Table VII Panel A presents the average firm characteristics across the SUE portfolios. Stocks in the lowest SUE portfolio, P1, have negative earnings on average whereas stocks in the highest SUE portfolio, P10, have positive average earnings as evidenced by the earnings price ratio. The book to market ratio of the P1 portfolio is 1.3040 while that of P10 is 0.6801. In other words, the P10 portfolio is more like a growth portfolio whereas the P1 portfolio behaves more like a value portfolio. Also, the P10 portfolio stocks are larger as measured by market capitalization and have higher prices than the P1 portfolio stocks, confirming the negative correlation between SMB and PMN. The average monthly returns are significantly different across the two portfolios. The P1 portfolio has an average monthly return of -0.7296% whereas the P10 portfolio has an average monthly return of 2.6779%. Furthermore, I also look at debt ratio across SUE portfolios. The average debt ratio for the lowest SUE firms is 0.6031 and the average debt ratio for the highest SUE firms is 0.5937. I perform a non-parametric Mann-Whitney U test and find that these differences are statistically significant between the lowest and highest SUE portfolios. In addition, following Lamont et al. (2001), I also construct an index of the likelihood that a firm faces financial constraints (Kaplan and Zingales (1997) "KZ Index") by applying the following linearization to the data:

KZ Index = -1.001909 x Cash Flows / K + 0.2826389 x Q + 3.139193 x Debt / Total Capital + -39.3678 x Dividends / K + -1.314759 x Cash / K

Where:

Cash Flows = (Income Before Extraordinary Items$_t$ + Total Depreciation and Amortization$_t$)

K = Property, Plant, and Equipment$_{t-1}$

Q = (Market Capitalization$_t$ + Total Shareholder's Equity$_t$ - Book Value of Common Equity$_t$ - Deferred Tax Assets$_t$) / Total Shareholder's Equity$_t$

Debt = Total Long Term Debt$_t$ + Notes Payable$_t$ + Current Portion of Long Term Debt$_t$

Dividends = Total Cash Dividends Paid$_t$ (common and preferred)

Cash = Cash and Short-Term $Investments_t$

The KZ-Index (Kaplan-Zingales Index) is a relative measurement of reliance on external financing. Companies with higher KZ-Index scores are more likely to experience difficulties when financial conditions tighten since they may have problems financing their ongoing operations. The KZ Index value for P10 portfolio is, on average, lower than that of the P1 portfolio. However, the differences between the two are not statistically significant. Similarly, I also study the characteristics of firms in the two extreme price momentum portfolios P10 and P1. Table VII Panel B presents the average firm characteristics across the price momentum portfolios. The book-to-market ratio of the P1 portfolio is 0.5575 while that of P10 is 1.7053. Also, the winner portfolio stocks are much larger as measured by the market capitalization and have higher prices than the loser portfolio stocks. Furthermore, I also look at

Table VII. Average Characteristics Across 1st and 10th Portfolios

The decile portfolios are formed as in Table I. The characteristics are obtained for each month for each portfolio by averaging the relevant variable across all stocks in that portfolio in that month. These means are then averaged across months and the table reports the time-series averages P1 as the 1st portfolio and P10 is the 10th portfolio. All accounting values (namely, book value of equity, earnings and total assets) are taken from the most recent quarter that ends at least four months prior to formation month. All market variables (namely, market value of equity, turnover, volume and price) are collected at the end of the quarter prior to the formation month. The variable definitions are as follow: BM is the book-to-market ratio; Size represents market capitalization; EP represents the earnings to price ratio; price is the share price; and the KZ-Index (Kaplan-Zingales Index) is constructed based on Kaplan and Zingales (1997) following Lamont et al. (2001). The table also presents the results of the non-parametric Man-Whitney Rank test.
.

Panel A. Earnings Momentum 1st and 10th Portfolio Comparison

	P1	P10	H0: P1=P10
BM (Book-to-market ratio)	1.3040	0.6801	44.8273
Size ($million)	302438300	423936340	74.9397
Log(size)	20.1324	20.6239	74.4281
EP(%)	-0.0193	0.0862	-39.7666
EPS(%)	-0.0160	0.0334	-39.8392
Debt Ratio	0.6031	0.5937	4.8624
Interest and related Expense	64.1691	54.5549	7.2550

Price($)	35.8920	71.4503	159.7036
Turnover Ratio	0.0403	0.0403	7.3720
Return	-0.7296	2.6779	113.5345
Total Asset	3207.9700	3756.6100	-13.4009
Net Income	959.1368	1194.2000	78.7870
KZ Index	-4.9696	-17.5224	1.1550

Panel B. Price Momentum 1st and 10th Portfolio Comparison

	P1	P10	H0: P1=P10
Book-to-market ratio	0.5575	1.7053	35.8582
Size ($million)	111651490	328734110	148.1064
Log(size)	19.5040	20.2101	149.4318
EP(%)	-0.3114	-0.0307	96.7466
EPS(%)	-0.2568	-0.0316	97.1035
Debt Ratio	0.6840	0.6266	-29.3510
Interest and related Expense	42.6334	36.4951	-15.4906
Price($)	8.0847	51.1550	384.6425
Turnover Ratio	0.0424	0.2089	150.3226
Return	-7.2373	10.8771	427.8234
Total Asset	1217.1300	1491.7600	-3.0688
Net income	470.3570	852.9308	103.1851
KZ Index	6.0240	-10.0377	-15.6006

debt ratio across price momentum portfolios. The average debt ratio for the loser firms is 0.6840, which is much higher than the average debt ratio for the winner firms are 0.6266. The non-parametric Mann-Whitney U tests also suggest that these differences are statistically significant between the loser and winner portfolios. Different from the SUE portfolios, the KZ Index value for the winner portfolio is, on average, lower than that of loser portfolio with the differences between the two are statistically significant at the 1% level.

So far the extended four-factor models have been estimated separately for each portfolio and therefore do not impose the condition that high volatility occurs simultaneously for all portfolios. More generalized estimates of the underlying state may be obtained from a jointly estimated bivariate model imposing a common process driving all excess return deciles.[9] As discussed earlier, lowest SUE and loser firms generally have high book-to-market ratios and small market value, while highest SUE and winner firms have low book-to-market ratios and high market value. Lowest SUE and loser firms therefore generally have higher information asymmetry and limited access to the external capital markets, and thus a higher cost of capital. Given these reasons, lowest SUE or loser firms may be affected more by changes in the risk factors than highest SUE or winner firms across different states. Moreover, it is important to extract the variation in the risk premium of highest SUE over lowest SUE portfolios and winner over loser portfolios. It is also critical to find the source that contributes to these variations. In other words, I want to find which risk factors cause a higher differential response in regards to the risk premium of the 10^{th} portfolio over the 1^{st} portfolio. Specifically, for the SUE portfolios, I investigate whether lowest SUE firms and highest firms display an identical differential response to risk factors across the two states. In the same fashion, I examine whether loser firms and winner firms display an identical differential response to the risk factors across the two states.

I extend the previous general econometric framework by applying it to estimate a bivariate Markov-switching model for the excess returns on the first and tenth decile. The bivariate model imposes the assumption that the high volatility state occurs simultaneously for both deciles, and therefore allows me to extract the variation in the risk premium of the highest SUE portfolio over the lowest SUE portfolio. This also results in a more generalized estimation of the underlying state. Furthermore, the joint estimation permits me to seek an answer to the first question, whether the lowest SUE firms display the same asymmetry across states as the highest SUE firms. Similarly and separately, for the price momentum, I jointly estimate loser and

[9] Two (1^{st} and 10^{th}) rather than ten portfolios are considered in order to (1) keep the estimation feasible and (2) extract the variation in the risk premium of 10^{th} portfolio over 1^{st} portfolio.

winners portfolios and impose the assumption that the state transition probabilities are the same for both the loser and winner firms. The process allows me to extract the variation in the risk premium of winners over losers and examine the second question of whether losers and winners display the same asymmetry across states.

6.1. Specification of Joint Estimation of 1st and 10th Decile

To examine the first question (lowest SUE firms display identical asymmetry in their risk across volatility states as highest SUE firms), I make the following specification,

Let $r_t^{Earnings} \equiv \left(r_t^{Low}, r_t^{High}\right)'$ be a $\left(2\times1\right)$ vector consisting of the excess returns of the lowest SUE portfolio, r_t^{Low}, and the excess returns of the highest SUE portfolio, r_t^{High}. The joint Markov-switching model is specified as follows:

$$r_t^{Earnings} = \alpha_{S_t} + \beta_{1,S_t} MKT_t + \beta_{2,S_t} SMB_t + \beta_{3,S_t} HML_t + \beta_{4,S_t} WML_t + \varepsilon_t. \qquad (18)$$

in which, $\alpha_{S_t} \equiv \left(\alpha_{S_t}^{Low},\ \alpha_{S_t}^{High}\right)$, $\beta_{k,S_t} \equiv \left(\beta_{k,S_t}^{Low}, \beta_{k,S_t}^{High}\right)$ for $k = 1,\ 2,\ 3,\ 4$, $S_t = \{1,2\}$, and

$\varepsilon_t \sim N\left(0,\ \Sigma_{S_t}\right)$ is a vector of residuals. Σ_{S_t} is a positive semi-definite $\left(2\times2\right)$ matrix that contains the variance and covariances of the residuals of the lowest SUE and highest SUE portfolio excess returns in state S_t. The diagonal elements of this variance-covariance matrix, Σ_{ii,S_t}, take a similar form as the univariate model. The off-diagonal elements, Σ_{ij,S_t}, assume a state-dependent correlation between two residuals , denoted ρ_{S_t}, where

$\Sigma_{ij,S_t} = \rho_{S_t}\left(\Sigma_{ii,S_t}\right)^{1/2}\left(\Sigma_{jj,S_t}\right)^{1/2}$ for $i \neq j$. In addition, I maintain the state transition probabilities from the univariate model, which are estimated through Equations (12) to (15), but with the same state driving both the lowest SUE and the highest SUE portfolios. The estimations are again carried out through maximum likelihood estimation and the results are reported in Table VIII Panel A.

I also conduct likelihood ratio tests to see whether the difference across the two states in the coefficients of the lowest SUE decile is the same as the difference in the coefficients of the highest SUE decile. For each set of regression coefficients indexed by k, I test the following null hypotheses:

$$\alpha_1^{Low} - \alpha_2^{Low} = \alpha_1^{High} - \alpha_2^{High}$$

$$\beta_{k,1}^{Low} - \beta_{k,2}^{Low} = \beta_{k,1}^{High} - \beta_{k,2}^{High} \qquad k = 1,2,3,4$$

Alternatively, I expect that the coefficient differential is larger for the lowest SUE firms. [10]

I examine the second question, regarding loser and winner firms, in a similar fashion as that for lowest and highest SUE firms. For each set of regression coefficients indexed by k, I test the following hypothesis:

$$\alpha_1^{Loser} - \alpha_2^{Loser} = \alpha_1^{Winner} - \alpha_2^{Winner}$$

$$\beta_{k,1}^{Loser} - \beta_{k,2}^{Loser} = \beta_{k,1}^{Winner} - \beta_{k,2}^{Winner} \qquad k = 1,2,3,4$$

Alternatively, I expect that the coefficient differential is larger for the loser firms. Again, the above estimations are carried out through maximum likelihood estimation and the results are reported in Table VIII Panel B.

6.2. Estimation Results

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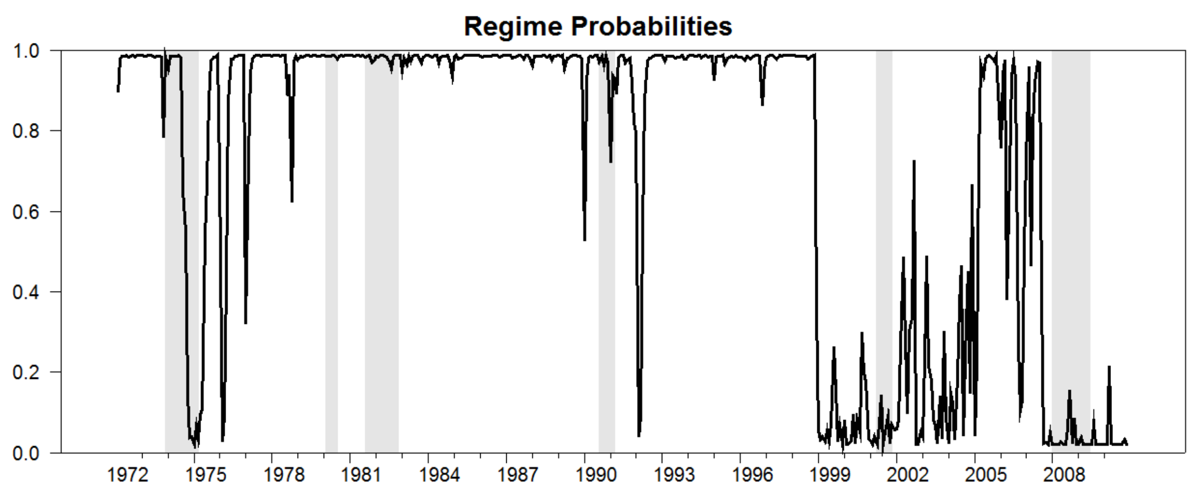
[10] If one thinks of the sampling distribution of χ^2, one can argue that χ^2 is a one-tailed test because the null hypothesis can only be rejected when the value of χ^2 lies in the far right tail. The p-value here indicates the area under the chi-square distribution to the right of the test statistic. Also, the hypotheses are tested based on critical values of chi-square for a one-tail (right-tail) test. Therefore, it is reasonable to use χ^2 to test the null against alternative in this case. (Right-tailed test: Equal hypothesis verses greater than hypothesis).

Figure VI Panel A plots the conditional transition probabilities of being in the low volatility state at time *t*, for the lowest and highest SUE portfolios in the bivariate case. Similarly, Figure VI Panel B plots the conditional transition probabilities of being in the low volatility state at time *t*, for the loser's and winner's portfolios in the bivariate case. For the bivariate case, probabilities of being in the high volatility state are also more frequent than the NBER recessions, but less frequent than in univariate case. The probabilities obtained from the joint estimation of the 1st and 10th portfolios are used to extract the variation of profits from the earnings and price momentum portfolios.

Figure VI Bivariate Regime-Switching Probabilities

I plot the time series of the probability of being in state 1 (low volatility) at time *t* conditional on information in period *t−1* in the bivariate Markov-switching model that estimates the expected lowest SUE and highest SUE portfolios returns jointly (Panel A), and the expected loser's and winner's portfolio returns jointly (Panel B). Shaded areas indicate NBER recession periods.

Panel A. Lowest SUE and Highest SUE Portfolios



Panel B. Loser's and Winner's Portfolios

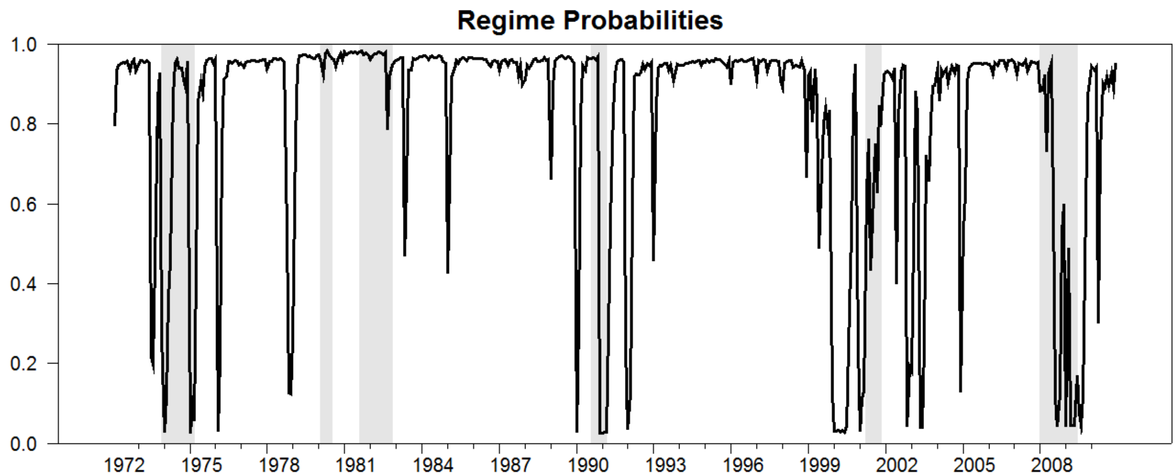


Table VIII Panel A presents the estimation results for earnings from the bivariate model. Panel A confirms that the null is strongly rejected at the 5% significance level for the intercept and at the 1% significance level for the loadings on the market premium. The evidence suggests that the lowest SUE decile is more sensitive than the highest SUE decile to changes in the market risk premium in the high volatility state. However, the asymmetry tests cannot reject the null for loadings on the SMB, HML and WML factors. These results suggest that the market risk premium is the most important factor contributing to the variation in the risk premium of highest SUE portfolio over lowest SUE portfolio.

Table VIII. The Bivariate Markov-Switching Model for the Earnings (PMN) and the Price Momentum Strategy (WML) (January 1972 to December 2010)

For Panel A, the following are estimated:

$$
\begin{aligned}
& r_t^{Earnings} = \alpha_{S_t} + \beta_{1,S_t} MKT_t + \beta_{2,S_t} SMB_t + \beta_{3,S_t} HML_t + \beta_{4,S_t} WML_t + \varepsilon_t \\
& \varepsilon_t^i \sim N(0,\Sigma_{S_t}) \ , \qquad S_t^i = \{1,2\}, \Sigma_{ij,S_t} = \rho_{S_t}(\Sigma_{ii,S_t})^{1/2}(\Sigma_{jj,S_t})^{1/2} \qquad for \ i \neq j \\
& p_t^i = P(S_t^i = 1 \mid S_{t-1}^i = 1) = \Phi\left(\mu_0^i + \mu_i^i TB_{t-1}\right); \ 1 - p_t^i = P(S_t^i = 2 \mid S_{t-1}^i = 1) \\
& q_t^i = P(S_t^i = 2 \mid S_{t-1}^i = 2) = \Phi\left(\mu_0^i + \mu_2^i TB_{t-1}\right); \ 1 - q_t^i = P(S_t^i = 1 \mid S_{t-1}^i = 2)
\end{aligned}
$$

in which $r_t^{Earnings}$ is the (2×1) vector that contains the monthly returns of the Low SUE and High SUE portfolio, $r_t^{Low\ SUE}$ and $r_t^{High\ SUE}$ respectively, where $\alpha_{S_t} \equiv \left(\alpha_{S_t}^{Low},\ \alpha_{S_t}^{High}\right)$, $\beta_{k,S_t} \equiv \left(\beta_{k,S_t}^{Low}, \beta_{k,S_t}^{High}\right)$ for $k = 1,\ 2,\ 3,\ 4,\ , S_t = \{1,2\}$. $\varepsilon_t \sim \mathrm{N}(0,\Sigma_{S_t})$, is a vector of residuals. Σ_{S_t} is a positive semi-definite (2×2) matrix containing the variances and covariances of the residuals of the PMN strategy and WML Strategy profits in state s_t . The diagonal elements of this variance-covariance matrix, (Σ_{ii,S_t}) , take the similar form as in the univariate model. The off-diagonal elements, Σ_{ij,S_t} , assume a state-dependent correlation between the residuals, denoted ρ_{S_t} , that is, $\Sigma_{ij,S_t} = \rho_{S_t}(\Sigma_{ii,S_t})^{1/2}(\Sigma_{jj,S_t})^{1/2} \ for\, i \neq j$.*Φ* is the cumulative density function of a standard normal variable. Standard errors are in parentheses to the right of the estimates. The *p*-value from the likelihood ratio test is the probability of the restriction that the asymmetry between the excess returns of two portfolios is identical against the alternative, that the asymmetry is larger for the Lowest SUE Portfolio.

Similarly and separately, for Panel B, the following are estimated:

$$
\begin{aligned}
& r_t^{\text{Price}} = \alpha_{S_t} + \beta_{1,S_t} MKT_t + \beta_{2,S_t} SMB_t + \beta_{3,S_t} HML_t + \beta_{4,S_t} PMN_t + \varepsilon_t \\
& \varepsilon_t^i \sim N(0,\Sigma_{S_t}) \ , \qquad S_t^i = \{1,2\}, \Sigma_{ij,S_t} = \rho_{S_t}(\Sigma_{ii,S_t})^{1/2}(\Sigma_{jj,S_t})^{1/2} \qquad for \ i \neq j \\
& p_t^i = P(S_t^i = 1 \mid S_{t-1}^i = 1) = \Phi\left(\mu_0^i + \mu_i^i TB_{t-1}\right); \ 1 - p_t^i = P(S_t^i = 2 \mid S_{t-1}^i = 1) \\
& q_t^i = P(S_t^i = 2 \mid S_{t-1}^i = 2) = \Phi\left(\mu_0^i + \mu_2^i TB_{t-1}\right); \ 1 - q_t^i = P(S_t^i = 1 \mid S_{t-1}^i = 2)
\end{aligned}
$$

in which r_t^{Price} is the (2×1) vector that contains the monthly returns of the Low SUE and High SUE portfolio, r_t^{Loser} and r_t^{Winner} respectively, where $\alpha_{S_t} \equiv \left(\alpha_{S_t}^{Loser},\ \alpha_{S_t}^{Winner}\right)$, $\beta_{k,S_t} \equiv \left(\beta_{k,S_t}^{Loser}, \beta_{k,S_t}^{Winner}\right)$ for $k = 1,\ 2,\ 3,\ 4\ , S_t = \{1,2\}$. $\varepsilon_t \sim \mathrm{N}(0,\Sigma_{S_t})$, is a vector of residuals. Σ_{S_t} is a positive semi-definite (2×2) matrix containing the variances and covariances of the residuals of the PMN strategy and WML Strategy profits in state s_t . The diagonal elements of this variance-covariance matrix, (Σ_{ii,S_t}) , take the similar form as in the univariate model. The off-diagonal elements, Σ_{ij,S_t} , assume a state-dependent correlation between the residuals, denoted ρ_{S_t} , that is, $\Sigma_{ij,S_t} = \rho_{S_t}(\Sigma_{ii,S_t})^{1/2}(\Sigma_{jj,S_t})^{1/2} \ for\, i \neq j$.*Φ* is the cumulative density function of a standard normal variable. Standard errors are in parentheses to the right of the estimates. The *p*-value from the likelihood ratio test is the probability of the restriction that the asymmetry between the excess returns of two portfolios is identical against the alternative that the asymmetry is larger for the loser Portfolio.

Panel A reports the results of the Low SUE and High SUE Portfolio. Panel B reports the results of the Loser's and Winner's Portfolio. (***, ** and * denote significance level of 1%, 5%, and 10%)

Panel A. Earnings Momentum

	Low SUE	T-stat	High SUE	T-stat	Tests for Identical Asymmetries
					Intercept: α_1^{Low} - α_2^{Low} = α_1^{High} - α_2^{High}
Intercept, State 1	-0.0128***	-17.63	0.0107***	18.35	Log-likelihood value 2431.76
Intercept, State 2	-0.0198***	-4.80	0.0161***	5.38	*p*-value 0.02
					MKT : $\beta_{1,1}^{Low}$ - $\beta_{1,2}^{Low}$ = $\beta_{1,1}^{High}$ - $\beta_{1,2}^{High}$
MKT, State 1	1.0590***	74.25	1.0361***	85.10	Log-likelihood value 2407.25
MKT, State 2	0.8332***	14.74	0.8740***	21.80	*p*-value 0.00
					SMB: $\beta_{2,1}^{Low}$ - $\beta_{2,2}^{Low}$ = $\beta_{2,1}^{High}$ - $\beta_{2,2}^{Hgih}$
SMB, State 1	0.7898***	38.14	0.7740***	32.72	Log-likelihood value 2433.27
SMB, State 2	0.6177***	5.92	0.3981***	5.83	*p*-value 0.14
					HML: $\beta_{3,1}^{Low}$ - $\beta_{3,2}^{Low}$ = $\beta_{3,1}^{High}$ - $\beta_{3,2}^{High}$
HML, State 1	0.3185***	11.78	0.1547***	7.40	Log-likelihood value 2433.98
HML, State 2	0.4638***	4.74	0.4189***	7.16	*p*-value 0.38
					WML: $\beta_{4,1}^{Low}$ - $\beta_{4,2}^{Low}$ = $\beta_{4,1}^{High}$ - $\beta_{4,2}^{High}$
WML, State 1	-0.2784***	-23.74	0.0045	0.42	Log-likelihood value 2434.30
WML, State 2	-0.3489***	-16.50	-0.0889***	-4.67	*p*-value 0.75
σ, State 1	0.0130***	28.16	0.0110***	29.42	
σ, State 2	0.0481***	36.03	0.0344***	23.61	

Parameters Common to Both Deciles

Correlation parameters		T-stat	
ρ, State 1	0. 5259***	3.90	
ρ, State 2	0.6257***	3.37	
Transition probability Parameters			*TB*: $\mu_1 = \mu_2$
Constant	2.0829***	15.41	
TB, State 1	0.4677*	1.68	Log-likelihood value 2432.90
TB, State 2	-0.3943	-0.75	*p*-value 0.09
Unconstrained log-likelihood	2434.36		

Panel B. Price Momentum

	Loser's	T-stat	Winners	T-stat	Tests for Identical Asymmetries
					Intercept:α_1^{Loser}- α_2^{Loser}=$\alpha_1^{Winner} - \alpha_2^{Winner}$
Intercept, State 1	0.0029**	2.16	0.0006	0.65	Log-likelihood value 2100.11
Intercept, State 2	0.0774***	4.17	-0.0143***	-2.62	*p*-value 0.00
					MKT : $\beta_{1,1}^{Loser}$- $\beta_{1,2}^{Loser}$ =$\beta_{1,1}^{Winner}$- $\beta_{1,2}^{Winner}$
MKT, State 1	1.1658***	46.14	1.0970***	60.82	Log-likelihood value 2095.58
MKT, State 2	1.7641***	6.28	0.9711***	12.51	*p*-value 0.00
					SMB: $\beta_{2,1}^{Loser}$- $\beta_{2,2}^{Loser}$ =$\beta_{2,1}^{Winner}$- $\beta_{2,2}^{Winner}$
SMB, State 1	1.0978***	24.49	0.9290***	34.26	Log-likelihood value 2106.82
SMB, State 2	0.6104**	2.43	0.8286***	10.35	*p*-value 0.30
					HML: $\beta_{3,1}^{Loser}$- $\beta_{3,2}^{Loser}$ =$\beta_{3,1}^{Winner}$- $\beta_{3,2}^{Winner}$
HML, State 1	0.3375***	7.28	0.2661***	9.67	Log-likelihood value 2106.94
HML, State 2	0.7822***	2.68	0.3748***	3.55	*p*-value 0.37
					PMN: $\beta_{4,1}^{Loser}$- $\beta_{4,2}^{Loser}$ =$\beta_{2,1}^{Winner}$- $\beta_{2,2}^{Winner}$
PMN, State 1	-0.4278***	-17.78	0.1774***	9.86	Log-likelihood value 2105.32
PMN, State 2	-1.0298***	-4.51	0.2696***	2.72	*p*-value 0.04
σ, State 1	0.0251***	26.67	0.0164***	25.90	
σ, State 2	0.1217***	11.16	0.0402***	10.58	

Parameters Common to Both Deciles

Correlation parameters		T-stat	
ρ, State 1	0.5177***	5.68	
ρ, State 2	0.5356***	3.63	
Transition probability			*TB*: $\mu_1 = \mu_2$
Parameters			
Constant	1.7407***	6.43	
TB, State 1	0.4150	0.92	Log-likelihood value 2091.37
TB, State 2	-1.4844***	-2.77	*p*-value 2E-08
Unconstrained			
log-likelihood	2107.35		

Similarly, Table VIII Panel B presents the estimation results for earnings from the bivariate model. Panel B confirms that the null is strongly rejected at the 1% significance level for the intercept and the market risk premium factor and at the 5% significance level for the loadings on the PMN factor. The evidence suggests that the loser's decile is more sensitive than the winner's decile to changes in the market risk premium and PMN factor in the high volatility state. In addition, the asymmetry tests cannot reject the null for loadings on the SMB and HML factor. The market risk premium and earnings momentum here are the main sources for the variation in the risk premium of winner over loser portfolio. This again supports the earlier finding that earnings momentum dominates price momentum, yet it cannot fully subsume price momentum. For the loser decile, the coefficient for PMN is -0.428 in state 1 and -1.030 in state 2. For the winner decile, the coefficient for PMN is 0.178 in state 1 and 0.267 in state 2. Loser firms display a higher degree of differential response to earnings momentum between the two states than winner firms, with the stronger sensitivity occurring in the high volatility state. One explanation for this is that PMN captures future macroeconomic activities such as aggregate investment opportunities.[11] Loser firms are generally small firms with high book-to-market ratios that have limited financing access, higher financing costs and are potentially associated with higher credit risk. These properties make loser firms more sensitive to PMN than winner firms.

7. Investor Sentiment and Momentums

This section first examines the relationship between investor sentiment and the two momentums by analyzing the momentum profits during optimistic and pessimistic sentiments. Next I further investigate the predictive power of investor sentiment using both linear and nonlinear analysis.

[11] Chordia and Shivakumar (2006)

The sentiment measures of choice are comprehensive ones developed by Baker and Wurgler (2006). This composite index is based on components of six (standardized) sentiment proxies: (1) Value-weighted dividend premium, (2) IPO volume, (3) First-day returns on IPOs, (4) Closed-end fund discount, (5) NYSE turnover, and (6) Natural log NYSE turnover, detrended using past five-year average. They define this index as *SENTIMENT*. They then form another index $SENTIMENT^{\perp}$ from the orthogonalized proxies following the same procedure as before.[12] As mentioned in Baker and Wurgler (2006), optimistic sentiment is correlated with positive value of sentiment and pessimistic sentiment is correlated with negative $SENTIMENT^{\perp}$.[13] Overall, $SENTIMENT^{\perp}$ is positive for the years 1972, 1979–1987, 1994, 1996–1997, 1999–2002, and 2006 to first half of 2008. Table IX panel A shows that when $SENTIMENT^{\perp}$is negative, returns average -0.32% per month for the lowest SUE portfolio and 2.27% per month for the highest SUE portfolio; when $SENTIMENT^{\perp}$ is positive, returns average -1.30% per month for the lowest SUE portfolio and 1.53% per month for the highest SUE portfolio. Table IX Panel B shows that when $SENTIMENT^{\perp}$ is negative, returns average 1.68% per month for the loser's portfolio and 1.35% per month for the winner's portfolio; when $SENTIMENT^{\perp}$ is positive,

[12] The authors regress each of the above six raw proxies on growth in the industrial production index, growth in consumer durables, nondurables, and services, and a dummy variable for NBER recessions. They argue that residuals from these regressions may be cleaner proxies for investor sentiment. They form an index of the orthogonalized proxies following the same procedure as before.

[13] As indicated in unreported results, the two measures of sentiment, $SENTIMENT\ and\ SENTIMENT^{\perp}$, roughly follow the same pattern.

Table XI. Future Returns by Sentiment Index (January 1972–December 2010)

For each month, I report average portfolio returns over months in which *SENTIMENT*□ from the previous year-end is positive, months in which it is negative, and the difference between these two averages. Panel A reports the earnings momentum portfolios and Panel B reports the price momentum portfolio.

Panel A. Earning Momentum Portfolios

	$SENTIMENT^{\perp}_{t-1}$	**Low SUE**	**Decile 2**	**Decile 3**	**Decile 4**	**Decile 5**	**Decile 6**	**Decile 7**	**Decile 8**	**Decile 9**	**High SUE**	**10 –1**	**10–5**	**5– 1**
Earnings	Negative	-0.32%	0.10%	0.49%	0.64%	1.01%	1.52%	1.52%	1.95%	2.02%	2.27%	2.59%	1.26%	1.33%
Momentum	Positive	-1.30%	-0.58%	-0.50%	-0.23%	0.00%	0.43%	0.59%	0.94%	1.16%	1.53%	2.83%	1.53%	1.30%
	Difference	-0.98%	-0.69%	-0.99%	-0.88%	-1.01%	-1.09%	-0.92%	-1.01%	-0.86%	-0.74%	0.24%	0.27%	-0.03%

Panel B. Price Momentum Portfolios

	$SENTIMENT^{\perp}_{t-1}$	**Loser's**	**Decile 2**	**Decile 3**	**Decile 4**	**Decile 5**	**Decile 6**	**Decile 7**	**Decile 8**	**Decile 9**	**Winner's**	**10 –1**	**10–5**	**5– 1**
Price	Negative	1.68%	1.26%	1.21%	1.16%	1.13%	1.08%	1.11%	1.08%	1.16%	1.35%	-0.32%	0.23%	-0.13%
Momentum	Positive	-0.14%	0.31%	0.64%	0.71%	0.81%	0.88%	0.87%	0.91%	0.95%	1.09%	1.22%	0.28%	0.50%
	Difference	-1.81%	-0.95%	-0.57%	-0.45%	-0.32%	-0.20%	-0.23%	-0.17%	-0.21%	-0.27%	1.54%	0.05%	0.63%

returns average -0.14 per month for the lowest SUE portfolio and 1.09% per month for the winner's portfolio. In general, when sentiment is pessimistic, the highest SUE decile returns 2.59% per month more than the lowest SUE decile; it returns 2.83% more when sentiment is optimistic, meaning there is a only 0.24% differential between the optimistic sentiment and pessimistic sentiment. On the other hand, when sentiment is pessimistic, the winner's decile returns -0.32% per month less than the loser's decile; it returns 1.22% more when sentiment is optimistic, meaning there is a 1.54% differential between the optimistic sentiment and pessimistic sentiment.

These results seem to indicate that sentiment has a much larger impact on price momentum than on earnings momentum. To further investigate the relationship between the two momentums and sentiment, I run the following regression based on Baker and Wurgler (2006) to see whether sentiment can predict the various long–short portfolio profits.

Earnings Momentum:

$$r_{it=High\ SUE,t} - r_{it=Low\ SUE,t} = \alpha_{S_t} + \beta_{1,S_t} MKT_t + \beta_{2,S_t} SMB_t + \beta_{3,S_t} HML_t + \beta_{4,S_t} WML_t + \beta_{5,S_t} Sentiment\ Index_{t-1} + \varepsilon_t \quad (20)$$

Price Momentum:

$$r_{it=Winner's,t} - r_{it=Loser's,t} = \alpha_{S_t} + \beta_{1,S_t} MKT_t + \beta_{2,S_t} SMB_t + \beta_{3,S_t} HML_t + \beta_{4,S_t} WML_t + \beta_{5,S_t} Sentiment\ Index_{t-1} + \varepsilon_t \quad (21)$$

where $\varepsilon_t \sim N(0, \sigma^2_{S_t})$, and $S_t = (1, 2)$ and the conditional variance of excess returns, $\sigma^2_{S_t}$, is allowed to depend on the state of economy. The sentiment index is measured in two ways: *SENTIMENT* and *SENTIMENT*$^{\perp}$.

The dependent variable is the monthly return on a long–short portfolio, and the monthly returns are regressed on the lagged value of the sentiment index. The regressions are controlled for MKT, SMB, HML, WML or PMN, respectively. I run the regressions for a single-regime (linear regression) and two-regime model both with the lagged value of the sentiment index. For the two-regime estimation, the state transition probabilities are estimated using Equations (12) to (15). The two-regime estimations are again carried out using the maximum likelihood estimation.

Table X Time Series Regressions of Portfolio Returns with Sentiment Index (January 1972 to December 2010)

Regressions of long–short portfolio returns on lagged *sentiment measure*, Fama-French factors and WML or PMN

Earnings Momentum: $r_{it=High\ SUE,t} - r_{it=Low\ SUE,t} = \alpha_{S_t} + \beta_{1,S_t} MKT_t + \beta_{2,S_t} SMB_t + \beta_{3,S_t} HML_t + \beta_{4,S_t} WML_t + \beta_{5,S_t} Sentiment\ Index_{t-1} + \varepsilon_t$

Price Momentum: $r_{it=Winner's,t} - r_{it=Loser's,t} = \alpha_{S_t} + \beta_{1,S_t} MKT_t + \beta_{2,S_t} SMB_t + \beta_{3,S_t} HML_t + \beta_{4,S_t} WML_t + \beta_{5,S_t} Sentiment\ Index_{t-1} + \varepsilon_t$

$\varepsilon_t \sim N(0,\sigma^2_{s_t})$, $S_t = (1,2)$

$p_t = P(S_t = 1 \mid S_{t-1} = 1) = \Phi\left(\mu_0 + \mu_1 TB_{t-1}\right)$; $1 - p_t = P(S_t = 2 \mid S_{t-1} = 1)$ $q_t = P(S_t = 2 \mid S_{t-1} = 2) = \Phi\left(\mu_0 + \mu_2 TB_{t-1}\right)$; $1 - q_t = P(S_t = 1 \mid S_{t-1} = 2)$

The sentiment index is measured in two ways: $SENTIMENT$ and $SENTIMENT^{\perp}$. $SENTIMENT$ is based on first principal component of six (standardized) sentiment proxies: (1) Value-weighted dividend premium, (2) IPO volume, (3) First-day returns on IPOs, (4) Closed-end fund discount, (5) NYSE turnover, and (6) Natural log NYSE turnover, detrended using past five-year average. $SENTIMENT^{\perp}$ is orthogonalized to a set of marcoeconomic conditions. Panel A reports the results for PMN and Panel B reports the results for WML. (***, ** and * denote significance level of 1%, 5%, and 10%).

Panel A. PMN

	OLS		State 1		State 2		OLS		State 1		State 2	
	PMN	T-Stat	PMN	T-Stat	PMN	T-Stat	PMN	T-Stat	PMN	T-Stat	PMN	T-Stat
Constant	0.0267***	16.79	0.0245***	26.51	0.0534***	5.60	0.0267***	16.77	0.0246***	26.13	0.0513***	5.11
RPM	0.0045	0.09	-0.0668***	-3.26	0.365***	2.56	0.0045	0.09	-0.0673***	-3.04	0.3516**	2.27
SMB	-0.0939	-1.38	-0.0203	-0.76	-0.4015**	-2.08	-0.0941	-1.39	-0.0199	-0.67	-0.3933**	-1.98
HML	-0.0926	-1.33	-0.101**	-3.37	-0.0576	-0.27	-0.0936	-1.35	-0.1028***	-3.25	-0.0552	-0.26
WML	0.2547***	5.89	0.2618***	22.02	0.3484***	5.99	0.2541***	5.86	0.261***	22.08	0.3542***	5.90
$SENTIMENT$	0.0116	0.09	0.071	0.63	1.192	0.74						
$SENTIMENT^{\perp}$							0.0557	0.50	0.1186	1.04	0.9596	0.66
TB, Constant			2.549***	13.16	2.549***	13.16			2.547***	12.98	2.547***	12.98
TB, Slope			-0.2403	-0.78	-2.397***	-2.96			-0.2379	-0.78	-2.3867***	-2.97
σ			0.019***	32.36	0.0726***	14.71			0.019***	30.88	0.0728***	14.75

Panel B. WML

	OLS		State 1		State 2		OLS		State 1		State 2	
	WML	T-Stat	WML	T-Stat	WML	T-Stat	WML	T-Stat	WML	T-Stat	WML	T-Stat
Constant	-0.015***	-2.62	-0.0028*	-1.86	-0.0859***	-4.28	-0.0149***	-2.60	-0.0026*	-1.77	-0.0868***	-4.34
RPM	-0.2425**	-2.36	-0.0704***	-2.97	-0.7987***	-2.77	-0.2421**	-2.35	-0.0704***	-2.96	-0.7871***	-2.73
SMB	-0.3031**	-2.07	-0.1927***	-4.32	0.0822	0.30	-0.3075**	-2.10	-0.1959***	-4.35	0.0828	0.32
HML	-0.3002*	-1.70	-0.1117***	-2.59	-0.3669	-1.15	-0.3026*	-1.70	-0.1112***	-2.59	-0.3817	-1.22
PMN	0.8393***	5.49	0.6226***	23.43	1.1937***	4.54	0.8392***	5.47	0.6201***	25.35	1.2011***	4.97
$SENTIMENT$	0.5901**	1.93	0.2754*	1.74	0.6646	0.32						
$SENTIMENT^{\perp}$							0.5322*	1.65	0.292*	1.73	0.8582	0.42
TB, Constant			1.3971***	8.97	1.3971***	8.97			1.3971***	9.87	1.3971***	9.87
TB, Slope			0.5837**	2.41	-1.7248***	-3.55			0.5801***	2.59	-1.7402***	-3.63

σ	0.0288***	25.85	0.1317***	10.36	0.0288***	27.51	0.1316***	10.45

Table X shows that the coefficients for *SENTIMENT* and $SENTIMENT^{\perp}$ are very similar. The coefficients for the sentiment measures are smaller in state 1, the low volatility state, and larger in state 2, the high volatility state. This makes sense since in a high volatility state stock returns are more highly impacted by investor sentiment than in a low volatility state, or expansion. Table X Panel A also shows that sentiment measures are insignificant in predicting the returns on the zero-based earning momentum portfolio that is long the highest SUE portfolio and short the lowest SUE portfolio, both in single-regime and two-regime regressions.

In contrast, Table X Panel B shows that sentiment measures are significant in predicting the returns on the long-short price momentum portfolio that are long the winner's portfolio and short the loser's portfolio. In the nonlinear regime-switching regression, the coefficient of sentiment measure is only significant in the low volatility state, state 1, but not significant in the high volatility state, state 2. This result is similar to Antoniou, Doukas and Subrahmanyam (2011) finding that changes in investor sentiment only influence price momentum in up-states, not in the down-states.

The results of earnings momentum are quite intriguing, since numerous papers argue that investor under or overreaction to news may cause earnings momentum (Barberis, Shleifer and Vishny, 1998). However, the estimation above shows that after controlling for price momentum, investor sentiment has no predictive power in explaining earnings momentum. Also, in unreported results, even without including WML factor, sentiment still has no predictive power for earnings momentum. This may be because corporate earnings are more influenced by firm specific factors instead of aggregate sentiment. Hou, Peng and Xiong (2009) also point out that price momentum profits are higher in up-market, but that earnings momentum profits are higher among low volume stock and down-market. Particularly, they find that in the long-run, price momentum profits reverse, but earnings momentum profits do not. This seems to indicate that the effect of investor sentiment on the profits of earnings momentum is somehow limited.

8. Robustness Tests: Alternative Instrument in Modeling State Transition Probabilities

In the benchmark estimation, I follow Gray (1996) in using the one-month Treasury bill rate as the instrument in modeling the state transition probabilities. I conduct a robustness test by using an alternative instrument to replace the one-month Treasury bill rate in the transition probabilities specifications in the bivariate Markov-switching model. I follow Perez-Quiros and Timmermann (2000) in using the year-on-year log-difference in the US Composite Leading Indicator, ΔCLI, as an alternative instrument. The monthly index is available through the OECD database.

Table XI. Parameter Estimates for the Univariate Markov-Switching Extended Four - Factor Model of Excess Returns to Momentum Portfolios, ΔCLI as an Alternative Instrument in Modeling State Transition Probabilities (January 1972 to December 2010)

Panel A. Earnings Momentum

	Low Sue	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	High SUE
Intercept, State 1	-0.0133***	-0.0076***	-0.0070***	-0.0040***	-0.0013**	0.0031***	0.0038***	0.0065***	0.0087***	0.0112***
Intercept, State 2	-0.0287***	0.9987***	-0.0065	-0.0067*	-0.0032	0.0021	0.0027	0.0089***	0.0090***	0.0150***
MKT, State 1	1.0833***	0.7660***	1.0208***	1.0227***	1.0430***	1.0250***	1.0595***	1.0468***	1.0670***	1.0439***
MKT, State 2	0.6281***	0.2768***	1.1467***	0.9146***	0.8391***	0.8420***	0.9106***	0.8838***	0.8952***	0.8083***
SMB, State 1	0.8283***	-0.1724***	0.8623***	0.8574***	0.9212***	0.8514***	0.8712***	0.8344***	0.8651***	0.7821***
SMB, State 2	0.4962***	-0.0151***	0.4364***	0.6411***	0.4555***	0.4687***	0.4400***	0.4937***	0.4286***	0.4125***
HML, State 1	0.4703***	0.9987***	0.3342***	0.2982***	0.3577***	0.3035***	0.3322***	0.2644***	0.3015***	0.1679***
HML, State 2	0.2660*	0.7660***	0.5124***	0.4776***	0.4603***	0.4792***	0.4642***	0.4289***	0.4497***	0.4239***
WML, State 1	-0.3066***	0.2768***	-0.1750***	-0.1857***	-0.1573***	-0.1518***	-0.1004***	-0.0784***	-0.0894***	0.0065
WML, State 2	-0.3440***	-0.1724***	-0.2456***	-0.1563***	-0.1217***	-0.1535***	-0.0706***	-0.1814***	-0.0966***	-0.0983***
Transition Probability										
Constant	2.4563***	2.5118***	2.3130***	2.0977***	2.5073***	2.5115***	2.8980***	2.4370***	2.4548***	2.2661***
ΔCLI[14], State 1	-13.2040	52.6077***	-45.6078**	11.7068	13.7660	13.9581	27.9940	-42.4365	41.4240	-0.8906
ΔCLI, State 2	-33.6169	57.7706***	-117.861***	57.3034*	-42.8509	-38.0679	1.4691	-65.9868**	54.0384*	-26.3668

[14] ΔCLI is the year-on-year log-difference in the Composite Leading Indicator from the Conference Board.

Standard Deviation										
σ, State 1	0.0156***	0.0116***	0.0129***	0.0109***	0.0125***	0.0124***	0.0104***	0.0105***	0.0120***	0.0117***
σ, State 2	0.0592***	0.0465***	0.0408***	0.0384***	0.0446***	0.0475***	0.0325***	0.0341***	0.0343***	0.0340***
Log Likelihood value	1175.65	1250.57***	1241.23	1250.72	1224.76	1243.29	1291.72	1257.30	1245.69	1256.17
	T-stat	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**
Intercept, State 1	-15.4197	-14.3552	-10.2648	-6.1774	-2.0507	4.2269	6.4602	9.8493	12.2940	16.6350
Intercept, State 2	-3.9524	-3.3223	-1.4924	-1.8662	-0.7882	0.4689	1.0927	3.4886	3.1197	5.0245
MKT, State 1	71.3344	80.3543	77.0976	66.0586	70.2823	61.1084	90.7264	78.1660	65.6694	71.7431
MKT, State 2	5.0697	15.3813	15.4945	14.1619	12.1652	11.3218	24.5161	22.3744	18.9218	12.7526
SMB, State 1	33.7003	42.6131	42.5653	33.0787	46.7214	35.1216	44.8681	37.6522	38.1762	32.9725
SMB, State 2	3.0252	6.2159	4.2634	8.1991	4.5148	4.3845	6.8516	7.2750	5.6556	5.3099
HML, State 1	16.0677	12.3921	15.7888	10.2678	14.7771	10.8276	17.9331	10.4647	12.4742	6.5581
HML, State 2	1.7160	4.8863	5.5073	5.4458	4.1716	4.5062	9.5879	7.1130	6.9932	6.2257
WML, State 1	-18.5987	-14.3572	-22.2386	-13.9011	-15.9125	-12.3610	-10.5251	-6.2563	-8.9177	0.5303
WML, State 2	-6.3835	-12.9582	-9.9269	-4.7423	-4.0440	-4.8356	-3.9550	-8.2082	-3.7999	-3.5989
Transition Probability										
Constant	11.6982	10.8898	11.4170	13.3855	11.6469	10.8204	6.7833	10.5335	10.6706	11.7685
ΔCLI, State 1	-0.5534	3.6510	-2.3687	0.4494	0.3805	0.5153	0.6640	-1.5917	1.4676	-0.0380
ΔCLI, State 2	-0.6472	2.7207	-3.3773	1.7618	-1.5512	-0.8947	0.0215	-2.5724	2.0605	-0.6093
Standard Deviation										
σ, State 1	30.0921	27.0577	28.8755	21.3250	26.0744	28.3416	27.1737	24.5144	25.2481	23.6777
σ, State 2	11.5796	18.9665	17.1674	19.6811	27.2734	13.1331	18.2006	18.4410	25.5227	18.4054

Panel B. Price Momentum

	Loser's	**Decile 2**	**Decile 3**	**Decile 4**	**Decile 5**	**Decile 6**	**Decile 7**	**Decile 8**	**Decile 9**	**Winner's**
Intercept, State 1	0.0611***	0.0156***	0.0114***	0.0048***	0.0042***	0.0036***	0.0032***	0.0025***	0.0004	0.0010
Intercept, State 2	0.0037**	0.0011	0.0021**	0.0057*	0.0050**	0.0037**	0.0022*	0.0002	-0.0032**	-0.0077***
MKT, State 1	1.6386***	1.2389***	1.1520***	1.0177***	0.9706***	0.9749***	0.9655***	1.0061***	1.0917***	1.1461***
MKT, State 2	1.1453***	1.0071***	0.9821***	0.4760***	0.9608***	0.9176***	0.9870***	0.7457***	0.8961***	0.9471***
SMB, State 1	0.8094***	1.4536***	1.0781***	0.7103***	0.6695***	0.6014***	0.5936***	0.6601***	0.8149***	1.0818***
SMB, State 2	1.0711***	0.5725***	0.4539***	-0.1140***	0.3708***	0.3738***	0.3931***	0.3610***	0.4809***	0.6570***
HML, State 1	0.9766***	0.3323***	0.3415***	0.4132***	0.2234***	0.2076***	0.1814***	0.2802***	0.2398***	0.2376***
HML, State 2	0.2637***	0.5053***	0.6415***	0.2257***	0.8583***	0.8110***	0.7956***	0.5497***	0.4779***	0.2937***
PMN, State 1	-0.4318***	-0.1628***	-0.1028***	-0.1295***	-0.0614***	-0.0259**	0.0010	0.0346**	0.1277***	0.1210***
PMN, State 2	-0.9980***	-0.3594***	-0.2891***	-0.1507**	-0.1961***	-0.1543***	-0.0163	0.0426	0.1305***	0.2559***
Transition Probability										
Constant	1.5683***	1.6459***	2.0775***	2.2450***	2.4987***	2.4481***	2.5134***	2.7796***	2.1537***	2.2204***
ΔCLI, State 1	8.7052	-1.2667	57.0240**	17.7933	114.0730***	95.4331**	43.1407	44.5277*	-1.9167	-1.8884
ΔCLI, State 2	-8.6587	-57.7609	-1.0470	198.9976***	188.0451***	158.1088***	-71.1602**	-128.0838***	55.5298**	23.3157
Standard Deviation										

σ, State 1	0.0247***	0.0171***	0.0149***	0.0073***	0.0091***	0.0089***	0.0089***	0.0101***	0.0111***	0.0160***
σ, State 2	0.1132***	0.0357***	0.0197***	0.0149***	0.0149***	0.0124***	0.0131***	0.0132***	0.0144***	0.0255***
Log Likelihood value	901.6486	1123.31	1220.33	1283.77	1446.49	1478.38	1489.44	1452.69	1373.50	1194.17
	T-stat	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**	**T-stat**
Intercept, State 1	4.2736	3.3945	6.1974	7.2916	7.1844	6.4646	6.5486	3.8804	0.4231	0.8244
Intercept, State 2	2.5217	0.9477	2.0457	1.8424	2.4758	2.3184	1.8043	0.1571	-2.4205	-2.9054
MKT, State 1	7.5293	22.7220	46.7643	92.2812	54.2845	113.5685	110.4573	134.3389	74.9677	56.5476
MKT, State 2	43.9229	44.3214	46.6916	15.6524	34.6970	43.5838	43.9387	27.5686	40.5217	21.6685
SMB, State 1	3.8597	12.5917	23.8661	49.2373	16.7100	44.3520	28.1024	43.3381	37.6432	28.6696
SMB, State 2	23.4968	18.3096	18.0045	-2.7281	10.3450	15.7640	19.6703	14.7272	20.6438	12.7703
HML, State 1	4.1643	3.8774	8.6503	24.0279	4.1697	14.6737	11.1738	15.5001	6.6707	6.6244
HML, State 2	5.3689	13.3134	21.2682	6.9561	25.8107	32.6095	33.9879	19.5703	17.4296	5.6310
PMN, State 1	-17.2698	-6.7965	-4.8196	-12.3314	-6.2042	-2.2300	0.0969	2.4672	5.5502	4.0433
PMN, State 2	-5.5812	-4.3924	-7.1979	-2.0577	-4.9222	-4.5423	-0.8176	1.4933	5.9087	6.2891
Transition Probability										
Constant	12.9086	8.6111	11.2118	15.2325	5.9328	8.1148	9.5294	14.0831	8.8030	10.5564
ΔCLI, State 1	0.9040	-0.0556	1.9648	0.9838	3.6271	2.2935	1.5015	1.8147	-0.0624	-0.0825
ΔCLI, State 2	-0.4087	-1.3387	-0.0515	3.6416	3.9313	2.8161	-2.1971	-3.4975	2.1856	0.6990
Standard Deviation										
σ, State 1	23.8380	23.8878	24.4686	73.7596	18.4921	28.3832	35.0891	44.6139	30.4467	26.7727
σ, State 2	14.3565	12.0940	19.4942	6.0630	8.9125	16.2180	15.3069	11.9989	17.9999	14.6159

Tables XI and XII repeat the same tests as in Table V and VIII by estimating the bivariate Markov-switching model for the 1st and 10th portfolio excess returns, but with ΔCLI as the instrument used in the modeling of the state transition probabilities, respectively. The two new tables show that the basic inferences from Table V and VIII are robust to the specification changes of the state transition probabilities.

Table XII. The Bivariate Markov-Switching Model for the Earnings (PMN) and the Price Momentum Strategy (WML) ΔCLI as an Alternative Instrument in Modeling State Transition Probabilities (January 1972 to December 2010)

Panel A. Earnings Momentum

	Low SUE	T-stat	High SUE	T-stat	Tests for Identical Asymmetries
					Intercept: α_1^{Low} - α_2^{Low} = α_1^{High} - α_2^{High}
Intercept, State 1	-0.0199***	-4.7905	0.0106***	17.4277	Log-likelihood value 2433.7793
Intercept, State 2	0.8291***	14.4937	0.0164***	5.7237	*p*-value 0.8115
					MKT : $\beta_{1,1}^{Low}$ - $\beta_{1,2}^{Low}$ = $\beta_{1,1}^{High}$ - $\beta_{1,2}^{High}$
MKT, State 1	0.6163***	5.8840	1.0375***	79.6384	Log-likelihood value 2376.1750
MKT, State 2	0.4582***	4.6438	0.8714***	21.4409	*p*-value 0.0000
					SMB: $\beta_{2,1}^{Low}$ - $\beta_{2,2}^{Low}$ = $\beta_{2,1}^{High}$ - $\beta_{2,2}^{Hgih}$
SMB, State 1	-0.3531***	-16.0554	0.7754***	32.5295	Log-likelihood value 2431.7308
SMB, State 2	-0.3531***	-17.0931	0.3972***	6.0145	*p*-value 0.0415
					HML: $\beta_{3,1}^{Low}$ - $\beta_{3,2}^{Low}$ = $\beta_{3,1}^{High}$ - $\beta_{3,2}^{High}$
HML, State 1	1.0563***	69.0052	0.1599***	7.2198	Log-likelihood value 2432.4409
HML, State 2	0.7908***	36.3765	0.4155***	7.4814	*p*-value 0.0983
					WML: $\beta_{4,1}^{Low}$ - $\beta_{4,2}^{Low}$ = $\beta_{4,1}^{High}$ - $\beta_{4,2}^{High}$
WML, State 1	-0.2766***	-11.4605	0.0046	0.4087	Log-likelihood value 2434.3043
WML, State 2	-0.3184***	-22.8442	-0.0899***	-4.8706	*p*-value 0.1512
σ, State 1	0.0131***	27.9187	0.0110***	26.6060	
σ, State 2	0.0479***	34.3844	0.0344***	21.7279	

Parameters Common to Both Deciles

Correlation parameters		T-stat	
ρ, State 1	0. 5123***	3.90	
ρ, State 2	0.6077***	3.37	
Transition probability			*TB*: $\mu_1 = \mu_2$
Parameters			
Constant	-2.4815***	-12.1144	
TB, State 1	50.7459**	2.2782	Log-likelihood value 2432.8324
TB, State 2	-35.7376	-1.3311	*p*-value 0.1625
Unconstrained			
log-likelihood	2433.8078		

Panel B. Price Momentum

	Loser's	T-stat	Winners	T-stat	Tests for Identical Asymmetries
					Intercept: α_1^{Loser} - α_2^{Loser} = $\alpha_1^{Winner} - \alpha_2^{Winner}$
Intercept, State 1	0.0027**	2.1091	0.0005	0.5831	Log-likelihood value 2086.2771
Intercept, State 2	0.0783***	4.2687	-0.0141***	-2.4111	p-value 0.0000
					MKT : $\beta_{1,1}^{Loser}$ - $\beta_{1,2}^{Loser}$ = $\beta_{1,1}^{Winner}$ - $\beta_{1,2}^{Winner}$
MKT, State 1	1.1687***	50.9220	1.0982***	67.6045	Log-likelihood value 2080.4924
MKT, State 2	1.7851***	6.2295	0.9669***	11.8080	p-value 0.0000
					SMB: $\beta_{2,1}^{Loser}$ - $\beta_{2,2}^{Loser}$ = $\beta_{2,1}^{Winner}$ - $\beta_{2,2}^{Winner}$
SMB, State 1	1.0953***	25.3294	0.9285***	34.9086	Log-likelihood value 2092.9705
SMB, State 2	0.5947**	2.4111	0.8296***	10.2175	p-value 0.3700
					HML: $\beta_{3,1}^{Loser}$ - $\beta_{3,2}^{Loser}$ = $\beta_{3,1}^{Winner}$ - $\beta_{3,2}^{Winner}$
HML, State 1	0.3432***	7.7753	0.2687***	11.6582	Log-likelihood value 2092.8748
HML, State 2	0.7749***	2.6440	0.3715***	3.3682	p-value 0.3200
					PMN: $\beta_{4,1}^{Loser}$ - $\beta_{4,2}^{Loser}$ = $\beta_{2,1}^{Winner}$ - $\beta_{2,2}^{Winner}$
PMN, State 1	-0.4275***	-2.5956	0.1782***	11.5635	Log-likelihood value 2091.0050
PMN, State 2	-1.0522***	-18.4780	0.2698***	2.5758	p-value 0.0200
σ, State 1	0.0250***	29.2668	0.0164***	26.9080	
σ, State 2	0.1224***	11.3286	0.0406***	9.9983	

Parameters Common to Both Deciles

Correlation parameters		T-stat	
ρ, State 1	0.5258***	4.9812	
ρ, State 2	0.4907***	3.5436	
Transition probability Parameters			*TB*: $\mu_1 = \mu_2$
Constant	1.8929***	17.1850	
TB, State 1	5.4815	0.5613	Log-likelihood value 2093.3689
TB, State 2	5.8210	0.2584	p-value 0.9800
Unconstrained log-likelihood	2093.3691		

9. Conclusion

Using a two-state Markov-switching framework with time-varying transition probabilities, this paper examines time variations of the relationship between earnings momentum and price momentum. This framework allows for the intercept, slope coefficient, and variance to vary with a single latent state variable. By incorporating macroeconomic information in the state transition probabilities, I am able to capture the time variation in the coefficients across low and high volatility states. I apply this framework to a extend four-factor model (Fama-French factors, and WML/PMN) to investigate the interaction between earnings and price momentum. WML is the return of an investment portfolio that consists of long positions in past winners and short positions in past losers; PMN is the return of an investment portfolio that is long in the highest earnings surprise decile and is short in the lowest earnings surprise decile. From this model I find that price momentum is significantly more influenced by earnings momentum in the high volatility state. From a financing perspective, the discount rate has a large impact on stock prices but not on companies' earnings in the low volatility state. However in the high volatility state, when financing is more constrained, the discount rate makes a bigger difference on earnings. Therefore, the co-movement of price momentum and earnings momentum becomes stronger. From an investing perspective, PMN captures future aggregate investment opportunities and its predictive content becomes more important for investors in the high volatility state. Because of this investors pay more attention and place higher weights on earnings.

Loser and lowest SUE firms are generally smaller in size with high book-to-market ratios, while winner and highest SUE firms are larger in size with low book-to-market. These differences in firm characteristics might make lowest SUE or loser firms more sensitive to changes in the state of the economy than highest SUE or winner firms. Therefore I examine whether this is the case and find that the loser portfolio is more sensitive than the winner portfolio to changes in the earnings momentum across the two states. One explanation for this is that PMN captures future macroeconomic activities such as aggregate investment opportunities. Because loser firms are generally smaller firms with high book-to-market ratios they tend to have limited financing access, higher financing costs and are potentially associated with higher credit risk. These properties make loser firms more sensitive to PMN than winner firms.

Finally, I adopt two sentiment measures constructed by Baker and Wurgler (2006) to further investigate the relationship between sentiment and the two momentums. I find that profits from earnings momentum are positive and do not vary much, regardless of whether investor sentiment is optimistic or pessimistic. This may be because corporate earnings are more influenced by firm specific factors instead of aggregate investor sentiment. In contrast, the profit for price momentum exists only when investor sentiment is optimistic. When pessimistic, profits for price momentum disappear. The results indicate that sentiment has predictive power for price momentum profit, but not for earnings momentum profit. Moreover, this predictive power of sentiment for price momentum only seems to be pronounced for the low volatility state.

In conclusion, this regime-switching framework allows me to capture the variation in the relationship between earnings momentum and price momentum. This framework is flexible enough to be applied to the study of a variety of topics within financial economics. By incorporating regime-switching one may examine the time-varying nature of financial markets, making this a beneficial tool for empirical studies.

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Appendix:

List of variables used in the paper:

$\mathrm{r_t}$	Excess return of a portfolio over period *t*
$\mathrm{S_t}$	Latent state variable, $\mathrm{S_t} = i$ or j denote state *i* or state *j*
$\mathrm{X_t}$	A vector of conditioning variables used to explain the excess return $\mathrm{r_t}$
β'_{S_t}	Regression coefficients of $\mathrm{X_t}$
α_{S_t}	Intercept term
ε_t	Error term $\varepsilon_t \sim N(0, \sigma^2_{S_t})$
p_t ,1-p_t , q_t, 1-q_t	State transition probabilities
$P(S_t = i \mid S_{t-1} = j, Y_{t-1})$	Transition probability from state *j* to *i*, given information Y_{t-1}
Y_{t-1}	A vector of information variables that are publicly known at time $t-1$ and affects the state transition probabilities between time $t-1$ and t
θ	A vector of parameters entering the likelihood function
$f(r_t \mid S_t = j, X_t; \theta)$	The density of the innovations, ε_t, conditional on being in state *j*, *j*=1, 2
α_j, β'_j, σ_j	Intercept, slope coefficients, standard deviation in state *j* (given $S_t = j$, j=1,2)
Ω_{t-1}	Information set contains $X_{t-1}, r_{t-1}, Y_{t-1}$, and also the lagged value of these variables
$\phi(r_t \mid \Omega_{t-1}; \theta)$	The density obtained by summing the probability-weighted state densities, $f(\bullet)$, across two possible states.
$L(r_t \mid \Omega_{t-1}; \theta)$	Log-likelihood function obtained by summing $\log(\phi(r_t \mid \Omega_{t-1}; \theta))$ from 1 to T
$P(S_t = j \mid \Omega_{t-1}, ; \theta)$	The conditional probability of state j at time t given information at time $t-1$, obtained recursively based on the total probability theorem.
r_t^i	Monthly excess return for the ith earnings or price momentum decile
$\alpha^i_{S_t}$	The intercept term from regression of ith decile, $S_t = 1, 2$
β^i_{k,S_t} k=1,2,3,4	Coefficients on MKT, SMB, HML, WML (for earnings momentum regressions) or PMN (for price momentum regressions).
ε^i_t	Error term from regression of ith decile
σ_{i,S_t}	Standard deviation from regression of ith decile, $S_t = 1, 2$
$p^i_t, 1 - p^i_t, q^i_t, 1 - q^i_t$	State transition probabilities of ith decile
S^i_t	State indicator for ith portfolio
Φ	The cumulative density function of a standard normal variable
μ^i_0, $\mu^i_{S_t}$	Intercept, slope coefficients for T-bill regression, $S_t = 1, 2$ of *ith* decile
TB	One-month Treasury bill rate
MKT	The excess return on the market (Value-weight return on all NYSE, AMEX, & NASDAQ stocks minus the one-month Treasury bill rate)

SMB	The average return on the three small portfolios minus the average return on the three big portfolios.
HML	The average return on the two value portfolios minus the average return on the two growth portfolios.
WML	Returns on portfolio that shorting the past loser's portfolio and going long the past winner's portfolio.
PMN	Returns on portfolio that Returns on portfolio that shorting the lowest SUE portfolio and going long the highest SUE portfolio.
$r_t^{Earnings} \equiv \left(r_t^{Low}, r_t^{High}\right)'$	(2×1) vector consisting of the excess returns to the lowest SUE portfolio, r_t^{Low}, and the highest SUE portfolio, r_t^{High}
$\alpha_{S_t} \equiv \left(\alpha_{S_t}^{Low}, \alpha_{S_t}^{High}\right)$	Vector of intercept term of the lowest SUE portfolio, and the highest SUE portfolio.
$\beta_{k,S_t} \equiv \left(\beta_{k,S_t}^{Low}, \beta_{k,S_t}^{High}\right)$ $k = 1,\ 2,\ 3,\ 4$	Vector of coefficients on MKT, SMB, HML, WML of the lowest SUE portfolio, and the highest SUE portfolio.
$r_t^{\text{Price}} \equiv \left(r_t^{Loser}, r_t^{Winner}\right)'$	(2×1) vector consisting of the excess returns to the loser's portfolio, r_t^{Loser}, and the excess returns to the winner's portfolio, r_t^{Winner}
$\alpha_{S_t} \equiv \left(\alpha_{S_t}^{Loser}, \alpha_{S_t}^{Winner}\right)$	Vector of intercept term of the loser's portfolio, and the winner's portfolio.
$\beta_{k,S_t} \equiv \left(\beta_{k,S_t}^{Loser}, \beta_{k,S_t}^{Winner}\right)$	Vector of coefficients on MKT, SMB, HML, PMN of the loser's portfolio, and the winner's portfolio.
ε_t	$\varepsilon_t \sim N\left(0,\ \Sigma_{S_t}\right),\ S_t = \{1,2\}$ are residuals
Σ_{S_t}	A positive semi-definite (2×2) matrix that contains the variance and covariances of the residuals of the 1st decile and 10th decile portfolio excess returns in state S_t
Σ_{ii,S_t}	The diagonal elements of this variance-covariance matrix, take the similar form as in the univariate model.
Σ_{ij,S_t}	The off-diagonal elements, Σ_{ij,S_t}, assume a state-dependent correlation between two residuals , denoted ρ_{S_t}, that is $\Sigma_{ij,S_t} = \rho_{S_t}\left(\Sigma_{ii,S_t}\right)^{1/2}\left(\Sigma_{jj,S_t}\right)^{1/2}$ for $i \neq j$.
ρ_{S_t}	State-dependent correlation between two residuals
$SENTIMENT^{\perp}$	Sentiment index in Baker and Wurgler (2006), based on first principal component of six (standardized) sentiment proxies: (1) Value-weighted dividend premium, (2) IPO volume, (3) First-day returns on IPOs, (4) Closed-end fund discount, (5) NYSE turnover, (6) Natural log NYSE turnover, detrended using past five-year average
$SENTIMENT^{\perp}$	Sentiment index in Baker and Wurgler (2006), based on first principal component of six (standardized) sentiment proxies, where each of the proxies has first been orthogonalized with respect to a set of macroeconomic conditions.

Chapter 2

The Relative Pricing of Cross-Listed Securities: The Case of Chinese A- and H-Shares

1. Introduction

Despite being issued by the same company, prices for H-shares in Hong Kong are persistently lower than the corresponding A-share prices traded in Shanghai and Shenzhen. This is somewhat puzzling given that A- and H-shares represent a claim to the same future cash flow. In theory, according to the law of one price, securities with claims to the same cash flow should trade at the same price in different markets. Therefore, it is important to examine the factors that might affect the price disparity between A-and H-shares. This study differentiates from previous studies in that it focuses on the potential liquidity and transparency effects on the discount attached to H-shares. In particular, I examine multiple liquidity and transparency measures that have not yet been analyzed in earlier literature concerning A- and H-shares.

Previous research establishes that a difference in liquidity across markets contributes to the price differential between financial assets with claims on identical cash flows trading in different markets.[15] Because of this, it becomes necessary to examine this aspect. Particularly, in terms of liquidity effects, this paper examines the Amihud illiquidity measure (Amihud, 2002) and the turnover ratio for both A- and H-shares as well as the infrequency of trading associated with H-shares. The higher the illiquidity of H-shares than that of A-shares, the more H-shares is discounted relative to the underlying price of A-shares. In contrast, relatively active trading of A-shares, as measured by the turnover ratio of A-shares divided by that of H-shares, are associated with a larger H-share discount. Additionally, an increase of the infrequency of trading of H-

[15] Chen, Lee and Rui (2001) find that the A- and B-share price differences (in China) are caused by B-share market illiquidity. Chan, Hong and Subrahamanyam (2008) investigate the liquidity effect in asset pricing by studying the liquidity-premium relation of an ADR and its underlying share.

shares is accompanied with a larger H-share discount. Thus, the results suggest that liquidity plays a role in the relative pricing of A-and H-shares.

Regarding transparency effects, this paper first examines the quality of auditors as a measure of accounting transparency by comparing firms that are audited by Big 4 auditors [16] versus those audited by local auditors. I find that firms audited by the Big 4 are generally associated with smaller H-share discounts, higher mutual fund holdings, a higher number of A- and H-share analysts, and higher liquidity. The difference between the local auditors and the Big 4 auditors groups is statistically significant, both in mean and median for most years covered in the sample. This finding provides evidence that transparency impacts the price differential between A- and H-shares.

Further analyses of transparency provide more support for the role of transparency in the relative pricing of A- and H-shares. Analyst coverage, as measured by the number of analysts following a particular firm, is also commonly regarded as a mechanism that makes firms more transparent. [17] Therefore, I examine analyst coverage for both A-and H-shares and find that an increase in the analyst coverage for both A- and H-shares is associated with a smaller discount for H-shares. In addition, mutual funds may also provide more transparency to a firm through their monitoring of a firm's activities.[18] Empirical results suggest that an increase in mutual fund holdings of firm's A-shares is associated with a smaller H-share discount. These results also suggest the importance of transparency on the A-and H-share price disparity.

The remainder of the paper is organized as follows: Section 2 is the literature review; Section 3 provides some background information concerning share structure in China, Section 4

[16] Price Waterhouse Coopers, Deloitte Touche Tohmatsu, Ernst & Young, and KPMG

[17] Yu (2008) reports that firms with higher analyst coverage exhibit less accrual-based earnings management.

[18] Choi and Seo (2008) find that firms with higher levels of institutional ownership exhibit higher accounting transparencies and that institutional monitoring curbs managers' opportunistic behaviors associated with investing, financing, and operating activities as well as accounting reporting activities.

describes variables and summary statistics, Section 5 presents the methodology and empirical results, and Section 6 gives the conclusion.

2. Literature Review

Many previous studies try to explain why financial assets with claims on the same cash flow streams are traded at different prices in different markets. Possible explanations for the price differential can generally be summarized into the following categories: differential demand theory, differential risk preference theory, information asymmetry theory, hedging for exchange rate theory, and the liquidity theory. Each of these is described below.

The differential demand hypothesis states that the demand functions for domestic shares differ between foreign and domestic investors in terms of shares price elasticity. Foreign investors' demand elasticity for local shares may be higher because they have wider access and better chances for diversification opportunities. Therefore, foreigner investors require a higher premium to invest in local shares. On the other hand, local firms understand this difference and, in order to maximize market value, discriminate between local and foreign investors. Sun and Tong (2000) apply this theory and discover that the B-share discount (B-shares were originally only for purchase by foreigners on the Shanghai and Shenzhen Exchanges) increases with the number of listings of H-shares and in Hong Kong. They suggest this happens because H-shares are close substitutes for China B-shares. Fernald and Rogers (2002) argue that an A-share premium exists because the domestic investors in China are willing to pay more, since they have limited alternative investments available. Indeed, there is little opportunity for overseas diversification for Chinese mainland investors due to the capital controls imposed by the state. Secondly, the real interest rate on Renminbi (RMB) deposits is close to zero (or negative). Thirdly, Chinese's treasuries often offer unattractive rates. In addition, the tradable A-shares that are available for individual investors are quite limited since there is a substantial amount of shares still owned by the State. The limited supply coupled with a relatively high demand causes A-shares to trade at a premium to both H-and B-shares.

The differential risk preference theory states that barriers to international investment restrict the access of foreigners to the local capital market and limit the fraction of a local firm's equity that can be owned. The two different price rules in the foreign securities market (that arise from this theory) reflects the premium paid by domestic investors, under no constraints, versus the discount demanded by foreign investors under constraints, as suggested by Eun and Janakiramanan (1986) in their general equilibrium asset pricing model. Ma (1996) argues that price differences between A- and B-shares can be attributed to investors' attitude towards risk. He further states that the beta of the stocks partially explains the discount attached to Chinese B-shares and that Chinese mainland investors' risk taking preferences are associated with this result. Using a CAPM model, Sue (1999) investigates the relationship between restrictions on ownership and the stock prices for A- and B-shares. His finding suggests that the B-share price discount is related to expectations on the return premium for B-shares. He further states that foreign investors tend to be more risk averse in investing in the Chinese stock market, due to the fact that the market is segmented. Therefore, this requires that investors receive more compensation for bearing this risk.

Another study by Sun and Tong (2000) looks at the relative volatility of B-share and A-share returns. They argue that given that a pair of A- and B-stocks share identical information of the firm, any A-share volatility in excess of the B-share volatility is due to speculative trading .Their study suggests that excessive speculation is associated with an A-share price being traded at a premium, relative to the B-share price. Chen, Lee and Rui (2001) employ a return variance ratio between A- and B-shares to investigate changes in risk preferences. They find no statistically significant connection between B-share discounts and levels of risk. Their findings are consistent with Bailey, Chung and Kang (1999). Wang and Jiang (2004) argue that H-shares exhibit significant exposure to Hong Kong market factors and behave more like Hong Kong stocks than mainland Chinese stocks. However, H-shares retain significant exposure to their domestic market and therefore provide foreign investors with diversification opportunities. They also suggest that the time-varying H-share price discount, relative to A-shares, is highly correlated with the domestic and foreign market factors as well as relative market illiquidity.

The hedging for exchange rate hypothesis argues that investors want to protect themselves from unexpected movements in the exchange rates. Arquette, Brown and Burdekin (2008) examine the differences between the share prices of Chinese securities traded on the Shanghai Stock Exchange versus the prices in the Hong Kong Stock Exchange and the New York Stock Exchange. They find that the discounts in relation to home share prices are significantly influenced by changes in both exchange rate expectations and investor sentiment during the 1998 to 2006 period. They argue that expected exchange rate changes alone account for approximately 40% of the total variation. Their results also suggest that the cross-sectional variation in discounts is due to market-specific and company-specific sentiment effects. Cai, McGuinness and Zhang (2011) develop a non-linear Markov error-correction approach to examine the general co-integration relationship between H- and A-prices during the period 1999 to 2009. They focus on three dimensions of the relationship: (i) the long-run expectation of the H- (to A-price) discount; (ii) the level of short-run co-movement in prices; and (iii) the magnitude of error corrections. They also find similar evidence as Arquette, Brown and Burdekin (2008) that the H-discounts are related to the revaluation of the RMB; in other words, the exchange rate movement between the RMB and Hong Kong Dollar. Lastly, they suggest that the higher the H-discounts the higher the relative difference in the markets' information asymmetry and opinion divergence levels.

The information asymmetry theory states that foreign investors possess less information than local investors in the home market and therefore the discount represents a compensation for the asymmetric information. Chakravarty, Sakar and Wu (1998) argue that one reason for the large price discount of B-shares is because foreign investors have less information on Chinese stocks than domestic investors. They develop a model incorporating both informational asymmetry and market segmentation and derive a relative pricing equation for A-shares and B-shares. They show that their model-based proxies for informational asymmetry explain a significant portion of the cross-sectional variation of the B-share discounts. Their asymmetry includes for language barriers, different accounting standards, and the lack of reliable information regarding the aggregate economy as well as individual companies. They also find that the size of the B-share price discount is negatively related to the news coverage in the mainland home market. Karolyi and Li (2003) find that there is a negative relationship between information asymmetry and firm size, and that there is a statistically significant relationship between firm size and B-share discount variations.

The liquidity hypothesis suggests that illiquidity lowers security prices and is associated with price differentials amongst otherwise identical or essentially comparable securities. Amihud and Mendelson (1986) using a sample of U.S. stocks finds a positive relationship between the bid-ask spread and the average risk adjusted return. In addition, illiquid shares suffer higher trading costs and therefore are forced to reduce their price in order to provide higher expected returns. Chung and Wei (2005) examine the relationship between bid-ask spreads and holding periods across Chinese A- and B- shares and find that there is a positive relationship between holding periods and bid-ask spreads. They conclude that although liquidity plays a role in explaining the discount attached to B-shares the evidence is not conclusive. In contrast Chan, Hong and Subrahamanyam (2008) investigate the liquidity effect in asset pricing by studying the liquidity-premium relation of an ADR and its underlying share. They find that an increase in the ADR premium is associated with an increase in the liquidity of the ADR market and is also associated, to a lesser degree, with a decrease in home-share liquidity.

Although there is a large body of literature on this topic already, several potential factors have not been examined in regards to the H-share discount. One such issue is transparency. There are numerous studies documenting a correlation between greater corporate transparency and greater analyst coverage. Piotroski and Roulstone (2004) find that return synchronicity increases with analyst coverage. They interpret return synchronicity as a result of greater analyst coverage since specializing by industry encourages more industry-wide and market-wide information to be incorporated into stock prices. Using data from emerging markets Chan and Hameed (2006) report that greater analyst coverage increases return synchronicity and therefore increases the transparency of the corporation. Chang, Dasgupta and Hilary (2006) provide evidence that analyst coverage affects security issuance. They argue that firms covered by fewer analysts are less likely to issue equity as opposed to issuing debt. However, even though these firms tend to issue equity less frequently, when they do decide to issue equity they tend to do so in larger amounts. Moreover, these firms depend more on favorable market conditions for their equity issuance decisions. In addition, debt ratios of less covered firms are more affected by the "external finance-weighted" average market-to-book ratio. Their findings are consistent with the market timing behavior associated with information asymmetry, as well as the behavior implied by dynamic adverse selection models of equity issuance. Moreover, McNichols and O'Brien (1996) suggest that analysts tend to start covering companies when they believe the companies' near future prospects are optimistic. Analysts may drop coverage of a firm because the firm is no longer a good prospect for generating future investment banking or brokerage income. Alternatively, analysts may drop coverage because they become pessimistic about the firm or future share performance. Investors generally must infer the reason for dropped coverage. If investors typically emphasize the latter explanation when they initially interpret the coverage drop decision, they may over-react by selling shares and driving stock prices below fundamental values. The most plausible interpretation of this evidence is that investors respond to extreme losses in analyst coverage by selling shares in the coverage loss year and thus driving down stock prices. These studies suggest that analyst coverage plays an important role in transparency.

Aside from the role that analyst coverage plays in the role of corporate governance and transparency, institutional shareholders can also contribute to better governance and more transparency. Shleifer and Vishny (1986) find that monitoring by large external shareholders like institutions reduces the agency costs of equities by effectively controlling managers' decisions that are in conflicts with shareholders' interests. Choi and Seo (2008) find that firms with higher level of institutional ownership exhibit higher accounting transparencies and institutional monitoring curbs managers' opportunistic behaviors associated with investing, financing, and operating activities as well as accounting reporting activities. These papers suggest that institutional shareholders have an important role in transparency. This study examine institutional shareholders', particularly, mutual funds'[19] role in the price differential between Chinese A-share and Hong Kong H-share.

[19] Due to the availability of data I was able to examine mutual funds for A-shares; unfortunately, data for mutual funds of H-shares is not available.

3. Background Information Concerning the Share Structure in China

China began to open its economy in 1978. After the successes of farm liberalization in the 1980's China began to shift its focus to building stronger financial markets. To that end they opened the Shanghai Stock Exchange on December of 1990. It was followed in 1991 (a year later) by the Shenzhen Stock Exchange.[20] Most of the original companies listed on the two exchanges were state-owned enterprises. The first shares traded on the exchanges were A-shares. A-shares are denominated in Renminbi (RMB) and are issued to local investors. In 1992 the two exchanges also began trading B-shares. B-shares are denominated in U.S. dollars and allowed foreigners, for the first time, to own and trade shares on the two mainland exchanges.

During this initial start-up period, the Hong Kong Stock Exchange had already established itself as a major figure in the Asian financial markets. China knew of Hong Kong's ability to raise large amount of capital and soon approached the Hong Kong Exchange with an offer. In 1993 China brokered a deal between the Hong Kong Exchange and the two mainland exchanges called the Memorandum of Regulatory Co-operation. This allowed Chinese businesses to be listed directly on the Hong Kong Exchange. Since Hong Kong begins with the letter "H" the new shares were known as H-shares.

H-shares are stocks traded on the Hong Kong stock market and are denominated in Hong Kong dollars. In order to sell H-shares companies must meet certain requirements: (1) the company must be incorporated in mainland China; (2) the company must have a market capitalization of HK $200 million; (3) the company must have earned, 3 years prior to application, a profit of HK $5 billion; this means a profit of HK $2 billion the year before the

[20] Shenzhen was designated by the state as a special economic zone in 1980. The stock exchange extended its growing financial flexibility.

application and a total profit of HK $3 billion the two years prior to that; and (4) during the 3 year period prior to application management must have remained unchanged.

A-shares generally trade at a premium to H-shares, and this might be partially due to the fact that the Chinese government restricts mainland Chinese from investing abroad and foreigners from investing in the H-share market in mainland China. In mainland China, there are three ways for individual investors to invest in H-shares: (1) individual investors can travel to Hong Kong to set up an account in Hong Kong to buy H-shares; (2) individual investors can buy H-shares through Hong Kong brokerage companies that have offices in China; (3) in selected cities, individual investors can purchase H-shares using a special service called "H-share Express" provided by the Bank of China.

In contrast, institutional investors on the mainland, such as mutual funds and social security funds, can invest in H-shares. State social security funds are large players in the Hong Kong market. However, Hong Kong and international investors can only invest in H-shares. According to the trading regulations in mainland China, Hong Kong and international investors are restricted to investing in A-Shares.

Historically Chinese domestic A-shares are divided into tradable and non-tradable shares, even though both types of shares have the same cash flow and voting rights. This unique split-share structure can result in divergent interests and incentive conflicts between tradable and non-tradable shareholders. It has long been recognized as a source of corporate governance problems in China. To help solve these fundamental governance problems, the Chinese government initiated a split-share structure reform program in April 2005. The aim of the reform was to convert non-tradable shares into tradable shares. The non-tradable shareholders gained from the reform as their shares become tradable (this increased liquidity and enabled controlling shareholders to sell at market prices). In contrast, tradable shareholders suffered in the short term since there was an extra supply of tradable shares in the market, and this lead to a steep decline in stock prices.

The roles of state shareholders and mutual funds in this reform are particularly interesting. The state is the largest non-tradable shareholder, while mutual funds are the largest type of institutional investor for tradable shares in China's stock market. Thus, non-tradable shareholders need to offer compensation to tradable shareholders (including mutual funds) in order for the latter to agree to the reform. In theory, the interests of mutual funds should align with the interests of individual investors for tradable shares. Individual investors can therefore free-ride on the efforts of mutual funds in the belief that the funds will be looked after. However, in recent research (Mehran and Stulz (2007)), it has been shown that the incentives facing financial institutions are complex and conflicts of interest and political pressures often arise. Regarding mutual fund growth in China, since 2000, the growth of the industry has been phenomenal. The voting rules set out by the CSRC[21] Measures (2000) make mutual funds a powerful and influential party in the bargaining process because mutual funds frequently appear in the top-ten shareholders of many listed companies. The attitudes of the mutual fund shareholders were therefore crucial to the passing of the proposed reform plan. As such, it is interesting to examine the impact that mutual fund shareholders have on a firm's transparency and corporate governance, as well as the relative pricing of A-and H-shares.

[21] China Securities Regulatory Commission

4. Variables and Summary Statistics

This study particularly focuses on how liquidity and transparency impact the relative pricing of A-and H-shares. In terms of liquidity, I examine three different measures: Amihud illiquidity measure, turnover ratio measure, and infrequent trading of H-share. In terms of transparency, I examine accounting transparency (or auditor quality), analyst following, and percentage of a firm's share hold by mutual funds. The first part of this section describes the sample data used in this study and how variables of interest are constructed. Then, the second part of this section presents the summary statistics for variables of interest and analyzes the correlations of these variables.

4.1. Data and Variables

The initial sample is constructed using all cross-listed A- and H-shares in both the Shanghai and Shenzhen Stock Exchange for the period of 2003 to 2011. For a firm to be included in the sample, it must have daily price data, daily trading volume, shares outstanding, and analyst following data available for both the A-and H-share market. Moreover, firms are also required to have monthly mutual fund holdings data for A-shares. Additionally, for each firm in the sample I collect financial data such as tradable A- and H-share size, which is defined as the market value of A- and H-shares. Since H-shares are denoted in Hong Kong dollars, I convert their amounts to Renminbi. A detailed list of all the variables and the sources can be found in the Appendix. The final sample covers 68 firms and spans from January 1st, 2003 to December 31st, 2011. Table I reports the sample firms and their respective industries and listing dates for the A- and H-shares markets.

Table I Sample Company Information

This table provides the basic information for the dual-listed A- and H-shares included in the sample. Column 1 provide the name of the company, column 2 provides the respective industry, column 3 provides the listing date on the Shanghai or Shenzhen Stock Exchange, and column 4 provides the listing date on the Hong Kong Stock Exchange.

Company Name	Industry	A List Date	H List Date
ZTECorporation	Communications and Related Equipment Manufacturing	11/18/97	12/9/2004
Zoomlion Heavy Industry Science And Technology Co., Ltd.	Special Equipment Manufacturing	10/12/2000	12/23/2010
Weichai Power Co., Ltd.	Transportation Equipment Manufacturing	4/30/2007	3/11/2004
Shandong Chenming Paper Holdings Ltd.	Paper and Allied Products	11/20/2000	6/18/2008
Northeast Electric Development Co., Ltd.	Electrical Machinery and Equipment Manufacturing	12/13/1995	7/6/1995
Jingwei Textile Machinery Co., Ltd.	Special Equipment Manufacturing	12/10/1996	2/2/1996
Shandong Xinhua Pharmaceutical Co., Ltd.	Medicine Manufacturing	8/6/1997	12/31/1996
Angang Steel Company Limited	Ferrous Metal Smelting and Extruding	12/25/1997	7/24/1997
Hisense Kelon Electrical Holdings Company Limited	Electrical Machinery and Equipment Manufacturing	7/13/1999	7/23/1996
Xinjiang Goldwind Science&Technology Co.,Ltd	Electrical Machinery and Equipment Manufacturing	12/26/2007	10/8/2010
Shandong Molong Petroleum Machinery Co. Ltd.	Special Equipment Manufacturing	10/21/2010	2/7/2007
BYD Co., Ltd	Other Manufacturing	6/30/2011	7/31/2002
Huaneng Power International Co., Ltd	Electric Power, Steam and Hot Water Generation and Supply	12/6/2001	1/21/1998
Anhui Expressway Co., Ltd	Support Service for Transportation	1/7/2003	11/13/1996
China Minsheng Banking Co., Ltd.	Banking	12/19/2000	11/26/2009
China Shipping Development Co., Ltd	Water Transportation	5/23/2002	11/11/1994
Huadian Power International Co., Ltd.	Electric Power, Steam and Hot Water Generation and Supply	2/3/2005	6/30/1999
China Petroleum & Chemical Corporation	Oil and Gas Extraction	8/8/2001	10/19/2000
China Southern Airlines Co., Ltd	Air Transportation	7/25/2003	7/31/1997
China Merchants Bank Co., Ltd	Banking	4/9/2002	9/22/2006
China Eastern Airlines Co., Ltd.	Air Transportation	11/5/1997	2/5/1997
Yanzhou Coal Mining Co., Ltd.	Coal Mining and Quarrying	7/1/1998	4/1/1998
Guangzhou Pharmaceutical Co., Ltd.	Medicine Manufacturing	2/6/2001	10/30/1997
Jiangxi Copper Co., Ltd.	Non-Ferrous Metal Smelting, Rolling, Drawing, and Extruding	1/11/2002	6/12/1997
Jiangsu Expressway Co., Ltd	Support Service for Transportation	1/16/2001	6/27/1997
Shenzhen Expressway Co., Ltd	Support Service for Transportation	12/25/2001	3/12/1997
Anhui Conch Cement Co.,Ltd	Non-metallic Mineral Products	2/7/2002	10/21/1997
Tsingtao Brewery Co., Ltd.	Beverages	8/27/1993	7/15/1993
Guangzhou Shipyard International Co., Ltd.	Transportation Equipment Manufacturing	10/28/1993	8/6/1993
Sinopec Shanghai Petrochemical Co., Ltd.	Petroleum Processing & Coking	11/8/1993	7/26/1993
Nanjing Panda Electronics Co., Ltd.	Communications and Related Equipment Manufacturing	11/18/1996	5/2/1996
Shenji Group Kunming Machine Tool Co.,Ltd	Special Equipment Manufacturing	1/3/1994	12/7/1993
Maanshan Iron & Steel Co., Ltd.	Ferrous Metal Smelting and Extruding	1/6/1994	11/3/1993
Beiren Printing Machinery Holdings Ltd.	Special Equipment Manufacturing	5/6/1994	8/6/1993
Sinopec Yizheng Chemical Fibre Co., Ltd.	Chemical Fibre Manufacturing	4/11/1995	3/29/1994
Tianjin Capital Environmental Protectiongroup Co., Ltd.	Public Facilities Services	6/30/1995	5/17/1994

Dongfang Electric Corporation Limited	Electrical Machinery and Equipment Manufacturing	10/10/1995	6/6/1994
Luoyang Glass Co., Ltd.	Non-metallic Mineral Products	10/31/1995	7/8/1994
Chongqing Iron & Steel Company Limited	Ferrous Metal Smelting and Extruding	2/28/2007	10/17/1997
China Shenhua Energy Company Limited	Coal Mining and Quarrying	10/9/2007	6/15/2005
Sichuan Expressway Company Limited	Support Service for Transportation	7/27/2009	10/7/1997
Air China Limited	Air Transportation	8/18/2006	12/15/2004
China Railway Construction Corporation Limited	Civil Engineering Construction	3/10/2008	3/13/2008
Agricultural Bank Of China Limited	Banking	7/15/2010	7/16/2010
Ping An Insurance (Group) Company Of China, Ltd.	Insurance	3/1/2007	6/24/2004
Bank Of Communications Co., Ltd.	Banking	5/15/2007	6/23/2005
Guangshen Railway Company Limited	Railroad Transportation	12/22/2006	5/14/1996
China Railway Group Limited.	Civil Engineering Construction	12/3/2007	12/7/2007
Industrial And Commercial Bank Of China Limited	Banking	10/27/2006	10/27/2006
Beijing North Star Company Limited	Estate Development and Operation	10/16/2006	5/14/1997
Aluminum Corporation Of China Limited	Nonferrous Metal Mining	4/30/2007	12/12/2001
China Pacific Insurance (Group) Co., Ltd.	Insurance	12/25/2007	12/23/2009
Shanghai Pharmaceuticals Holding Co.,Ltd.	Medicine Manufacturing	3/24/1994	5/20/2011
Metallurgical Corporation Of China Ltd.	Civil Engineering Construction	9/21/2009	9/24/2009
China Life Insurance Company Limited	Insurance	1/9/2007	12/18/2003
Shanghai Electric Group Company Limited	Electrical Machinery and Equipment Manufacturing	12/5/2008	4/28/2005
China South Locomotive & Rolling Stock Co., Ltd.	Transportation Equipment Manufacturing	8/18/2008	8/21/2008
China Oilfield Services Limited	Oil and Gas Extraction	9/28/2007	11/20/2002
Petrochina Company Limited	Oil and Gas Extraction	11/5/2007	4/7/2000
China Shipping Container Lines Company Limited	Water Transportation	12/12/2007	6/16/2004
Dalian Port (Pda) Co., Ltd.	Port	12/6/2010	4/28/2006
China Coal Energy Company Limited	Coal Mining and Quarrying	2/1/2008	12/19/2006
Zijin Mining Group Co., Ltd.	Nonferrous Metal Mining	4/25/2008	12/23/2003
China Cosco Holdings Company Limited	Water Transportation	6/26/2007	6/30/2005
China Construction Bank Corporation	Banking	9/25/2007	10/27/2005
Bank Of China Limited	Banking	7/5/2006	6/1/2006
Datang International Power Generation Co., Ltd.	Electric Power, Steam and Hot Water Generation and Supply	12/20/2006	3/21/1997
China Citic Bank Corporation Limited	Banking	4/27/2007	4/27/2007

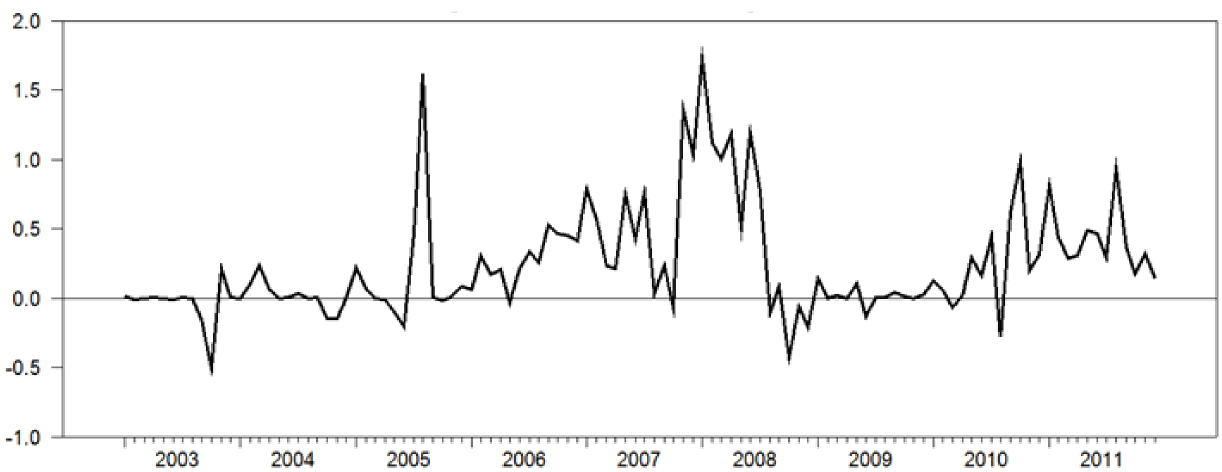
The change in exchange rate of Hong Kong Dollars to one Renminbi (HKD/RMB) is calculated as monthly variations in the change of exchange rates.[22] Figure I plots the change of exchange rate (in percentage) between the Hong Kong Dollar and the Renminbi over the 2003 to 2011 period. Figure I suggests that exchange rate may be one important reason for changes in

[22] I also calculated the change of implied exchange rate using the implied exchange rate. It is similar to the change of exchange rate.

the H-share discount since exchange rate policy seems to be going through considerable changes over that period. Indeed, Arquette, Brown and Burdekin (2008) find that the differences between the share prices of Chinese securities traded on the Shanghai Stock Exchange versus the prices in the Hong Kong Stock Exchange and the New York Stock Exchange are significantly influenced by changes in exchange rate expectations during the 1998 to 2006 period.

Figure I. Change in the Renminbi Exchange Rate: January 2003 - December 2011

The change in exchange rate of Hong Kong Dollars to Renminbi (HKD/RMB) is calculated as monthly variations in the change of exchange rates. The following times series plot this change in percentage over the period from January 2003 to December 2011.



I also plot the price differential of A- and H-share during the 2003 to 2011 period. First, the discounts or premiums are computed as follow:

$$Discount\_H_{i,t} = \frac{P^H_{i,t} \times \left({}^{RMB}/_{HKD} \right)}{P^A_{i,t}} \text{-1}$$

where $Discount_{i,\,t}$ is the discount (premium) for H-shares i if it is negative (positive). $P^H_{i,t}$ is the H-share price from the Hong Kong Stock Exchange, ${}^{HKD}/_{RMB}$ is the exchange rate for Hong

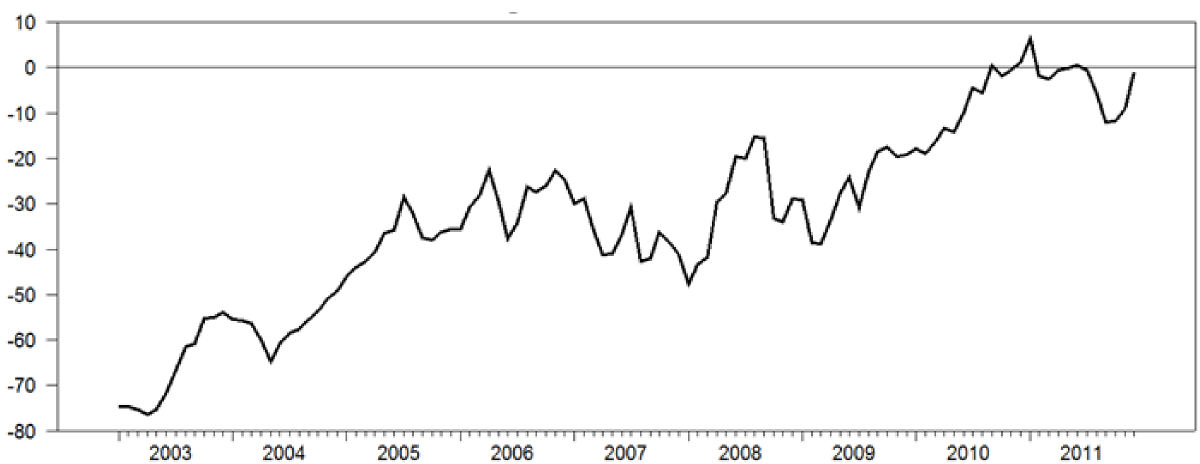
Kong dollars to one Renminbi, and $P_{i,t}^{A}$ is the underlying A-share price from the Shanghai and Shenzhen Stock Exchange. After computing the daily discount for each H-share, I compute the average for each month to get its monthly discount. Figure II plots the average monthly H-share

Figure II. Average H-share Discount: January 2003 - December 2011

The discounts or premiums are computed as follow:

$$Discount\_H_{i,t} = \frac{P_{i,t}^{H} \times \left(RMB/_{HKD}\right)}{P_{i,t}^{A}} - 1$$

where $Discount_{i,t}$ is discount (premium) for H-shares i, if it is negative (positive). $P_{i,t}^{H}$ is the H-share price from Hong Kong stock exchange, $HKD/_{RMB}$ is the exchange rate for Hong Kong dollars to Renminbi, and $P_{i,t}^{A}$ is the underlying A-share price from the Shanghai and Shenzhen stock exchange. After computing the daily discount for each H-share, I compute the average for each month to get its monthly discount.



discount over the sample period. It is apparent from the plot that the H-share discount is shrinking over time. In the beginning of 2003, the average H-share discount is almost 80%, contrasted with the mid-2010s when the average H-share premium is slightly more than 5%. This is consistent with the fact that the Chinese government has relaxed constraints and allowed more Chinese citizens to invest in H-shares. This also suggests that the appreciation of the Renminbi may have an effect that lowers the H-share discount. The role of changes in the exchange rate between the Hong Kong Dollar and the Renminbi will be incorporated in the analysis.

Next, I calculate the three liquidity measures: the Amihud illiquidity measure for both A- and H-shares, the turnover ratios for both A- and H- shares, and the infrequency of trading measure of H-shares. The Amihud (2002) measure of illiquidity is computed from the A- and H-market daily price and volume data. For H-shares, I begin by calculating the measure daily, when there is trading. Then I average these measures across all trading days of each month to obtain the monthly measure:

$$Illiqudity_{i,t} = \frac{1}{D_t} \sum_{d=1}^{D_t} \frac{|R_{i,\, d}|}{Vol_{i,d}}$$

where D_t is the number of trading days in month t, $R_{i,\, d}$ is the daily return of share i on day d (within month t), and $Vol_{i,d}$ is the trading volume of share i on day d, defined as number of shares traded times the H-share price on day d. The measure is computed for A-and H- markets in the same way. The daily money trading volume for the H-shares market is converted into Renminbi at the corresponding spot exchange rate on day d in order to ensure the liquidity measure is calculated on the same basis.

Amihud illiquidity measures the price impact aspect of liquidity and quantifies the price/return response to a given size of trade. Liquidity, also has another aspect – trading. To address this aspect, I use the turnover ratio as an alternative liquidity measure and perform a similar analysis. The turnover ratio measures trading activity of the stocks and is adjusted by the number of shares outstanding in each market available for trading. The monthly turnover ratio is defined as the average of daily turnover ratios in each month. The turnover ratio for H-shares is calculated as follow:

$$Turnover\ Ratio_{i,t} = \frac{1}{D_t}\sum_{d=1}^{D_t}\frac{Vol_{i,d}}{Outstanding_{i,d}}$$

where $Vol_{i,d}$,is the number of i shares traded and , $Outstanding_{i,d}$ is the total i shares outstanding on day *d* in the market. The measure is computed for A-and H- markets in the same way, as well.

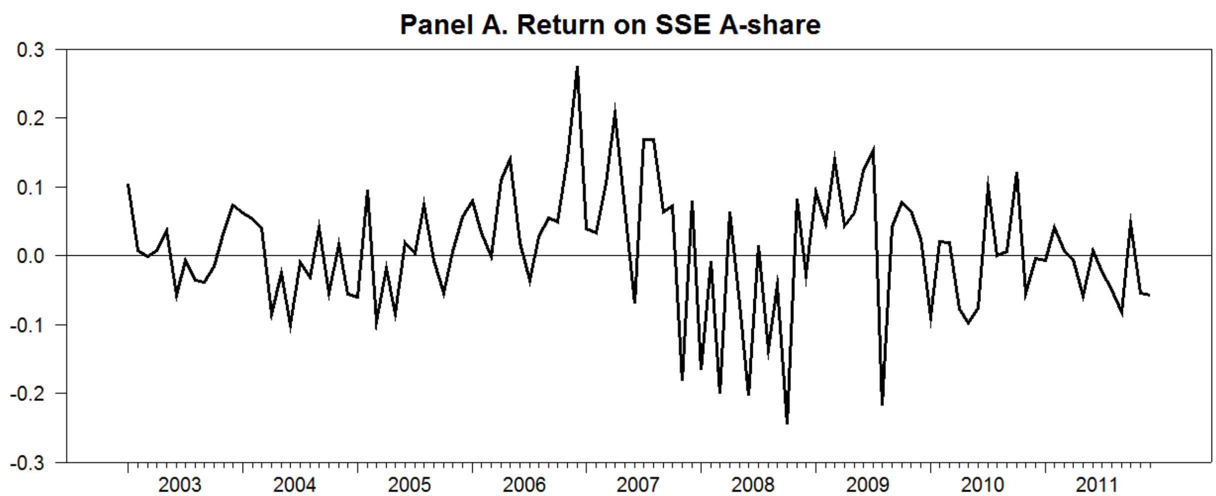
Furthermore, in some extreme situations, H-shares are so illiquid that there is virtually no trading at all during a regular trading day in the Hong Kong market. In a way, this type of trading infrequency captures another aspect of illiquidity. Therefore, I construct another variable, the monthly trading "infrequency," defined as the number of days that the H-share is not traded at all; specifically, it is computed as zero trading activity days divided by the total number of trading days in the month. This trading infrequency is typically an issue only for the H-shares, but not for their A-shares counterparts since the underlying shares in the home markets are generally more actively traded in the local markets. Hence, it is only necessary to compute this variable for H-shares.

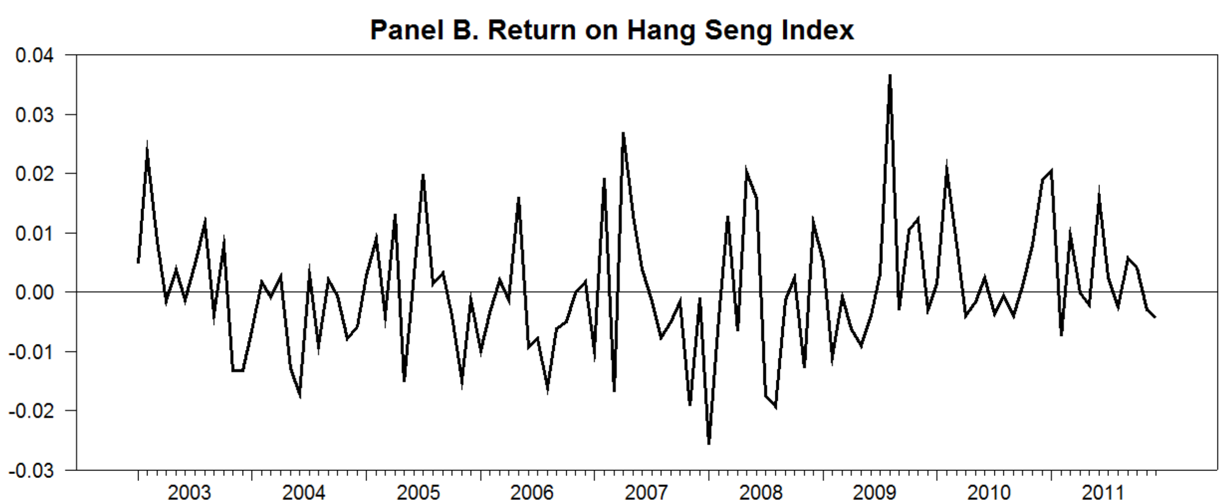
As mentioned earlier, regarding transparency, I examine accounting transparency (or auditor quality), analyst following, and percentage of a firm's share hold by mutual funds. The analyst coverage is collected for both A- and H-shares, defined as the number of analysts providing one-year earnings forecasts at any time over a one-month period. Mutual fund holding is defined as the number of shares of a firm held by mutual funds divided by the total number of shares at the end of the period.

Additionally, I calculate the market performance measure, which reflects relative market-wide performance across two markets, measured as the relative performance of the two cross market indices for the Chinese A-shares market. This relative market performance measure is

Figure III. Movement of Market Indices

Panel A plots the return on SSE A-share Index. The base day for the SSE A-share Index is December 19, 1990. The base period is the total market capitalization of all A-shares of that day at a base value of 100. The index was launched on February 21, 1992. Panel B plots the return on Hang Seng index as the market proxy for the Hong Kong market.





later used as a control variable.[23] To this end, I use the SSE A-share Index and Hang Seng Index for Chinese mainland and Hong Kong stock markets, respectively. The base day for the SSE A-share Index is December 19, 1990. The base period is the total market capitalization of all A-shares on that day at a base value of 100. The data of this index was publicly available on February 21, 1992. For the Hong Kong market, I choose the Hang Seng Index as the market proxy. Figure III Panels A and B plot the returns of the two indexes over the sample period. As shown in the figure, for most of the sample period the two indices have similar patterns of general movement, but they do experience ups and downs differently as well as differences in magnitude. I later incorporate this relative market performance measure in the analysis for the price differential between A- and H-shares.

4.2. Summary Statistics and Correlations between Liquidity, Transparency and Size

Table II provides summary statistics for the 68 firms in the sample. The sample period is from January 2003 to December 2011. The average (median) total asset is 1,102,470.00 (76,912.96) millions of Renminbi. The average (median) total liabilities is 991,832.00 (41,644.26) millions of Renminbi. The average (median) market capitalization is 39,567.80 (14,316.90) millions of Renminbi. The mean of tradable A-share is 15,681.03 millions of shares almost twice of the mean of tradable H-shares (8,745.80 millions of shares).

[23] Previous studies tended to use the SSE Composite Index. Constituents for the SSE Composite Index include all listed stocks, both A- and B-shares, on the Shanghai Stock Exchange. However, this index cannot accurately reflect the performance of the A-share market.

Table II Summary Statistics for the Sample Company

Table II contains descriptive statistics of the 68 sample firms dual-listed in the A- and H-share market during the years 2003-2011. Total assets are obtained from the Hong Kong Stock Exchange. Cashflow s are obtained from operations cash flow generated from operating activities and are measured as a ratio relative to the total assets of the firm. Operating revenue is Sales minus Cost of Goods Sold (and other expenses), before depreciation and amortization. Debt ratio is measured as the ratio of the short-term and long-term debt to the total assets of the firm. Items are in millions of RMBs. Tradable A-share size is number of outstanding A-shares (in millions), while tradable H-share size is number of H-shares (in millions).

Variable	Maximum	Minimum	Mean	Median	Std Deviation
Total Asset	15476900.00	557.05	1102470.00	76912.96	3064500.00
Long Term Debt	180675.00	0.00	27504.46	9042.46	42053.88
Cash And Cash Equivalents	2762156.00	56.68	181576.38	7918.48	571080.97
Total Liabilities	14519000.00	295.05	991832.00	41644.26	2879280.00
Total Shareholders' Equity	1082570.00	78.71	110634.00	28087.92	227508.00
Total Liabilities and Shareholder's Equity	15476900.00	557.05	1102470.00	76912.96	3064500.00
Market Capitalization	1015780.00	139.47	39567.80	14316.90	124812.00
Total Profit	272311.00	-6805.55	23079.94	3035.10	54257.25
Total Operating Revenue	271000.00	-7807.39	22730.63	2873.73	54100.76
Net Profit	208445.00	-8838.83	17834.58	2446.03	41922.51
Basic Earnings per Share	3.36	-1.02	0.58	0.43	0.71
Net Cash Flow From Operating Activities	348123.00	-13480.35	33978.48	1872.31	77217.37
Total Number of Shares Outstanding	349083.00	398.92	29356.67	6771.08	72917.20
State Shares	268485.00	0.00	4421.00	0.00	32303.18
Tradable A Shares	262289.00	72.62	15681.03	3627.39	43233.64
Tradable H Shares	214837.00	100.00	8745.80	1431.03	29314.80

Table III Panel A provides summary statistic characteristics of the liquidity measure, the transparency measure, and the firm size in A- and H-shares respectively. The mean and median Amihud measures for H-shares are almost 10 times larger than those of the A-shares. This implies that H- shares are generally more illiquid than their underlying A-shares. This pattern is also confirmed by the measure of trading activity, the turnover ratio. The mean and median of the turnover ratios are much higher for the A-shares market than those of the H-shares market, implying that the trading is more active in the A-shares market. In addition the average number of analysts following a firm in the A-shares market is 3, and the corresponding number in the H-shares market is 1. In other words, the average analyst coverage for A-shares is 3 times that of H-shares. Further, the size of A-shares is generally larger than that of H-shares as well. The average mutual fund holding is 2.49% of outstanding A-shares for the sample firm. Unfortunately, the corresponding information for the H-share market is not available. Table III Panel B provides results of the nonparametric Mann-Whitney Rank test to examine the difference of Amihud measure, turnover ratio, number of analyst, and size between A-and H-shares. For these four measures, the difference between A-and H-shares are statistically significant.

Table III Characteristics of A and H Shares

This table provides the basic statistics for the Amihud measure, turnover ratio, infrequency of trading, mutual fund holdings, analyst coverage, and size characteristics of A- and H-shares. The sample includes 68 pairs of H-shares and corresponding A-shares in the home market from 2003 to 2011. Individual H-shares and A-shares' Amihud liquidity measures are defined as the ratio of absolute daily return and dollar volume. Daily measures are then averaged to provide a monthly series. Amihud measures are scaled by 100,000. Turnover is defined as the number of shares traded divided by the total number of shares outstanding. H-shares trading infrequency is obtained by dividing the number of days that H-share are not traded by the number of trading days in a given month. Analyst coverage is defined as the maximum number of analysts following a firm in a given month. A-or H-share size are defined as the market value of A-share or H-share (in millions of RMB). A mutual fund holding is the percentage of firms shares hold by mutual funds. Panel A provides the time series averages of the monthly cross-sectional mean, median, standard deviation, maximum, and minimum values. Panel B provides results of the nonparametric Mann-Whitney Rank test (or Wilcoxon Rank Sum) for Amihud measure, turnover ratio, number of analyst, and size between A-and H-shares .Panel C provides the time series averages of the monthly correlations among the measures (***, ** and * denote significance level of 1%, 5%, and 10%).

Panel A: Summary Statistics

	Mean	Median	Std. Dev	Max	Min
A-share Amihud Measure	0.0010	0.0002	0.0027	0.0712	0.0000
A-share turnover	0.0214	0.0138	0.0300	1.0400	0.0001
A-share number of analysts	2.9600	1.0000	5.4300	56.0000	0.0000
A-share mutual fund holding (%)	2.4900	0.9690	4.0300	33.4000	0.0000
A-share size (in RMB)	44600	6890	152000	1940000	117
H-share Amihud Measure	0.1030	0.0005	1.7100	60.9000	0.0000
H-share turnover	0.0093	0.0071	0.0094	0.1770	0.0000
H-share number of analysts	1.1400	1.0000	1.4100	11.0000	0.0000
H-share trading infrequency	0.0208	0.0000	0.0583	0.9520	0.0000
H-share size (in RMB)	39000	5730	114000	1710000	59.8

Panel B: Testing the Difference between A-and H-shares

A-and H-shares Difference	Amihud Measure	Turnover Ratio	Number of analyst	Size
Mean	-21.71***	32.43***	-7.54***	5.02***
Median	-15.99***	27.39***	0.06	3.24***

Panel C: Correlations

Correlations (A share)	A-share turnover	A share number of analysts	A-share size	A-share mutual fund holding (%)
A-share Amihud Measure	-0.0940***	-0.1679***	-0.1025***	-0.1897***
A-share turnover		-0.0340**	-0.1473***	-0.0891***
A-share number of analysts			0.2078***	0.1989***
A-share size (in RMB)				0.0219
Correlations (H share)	H-share turnover	H-share number of analysts	H-share size	H-share trading infrequency
H-share Amihud Measure	-0.0559***	-0.0101	-0.0204	0.3448***
H-share turnover		0.0750***	-0.1022***	-0.0816***
H-share number of analysts			0.1505***	-0.1097***
H-share size (in RMB)				-0.1006***

Table III Panel C provides the correlation coefficients among the liquidity measures, the transparency measure, and the size of the H-shares and underlying home shares. For A- shares, the Amihud measure is negatively correlated with the turnover ratio, analyst coverage, mutual fund holdings, and the size of A-shares; the analyst coverage is positively correlated with mutual fund holdings as well as the size of A-shares. These results are consistent with the notion that liquidity is positively related to analyst coverage and mutual fund holding. However, the turnover ratio in the A-shares market is negatively correlated with analyst coverage, mutual fund holdings, and the size of the A-shares. This result is counter-intuitive. A possible reason is that some of the trading may come from excessive speculation or insider information; if so, analyst and mutual funds might avoid these shares. To the extent this explanation is true it suggests that turnover is a noisy indicator of liquidity. For H-shares the results are similar, but with one exception. Namely, the correlation between the number of analysts and turnover ratio is negative, which is consistent with the results of empirical studies that liquidity and transparency tend to be positively related. This is not true for the A-share market perhaps because, as previously argued, there is excessive speculation in the A-share market. Moreover, the negative correlation between H-share analyst coverage and H-share trading infrequency also indicates that less active trading activity is associated with little analyst coverage.

5. Methodology and Empirical Results:

There is considerable support in the literature in regards to the Big 4 auditors providing higher audit quality and therefore more transparency. Fan and Wong (2005) show that the Big 4 auditors provide a corporate governance role in emerging Asian markets. Gul, Kim and Qiu (2010) show greater stock price informativeness in firms audited by the Big 4 auditors in China. The alternative analysis is to include Big 4 as a dummy in the regression analysis; however, including it in a fixed effect regression might be problematic since the auditor information is only available as annual data.[24] Therefore, I categorize the firms into those audited by local auditors and those audited by Big 4 auditors in order to proxy for less transparent and transparent firms. I find that firms audited by the Big 4 are generally associated with smaller H-share discounts, higher mutual fund holdings, a higher number of A- and H-share analysts, and higher liquidity. Table IV reports the year by year and full sample period mean and median statistics of these two groups. I perform a non-parametric Mann–Whitney U test to test the difference in mean and median between local auditors and Big 4 auditors groups on a year by year basis. The yearly basis analysis is aimed to capture the group difference as much as possible. Since the H-shares discount also exhibits time-varying changes, as shown in Figure II, year by year analysis will mitigate the potential time-varying effect and offer a clear picture of the difference between the local auditors and Big 4 auditors groups.

Table IV shows that average H-share discounts are lower for Big 4 auditors through the entire sample, with the difference between the two groups both statistically significant in mean and median. In addition, the Big 4 auditor group is also associated with higher average mutual fund holdings, with the difference between the two groups statistically significant for years 2003, 2004, 2005, 2008, 2010, & 2011. The Big 4 auditor group also is associated with higher average A-share analyst coverage, with the difference between the two groups statistically significant for years 2003, 2006, 2007, 2008, 2009, 2010, & 2011. Finally, the Big 4 is associated with higher average H-share analyst coverage, with the difference between the two groups statistically significant for years 2003-2011.These findings provide further evidence that transparency does indeed impact the price differentials between A- and H-shares.

[24] Fixed effect regression models involve subtracting group means from the regressors. This means that one can only include time-varying regressors in the model. Since Big 4 is a yearly dummy, it is not desirable to include it in the fixed effects model.

Table IV. Firms Audited by Big4 VS. Non-Big 4

Breaking the sample into two groups by auditors and by year: Big4=1if firms use Big 4 auditors and Big4=0 if the firms use local auditors. H-discount: $\left(= P_{i,t}^{H} \times \left({}^{RMB}/_{HKD}\right)/P_{i,t}^{A} - 1\right)$, $P_{i,t}^{H}$ or $P_{i,t}^{A}$ is the H-or A-share price for firm *i* in month *t*. Individual H-shares and A-shares' Amihud liquidity measures are defined as the ratio of absolute daily return and dollar volume. Daily measures are then averaged to provide a monthly series. Turnover is defined as the number of shares traded divided by the total number of shares outstanding. Trading infrequency is obtained by dividing the number of days that H-share are not traded by the number of trading days in a given month. A or H analyst number are number of analysts following a firm in A-or H-share market, and A mutual fund holding is the percentage of firms shares hold by mutual funds. A-or H-share size is defined as the market value of A- or H-share. The following table reports the year by year mean and median statistics for these two groups. The results of the nonparametric Mann-Whitney Rank test (or Wilcoxon Rank Sum) are specified in the panels. (***, ** and * denote significance level of 1%, 5%, and 10%)

		Hdiscount	Aamihud	Aturnover	Holding	Asize	Hamihud	Hturnover	Infrequency	Hsize	Aanalyst	Hanalyst
Year=2003												
Big4=0	Mean	-0.72760	3.63E-09	0.01404	0.02010	892658336	1.39E-07	0.00932	0.06052	1014653287	0.14815	0.06481
Big4=1	Mean	-0.56856	2.20E-09	0.01516	1.13637	2173589576	1.73E-08	0.01203	0.02960	4144140812	0.27619	0.33654
	Difference	-7.35***	5.51***	0.5789	-7.80***	-7.43***	5.82***	-1.94*	2.72***	-6.27***	-1.90*	-3.55***
Big4=0	Median	-0.75399	2.98E-09	0.01006	0.00000	646792282	7.26E-09	0.00824	0.04348	406212893	0.00000	0.00000
Big4=1	Median	-0.60382	1.14E-09	0.00979	0.22176	1459021429	1.92E-09	0.00873	0.00000	1474803671	0.00000	0.00000
	Difference	-7.09***	4.26***	0.24	-6.41***	-6.15***	4.02***	-0.71	2.06**	-4.26***	-1.84*	-3.52***
Year=2004												
Big4=0	Mean	-0.65768	5.82E-09	0.01402	1.25732	1017569795	1.80E-07	0.00683	0.05571	1484055366	0.29897	0.43299
Big4=1	Mean	-0.44530	2.31E-09	0.01457	1.85828	2676003409	1.43E-08	0.01029	0.04284	6311075273	0.26754	0.76754
	Difference	-9.05***	6.22***	-0.38	-2.62***	-7.75***	7.01***	-4.10***	1.06	-7.06***	0.30	-2.29**
Big4=0	Median	-0.69986	3.20E-09	0.01092	0.22438	590584615	1.51E-08	0.00501	0.04545	374000000	0.00000	0.00000
Big4=1	Median	-0.43084	1.04E-09	0.01093	0.79267	1635324394	1.19E-09	0.00757	0.04545	2834733156	0.00000	0.00000
	Difference	-8.56***	5.48***	-0.08	-1.54	-6.86***	5.72***	-2.51**	0.60	-5.62***	0.27	-1.82*
Year=2005												
Big4=0	Mean	-0.50313	6.62E-09	0.01789	0.97404	767325676	1.94E-07	0.00621	0.07473	1677841808	0.38824	0.48235
Big4=1	Mean	-0.24541	3.10E-09	0.01540	2.27862	2321431481	2.41E-08	0.00677	0.04849	6338587191	0.83740	0.86122
	Difference	-8.61***	7.15***	1.42	-4.08***	-7.27***	6.51***	-1.41	1.84*	-7.04***	-1.58	-2.92***

Big4=0	Median	-0.54310	5.39E-09	0.01275	0.54984	432198520	1.10E-08	0.00507	0.04762	329560000	0.00000	0.00000
Big4=1	Median	-0.22168	1.07E-09	0.01198	1.10243	1561835000	1.25E-09	0.00577	0.04762	3192907901	0.00000	0.00000
	Difference	-7.38***	6.69***	0.41	-2.85***	-7.19***	5.43***	-1.60	1.15	-6.88***	-1.14	-2.50*
Year=2006												
Big4=0	Mean	-0.47604	2.39E-09	0.03206	1.29914	892853058	3.80E-08	0.00742	0.03470	1572836221	0.82418	0.39560
Big4=1	Mean	-0.17004	7.51E-10	0.03337	1.98394	4691602059	1.46E-08	0.01039	0.03352	1.8867E+10	1.22481	1.33865
	Difference	-9.08***	8.57***	1.71*	-1.20	-9.62***	9.63***	-2.66***	0.48	-9.63***	-2.63***	-7.37***
Big4=0	Median	-0.57982	1.93E-09	0.02970	0.57795	472133333	1.66E-08	0.00519	0.00000	376736742	0.00000	0.00000
Big4=1	Median	-0.13471	3.82E-10	0.02567	0.48024	2234657143	6.93E-10	0.00780	0.00000	4325920359	0.00000	1.00000
	Difference	-6.66***	6.73***	2.35**	0.64	-7.39***	8.19***	-2.77***	0.73	-8.13***	-2.92***	-7.87***
year=2007												
big4=0	Mean	-0.48328	5.89E-10	0.04980	3.50367	6519158249	6.62E-09	0.01434	0.04575	7487773181	1.43119	0.45794
big4=1	Mean	-0.38234	2.86E-10	0.04267	2.89575	2.3692E+10	5.63E-10	0.01269	0.02773	7.8114E+10	1.89974	1.65229
	Difference	-5.37***	9.30***	2.39**	-0.53	-9.24***	10.88***	0.19	2.68***	-10.28***	-1.79*	-8.59***
big4=0	Median	-0.50310	3.65E-10	0.04473	1.88556	2288156367	2.60E-09	0.00914	0.04545	1218834058	0.00000	0.00000
big4=1	Median	-0.37287	7.63E-11	0.03594	1.09923	1.1389E+10	1.63E-10	0.01005	0.00000	1.2974E+10	0.00000	1.00000
	Difference	-4.67***	7.27***	1.63	0.54	-5.75***	7.93***	-0.76	2.82***	-7.71***	-1.17	-8.76***
year=2008												
big4=0	Mean	-0.53351	1.25E-09	0.02330	3.24822	7831529314	1.08E-07	0.01014	0.01578	9168012639	3.50000	1.22436
big4=1	Mean	-0.41150	4.49E-10	0.01902	3.12638	3.063E+10	1.32E-07	0.01060	0.01336	5.6793E+10	4.97474	1.59488
	Difference	-5.33***	6.98***	6.61***	1.96**	-9.21***	7.96***	-1.10	1.74*	-8.83***	-3.26***	-3.86***
big4=0	Median	-0.57303	4.47E-10	0.02033	1.87487	3340988381	1.95E-09	0.00825	0.00000	2393774760	1.00000	1.00000
big4=1	Median	-0.42100	1.76E-10	0.01261	1.27992	1.3151E+10	3.04E-10	0.00901	0.00000	1.4538E+10	2.00000	1.00000
	Difference	-4.40***	4.63***	6.11***	2.42**	-6.62***	5.00***	-1.27	1.65*	-5.51***	-2.50**	-3.12***
year=2009												
big4=0	Mean	-0.54520	4.56E-10	0.03812	2.75474	8630080303	5.63E-08	0.01585	0.01382	5810210034	2.34300	1.10244
big4=1	Mean	-0.37897	1.16E-10	0.02439	3.00480	5.5269E+10	5.90E-07	0.00990	0.00747	5.8111E+10	4.19008	1.51975

	Difference	-7.22***	10.37***	7.11***	-1.48	-11.21***	10.18***	6.71***	1.29	-12.17***	-6.38***	-5.12***
big4=0	Median	-0.58096	1.77E-10	0.02907	1.15075	3973218612	1.73E-09	0.01163	0.00000	1722016961	0.00000	0.00000
big4=1	Median	-0.40036	5.47E-11	0.01863	1.12335	1.7032E+10	1.97E-10	0.00808	0.00000	1.5484E+10	2.00000	1.00000
	Difference	-6.53***	8.07***	4.26***	0.27	-7.52***	7.74***	5.91***	1.31	-7.86***	-6.22***	-5.67***
year=2010												
big4=0	Mean	-0.44433	3.08E-10	0.02101	2.58307	1.2572E+10	7.61E-09	0.00888	0.00143	7518456897	2.62551	0.72083
big4=1	Mean	-0.23672	1.25E-10	0.01399	2.95193	1.2066E+11	2.26E-08	0.00666	0.00403	7.0293E+10	5.68327	1.43687
	Difference	-8.46***	11.00***	10.24***	-0.21	-12.56***	11.49***	4.98***	-0.35	-13.11***	-6.02***	-7.26***
big4=0	Median	-0.47811	1.78E-10	0.01593	1.46900	6703820455	1.56E-09	0.00707	0.00000	2386747000	0.00000	0.00000
big4=1	Median	-0.25797	5.27E-11	0.00729	1.19928	2.1848E+10	1.35E-10	0.00531	0.00000	2.1483E+10	2.00000	1.00000
	Difference	-6.14***	9.01***	9.16***	1.67*	-8.96***	8.85***	4.63***	-0.33	-9.74***	-4.65***	-7.38***
year=2011												
big4=0	Mean	-0.47994	4.81E-10	0.01306	1.51994	1.8957E+10	4.54E-08	0.00729	0.01194	7797835987	2.71681	0.62222
big4=1	Mean	-0.27652	1.93E-10	0.00907	2.84861	1.4295E+11	2.45E-08	0.00576	0.00659	7.9608E+10	4.58574	1.34354
	Difference	-8.80***	9.20***	5.60***	-4.91***	-10.51***	9.04***	2.45**	1.67*	-11.16***	-4.61***	-7.66***
big4=0	Median	-0.52860	2.17E-10	0.00672	0.79911	6899028021	1.40E-09	0.00594	0.00000	3203007300	1.00000	0.00000
big4=1	Median	-0.28309	7.12E-11	0.00457	1.21028	4.2076E+10	2.30E-10	0.00475	0.00000	1.5518E+10	2.00000	1.00000
	Difference	-7.01***	7.84***	4.24***	-2.48**	-6.55***	7.22***	2.21**	1.55	-9.36***	-4.00***	-7.80***
Full Sample												
big4=0	Mean	-0.53897	2.39E-09	0.02481	1.90669	6453352748	8.61E-08	0.00959	0.03493	4836852824	1.58623	0.61150
big4=1	Mean	-0.34615	1.06E-09	0.02085	2.45385	42784847392	9.33E-08	0.00945	0.02374	42064422586	2.65995	1.20570
	Difference	-9.00***	2.99***	2.43***	-2.51***	-2.29**	-0.10	0.13	2.88***	-3.78***	-3.10***	-5.60***
big4=0	Median	-0.58229	1.65E-09	0.02002	0.94794	2816324510	6.58E-09	0.00728	0.02022	1378987746	0.22222	0.11111
big4=1	Median	-0.33240	4.09E-10	0.01242	0.89210	12239131203	5.99E-10	0.00659	0.01034	9722160525	0.88889	0.55556
	Difference	-7.00***	2.53***	3.43***	0.02	-2.62***	3.04***	-0.25	1.51	-4.17***	-2.31**	-3.16***

Next, a panel approach is used to examine the extent to which variations of the discount attached to H-shares across time and firms are related to exchange rate, market return, liquidity effect, and transparency effect. More specifically, the independent variables include: the change in exchange rate of Hong Kong Dollars to one Renminbi to (HKD/RMB), the ratio of A- and H-shares' market return, the size ratio of A- and H-shares, the relative Amihud illiquidity measure of A-and H- share, the relative turnover ratio measure of A-and H- share, H share trading infrequency, the number of analysts for A-shares, the number of analysts for H-shares, and mutual fund holdings of A-shares.

The full model of the regression is specified as follow:

$$Discount_{H,it}=\beta_0+\beta_1\Delta Exchange\ Rate({}^{HKD}/_{RMB})_t+\beta_2{}^{A}/_{H}Market\ Return\ Ratio_t+$$
$$\beta_3{}^{A}/_{H}Share\ Size_{it}+\beta_4{}^{A}/_{H}Amihud\ Ratio_{it}+\beta_5{}^{A}/_{H}Turnover\ Ratio_{it}+\beta_6 H\ Trading\ Infrequency_{it}$$
$$+\beta_7\ No.A.Analyst_{it}+\beta_8\ No.H.Analyst_{it}+\beta_9 Mutual\ Fund\ Holdings_{it}+\varepsilon_{it} \qquad (1)$$

where $\Delta Exchange\ Rate({}^{HKD}/_{RMB})_t$ is the change in the exchange rate of Hong Kong Dollar to one Renminbi (1 RMB to X HKD), ${}^{A}/_{H}Market\ Return\ Ratio_t$ is the return on the Shanghai Composite A-share Index divided by the return on Hong Kong Hang Seng Index for month *t*, ${}^{A}/_{H}Share\ Size_{it}$ is the size of the A-shares for firm *i* divided by the size of the H-shares for month *t* , ${}^{A}/_{H}Amihud\ Ratio_{it}$ is A-share Amihud illiquidity measure divided by that of H-share, ${}^{A}/_{H}Turnover\ Ratio_{it}$ is A-share turnover ratio divided by that of H-share adjusted by number of outstanding shares in each market, $No.A.Analyst_{it}$ and $No.H.Analyst_{it}$ are numbers of analysts following firm *i* in month *t* for A-and H-share markets respectively, and $Mutual\ Fund\ Holdings_{it}$ is the percentage of firm *i*'s A-shares held by mutual funds in month *t*.

Table V presents the results of employing this model to explain the H-share discount with and without allowance for company-specific fixed effects.[25] The negative coefficients indicate that the variables in question have the effect of making the H-share discount bigger, i.e., more negative. The panel analysis first looks at aggregate effects such as change in the exchange rate, relative market performance, and then focuses on firm-level relative liquidity and transparency effects. The regression results presented in Table V consist of 68 firms for the period of January 2003 to December 2011. The number of total observation is 4,695.

[25] The choice for using a fixed effects model is based on the results of the Hausman test. The Hausman specification test compares the fixed versus random effects under the null hypothesis that the individual effects are uncorrelated with the other regressors in the model. Based on my test results the null hypothesis is rejected; therefore, a random effects model produces biased estimators. So, a fixed effects model is preferred.

Table V. Panel Regression of H-share Discount

The dependent variable is H-share discount: $\left(= P_{i,t}^{H} \times \left({}^{RMB}/_{HKD}\right)/P_{i,t}^{A} - 1\right)$, $P_{i,t}^{H}$ or $P_{i,t}^{A}$ is the H-or A-share price for firm *i* in month *t*. Δ Exchange Rate is the change in the exchange rate of HK Dollars against 1 RMB. A/H market return is the return on the Shanghai Composite A-share Index divided by that of Hong Kong Hang Seng Index, A/H Share Size is the A-share market value divided by that of H-share, A/H Amihud is A-share illiquidity divided by H-share illiquidity, A/H Turnover is the A-share turnover ratio divide by that of H-share, H trading infrequency is the fraction of zero trading days in month t for H-share, No.A.Aanlysts and No.H.Aanlysts are numbers of analysts following a firm in A-or H-share market, and mutual fund holdings (A) is the percentage of firms shares held by mutual funds. All data is monthly data. Models (1)-(11) are pooled regressions, and (12)-(20) are regressions controlling for company fixed effect. Models (11) and (22) are full models that also include the lagged value of independent variables (***, ** and * denote significance level of 1%, 5%, and 10%).

Pooled Regression	***Model (1)***	***Model (2)***	***Model (3)***	***Model (4)***	***Model (5)***	***Model (6)***	***Model (7)***	***Model (8)***	***Model (9)***	***Model (10)***	***Model (11)***
Constant	-0.2940***	-0.2430***	-0.2430***	-0.2512***	-0.2497***	-0.2212***	-0.3130***	-0.3668***	-0.4001***	-0.4000***	-0.4341***
Δ Exchange Rate	0.0912***	0.0945***	0.0952***	0.0957***	0.0946***	0.0900***	0.0947***	0.0855***	0.0688***	0.0689***	0.0417***
A/H Market Return		0.0030***	0.0029***	0.0030***	0.0030***	0.0026***	0.0049***	0.0044***	0.0037***	0.0037***	0.0032***
A/H Share Size			-0.0284***	-0.0271***	-0.0267***	-0.0250***	-0.0242***	-0.0211***	-0.0252***	-0.0251***	-0.0248***
A/H Amihud Ratio				0.0059***	0.0058***	0.0055***	0.0045***	0.0040***	0.0055***	0.0055**	0.0032**
A/H Turnover Ratio					-0.0284***	-0.0041	-0.0098*	-0.0104*	-0.0094*	-0.0002*	-0.0020
H Trading Infrequency						-1.5052***	-1.2199***	-1.1272***	-1.0280***	-1.0266***	-0.7676***
No.A.Aanlysts							0.0269***	0.0255***	0.0220***	0.0220***	0.0188***
No.H.Aanlysts								0.0469***	0.0405***	0.0405***	0.0116***
Mutual Fund Holdings (A)									0.0248***	0.0248***	0.0093***
R-square	0.3431		0.3630	0.3647	0.3678	0.4013	0.4983	0.5183	0.5615	0.5615	0.6218
Company Fixed Effect	***Model (12)***	***Model (13)***	***Model (14)***	***Model (15)***	***Model (16)***	***Model (17)***	***Model (18)***	***Model (19)***	***Model (20)***	***Model (21)***	***Model (22)***
Constant	-0.1960***	-0.2017***	-0.2224***	-0.2227***	-0.2224***	-0.2141***	-0.2436***	-0.2576***	-0.2739***	-0.2720***	-0.3118***
Δ Exchange Rate	0.0438***	0.0468***	0.0470***	0.0470***	0.0470***	0.0468***	0.0516***	0.0525***	0.0492***	0.0492***	0.0440***
A/H Market Return		0.0026	0.0026***	0.0026***	0.0026***	0.0025***	0.0032***	0.0031***	0.0030***	0.0030***	0.0028***

A/H Share Size			-0.016 1***	-0.0159 ***	-0.0159 ***	-0.0160 ***	-0.0160 ***	-0.0167***	-0.0167***	-0.0076***	-0.0257***
A/H Amihud Ratio				0.0026***	0.0026***	0.0026***	0.0026***	0.0029***	0.0029***	0.0008***	0.0025***
A/H Turnover Ratio					-0.0011	-0.0033	-0.0028	-0.0031	-0.0029	-0.0003	-0.0047
H Trading Infrequency						-0.4120***	-0.3875***	-0.3817***	-0.3658***	-0.3633***	-0.3158***
No.A.Aanlysts							0.0075***	0.0076***	0.0076***	0.0076***	0.0080***
No.H.Aanlysts								0.0133***	0.0129***	0.0129	0.0033
Mutual Fund Holdings (A)									0.0062***	0.0062	0.0001
R-square	0.7012	0.7041	0.7062	0.7062	0.7062	0.7095	0.7187	0.7235	0.7248	0.8176	0.7523
Observations	4695	4695	4695	4695	4695	4695	4695	4653	4653	4526	4526

Model (1) indicates that the change of the exchange rate does in fact play an important role in determining the discount, explaining over 30% of the total variation on its own. The impact of change in exchange rate remains both statistically and economically significant as adding additional explanatory variables. An increase in the change in the exchange rate of Hong Kong Dollar to Renminbi (1 RMB to X HKD) means that the RMB is appreciating. The coefficient of $\Delta \text{Exchange Rate}(HKD/RMB)$ is positive and significant indicating that the appreciating value of the RMB against the HKD is associated with a lower H-share discount. This means that the value of H-shares will benefit from a RMB appreciation. The reason is that the revenue of most of the H-share companies is denominated in RMB and, when converted into the HKD, this would result in higher revenue and profit. Further, this is also consistent with increased demand for Renminbi denominated Chinese stocks at times when investors expect Renminbi values to go up.

Model (2) allows for sentiment effects in addition to changes in exchange rates. The relative A/H market performance measure is positive and significantly related to the H-share discount. This implies that better market performance in the Chinese mainland stock market than that of the Hong Kong stock market is associated with a smaller H-share discount. This indicates A- and H-dual listed companies become more preferred than companies listed solely on the Hong Kong Stock Exchange when the Hong Kong stock market goes down. In other words, dual listed company represents a source of diversification and therefore the demand for their stock is higher when the Chinese mainland stock market has relatively better market performance. Model (3) adds relative A/H share size as an explanatory variable. The negative coefficient indicates the smaller the H-share size, relative to the underlying A-share size, the higher the H-share discount. This is consistent with smaller companies that generally have higher trading costs, less cross border information and more barriers to arbitrage – resulting in a higher H-share discount. This may also be a result of Hong Kong investors viewing the smaller issue of H-shares as being more risky and less liquid; therefore, requesting greater discount as compensation.

Models (4)-(6) add liquidity factors and examine their impacts on the H-share discount. Model (4) looks at the relative Amihud illiquidity ratio, which measures the price impact of liquidity. The positive coefficient suggests that the higher the relative illiquidity of H-share, as measured by the illiquidity of A-share divided by the illiquidity of H-share, the more the price of the H-share is discounted relative to the underlying A-share price. This result is consistent with the economic notion that an increase in the illiquidity requires more discount as compensation. This result remains robust as more explanatory variables are added in the model. Model (5) further examines the trading aspect of liquidity by adding a relative turnover ratio. Empirical results suggest that relatively active trading of A-share, as measured by turnover ratio of A-share divided by that of H-share, are associated with a larger H-share discount. This makes sense because investors require a higher discount for less actively traded H-shares for being less liquid. As mentioned earlier in some situations H-shares are so illiquid that there is virtually no trading at all. Model (6) examine this aspect of illiquidity by including H-share trading infrequency, computed as zero trading activity days divided by the total number of trading days in the month. The negative coefficients of H-share trading infrequency are significant at the1% level, which is consistent with the economic intuition that the more infrequently the company' stock trades in the Hong Kong market, the more discount investors will require for its H-share. In sum, the results suggest that liquidity plays a role in the relative pricing of A-and H-shares.

Models (7)-(8) focuses on the transparency effect on the H-share discount. The transparency measures are positively associated with a lower H-share discount. More specifically, increases in the A- and H-share analyst coverage are associated with a smaller H- share discount. This indicates that as the number of analyst following a firm increases, the more transparent the firm becomes; thus, the smaller the price differentials across the two markets. Mutual fund holdings of A-shares also prove to be positively associated with a lower H-share discount. This is consistent with the notion that mutual funds provide governance and transparency, resulting in a decreasing price differential between A- and H-shares.

Model (9) is the full model, as specified in Equation (1). Model (10) controls for aggregate liquidity in two markets.[26] Model (11) adds the lagged one-period value of independent variables to the full model , which should be subject to less potential endogeneity issues. The coefficients and their significance level obtained from these models are essentially the same with Model (9). Meanwhile, Models (12)-(22) show the estimates that result after controlling for company fixed effects; these findings are generally similar to those of the pooled regression. Thus, the estimation results from this study are robust and provide support for the notion that liquidity and transparency affect the relative pricing of A- and H-shares.

6. Conclusion

This paper investigates the impact of liquidity and transparency on the relative pricing of A- and H-shares using a sample of 68 cross-listed A- and H-share Chinese firms from 2003 to 2011. In terms of liquidity effects, I focus on three different aspects: Amihud illiquidity measure (Amihud, 2002), turnover ratio, as well as the infrequency of trading associated with H–shares. The higher the relative illiquidity of A-share, the more the price of the H-share is discounted relative to the underlying A-share price. In contrast, relatively active trading of A-shares is

[26]The turnover ratio is calculated as individual firm turnover ratio as a percentage of aggregate A- or H-share market turnover ratio $({}^{A}/_{H}\,Turnover\ Ratio_{it})/({}^{A}/_{H}\,Turnover\ Ratio_{t})$.

associated with a larger H-share discount. Additionally, an increase of the infrequency of trading of H-share is accompanied with a larger H-share discount.

In regards to transparency effects, this paper first examines the quality of auditors as a measure of accounting transparency by comparing firms audited by Big 4 auditors versus firms audited by local auditors. Firms audited by the Big 4 are generally associated with smaller H-share discounts, higher mutual fund holdings, a higher number of A- and H-share analysts, and higher liquidity. Moreover, analyst following is a mechanism that makes firms more transparent. Therefore, I examine analyst coverage for both A-and H-shares and find that an increase in the analyst coverage for both A- and H-shares is associated with a smaller discount for H-shares. In addition, mutual funds as institutional shareholders may also provide more transparency to a firm through their monitoring of firm's activities. Empirical results suggest that an increase in mutual fund holdings of A-shares as measured by the percentage of a firm's A-share hold by mutual funds is associated with a smaller H-share discount.

Overall, the results of this study provide support for the notion that liquidity and transparency affect the relative pricing of A- and H-shares.

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Appendix. Data Collecting Resource:

Daily stock price and trading volume

Yahoo Finance: Historical Price, Hong Kong Stock Exchange, Shanghai Stock Exchange and Shenzhen Stock Exchange.

Analyst coverage data:

http://finance.sina.com.cn/stock/ http://quote.eastmoney.com/ http://stock.hexun.com/
http://finance.people.com.cn/stock/ http://stock.stockstar.com/ http://www.caiguu.com/
http://www.southmoney.com/ http://stock.fivip.com/ http://stock.sohu.com/ http://hao.360.cn/gupiaojijin.html

I/B/E/S summary history data for analyst coverage before December 31st, 2009

Return on the market indices:

Yahoo Finance, Hong Kong Stock Exchange, and Shanghai Stock Exchange

Exchange rate between Hong Kong Dollars to Renminbi:

Yahoo Finance, Federal Reserve Economic *Data* – (St. Louis Fed)

Mutual fund holding data:

http://finance.sina.com.cn/stock/ http://funds.money.hexun.com/fundsdata/ http://www.chinafund.cn/
http://fund.sohu.com/jjsj/ http://data.eastmoney.com/center/fund.html
http://money.business.sohu.com/jijinshuju.shtml http://data.cnfund.cn/
http://quote.hexun.com/fund/default.html http://fund.jrj.com.cn/funddata/

Other data on the size of A-and H-shares and summary statistic for the sample firms:

http://finance.sina.com.cn/stock/ http://datainfo.stock.hexun.com/ http://www.wstock.net/wstock/shsz.htm
Hong Kong Stock Exchange, Shanghai Stock Exchange and Shenzhen Stock Exchange.

Data on auditing firms are collected through each firm's auditing reports.

The other financial data for the sample firms are collected through the company's annual or quarterly accounting report

Vita—Yao Zheng

Yao Zheng received her Bachelors in Economics from Renmin University of China in 2008. She received her Master of Science in Financial Economics from University of New Orleans in 2011. She published three papers in peer-reviewed journals before graduating with her Ph.D. Ms. Zheng is currently scheduled to receive her Ph.D. in Financial Economics from the University of New Orleans in December 2012. Her research interests include investment, corporate finance and international finance.