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Idiosyncratic Risk and Expected Returns in REITs

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Idiosyncratic Risk and Expected Returns in REITs

BY

TOYOKAZU IMAZEKI

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Of

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ACCEPTANCE

This dissertation was prepared under the direction of the Toyokazu Imazeki Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctoral of Philosophy in Business Administration in the J. Mack Robinson College of Business of Georgia State University.

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ABSTRACT

Idiosyncratic Risk and Expected Returns in REITs

BY

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Ooi, Wang and Webb (2009) employ the Fama-French (1993) three-factor model to estimate the level of nonsystematic return volatility in REITs as a proxy for idiosyncratic risk. They report that idiosyncratic risk constitutes nearly 80% of the overall return volatility of REITs between 1990 and 2005. This result is consistent with the estimates in the finance literature that average common stock volatility is mostly driven by idiosyncratic risk (Goyal and Santa-Clara, 2003). Ooi et al. (2009) also analyze the relationship between expected returns and conditionally estimated idiosyncratic risk as well as market risk (beta). They employ the methodology of Fama and French (1992) to control for other systematic risks including size, value and momentum at the firm-level, and find a significant positive relationship between expected returns and conditionally estimated idiosyncratic risk contrary to Modern Portfolio Theory (MPT).

In this research, I examine other potential sources of systematic risk in REITs which may explain the seeming violation of the MPT found by Ooi et al. (2009). MPT argues that all unsystematic risk can be diversified away thus there should be no relationship between idiosyncratic risk and return. The fact that REITs tend to be a homogeneous asset class suggests that the level of systematic risk in REITs should be higher than that found in common stocks.

I re-examine the proportion of idiosyncratic risk in REITs following the methodology of Ooi et al. (2009). Historic idiosyncratic risk in REITs is calculated from 1996 to 2007 based on the Fama-French three-factor model (FF3). Monthly idiosyncratic risk is the regression residual and measured by daily excess returns over the past month for each REIT as a first-pass regression. Next, I add a potential systematic risk variable not included by Ooi et al. (2009), Carhart's (1997) momentum factor, which is largely applied on the FF3 to control for the persistency of stock returns as supplemental risk in the finance literature. Obtained factor loadings for each idiosyncratic risk and systematic risks are further applied into a second-pass regression model. I hypothesize that systematic risk will be increased significantly and idiosyncratic risk will be reduced accordingly.

Next, I conduct a second-pass regression. Due to the time varying property of idiosyncratic risk (Ooi et al., 2009; and Fu, 2009), I apply a conditional estimation GARCH model for expected idiosyncratic risk and market risk (beta). I also employ the methodology of Fama and French (1992) to control other systematic risks at the firm-level including size, value and momentum. Cross-sectional regression is conducted every month throughout the sample period and the significance of results is tested by t-statistics. I hypothesize that the expansion of applied asset pricing model from the FF3 to the FF4 including the momentum factor eliminates or at least significantly weakens the relationship.

I further test the role of property sector on idiosyncratic risk as well as on its relationship with expected returns. I hypothesize that market risk is systematically different by property sector and significant difference in the amount of idiosyncratic risk as well as in its relationship to returns are attributed to property sector. I employ both intercept and slope dummy variables and test if there is a significant proportion of systematic risk attributed to particular property sectors.

The addition of the momentum factor to the FF3 slightly reduces the proportion of idiosyncratic risk in REITs consistent with the findings in the finance literature though the level of reduction is not statistically significant. The second hypothesis is rejected. Although the positive relationship between idiosyncratic risk and return is weakened due to the addition of momentum to the Fama French three-factor model (FF3), the positive relationship does not totally disappear. The third hypothesis is also rejected. I find that the relationship between idiosyncratic risk and expected returns becomes insignificant when I control for property sector; however, none of dummy variables show any statistical significance.

These conclusions suggest three things. First, momentum has a relatively minor effect on the idiosyncratic risk consistent with the financial literature. Second, the effect of momentum is not strong enough to cause a significant change in the relationship between idiosyncratic risk and expected returns. Third, a REIT portfolio diversified across property sectors neutralizes the relationship between idiosyncratic risk and expected returns, though the contribution of each property sector is not statistically significant. These findings could shed light on the idiosyncratic risk in REITs as a contribution to the real estate literature.

1. Introduction

1.1 The Purpose of the Study

The capital asset pricing model (CAPM) implies that each security has two sources of risk: a systematic component and an idiosyncratic component. Systematic risk is attributable to its sensitivity to the market and persists regardless of the extent of portfolio diversification. This sensitivity is measured as beta which describes the expected risk premium on any asset as the proportion of that attributable to the market portfolio. In contrast, idiosyncratic risk is firm specific and therefore diversifiable based on the implication of the CAPM. In other words, idiosyncratic risk is independent from the market and has zero expected value due to its diversifiability. As a result, stocks are priced according to market risk exposure, whereas idiosyncratic risk is negligible and theoretically un-priced. Due to this implication of un-priced risk, idiosyncratic risk has attracted relatively limited attention in literature until recent years compared with systematic risk.

Recent finance literature shows significant progress in the relationship between idiosyncratic risk and expected returns; however, the results provide mixed empirical evidence and suggest the argument is still far from consensus. As summarized in Table 1, reported results include positive, negative and neutral relationships between idiosyncratic risk and return depending on the methodology employed. For example, Malkiel and Xu (2006) analyze the relationship between idiosyncratic risk and expected returns by extending the analysis of Fama and MacBeth (1973) for longer time frames. They report contradictory results from the MPT’s implication that the relationship between idiosyncratic volatility and the cross sectional expected returns is significantly positive at the firm-level. On the other hand Ang, Hodrick, Yuhang and Xiaoyan (2006) report a strong negative relation between idiosyncratic risk and expected returns. Bali and Cakici (2008) argue no robustly significant relationship exists between idiosyncratic volatility and expected returns, and conclude that the conflicting evidence in literature is largely due to methodological differences. Boehme, Danielsen, Kumar and Sorescu (2009) highlight two contradictory hypotheses, Merton (1987) supporting a positive relationship and Miller (1977) supporting a negative relationship, and find more robust evidence for Merton's hypothesis.

Fu (2009) employs the Fama-French three-factor model on time-series return data and shows that idiosyncratic risk varies substantially over time. Using the exponential GARCH model, he also finds a significant positive relationship between conditionally estimated idiosyncratic volatilities and expected returns. Endorsing Fu (2009), Huang, Liu, Rhee and Zhang (2010) further find the return reversal of stocks classified as higher idiosyncratic risk in the following month as the cause of the apparent negative relationship found by Ang et al. (2006). Thus there remains no current consensus about the relationship between expected returns and idiosyncratic risk.

Compared with the finance literature, the analysis of idiosyncratic risk is significantly limited in the real estate literature particularly regarding how it relates to expected returns. The significantly homogeneous composition of REIT assets may suggest a unique relationship between idiosyncratic risk and expected returns compared with common stocks. REITs hold assets that are almost exclusively limited to tangible real estate which commonly generate a stable income stream across property sectors. In other words, REITs do not necessarily exhibit the same dominance of idiosyncratic risk as appears in common stocks since REITs are largely argued to be a separate asset class in the capital market (Kallberg and Liu, 1998).

Clayton and MacKinnon (2003) argue the higher efficiency of the REIT market improves the disclosure of firm-specific information and increases the non-systematic volatility of individual REIT returns. They decompose NAREIT-based return variance with four market indexes, namely large cap stocks (S&P 500 index), small cap stocks (Russell 2000 index), bonds (Lehman Brothers index) and real estate (NCREIF-based Transaction Value Index), and theorize that the observed rise of idiosyncratic effect throughout the 1990s indicates further maturity of the market together with a decline in the influence of large cap stocks thus reducing the correlation between REITs and common stocks. Anderson, Clayton, MacKinnon and Sharma (2005) extend the sample period and further confirm the declining exposure of REITs to systematic factors over time.

Ooi, Wang and Webb (2009) employ the Fama-French three-factor model to estimate the level of non-systematic return volatility in REITs as a proxy of firm-specific idiosyncratic risk based on daily-returns. They report that idiosyncratic risk constitutes nearly 80% of the overall return volatility of REITs between 1990 and 2005. They further assume each firm's risk variables are time varying based on highly volatile daily measurements regarding the relevance of expected idiosyncratic risk in explaining REIT returns. They regress the excess returns of REITs on conditionally estimated firm-level market risk (beta) and idiosyncratic risk controlling for the three systematic risks, namely size, value and momentum. Contrary to the modern portfolio theory (MPT), they find a significantly positive relationship between expected idiosyncratic risk and REIT returns despite the coefficients for market risk being insignificant in all models. Yet, the results are relatively consistent with estimates in the finance literature that average common stock volatility is mostly driven by idiosyncratic risk (Goyal and Santa-Clara, 2003). Sun and Yung (2009) further confirm the positive relationship as largely driven by small, low priced and illiquid E-REITs based on the idiosyncratic risk estimated from both CAPM and the Fama-French three factor model.

This research re-examines the proportion of idiosyncratic risk in REITs following the methodology of Ooi et al. (2009). Monthly idiosyncratic risk in REITs is calculated as the regression residuals of each REIT's excess returns based on the Fama-French (1993) three-factor model between 1996 and 2007 using daily excess returns over the past month. The equal-weighted idiosyncratic risk for all sample REITs is consolidated every month as the first-pass regression. I expect a significant decrease in idiosyncratic risk as well as the incremental accuracy of regression results compared with the result in Ooi et al. (2009) due to the additional control for a systematic risk variable, namely momentum.

Next, I analyze the relationship between expected returns and each systematic risk component at the firm-level following the methodology of Fama and French (1992). In order to accommodate the time-varying property of idiosyncratic risk and market risk (Ooi et al., 2009; Fu, 2009; and Huang et al., 2010), I employ conditional estimation methodology for each expected value, namely EGARCH and GARCH models respectively. This second-pass regression is also controlled for three systematic risk variables (size, value and momentum) estimated for each sample REIT. I examine the sign and significance of each coefficient and hypothesize the indicated relationship at the firm-level is consistent with Ooi et al. (2009).

This research is further extended to investigate a unique feature of REITs, namely property sectors. As intuitively thought, I assume that market risk is systematically different for the various property sectors; therefore, additional control for property sector could improve the accuracy of regression model. This could also mitigate the proportion of risk classified as idiosyncratic, and the reduced idiosyncratic risk might not display the same relationship with expected returns. There might be specific property sectors with more significant influence on the relationship. In other words, a part of idiosyncratic risk might be uniquely attributed to certain property sectors.

1.2 Research Questions

Regarding the exposure of REIT return volatility to systematic risk, both Clayton and MacKinnon (2003) and Ooi et al. (2009) argue that idiosyncratic risk has grown significantly in REITs over time during 1990s. Although the dominant role of idiosyncratic risk is consistent with arguments made in the finance literature, the argument for the dominance of idiosyncratic risk at the 80% level in total return volatility (Ooi et al., 2009) seems high for a sector investing exclusively and homogeneously in tangible real estate. These results infer an under-estimate of the exposure of REIT returns to systematic risk. I first measure the proportion of idiosyncratic risk in REIT return volatility based on the methodology modifying potentially biased approaches in existing papers. In order to mitigate probable over-estimation of idiosyncratic risk, I extend the Fama-French three-factor model to the four-factor model including Carhart's (1997) momentum due to the concern about possibly excluded systematic risks in Ooi et al. (2009).

The relationship of expected REIT returns to both idiosyncratic and systematic risks is the next focus of this dissertation. While the MPT suggests idiosyncratic risk should not be priced (or is insignificant), Ooi et al. (2009) report contradictive findings suggesting that idiosyncratic volatility has a significant positive relationship with REIT returns. They also report market risk (beta) has an insignificant relationship with REIT returns due to the dominant influence of idiosyncratic risk and other systematic risks. Although they conclude firm-specific risk matters in REIT pricing, the results are somehow puzzling with respect to the MPT. The relationship remains debated in the literature.

Thirdly, I assume property sector plays a substantial role in the amount of idiosyncratic risk as well as in its relationship to returns. As one of the unique features of REITs, many investors diversify their REIT investments across property sectors. At the property-level, real estate is known to behave differently by property sector such as retail, residential and office. I assume a part of idiosyncratic risk is attributed to this uniqueness in each property sector.

For each test, I hypothesize (i) systematic risk will be increased significantly, and idiosyncratic risk will be reduced after the inclusion of the momentum factor; (ii) consistent with the MPT, there will be no significant relationship between idiosyncratic risk and expected REIT returns at the firm-level with the control for momentum effect; and (iii) significant difference in the amount of idiosyncratic risk as well as in its relationship to returns are attributable to property sectors.

1.3 Importance of Study

CAPM makes a set of predictions concerning equilibrium expected returns on risky assets under the assumptions of an extremely simplified world. One of the assumptions is "all investors will choose to hold a portfolio of risky assets in proportions that duplicate representation of the assets in the market portfolio, which includes all traded assets. For simplicity, we generally refer to all risky assets as stocks." (Bodie, Kane and Marcus, 2002) However, the evolution of financial technology and constant development of market products may have made "the market" more complicated and difficult to explain with the conventional stock market index as a proxy of "the market". As Fama and French (1993) expanded the market model equation from a single factor CAPM model to three-factor model, there might be more unknown and un-tested market risks in each asset class as later demonstrated by Carhart (1997). Idiosyncratic risk is the residual of return volatility not explained by the systematic market risks. If "the market" becomes less explained by systematic risks, idiosyncratic risk simultaneously increases as the residual of the model. This also infers the increasing necessity to depart from the classic single factor model and to expand the knowledge of systematic risks such as Carhart (1997) finds with the effects of momentum.

The purpose of this dissertation is to re-examine the relationship between idiosyncratic risk and expected returns in REITs and contribute to the literature by expanding our knowledge of systematic risk in REITs. I examine the momentum effect as a potential source of systematic risk in REITs which may potentially reduce the risk categorized as unexplained residual or idiosyncratic risk. This research also sheds light on potential sources of systematic risk which might affect the expected returns and/or the relationship between expected returns and idiosyncratic risk in REITs.

Growing numbers of finance papers have analyzed idiosyncratic risk in common stocks with particular focus on their risk-return relationship. Yet, many of them exclude REITs due to the fundamental differences. Therefore, there is a lack of academic research focusing on idiosyncratic risk in REITs. The fact that REITs tend to be a homogeneous asset class suggests that the level of systematic risk in REITs should be higher than that found in common stocks. This should be even more obvious when REITs are grouped by property sectors. As ironically evidenced by the exclusion of REITs from a large part of the finance literature, the unique characteristics of REITs require real estate researchers to focus on the properties of idiosyncratic risk in a different platform. This lack of research suggests the importance of further investigation in the real estate literature as well as the primary contribution of this research.

1.4 Organization of Research Approach

The reminder of the dissertation proceeds as follows. In the next chapter, I will review the related literature. Chapter three, "Methodology", presents research hypotheses, data construction and test methodology. In chapter four and five, I will discuss the results and conclusions.

2. Literature Review

This section reviews the literature discussing idiosyncratic risk in the finance and real estate literature followed by the studies examining the momentum effect as a supplemental systematic risk and the role of property sectors in REIT returns. The first part discusses studies which examine the properties of idiosyncratic risk in the finance literature, where the relationship between idiosyncratic risk and expected returns has attracted increasing interest. Table 1, "List of research analyzing idiosyncratic risks", also summarizes the methodological difference of recent research. In this study, I follow the methodology of Fu (2009) and Ooi et al. (2009), and use daily-return-based idiosyncratic risk which Fu (2009) argue as more appropriate measurement of idiosyncratic risk due to its time-varying nature. The second part summarizes the papers discussing idiosyncratic risk in real estate particularly REITs. I highlight not only the results in each study but also the differences in methodology in these two sections. The third and fourth parts review previous studies including the momentum effect in the asset pricing model as an extension of the Fama-French three factor model (FF3) in each finance and real estate literature. In the last part, I cover the papers analyzing the effect of property sectors on REIT returns.

2.1 Idiosyncratic Risk Studies in the Finance Literature

CAPM (Sharpe, 1964 and Lintner, 1965) relates to the mean-variance efficiency of the market portfolio. Its primary implication is that there exists a positive linear relationship between expected returns on securities and their systematic market risk (beta). Variables other than beta should not capture the cross-sectional variation in expected returns; therefore, any role of idiosyncratic risk is completely eliminated through diversification under the assumptions of CAPM. Fama and

MacBeth (1973) support this theoretical implication empirically and observe that idiosyncratic risk does not have a significant relationship with the cross-sectional returns of common stocks.

On the other hand, Merton (1987) argues that idiosyncratic volatility is relevant to asset pricing under more realistic situations where investors can not invest in the "market portfolio" consisting of all the securities in the market as a matter of practicality. In addition to the difficulty associated with constructing the market portfolio, he further argues that tracking information on all securities is costly. If investors hold under-diversified portfolios, they will care about total risk (market risk and idiosyncratic risk), not simply market risk. Therefore, firms with larger total (or idiosyncratic) variance require higher returns to compensate for imperfect diversification, suggesting that idiosyncratic volatility is positively related to the cross section of expected returns if investors demand compensation for being unable to completely diversify away firm-specific variance.

Following the arguments made in recent research, under-diversification may cause a positive relationship between idiosyncratic risks and expected cross sectional stock returns. Goyal and Santa-Clara (2003) examine the relationship between stock variance and the returns on the market using regression models between lagged monthly variance based on daily volatility and subsequent market returns. They find (1) no forecasting power of market variance for the market returns and (2) a significant positive relation between average stock variance and the returns on the market. As stock variance is mostly driven by idiosyncratic risk reported as 85%, they argue that idiosyncratic equity risk is positively related with the returns on the market. Spiegel and Wang (2005) focuses on the contrasting role of idiosyncratic risk and liquidity and how each of them relates to stock returns. As expected, they find positive and negative relationship with stock returns respectively, while the impact of idiosyncratic risk is much stronger than that of liquidity.

Malkiel and Xu (2006) also find a significant positive relationship between idiosyncratic risk and the cross sectional expected returns at the firm-level. Extending the analysis periods of Fama and MacBeth (1973), they analyze monthly-return volatility to estimate idiosyncratic risk relative to both CAPM and the Fama-French three-factor model. The results demonstrate that idiosyncratic risk is priced to compensate rational investors for their inability to hold the market portfolio in both cases. Contrary to previous research, Ang et al. (2006) report a significant negative relationship between idiosyncratic volatility and cross-sectional expected stock returns. They define idiosyncratic volatility relative to the Fama-French three-factor model using daily-returns of individual stocks over the past month. They group stocks into five portfolios sorted by one-month lagged idiosyncratic volatility and estimate the value-weighted expected returns of each portfolio every month. The results show that stocks with low idiosyncratic risk earn high average returns, and the average return differential between quintile portfolios of the lowest and highest idiosyncratic risk is statistically significant.

Although some studies find a positive relation between idiosyncratic volatility and expected returns as predicted by Merton (1987), Bali and Cakici (2008) argue that the conflicting evidence in existing literature is largely due to the significant sensitivity of the cross-sectional relationships to methodological differences. They report differences of analytical schemes that play critical roles in determining the presence and significance of cross-sectional relationships in existing research including (i) the data frequency used to calculate idiosyncratic risk (daily- or monthly-return volatility) and (ii) the weighting scheme adopted for generating average portfolio returns. They analyze different combinations of data frequency and weighting schemes for average returns on the relationship between idiosyncratic risk and expected returns. Testing the experimental combinations of weighting schemes and data frequencies, they observe a negative relationship between idiosyncratic volatility and expected returns only under the conditions exactly replicating those assumed by Ang et al. (2006), namely value-weighted expected returns of quintiles sorted by daily-data-based idiosyncratic risk. Thus the negative relationship reported by Ang et al. (2006) is largely a result of the methodological choice of averaging returns for each quintile by value-weighting rather than equal-weighting.

Fu (2009) argues that the lagged idiosyncratic volatility might not be appropriate for the proxy of expected idiosyncratic volatility since idiosyncratic volatility of individual stocks changes over time. Employing the exponential GARCH models to estimate the expected idiosyncratic volatility based on time-series data of daily-return variance, he finds a significantly positive relationship to expected returns. Testing the model under the replicated framework of Ang et al. (2006), he finds that Ang et al. (2006)'s findings are largely caused by abnormal return reversal of some stocks in the highest idiosyncratic volatility quintile, and thus rejects their argument of a negative relationship between idiosyncratic volatility and cross-sectional expected stock returns. High monthly-return stocks often appear in combination with high contemporaneous idiosyncratic volatility; however, the returns in the following month frequently reverse and become low. As a result, the subsequent returns of these stocks tend to record relatively low returns. In addition, most of these stocks are small in size, therefore having little influence on total market returns while being highly influential in quintile-based returns.

Jiang, Xu and Tong (2009) extend the study of Ang et al. (2006) and find that idiosyncratic volatility is also inversely related with future earnings and earning shocks. Analyzing the triangular relation among idiosyncratic volatility, future earning shocks, and future stock returns with various control variables, they argue that the return predictive power of idiosyncratic risk depends on the information content about future earnings; therefore, it relates to corporate disclosure.

Boehme, Danielsen, Kumar and Sorescu (2009) test two contradicting hypotheses regarding the relationship between idiosyncratic risk and expected returns. Investor recognition hypothesis

(Merton, 1987) predicts a positive relationship under the condition of sub-optimally diversified portfolio holdings by investors. In contrast, Miller's (1977) hypothesis predicts a higher dispersion of investors' beliefs derives higher prices; therefore, it results in a negative relationship with returns under short-sale constraints. Testing a model with additional controls for visibility and short-sale constraints, Boehme et al. (2009) find idiosyncratic risk positively related with subsequent returns when firms display both low visibility and high short-selling cost; therefore, their results support Merton's hypothesis.

Huang, Liu, Rhee and Zhang (2010) re-examine the relationship between idiosyncratic risk and expected returns reported in existing studies. A negative relationship (Ang et al., 2006) is confirmed and explained as the result of return reversal in the following month consistent with Bali and Cakici (2008). A positive relationship between the conditional idiosyncratic volatility and expected returns (Fu, 2009) is also confirmed as robust even after controlling for the return reversal effect. They further construct a time series return gap between the highest and the lowest idiosyncratic risk groups of portfolios based not only on the FF3 but also on the FF4 at the portfolio-level. The reported increases of R-square from 0.66 to 0.68 also indicates that the inclusion of momentum factor improves the accuracy of asset pricing models from the FF3 to the FF4.

Regarding the measurement of idiosyncratic risk, Brown and Kapadia (2007) also apply the FF4 and analyze the time series of idiosyncratic volatility. They argue that the previously documented increase in idiosyncratic risk in the post-war era is the result of the new listing effect. Firms that list later in the sample period have persistently higher idiosyncratic volatility than firms that list earlier. Cao, Simin and Zhao (2008) apply both the FF3 and the FF4 to estimate idiosyncratic risk of stocks at the firm-level for the sample period from 1971 to 2002. They report a slight decline of idiosyncratic return variance from 0.024 to 0.023 based on the FF3 and the FF4 respectively.

2.2 Idiosyncratic Risk Studies in Real Estate

Benefiting from the characteristics of listed and daily traded assets, the risk in REITs is frequently estimated as the volatility of returns and the correlation coefficients with other assets. Corgel, McIntosh and Ott (1995) and Seiler, Webb and Myer (1999) categorize earlier papers in the real estate literature and provide a comprehensive overview of research analyzing the risk in REITs chronologically. These risk studies are mostly motivated to analyze diversification opportunities or the portfolio optimization of REITs as one of the financial asset classes.

Where the risk, or volatility of returns, can be decomposed into a systematic market component and an idiosyncratic firm-specific component, the real estate literature pays relatively limited attention to the idiosyncratic risk particularly regarding how it relates to the expected returns (See Table 1). "This is not surprising because the capital asset pricing model (CAPM; Sharp 1964; Lintner 1965; Black 1972) prescribes that only the non-diversifiable systematic risk matters in asset pricing. Idiosyncratic risk, on the other hand, should not matter because it can be completely diversified away according to modern portfolio theory (Ooi et al., 2009)." Gyourko and Nelling (1996) examine systematic risk in public real estate from the perspective of CAPM. Analyzing the monthly-returns of equity REITs, they compare the systematic risk (beta) by property sector and locational distribution during the 1988 – 1992 sample periods. They find that systematic risk varies by property sector with significantly higher risk for retail REITs. Their sample period is further extended to 1997 by Chen and Peiser (1999) in an attempt to capture the impact of REIT modernization in the early 1990s. They report newly launched REITs perform similarly to the existing older REITs except for slightly higher systematic risk (beta) in new REITs. Although these two studies provide a comprehensive analysis of systematic risk, they do not extend the argument to the role of idiosyncratic risk in REITs. They also examine the risk-return trade-off of different REIT sectors in comparison with the S&P Mid-Cap index. They report that storage, office, and hotel REITs have higher returns along with higher risk than the index, while healthcare, apartment, retail, and diversified REITs had lower returns coupled with higher risk than the index.

Employing a multiple-factor asset pricing model, Karolyi and Sanders (1998) examine the predictable components of returns on stocks, bonds, and REITs. Because of the lower R^2 for REITs, they conclude there should be an important economic risk premium not captured by the model although they do not address the results from the perspective of idiosyncratic risk. Litt, Mei, Morgan, Anderson, Boston and Adornado (1999) decompose the total risk of REIT returns into systematic risk, NAREIT factor (β_{NAREIT}), and firm-specific (idiosyncratic) risk; and test both firm-based and property sector based regression models from 1993 to 1997. They find higher returns for the group of higher systematic risk firms measured by beta. Moreover, they report a significant role in firm-specific (idiosyncratic) risk in REIT excess returns. On average, systematic risk explains 34% of REIT excess returns while firm-specific risk explains the remaining 66%. Although the authors admit the possibility that including macroeconomic-factors may increase systematic risk, they emphasize the significant role in firm-specific (idiosyncratic) risk in REIT excess returns.

In real estate literature, the initial focus on the idiosyncratic risk in REITs is made by Chaudhry, Maheshwari and Webb (2004), who decompose the idiosyncratic risk based on CAPM to find the determinants and compare the results in two periods: Period I (from 1994 to 1998) and Period II (from 1996 to 2000). They report that efficiency, liquidity and earnings variability are important determinants of idiosyncratic risk due to their significance in both periods though size and capital are not. They further argue that idiosyncratic risks are as important as aggregate volatility for understanding the risk and return relationships for a portfolio of stocks. This is particularly true in REITs due to their special and unique characteristics. However, they do not extend their analysis to the relationship between idiosyncratic risk and market returns.

Clayton and MacKinnon (2003) analyze how other assets influence REITs as well as the size of the unexplained idiosyncratic risk component. They employ a multi-factor model to decompose quarterly-return variance based on the NAREIT Index and four other market indexes, namely large cap stocks (S&P 500 index), small cap stocks (Russell 2000 index), bonds (Lehman Brothers index) and un-securitized real estate (NCREIF-based Transaction Value Index) between 1978 and 1998. The results indicate that large cap stocks were the most influential in the early years but small cap stocks became more influential in the late 1980s. In the 1990s with the modernization of REITs, REITs began to behave more like (underlying direct) real estate. Moreover, idiosyncratic risk rose dramatically and became the dominant factor in the same period. They argue that the increasing efficiency of the REIT market improved disclosure of firm-specific information and increased the non-systematic volatility of individual REIT returns. The authors view the institutionalization of REITs and improved informational transparency as the reasons since higher idiosyncratic risk is observed in the portfolio of larger size REITs.

Sun and Yung (2009) analyze the relationship between idiosyncratic volatility and expected returns in REITs under the Fama-French three factor model and CAPM. Using daily return data in previous month, they regress one-month lagged idiosyncratic risk with subsequent returns controlling for leverage, analyst coverage, institutional ownership and illiquidity at the firm-level, and find a significantly positive relationship. They further construct the portfolio excluding small, low price and illiquid samples, and find the positive relationship disappears; therefore, they suggest the positive relationship as largely driven by small, low priced and illiquid E-REITs.

Ooi, Wang and Webb (2009) use the Fama-French three-factor model to decompose REIT return volatility into systematic risk and firm-specific (idiosyncratic) risk, and report nearly 80% of the overall return volatility is attributable to idiosyncratic risk during the sample period between 1990 and 2005. They regress daily excess returns of each individual REIT, and regression residuals are transformed to monthly idiosyncratic volatility, which is used to measure the proportion of idiosyncratic risk to total volatility every month. They next employ the GARCH model to estimate one-month ahead expected idiosyncratic risk as well as expected market risk (beta) controlling for the time-varying nature of these risks, and examine the cross-sectional relationship between expected returns and these conditionally estimated risk measures. Cross sectional regression is conducted month-by-month at the firm-level, and they examine how idiosyncratic risk and market risk influence the expected returns of REITs. They measure t-statistics of each averaged coefficient across the sample period and report significantly positive result for the idiosyncratic risk, whereas non-significant returns associated with market risk. They further extend this analysis with additional controls for three other systematic risks, namely size, value and momentum at the firm-level following the methodology of Fama and French (1992). The average coefficients for idiosyncratic risk and momentum show significantly positive relationships with expected returns though those for expected market risk, size and value are not significant. They conclude that conditionally estimated idiosyncratic risk is positively related with expected returns after controlling for systematic risks at the firm-level. This conclusion supports the argument of Merton (1987) that idiosyncratic volatility is positively related to expected returns.

Liow and Addae-Dapaah (2010) examine the dynamics of idiosyncratic risk, market risk and return correlation using weekly return data on US REIT firms. They confirm that total return is positively related to the idiosyncratic risk for the extended sample period from 1993 to 2008.

2.3 Momentum Studies in the Finance Literature

Regarding the fundamental question of momentum's effect as a systematic risk factor, Fama and French (2011) argue that both the Fama French three factor model (FF3) and Carhart's four factor model (FF4) are "commonly used in applications, most notably to evaluate portfolio performance." Fama and French (2010) also include momentum in the asset pricing model though they admit that "there is controversy about whether the average SMBt, HMLt, and MOMt returns are rewards for risk or the result of mispricing. For my purposes, there is no need to take a stance on this issue. I can simply interpret SMBt, HMLt, and MOMt as diversified passive benchmark returns that capture patterns in average returns during our sample period, whatever the source of the average returns."

Although the finance literature might not have reached the consensus regarding momentum's effect, the FF4 is largely applied for the analysis as an established asset pricing model. Huang et al. (2010) trace the methodology of Fu (2009) for all NYSE/AMEX/NASDAQ individual stocks over the period from 1963 to 2004. They analyze the relationship between idiosyncratic risk and expected returns based on the FF4, and report the significantly positive relationship is unchanged from the finding of Fu (2009) based on the FF3. Boehme et al. (2009) also analyze the relationship between idiosyncratic risk and expected returns based on the FF4 at the portfolio-level. Controlling for visibility and short-selling by the proportion of institutional holdings as their proxy, they find a significantly positive relationship.

Jiang, Xu and Tong (2009) analyze the triangular relation among idiosyncratic volatility, future earning shocks, and future stock returns controlling for size, book-to-market, and momentum as "the three classical "anomalies" in the asset pricing literature", and find that the return predictive power of idiosyncratic risk is subject to corporate disclosure regarding future earnings. Kosowski, Timmermann, Wermers and White (2006) also apply the FF4 as one of the "commonly used performance models" proposed by past literature to analyze the performance of US mutual funds. While the FF4 based result is presented as "the best fit model according to standard model selection criteria", they confirm that the results of all 15 tested models, including the CAPM and the FF3, are consistent with that of the FF4.

In the analysis of persistency, the FF4 is largely applied in order to control models for momentum's effect. Among return persistency papers, Fama and French (2010) investigate actual net performance of mutual funds after deducting their fund management cost. Analyzing the existence of abnormally positive or negative return under the CAPM, the FF3 and the FF4, they find that mutual funds' returns are little influenced by momentum. The R-squares on the FF3 and the FF4 are essentially identical based on both equal weighted and value-weighted returns.

Forming ten price-momentum portfolios based on past returns, Chordia and Shivakumar (2005) analyze the monthly return of US stocks over the sample period from January 1972 through December 1999. They report that the inclusion of the momentum factor on the FF3 increases the proportion of return explained by the model. The average improvement is larger in the portfolios consisting of lower return stocks in the last six months though the largest improvement of the adjusted R-squared is only 3.5%, from 92.0% to 95.5%, in the lowest return stock portfolio.

Busse et al. (2010) apply CAPM, FF3 and FF4 on active domestic equity institutional products from 1991 to 2008, and examine their performance. They report reductions of alpha as well as the t-stat with the addition of risk variables in each model from one in the CAPM to four in the FF4. They explain this effect as the result of "the sophistication of risk adjustment" although they do not report R-squares or other figures showing the accuracy of each model. McLean (2010) estimates idiosyncratic risk based on the CAPM and the FF4 plus industrial factors on monthly returns. He finds that reversal effects are stronger in high idiosyncratic risk firms. Reversal represents a larger mispricing than momentum while momentum is not related to idiosyncratic risk.

2.4 Momentum Studies in the Real Estate Literature

In the real estate literature, only a few studies examine additional variables and attempt to extend the asset pricing model of REIT returns at the market-level. One of the notable variables is Carhart's (1997) momentum factor which is largely applied with the Fama-French three factor model to control for the persistency of stock returns as supplemental risk in the finance literature.

Nelling and Gyourko (1998) analyze the performance persistence of E-REITs at the portfolio-level and measure correlations between current and lagged REIT returns. They employ a time-series approach and find negative correlation in the first lag of monthly E-REIT returns as evidence of return predictability. They conclude that monthly E-REIT returns are predictable based on past performance due to persistence in performance. Chui, Titman and Wei (2003) analyze the cross-sectional determinants of expected REIT returns and find that the momentum effect is the dominant predictor of REIT returns particularly after 1990 among other factors including size, value, liquidity, and analyst coverage. By constructing the winner and loser portfolios, they also analyze the potential profit from a momentum investment strategy using the risk adjusted returns obtained from the Fama-French three-factor model. Zhou and Ziobrowski (2009) apply Carhart's (1997) four-factor model including momentum to the analysis of E-REIT performance persistency. They find little evidence of persistence in E-REIT returns using Carhart's four-factor model while persistence appears with CAPM; therefore, the four-factor model might capture additional systematic risk which is viewed as the persistence under the CAPM.

Although the papers above examine the momentum effects and return persistency in REITs, none of them employs an asset pricing model to examine the relationship between risk and return when controlling for Carhart's momentum effect. Applying the FF4 to analyze the behavior of REIT IPOs, Buttimer et al. (2005) note that "researchers have found this factor to be useful in explaining returns on portfolios." However, they do not analyze the effect of momentum on REIT returns. Compared to the relatively large amount of momentum analysis in the finance literature, there are few papers which apply the FF4 to the analysis of the risk-return relationship in REITs.

2.5 Studies of Property Sectors in REIT Returns

Initially, Gyourko and Nelling (1996) examine systematic risk in public real estate from the perspective of the CAPM and find that systematic risk varies by property sector with significantly higher risk for retail REITs.

Clayton and MacKinnon (2003) employ a multi-factor model to decompose quarterly-return variance based on the NAREIT Index and other market indexes. The results indicate that REITs began to behave more like (underlying direct) real estate in the 1990s and dramatically increasing idiosyncratic risk became the dominant factor. However, they have difficulty interpreting the influence of property sectors on REIT returns in contrast to the influence of other major asset classes. They find varied strength of relationships between sector-specific REIT returns and each sector-specific direct real estate index, and explain this result as evidence of the limited influence of the property sector on REIT returns. They also find relatively low idiosyncratic risk in office and diversified REITs compared with other sectors including apartment, industrial and retail properties. The relatively small market capitalization of diversified REITs implies limited informational transparency and is offered as a reason for low idiosyncratic risk. However, they admit that low idiosyncratic risk in the office sector cannot be explained with the same argument.

Anderson, Clayton, MacKinnon and Sharma (2005) extend the sample period of Clayton and MacKinnon (2003) until 2003 and increase the frequency of return data from quarterly to monthly. Employing a variance decomposition approach, they decompose the NAREIT Index return for the four market indexes (large cap stocks, small cap growth stocks, small cap value stocks and bonds) and confirm consistently declining REIT exposure to systematic risk over time.

Furthermore, they add the Green Street NAV series[1] in the model as a proxy of private real estate and find this proxy is the most significantly related variable to NAREIT returns among the five variables. The Fama-French three-factor model is also employed to confirm the robustness of the results.

Liow and Addae-Dapaah (2010) examine weekly return data on US REIT firms and find that total return is positively related to idiosyncratic risk. This relationship remains positive with the inclusion of nine property sector segment return indices (rather than dummy variables) with statistical significance in diversified, health-care, hotel, mortgage, residential and retail. This result suggests some property sectors might play an important role in the relationship between idiosyncratic risk and expected returns. However, the property sector segment return indices are not purified to consist exclusively of unique attributes to each property sector. Due to the inclusion of noise, they might not be appropriate for measuring the sensitivity of the various property sectors on the relationship between idiosyncratic risk and expected returns. A much improved adjusted R-square, from 0.022 to 0.822, also suggests significant difference in the model before and after the inclusion of these indices.

[1] "Green Street is a highly regarded buy-side REIT research firm, and its NAV data is widely quoted and regarded as the best available." (Anderson et al., 2005)

3. Methodology

3.1 Hypothesis

Tracing the analytical process of Ooi et al. (2009), this dissertation aims to re-examine the relationship between idiosyncratic risk and expected returns in REITs and contributes to the literature by expanding our knowledge of idiosyncratic risk in REITs. I (i) re-examine the proportion of idiosyncratic risk over total return volatility in REITs both with and without momentum at the portfolio-level as an additional systematic risk in the model, (ii) review the impact of momentum on the relationship between idiosyncratic risk and expected returns controlling for three systematic risks including size, value and momentum at the firm-level, and (iii) investigate whether property sector changes this relationship.

I test three hypotheses. First, I hypothesize that the proportion of idiosyncratic risk to total risk should decrease significantly with the inclusion of the momentum factor in addition to the Fama-French's three factors. Therefore, these extended market factors should explain a larger proportion of total return volatility. While finance journals have generally accepted Carhart's momentum effect on the FF4 as one of risk factors in asset pricing models, only a few papers employing similar methodologies have been published in real estate. This dissertation contributes to the real estate literature by extending our knowledge about the impact of momentum in REITs as an extension of Ooi et al. (2009).

Second, I hypothesize that Modern Portfolio Theory (MPT) holds for the relationship between idiosyncratic risk and expected returns in REITs. If the MPT holds, idiosyncratic risk is the residual of total risk after systematic risk; therefore, no relationship should be observed between idiosyncratic risk and expected returns in REITs. This hypothesis contradicts the findings of Ooi et al. (2009) who argue under-diversified REIT investors are compensated for their inability to hold well diversified portfolios; therefore, the idiosyncratic risk would be positively related to subsequent returns in REITs. If the first hypothesis is supported, expanded exposure of returns to systematic risk might eliminate or significantly weaken the relationship between idiosyncratic risk and expected returns.

Third, I hypothesize that additional firm-level controls on the FF3 for property sector will increase the systematic risk component of REIT return volatility. Property sectors are one of the unique characteristics of REITs reflecting the differences in property type uses. There might be a significant proportion of idiosyncratic risk attributed to property sectors in the case of REITs. Gyourko and Nelling (1996) report significantly higher risk in retail REITs, and Clayton and MacKinnon (2003) find relatively low idiosyncratic risk in office and diversified REITs compared with other sectors.

3.2 Estimation of idiosyncratic risk in REITs

I conduct regression analysis to estimate the standard deviation of residuals as idiosyncratic risk for each REIT. While the monthly-return-based idiosyncratic risk is arguably stable (Bali and Cakici, 2008), Fu (2009) views daily-return-based idiosyncratic risk as a more appropriate measurement of idiosyncratic risk due to its time-varying nature. In this study, I follow the methodology of Fu (2009) and Ooi et al. (2009). Idiosyncratic risk is measured every month as the volatility of daily-returns in the previous month (Ang et al., 2006; Fu, 2009; Ooi et al., 2009; Sun and Yung, 2009; and Huang et al., 2010) based on the Fama-French three factor model (FF3) as described in Equation (1).

$$R_{i,\tau} - r_{f,\tau} = \alpha_{i,t} + \beta_{MKT,i,t}(R_{MKT,\tau} - r_{f,\tau}) + \beta_{SMB,i,t} SMB_{\tau} + \beta_{HML,i,t} HML_{\tau} + \varepsilon_{i,t} \tag{1}$$

where $R_{i,\tau}$ - $r_{f,\tau}$ is the excess returns of REIT$_i$ on date $_\tau$, and $\alpha_{i,t}$ is intercept in month$_t$. $R_{MKT,\tau}$ - $r_{f,\tau}$, SMB_{τ} and HML_{τ} are Fama-French's benchmark factors. The three systematic risks are the market effect (excess returns to the market), the size effect (the difference in returns between small firms and large firms), and the value effect (the difference in returns between firms with high book-to-market (B/M) ratios and firms having low B/M ratio) respectively. $\beta_{MKT,i,t}$, $\beta_{SMB,i,t}$, and $\beta_{HML,,i,t}$ are the factor loadings on $REIT_i$ in month $_t$, and $\varepsilon_{i,t}$ indicates the residual.

Following the analytical process of Ooi et al. (2009), I run cross-sectional regressions for each REIT month-by-month from 1996 to 2007. Monthly idiosyncratic risk is measured as the standard deviation of regression residuals in Equation (1) and consolidated across sample REITs by equal-weighted averaging of daily-return-based idiosyncratic risk every month. I also report monthly idiosyncratic risk as an equal-weighted proportion of the total return volatility, the variance of the regression residuals divided by the total return volatility.

Although Ooi et al. (2009) do not attempt to apply additional systematic risks to measure idiosyncratic risk beyond the Fama-French three-factor model, I next repeat the cross-sectional regression above for an additional systematic risk capturing the effect of persistent performance over time, namely Carhart's momentum (Carhart, 1997), as described in Equation 2.

$$R_{i,\tau} - r_{f,\tau} = \alpha_{i,t} + \beta_{MKT,i,t}(R_{MKT,\tau} - r_{f,\tau}) + \beta_{SMB,i,t}SMB_\tau + \beta_{HML,i,t}HML_\tau + \beta_{MMNTM,i,t}Momentum_\tau + \varepsilon_{i,t} \quad (2)$$

where $Momentum_\tau$ is an additional systematic risk, momentum factor, on date $_\tau$. $\beta_{MMNTM,i,t}$ is the factor loading on $REIT_i$ in month$_t$. This model is a first-pass regression equation, and estimated risk measures (idiosyncratic risk and market risk) are used as independent variables of a second-pass regression in Section 3.4. Daily return data of publicly traded REITs is obtained from the CRSP Ziman Real Estate Data Series. Factor data for the four systematic risks including market, size, value, and momentum as well as monthly risk free rates are downloaded from Wharton Research Data Services (WRDS).

3.3 Relationship between idiosyncratic & systematic risks and REIT returns at the firm-level

I examine the cross-sectional relationship of expected returns to both idiosyncratic and systematic risk variables. I regress excess returns for risk variables conditionally estimated from the results of first-pass regression, namely idiosyncratic risk ($\varepsilon_{i,t}$) and market risk ($\beta_{MKT,i}$), at the firm-level every month. Consistent with the findings of Ooi et al. (2009), the market risk and idiosyncratic risk of REITs are non-stationary and therefore do not follow a random walk process. They conclude that "using lagged values to approximate expected values could lead to measurement errors in variables and unreliable inferences for our study sample." Following their lead, I also employ the EGARCH model to derive the conditional idiosyncratic volatility for the individual REITs (Equation 3).

$$\ln \sigma_{i,t}^2 = \alpha_t + \sum_{j=1}^{p} b_{i,j} \ln \sigma_{i,t-j}^2 + \sum_{k=1}^{q} c_{l,k} \left\{ \theta \left(\frac{\varepsilon_{i,t-k}}{\sigma_{i,t-k}} \right) + \gamma \left[\left| \frac{\varepsilon_{i,t-k}}{\sigma_{i,t-k}} \right| - (2/\pi)^{1/2} \right] \right\} \tag{3}$$

The monthly excess return process follows the specification in the Fama French three factor model. The idiosyncratic risk is the square root of conditional variance (σ^2), which is a function of the past p-period of residual variance and q-period of shocks, where $1 \leq p, q \leq 2$. Permutation of these orders yield four different EGARCH models: EGARCH (1,1), EGARCH (1,2), EGARCH (2,1) and EGARCH (2,2). We estimate the time-series conditional idiosyncratic volatility of each individual REIT using all four E-GARCH models and select the best one which converges within 500 iterations and yields the lowest Akaike Information Criterion (AIC). Expected market risk (beta) is also estimated conditionally using the GARCH (1,1) model following the methodology of Ooi et al. (2009).

Regression is also controlled for three additional systematic risk factors at the firm-level, namely size, book-to-market value and momentum. Following standard practice in Malkiel and Xu, (2006), Fu, (2009) and Ooi et al., (2009), I employ the methodology of Fama and French (1992) and estimate these systematic risks by replicating Ooi et al. (2009) as follows. "Firm size (ME) is measured by the market value of common equity, which is the product of the monthly closing price and the number of shares outstanding for June of year t. Book-to-market equity (B/M) is defined as the fiscal year-end book value of common equity divided by the calendar year-end market value of common equity. Due to the annual frequency of book equity, this variable is updated yearly. ME and B/M are transformed to a natural logarithm because they are significantly skewed. In order to capture the momentum effect, we construct a variable called Ret (−2, −13), which is essentially the cumulative return calculated over the past 12 months beginning with t−2 month, where t presents the current month. Following standard practice, the return of month t−1 is excluded to avoid any spurious association between the prior month return and the current month return caused by thin trading or the bid-ask spread effect, which may cause returns to exhibit first order serial correlations."

Equation (4) describes the second-pass regression model for both systematic and idiosyncratic risk. Systemic risks are the factor loadings obtained from the first-pass regression model (Equation 2) in Section 3.2 including $\beta_{MKT,i,t}$, $\beta_{SMB,i,t}$, and $\beta_{HML,,i,t}$; and the idiosyncratic risk is the residual, $\varepsilon_{i,t}$.

$$R_{i,t} - r_{f,t} = \alpha_{0,t} + \sum_{k=1}^{k} \beta_{k,t} X_{k,i,t} + \varepsilon_{i,t} \quad i = 1,2,\cdots,N_t,\ \ t = 1,2,\cdots,T \tag{4}$$

where $R_{i,t}$ - $r_{f,t}$ is the excess return on REIT_i in month_t, and $\alpha_{0,t}$ is intercept. $X_{k,i,t}$ is the explanatory variable_k including idiosyncratic risk, market (beta), size, value and momentum. $\beta_{k,t}$ is the coefficient for each explanatory variable. $\varepsilon_{i,t}$ is the residual capturing the deviation of the realized return from its expected value. N_t denotes the number of REITs in the cross-sectional regression in month_t. I select all the listed REITs available from the CRSP Ziman Real Estate Data Services with at least 24 to 60 months (as available) of consecutive market performance data consistent with the previous section. The firm-level financial data is obtained from the CRSP/COMPUSTAT Merged

Database and the CRSP/Ziman Real Estate Data Series. The significance of each factor loadings is tested by t-statistics, the average regression slope (average coefficient) divided by its time-series standard error.

I examine the t-statistics, time-series average of the difference over the standard deviation, for the significance of time-series return differences. If idiosyncratic risk is priced, obtained t-statistics should be significantly different from zero, either positive or negative. Otherwise, the result supports the argument that idiosyncratic risk is not priced. Equation 5, 6 and 7 describe the process used to estimate t-statistics for each factor loading.

$$\bar{\hat{\beta}}_k = \frac{1}{T}\sum_{t=1}^{T}\hat{\beta}_{k,t} \tag{5}$$

$$VAR(\hat{\beta}_k) = \frac{\sum_{t=1}^{T}(\hat{\beta}_{k,t} - \bar{\hat{\beta}}_k)^2}{T(T-1)} \tag{6}$$

$$t(\hat{\beta}_k) = \frac{\bar{\hat{\beta}}_k}{\sqrt{VAR(\hat{\beta}_k)/T}} \tag{7}$$

$\bar{\hat{\beta}}_k$ is the average slope of each explanatory variable, and $VAR(\hat{\beta}_k)$ is its variance. The t-statistic is the average slope divided by its time-series standard error, which is the square root of the variance of $\hat{\beta}_k$ divided by *T*.

3.4 Property sector in the relationship between idiosyncratic risk and REIT returns

Employing two types of dummy variables on idiosyncratic risk, I further examine how property sector influences the relationship between idiosyncratic risk and REIT returns. Equation (8) is expanded from Equation (4) with two dummy variables.

$$R_{i,t} - r_{f,t} = \alpha_{0,t} + \sum_{k=1}^{k}\beta_{k,t}X_{k,i,t} + \sum_{l=1}^{l}\gamma_{l,t}D_l + \sum_{l=1}^{l}\delta_{l,t}X_{Idiosyncratic\ risk,i,t}D_l + \varepsilon_{i,t} \quad i = 1,2,\cdots,N_t,\ \ t = 1,2,\cdots,T \tag{8}$$

where D_l are the intercept and slope dummy variables on idiosyncratic risk for Sector$_l$, including retail, office/industrial, residential and mortgage as well as diversified, lodging, and health-care following the definition of CRSP/Ziman Real Estate Data Series. $\gamma_{l,t}$ and $\delta_{l,t}$ are the coefficients for each intercept and slope dummy variables respectively. Slope dummy, $\delta_{l,t}$, is applied only for idiosyncratic risk to examine the influence of idiosyncratic risk on expected returns. Equation 9, 10 and 11 describe the process used to estimate t-statistics for the intercept dummy variables; and Equation 12, 13 and 14 for the slope dummy variables. Consistent with the previous section, I examine t-statistics of each dummy variable for the significance of each property sector.

$$\bar{\hat{\gamma}}_l = \frac{1}{T}\sum_{t=1}^{T}\hat{\gamma}_{l,t} \tag{9}$$

$$VAR(\hat{\gamma}_l) = \frac{\sum_{t=1}^{T}(\hat{\gamma}_{l,t} - \bar{\hat{\gamma}}_l)^2}{T(T-1)} \tag{10}$$

$$t(\hat{\gamma}_l) = \frac{\bar{\hat{\gamma}}_l}{\sqrt{VAR(\hat{\gamma}_l)/T}} \tag{11}$$

$$\bar{\hat{\delta}}_l = \frac{1}{T}\sum_{t=1}^{T}\hat{\delta}_{l,t} \tag{12}$$

$$VAR(\hat{\delta}_l) = \frac{\sum_{t=1}^{T}(\hat{\delta}_{l,t} - \bar{\hat{\delta}}_l)^2}{T(T-1)} \tag{13}$$

$$t(\hat{\delta}_l) = \frac{\bar{\hat{\delta}}_l}{\sqrt{VAR(\hat{\delta}_l)/T}} \tag{14}$$

4. Results

4.1 First Hypothesis

Ooi et al. (2009) employ the Fama-French (1993) three-factor model (FF3) to estimate the level of nonsystematic return volatility in REITs as a proxy for idiosyncratic risk. They report that idiosyncratic risk constitutes nearly 80% of the overall return volatility of REITs between 1990 and 2005. This result is consistent with the estimates in the finance literature that average common stock volatility is mostly driven by idiosyncratic risk (Goyal and Santa-Clara, 2003). Regarding the methodology to estimate idiosyncratic risk, a few studies in both the finance and the real estate literature examine additional variables to the Fama-French' s three factors and attempt to extend the asset pricing model.

One of notable variables is Carhart's (1997) momentum factor which is largely applied on the Fama-French's three factor model to control for the persistency of stock returns as supplemental risk. Constructing the four-factor model (FF4), he finds the substantial improvement on the average pricing errors of the FF3. In other words, the FF4 can capture larger proportion of return volatility explained by the market and reduce the proportion of residual or idiosyncratic risk not explained by the market.

Although few papers analyze the relationship between idiosyncratic risk and expected returns based on the FF4 in the real estate literature, a number of papers employ the FF4 in the finance literature. Comparing idiosyncratic risk of stocks based on the FF3 and FF4, Cao et al. (2008) report a slight decline in idiosyncratic risk from the addition of momentum. Other finance papers also report slight increases or no change of the R-squares between the two models (Huang et al., 2010;Fama and French, 2010; Chordia and Shivakumar, 2005).

I assume that Carhart's momentum factor expands the definition of systematic risk by capturing the effect of persistent performance and mitigating the dominant proportion of idiosyncratic risk. Therefore, I hypothesize that systematic risk will be increased significantly and idiosyncratic risk will be reduced accordingly due to the inclusion of the momentum factor. As summarized in Descriptive Statistics (Table 2) as well as graphically described in Figure 1 and Figure 2, the inclusion of momentum reduces idiosyncratic risk. Average standard deviation of the monthly regression residuals decreases by 0.002 from 0.067 to 0.065 during the period 1996 to 2007 and its proportion decreases by 0.048 from 0.733 to 0.685. In other words, the proportion of total return volatility explained by the market increased from 0.267 to 0.315. The contribution of the momentum factor is also constant across two 6-year sub-periods. As Ooi et al. (2009) argue, the dominance of idiosyncratic risk in total return is confirmed. In addition, the standard deviation declines due to the unique contribution of the momentum factor providing evidence that a part of idiosyncratic risk previously found in REITs is attributable to momentum effects.

The inclusion of momentum reduces idiosyncratic risk. However, the reduction is relatively minor consistent with previous studies in the finance literature. An F-test rejects the statistical significance of the reduction at the 10% level; therefore, I reject H1.

4.2 Second Hypothesis

In the finance literature, Choi (2008) analyzes common stocks and finds that positive relationship between idiosyncratic risk and expected returns becomes insignificant when the model is controlled for the omitted variables US bonds, REITs, commodity futures, foreign stocks and bonds. In the real estate literature, Ooi et al. (2009) finds a significant positive relationship between expected returns and conditionally estimated idiosyncratic risk. They argue that under-diversified REIT investors are compensated for their inability to hold well diversified portfolios; therefore, the idiosyncratic risk would be positively related to the subsequent returns of REITs. However, they do not attempt to apply any additional systematic risks beyond the Fama-French's three-factor's market, size and value.

In the second hypothesis, I examine the momentum factor as an additional source of systematic risk in REITs which may explain the seeming violation of the MPT found by Ooi et al. (2009). The MPT predicts that all un-systematic risk can be diversified away; thus, there should be no relationship between idiosyncratic risk and return. Although the first hypothesis is rejected, the additional control for momentum might weaken the relationship between idiosyncratic risk and expected returns in the FF4 model. I hypothesize that expansion of the applied asset pricing model from the FF3 to the FF4 including momentum may eliminate or at least weaken the relationship significantly.

I confirm significant positive relationship between expected returns and idiosyncratic risk, E(IR), on the FF3 in all models including those controlled for size, value and momentum at the firm-level as shown in Table 3 and Table 4. Consistent with existing finance papers (Boehme et al., 2009 and Huang et al., 2010), I continue to find a positive relationship based on the FF4. Comparing the results based on the FF3 and the FF4 in Table 3 as well as between Table 4 and Table 7, the inclusion of the momentum factor weakens the relationship in all five models: Model FF4-2, FF4-3, FF4-4C, FF4-5C and FF4-6C. Among these five models, Model FF4-2 displays the least significant relationship among the five models as indicated by the largest p-value. As Model FF4-2 includes the fewest numbers of independent variables, measured idiosyncratic risk could be less purified than others; therefore, the relationship should be noisier. As a result, the positive relationship between idiosyncratic risk and expected returns remains significant in four out of five models except for Model FF4-2. This result provides evidence that a proportional increase of systematic risk reduces the relationship between idiosyncratic risk and expected returns. In accordance with Choi (2008), the inclusion of additional systematic risk factor weakens this relationship; however, the positive relationship itself remains statistically significant in most of the tested models. The results do not provide enough evidence to support H2; therefore, H2 is rejected.

4.3 Third Hypothesis

I assume that market risk is systematically different for the various property sectors. Therefore, additional controls for property sectors could improve the accuracy of regression model. This could also mitigate the proportion of risk classified as idiosyncratic and reduced idiosyncratic risk might not display the same relationship with expected returns. I hypothesize that the MPT holds and no relationship is observed between idiosyncratic risk and expected returns when I control for property sector. Furthermore, there might be specific property sectors with more significant influence on the relationship as some real estate papers argue (Gyourko and Nelling, 1996; Clayton and MacKinnon, 2003; Anderson, Clayton, MacKinnon and Sharma, 2005; and Liow and Addae-Dapaah, 2010).

I test this hypothesis on the FF3 in two steps for each two patterns of property sector grouping. As slope-dummy is applied to the coefficient of idiosyncratic risk, E(IR), I firstly test intercept dummy alone on the models excluding idiosyncratic risk namely, Model FF3-1-4S, FF3-4A-4S, FF3-4B-4S, FF3-5A-4S, FF3-5B-4S, FF3-6A-4S and FF3-6B-4S. (See Table 5.) Next I examine both constant and slope-dummies on the models including idiosyncratic risk namely, Model FF3-2-4S, FF3-3-4S, FF3-4C-4S, FF3-5C-4S and FF3-6C-4S. Regarding property sectors, the CRSP/Ziman Real Estate Data Series defines nine property sectors in REITs, and I set two patterns of property sector grouping. Based on the number of REITs in the sample, major four property sectors consist of retail, office/industrial, residential, and mortgage composed of 44, 38, 25 and 19 REITs respectively as summarized in the Descriptive Statistics (Table 2). The total number of REITs in this four sector-group accounts for 126 out of 183 in total. REITs in the five other property sectors are consolidated as others in each model. Next I segregate three more sectors, diversified, lodging and health-care composed of 17, 15 and 12 REITs respectively. The total number of REITs in this seven property sector group accounts for 170 REITs.

As shown in Table 5, I first test the intercept dummy on Model FF3-1-4S, FF3-4A-4S, FF3-4B-4S, FF3-5A-4S, FF3-5B-4S, FF3-6A-4S and FF3-6B-4S. None of intercept dummies displays statistical significance in all of seven tested models although significant increase of R-square indicates that the accuracy of each regression model is improved. Both the size effect, ln(ME) and the momentum effect, Ret(-2, -13), decrease the statistical significance in all the models. In other words, these two effects are different by property sectors and weakened with the inclusion of the property sector dummies. In contrast, significance of value effect remains unchanged after the inclusion of intercept dummies controlling for four property sectors. I interpret this result to suggest that a part of the size and momentum effects are partially explained by the differences of the various property sectors but does not differentiate returns at a statistically significant level. In contrast, the value effect is only affected by the property sector.

Secondly, I test both intercept and slope-dummies on Model FF3-2-4S, FF3-3-4S, FF3-4C-4S, FF3-5C-4S and FF3-6C-4S. Again, neither the intercept nor the slope dummies display any statistical significance in all tested models though a significant increase of R-squares appears consistent with the models above. The inclusion weakens two particular variables: momentum and idiosyncratic risk. Without the property sector dummies, the momentum effect is statistically significant at the 1% level in Model FF3-6C; however, it is no longer significant after the inclusion of intercept and slope-dummies in Model FF3-6C-4S. The relationship between idiosyncratic risk and expected returns is also weakened in all of five models. Idiosyncratic risk looses statistical significance in Model FF3-2-4S and remains significant at the 5% or 10% level in the other four models.

This result could be interpreted that a part of disputed relationship between idiosyncratic risk and expected returns in REITs is derived from differences in property sectors though none of property sector dummies is statistically significant. It is also consistent with the argument of Gyourko and Nelling (1996) that systematic risk in REITs varies by property sector. The significant increase of each R-square also indicates that the accuracy of each model improves after the inclusion of four property sector dummies; therefore, it strengthens the quality of each asset pricing model as well as weakens the relationship between idiosyncratic risk and expected returns.

Next, I test the seven property sector dummies and find that the relationship between idiosyncratic risk and expected returns becomes insignificant in all models as reported in Table 6. Compared with Table 5, the inclusion of the seven property sector dummies offset the influence of idiosyncratic risk on expected returns and hardly affects any of the other variables in each model. Ooi et al. (2009) argue that a positive relationship exists as the compensation for under-diversified REIT investors who are unable to hold well diversified portfolios. These results rather suggest that this seeming violation of the MPT is largely derived from the unique difference of idiosyncratic risk in REITs by property sector; however, they are not significant enough to support H3. As none of dummy variables show statistical significance for either four or seven property sectors, H3 is rejected.

4.4 Robustness Check

As a robustness check, I test the impact of the four and seven property sector dummies on the FF4 as well. (See Table 3, Table 7, Table 8 and Table 9) When four property sector dummies are included, an increased R-square provides significantly improved accuracy of each regression model. Property sector dummies controlling for retail present statistical significance only on the models including idiosyncratic risk, E(IR), as a variable. As shown on Table 8, the intercept dummy for retail becomes statistically significant in four out of five models namely Model FF4-2-4S, FF4-3-4S, FF4-4C-4S and FF4-5C-4S. By the comparison of Table 7 and Table 8, a positive relationship between idiosyncratic risk and expected returns is strengthened in the FF4, while the opposite effect is observed in the FF3 by the comparison between Table 4 and Table 5. As the idiosyncratic risk in the FF4 reflects Carhart's momentum effect, relatively purified idiosyncratic risk might respond to property sector dummies more actively than the idiosyncratic risk on the FF3 does. The negative sign on slope-dummy for retail in Model FF4-4C-4S indicates that the positive slope on idiosyncratic risk is flattened, therefore weakening the influence of idiosyncratic risk on expected returns for retail REITs in particular. This also supports the argument of Gyourko and Nelling (1996) reporting significantly higher systematic risk for retail REITs, therefore lowering idiosyncratic risk.

Testing seven property sector dummies on the FF4 (Table 9), I find that the relationship between idiosyncratic risk, E(IR), and expected returns is insignificant as happened on the FF3 models (Table 6). The results of all 12 models from Model FF4-1-7S to Model FF4-6C-7S are almost identical with those on the FF3 models from Model FF3-1-7S to Model FF3-6C-7S. The comparison of the results between FF3 and FF4, or Table 6 and Table 9, suggests that property sector is more influential than the momentum factor in the models including seven property sector dummies. Results with four property sector dummies on Table 5 and Table 8 might be explained as the transitional phase to shift major influential factor from momentum to the property sectors.

5. Conclusion

This dissertation aims to re-examine idiosyncratic risk in REITs controlling for momentum as a supplemental systematic risk as well as for property sectors. I hypothesize (i) systematic risk will be increased significantly, and idiosyncratic risk will be reduced after the inclusion of the momentum factor; (ii) consistent with the MPT, there will be no significant relationship between idiosyncratic risk and expected REIT returns at the firm-level after controlling for the momentum effect; and (iii) significant difference in the amount of idiosyncratic risk and its relationship to returns are attributable to property sectors.

The first hypothesis is rejected. The addition of the momentum factor to the Fama-French three-factor model reduces the proportion of idiosyncratic risk in REITs though the reduction is not statistically significant. The analytical result is consistent with the findings in the finance literature analyzing stocks and stock mutual funds including the relatively minor reduction of idiosyncratic risk after the inclusion of the momentum factor,

The second hypothesis is rejected. I continue to find a significant positive relationship based on the Fama-French four factor model although it is weakened due to the addition of the momentum factor. Although the proportion of systematic risk to total risk has increased, the relationship between idiosyncratic risk and expected returns is weakened but not enough to disappear.

Third hypothesis is also rejected. Applying property sector dummies, I find that the relationship between idiosyncratic risk and expected returns becomes insignificant in all models although none of the property sector dummies is statistically significant. Ooi et al. (2009) argue that positive relationship between idiosyncratic risk and expected returns exists as compensation for under-diversified REIT investors who are unable to hold well diversified portfolios. However, this result rather suggests that this seeming violation of the Modern Portfolio Theory is largely derived from the intrinsic difference of relationship between idiosyncratic risk and expected returns across property sectors in REITs.

This conclusion suggests three things. First, momentum has a relatively minor effect on the idiosyncratic risk consistent with the financial literature. Second, the momentum effect is not strong enough to cause a significant change in the relationship between idiosyncratic risk and expected returns. Third, REIT portfolio diversified across property sector neutralizes the relationship between idiosyncratic risk and expected returns, though the contribution of property sector is not statistically significant.

The relationship between idiosyncratic risk and expected return is still in debate in the finance literature. These findings contribute to the real estate literature and shed light on potential sources of systematic risk currently recognized as idiosyncratic in REITs.

Table 1: List of research analyzing idiosyncratic risk

Finance literature (recent papers)

Author(s)	Goyal & Santa-Clara	Malkiel & Xu	Ang, Hodrick, Yuhang & Xiaoyan	Bali & Cakici	Fu	Huang, Liu, Rhee & Zhang
Year	2003	2006	2006	2008	2009	2010
Sample data period	1963 - 1999	1963 - 2000	1986 - 2000	1963 - 2004	1963 - 2006	1963 - 2004
Return data frequency	Daily	Monthly	Daily	Daily & monthly	Daily	Daily & monthly
Control for systematic risks	Firm-level	Firm-level	Portfolio-level	Portfolio-level	Firm-level	Firm-level
Proportion of Idiosyncratic risk	About 85%	N/A	N/A	N/A	N/A	N/A
Estimation of idiosyncratic risk	Lagged measure	Lagged measure	Lagged measure	Lagged measure & Time-series	Time-series (conditional estimation)	Time-series (conditional estimation)
Relationship between idiosyncratic risk and expected returns	Positive	Positive	Negative	Insignificant	Positive	Positive

Real estate literature

Authors	Litt, Mei, Morgan, Anderson, Boston & Adornado	Clayton & MacKinnon	Anderson, Clayton, MacKinnon & Sharma	Sun & Yung	Ooi, Wang & Webb
Year	1999	2003	2005	2009	2009
Sample data period	1993 - 1997	1979 - 1998	1978 - 2003	1977 - 2006	1990 - 2005
Return data frequency	Monthly	Quarterly	Monthly	Daily	Daily
Control for systematic risks	Firm-level	Index-level	Index-level	Firm-level	Firm-level
Proportion of Idiosyncratic risk	66%	'79-'84: 14% '85-'91: 21% '92-'98: 63%	'78-'84: 40% '85-'92: 37% '93-'03: 62%	N/A	78%
Estimation of idiosyncratic risk in subsequent period	N/A	N/A	N/A	Lagged measure	Time-series (conditional estimation)
Relationship between idiosyncratic risk and expected returns	N/A	N/A	N/A	Positive	Positive

Table 2: Descriptive statistics

	Average (1996– 2007)		Average (1996– 2001)		Average (2002– 2007)	
	Idiosyncratic risk	Proportion of idiosyncratic risk	Idiosyncratic risk	Proportion of idiosyncratic risk	Idiosyncratic risk	Proportion of idiosyncratic risk
FF3	0.067	0.733	0.074	0.802	0.060	0.664
FF4	0.065	0.685	0.072	0.751	0.058	0.618

	Number of REITs
Retail	44
Residential	25
Office/industrial	38
Mortgage	19
Others	57
Total	183

Others include diversified (17 REITs), health-care (12 REITs), lodging (15 REITs), self-storage (4 REITs) and un-classified (9 REITs).

Table 3: Average slopes (p-values) on FF3 and FF4

	Model	C	E(BETA)	E(IR)	R-square	Adj. R-square
FF3	FF3-1	0.009 ***	-0.001		0.036	0.029
		(0.001)	(0.875)			
	FF3-2	0.004		0.087 *	0.073	0.066
		(0.232)		(0.064)		
	FF3-3	0.003	-0.001	0.095 **	0.099	0.087
		(0.331)	(0.595)	(0.043)		
FF4	FF4-1	0.008 ***	0.000		0.036	0.029
		(0.002)	(0.907)			
	FF4-2	0.004		0.073	0.071	0.065
		(0.186)		(0.113)		
	FF4-3	0.004	-0.002	0.081 *	0.098	0.086
		(0.250)	(0.517)	(0.073)		

Average slope (p-value) from month-by-month regressions
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

Table 4: FF3 controlling for size, value and momentum effects at the firm-level

FF3	Model	C	E(BETA)	ln(ME)	ln(BE/ME)	Ret(−2,−13)	E(IR)	R−square	Adj. R−square
Size effect									
	FF3−4A	0.000		0.001 *				0.041	0.035
		(0.981)		(0.078)					
	FF3−4B	0.001	−0.001	0.001 *				0.074	0.061
		(0.921)	(0.718)	(0.086)					
	FF3−4C	−0.013 ***	−0.003	0.002 ***			0.134 ***	0.130	0.113
		(0.001)	(0.321)	(0.001)			(0.005)		
Value effect									
	FF3−5A	0.008 ***			−0.001			0.024	0.018
		(0.008)			(0.490)				
	FF3−5B	0.008 ***	−0.001		−0.001			0.060	0.047
		(0.002)	(0.646)		(0.466)				
	FF3−5C	−0.013 ***	−0.003	0.002 ***	−0.001		0.134 ***	0.149	0.125
		(0.003)	(0.223)	(0.002)	(0.689)		(0.007)		
Momentum effect									
	FF3−6A	0.007 ***				0.014 ***		0.034	0.028
		(0.025)				(0.010)			
	FF3−6B	0.007 **	−0.001			0.015 ***		0.069	0.056
		(0.011)	(0.658)			(0.006)			
	FF3−6C	−0.015 ***	−0.004	0.002 ***	−0.001	0.015 ***	0.142 ***	0.170	0.141
		(0.001)	(0.167)	(0.004)	(0.533)	(0.001)	(0.003)		

Average slope (p−value) from month−by−month regressions
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

Table 5: FF3 controlling for 3 effects at the firm-level plus 4 property sectors

4 Sector Model	C	E(BETA)	ln(ME)	ln(BE/ME)	Ret(−2,−13)	E(IR)	Constant Mortgage	Constant Retail	Constant Residential	Constant industrial &Office	Slope Mortgage	Slope Retail	Slope Residential	Slope industrial &Office	R−square	Adj. R−square
FF3																
FF3−1−4S	0.008 ***	0.000					0.000	0.001	0.002	0.003					0.101	0.070
	(0.006)	(0.943)					(0.907)	(0.688)	(0.331)	(0.155)						
FF3−2−4S	0.002					0.097	−0.005	0.006	0.005	0.001	0.039	−0.061	−0.046	0.043	0.220	0.171
	(0.617)					(0.119)	(0.502)	(0.146)	(0.335)	(0.884)	(0.659)	(0.443)	(0.616)	(0.637)		
FF3−3−4S	0.001	−0.001				0.115 *	−0.005	0.007	0.006	0.002	0.033	−0.074	−0.054	0.035	0.244	0.190
	(0.884)	(0.711)				(0.060)	(0.494)	(0.104)	(0.250)	(0.759)	(0.711)	(0.341)	(0.551)	(0.699)		
Size effect																
FF3−4A−4S	0.001		0.001				0.001	0.000	0.001	0.002					0.102	0.072
	(0.901)		(0.101)				(0.781)	(0.987)	(0.661)	(0.411)						
FF3−4B−4S	0.001	−0.001	0.001				0.001	0.000	0.001	0.002					0.134	0.098
	(0.744)	(0.828)	(0.139)				(0.792)	(0.980)	(0.543)	(0.356)						
FF3−4C−4S	−0.015 ***	−0.002	0.002 ***			0.150 **	−0.002	0.007	0.004	−0.001	0.011	−0.091	−0.037	0.063	0.270	0.212
	(0.001)	(0.366)	(0.001)			(0.014)	(0.808)	(0.102)	(0.483)	(0.774)	(0.903)	(0.242)	(0.678)	(0.472)		
Value effect																
FF3−5A−4S	0.008 **			−0.001			0.001	0.001	0.002	0.003					0.085	0.053
	(0.015)			(0.581)			(0.867)	(0.607)	(0.456)	(0.152)						
FF3−5B−4S	0.008 ***	−0.001		−0.001			0.000	0.001	0.002	0.003					0.120	0.082
	(0.007)	(0.745)		(0.603)			(0.951)	(0.650)	(0.381)	(0.117)						
FF3−5C−4S	−0.015 ***	−0.002	0.002 ***	0.000		0.155 **	0.000	0.005	0.004	−0.001	−0.006	−0.054	−0.047	0.056	0.286	0.223
	(0.001)	(0.369)	(0.001)	(0.837)		(0.011)	(0.962)	(0.276)	(0.420)	(0.838)	(0.954)	(0.488)	(0.608)	(0.519)		
Momentum effect																
FF3−6A−4S	0.007 **				0.009 *		0.001	0.001	0.002	0.003					0.093	0.061
	(0.041)				(0.086)		(0.842)	(0.458)	(0.308)	(0.125)						
FF3−6B−4S	0.007 **	−0.001			0.010 *		0.001	0.001	0.002	0.003					0.127	0.089
	(0.024)	(0.778)			(0.054)		(0.869)	(0.626)	(0.305)	(0.127)						
FF3−6C−4S	−0.015 ***	−0.002	0.002 ***	−0.001	0.007	0.152 **	−0.001	0.003	0.004	−0.001	−0.007	−0.032	−0.043	0.062	0.304	0.235
	(0.001)	(0.376)	(0.002)	(0.677)	(0.111)	(0.012)	(0.878)	(0.422)	(0.434)	(0.808)	(0.942)	(0.685)	(0.647)	(0.484)		

Average slope (p−value) from month−by−month regressions
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

Table 6: FF3 controlling for 3 effects at the firm-level plus 7 property sectors

7 Sector Model	C	E(BETA)	ln(ME)	ln(BE/ME)	Ret(−2,−13)	E(IR)	Constant							Slope							R−square	Adj. R−square
							Mortgage	Retail	Residential	industrial &Office	Lodging	Health−care	Diversified	Mortgage	Retail	Residential	industrial &Office	Lodging	Health−care	Diversified		
FF3																						
FF3−1−7S	0.008 ***	0.000					0.000	0.001	0.002	0.003	−0.002	0.001	0.001								0.135	0.086
	(0.006)	(0.968)					(0.945)	(0.692)	(0.393)	(0.196)	(0.603)	(0.693)	(0.836)									
FF3−2−7S	0.006					0.069	−0.009	0.002	0.001	−0.003	−0.013	−0.004	0.000	0.067	−0.033	−0.018	0.071	0.137	0.064	−0.073	0.310	0.234
	(0.249)					(0.495)	(0.242)	(0.707)	(0.880)	(0.542)	(0.110)	(0.596)	(0.986)	(0.567)	(0.766)	(0.876)	(0.515)	(0.333)	(0.633)	(0.545)		
FF3−3−7S	0.005	0.000				0.092	−0.009	0.003	0.002	−0.002	−0.011	−0.003	0.000	0.055	−0.054	−0.032	0.052	0.099	0.033	−0.076	0.325	0.246
	(0.383)	(0.941)				(0.359)	(0.254)	(0.585)	(0.754)	(0.679)	(0.170)	(0.690)	(0.957)	(0.644)	(0.617)	(0.779)	(0.630)	(0.478)	(0.807)	(0.525)		
Size effect																						
FF3−4A−7S	0.000		0.001 *				0.001	0.000	0.001	0.002	−0.002	0.002	0.001								0.137	0.088
	(0.995)		(0.083)				(0.747)	(0.864)	(0.633)	(0.384)	(0.592)	(0.608)	(0.680)									
FF3−4B−7S	0.001	−0.001	0.001				0.001	0.000	0.001	0.002	−0.003	0.001	0.001								0.167	0.114
	(0.825)	(0.841)	(0.113)				(0.785)	(0.950)	(0.586)	(0.388)	(0.527)	(0.755)	(0.675)									
FF3−4C−7S	−0.009	−0.002	0.002 ***			0.099	−0.007	0.001	−0.002	−0.007	−0.011	−0.004	−0.002	0.060	−0.043	0.012	0.102	0.095	0.037	−0.028	0.349	0.266
	(0.113)	(0.300)	(0.001)			(0.341)	(0.329)	(0.809)	(0.733)	(0.250)	(0.180)	(0.589)	(0.776)	(0.618)	(0.701)	(0.921)	(0.362)	(0.504)	(0.784)	(0.820)		
Value effect																						
FF3−5A−7S	0.007 **			−0.001			0.002	0.002	0.002	0.004	−0.001	0.002	0.001								0.123	0.072
	(0.030)			(0.558)			(0.724)	(0.413)	(0.351)	(0.112)	(0.833)	(0.473)	(0.639)									
FF3−5B−7S	0.007 **	−0.001		−0.001			0.001	0.001	0.002	0.004	−0.001	0.001	0.002								0.155	0.100
	(0.011)	(0.742)		(0.578)			(0.815)	(0.478)	(0.326)	(0.106)	(0.756)	(0.638)	(0.578)									
FF3−5C−7S	−0.009	−0.002	0.002 ***	0.000		0.102	−0.006	−0.001	−0.001	−0.006	−0.011	−0.003	−0.003	0.045	−0.007	0.005	0.097	0.104	0.028	−0.008	0.366	0.277
	(0.113)	(0.270)	(0.001)	(0.810)		(0.346)	(0.479)	(0.910)	(0.821)	(0.314)	(0.187)	(0.643)	(0.702)	(0.714)	(0.949)	(0.967)	(0.413)	(0.483)	(0.830)	(0.947)		
Momentum effect																						
FF3−6A−7S	0.006 *				0.009 *		0.001	0.002	0.002	0.003	−0.002	0.002	0.001								0.129	0.078
	(0.057)				(0.082)		(0.800)	(0.454)	(0.333)	(0.143)	(0.691)	(0.571)	(0.844)									
FF3−6B−7S	0.007 **	−0.001			0.010 **		0.001	0.001	0.002	0.003	−0.002	0.001	0.001								0.161	0.106
	(0.023)	(0.756)			(0.049)		(0.856)	(0.659)	(0.375)	(0.179)	(0.599)	(0.715)	(0.815)									
FF3−6C−7S	−0.010 *	−0.002	0.002 ***	−0.001	0.006	0.122	−0.006	−0.001	0.000	−0.005	−0.011	−0.002	−0.001	0.016	−0.008	−0.017	0.075	0.100	−0.002	−0.038	0.383	0.289
	(0.072)	(0.262)	(0.002)	(0.605)	(0.104)	(0.281)	(0.502)	(0.856)	(0.950)	(0.408)	(0.192)	(0.750)	(0.834)	(0.898)	(0.944)	(0.896)	(0.541)	(0.512)	(0.990)	(0.772)		

Average slope (p−value) from month−by−month regressions
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

Table 7: FF4 controlling for size, value and momentum effects at the firm level

FF4	Model	C	E(BETA)	ln(ME)	ln(BE/ME)	Ret(−2,−13)	E(IR)	R−square	Adj. R−square
Size effect									
	FF4−4A	0.000		0.001				0.042	0.035
		(0.991)		(0.107)					
	FF4−4B	0.001	−0.001	0.001				0.075	0.062
		(0.875)	(0.755)	(0.124)					
	FF4−4C	−0.011 ***	−0.003	0.002 ***			0.112 **	0.129	0.111
		(0.009)	(0.304)	(0.004)			(0.013)		
Value effect									
	FF4−5A	0.008 **			−0.001			0.024	0.018
		(0.012)			(0.640)				
	FF4−5B	0.008 ***	−0.001		−0.001			0.060	0.048
		(0.003)	(0.663)		(0.613)				
	FF4−5C	−0.011 ***	−0.004	0.002 ***	0.000		0.120 **	0.150	0.126
		(0.010)	(0.168)	(0.004)	(0.915)		(0.015)		
Momentum effect									
	FF4−6A	0.006 **				0.014 ***		0.034	0.028
		(0.046)				(0.009)			
	FF4−6B	0.006 **	−0.001			0.015 ***		0.069	0.056
		(0.022)	(0.670)			(0.005)			
	FF4−6C	−0.013 ***	−0.004	0.002 ***	0.000	0.014 ***	0.126 ***	0.172	0.143
		(0.003)	(0.118)	(0.007)	(0.926)	(0.002)	(0.008)		

Average slope (p−value) from month−by−month regressions
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

Table 8: FF4 controlling for 3 effects at the firm-level plus 4 property sectors

4 Sector Model	C	E(BETA)	ln(ME)	ln(BE/ME)	Ret(−2,−13)	E(IR)	Constant				Slope				R−square	Adj. R−square
							Mortgage	Retail	Residential	industrial &Office	Mortgage	Retail	Residential	industrial &Office		
FF4																
FF4−1−4S	0.008 ***	0.000					0.000	0.001	0.000	0.002					0.101	0.070
	(0.006)	(0.946)					(0.928)	(0.683)	(0.858)	(0.424)						
FF4−2−4S	0.001					0.104	−0.001	0.008 *	0.001	0.000	0.003	−0.096	0.009	0.032	0.222	0.173
	(0.702)					(0.076)	(0.844)	(0.065)	(0.828)	(0.931)	(0.968)	(0.248)	(0.915)	(0.737)		
FF4−3−4S	0.000	−0.002				0.122 **	−0.002	0.009 **	0.002	0.001	0.004	−0.116	−0.002	0.023	0.245	0.192
	(0.923)	(0.483)				(0.031)	(0.756)	(0.034)	(0.687)	(0.812)	(0.967)	(0.150)	(0.978)	(0.803)		
Size effect																
FF4−4A−4S	0.001		0.001				0.001	0.000	−0.001	0.001					0.103	0.073
	(0.847)		(0.119)				(0.785)	(0.980)	(0.771)	(0.795)						
FF4−4B−4S	0.002	−0.001	0.001				0.001	0.000	0.000	0.001					0.135	0.099
	(0.672)	(0.836)	(0.165)				(0.778)	(0.962)	(0.877)	(0.730)						
FF4−4C−4S	−0.014 ***	−0.003	0.002 ***			0.150 ***	0.000	0.009 **	0.000	−0.002	−0.011	−0.135 *	0.015	0.062	0.270	0.213
	(0.001)	(0.242)	(0.001)			(0.008)	(0.955)	(0.028)	(0.952)	(0.642)	(0.900)	(0.082)	(0.858)	(0.493)		
Value effect																
FF4−5A−4S	0.008 **			−0.001			0.001	0.001	0.000	0.002					0.086	0.053
	(0.013)			(0.707)			(0.891)	(0.563)	(0.962)	(0.426)						
FF4−5B−4S	0.008 ***	−0.001		−0.001			0.000	0.001	0.000	0.002					0.121	0.083
	(0.005)	(0.734)		(0.718)			(0.953)	(0.618)	(0.893)	(0.362)						
FF4−5C−4S	−0.015 ***	−0.003	0.002 ***	0.000		0.164 ***	0.002	0.007 *	0.001	−0.002	−0.029	−0.101	−0.005	0.053	0.288	0.225
	(0.001)	(0.163)	(0.001)	(0.976)		(0.004)	(0.795)	(0.081)	(0.838)	(0.712)	(0.759)	(0.183)	(0.955)	(0.560)		
Momentum																
FF4−6A−4S	0.006 **				0.009 *		0.001	0.001	0.000	0.002					0.093	0.061
	(0.046)				(0.068)		(0.822)	(0.468)	(0.865)	(0.398)						
FF4−6B−4S	0.007 **	−0.001			0.010 **		0.001	0.001	0.000	0.002					0.127	0.090
	(0.024)	(0.756)			(0.043)		(0.831)	(0.626)	(0.887)	(0.417)						
FF4−6C−4S	−0.015 ***	−0.004	0.002 ***	0.000	0.007 *	0.159 ***	0.001	0.006	0.001	−0.002	−0.028	−0.075	−0.003	0.058	0.305	0.237
	(0.000)	(0.136)	(0.001)	(0.946)	(0.079)	(0.005)	(0.878)	(0.170)	(0.839)	(0.693)	(0.773)	(0.325)	(0.975)	(0.528)		

Average slope (p−value) from month−by−month regressions
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

Table 9: FF4 controlling for 3 effects at the firm-level plus 7 property sectors

7 Sector Model	C	E(BETA)	ln(ME)	ln(BE/ME)	Ret(−2,−13)	E(IR)	Constant							Slope							R−square	Adj. R−square
							Mortgage	Retail	Residential	industrial &Office	Lodging	Health−care	Diversified	Mortgage	Retail	Residential	industrial &Office	Lodging	Health−care	Diversified		
FF4																						
FF4−1−7S	0.008 ***	0.000					0.000	0.001	0.000	0.002	−0.002	0.001	0.001								0.135	0.087
	(0.005)	(0.981)					(0.966)	(0.682)	(0.856)	(0.460)	(0.598)	(0.695)	(0.818)									
FF4−2−7S	0.007					0.050	−0.006	0.003	−0.004	−0.005	−0.012	−0.008	0.000	0.058	−0.042	0.063	0.086	0.123	0.141	−0.051	0.312	0.237
	(0.233)					(0.618)	(0.389)	(0.616)	(0.476)	(0.433)	(0.141)	(0.327)	(0.997)	(0.625)	(0.712)	(0.564)	(0.445)	(0.384)	(0.312)	(0.661)		
FF4−3−7S	0.005	−0.001				0.071	−0.007	0.004	−0.003	−0.003	−0.011	−0.006	0.001	0.053	−0.066	0.046	0.066	0.108	0.109	−0.062	0.329	0.249
	(0.333)	(0.720)				(0.468)	(0.368)	(0.468)	(0.601)	(0.561)	(0.175)	(0.419)	(0.895)	(0.654)	(0.550)	(0.673)	(0.548)	(0.442)	(0.434)	(0.593)		
Size effect																						
FF4−4A−7S	0.000		0.001 *				0.001	0.000	0.000	0.001	−0.002	0.002	0.001								0.138	0.089
	(0.949)		(0.099)				(0.752)	(0.863)	(0.898)	(0.718)	(0.594)	(0.606)	(0.693)									
FF4−4B−7S	0.001	−0.001	0.001				0.001	0.000	0.000	0.001	−0.003	0.001	0.001								0.168	0.115
	(0.754)	(0.859)	(0.135)				(0.773)	(0.935)	(0.895)	(0.746)	(0.521)	(0.756)	(0.672)									
FF4−4C−7S	−0.007	−0.002	0.002 ***			0.083	−0.006	0.003	−0.006	−0.008	−0.011	−0.006	−0.001	0.053	−0.067	0.078	0.116	0.096	0.085	−0.029	0.352	0.270
	(0.157)	(0.231)	(0.001)			(0.397)	(0.458)	(0.594)	(0.276)	(0.182)	(0.180)	(0.466)	(0.910)	(0.652)	(0.538)	(0.476)	(0.297)	(0.492)	(0.541)	(0.804)		
Value effect																						
FF4−5A−7S	0.007 **			−0.001			0.001	0.002	0.001	0.002	−0.001	0.002	0.001								0.123	0.072
	(0.026)			(0.683)			(0.751)	(0.393)	(0.735)	(0.306)	(0.816)	(0.471)	(0.650)									
FF4−5B−7S	0.008 ***	−0.001		−0.001			0.001	0.001	0.001	0.002	−0.001	0.001	0.002								0.156	0.101
	(0.008)	(0.740)		(0.693)			(0.812)	(0.441)	(0.731)	(0.292)	(0.746)	(0.626)	(0.551)									
FF4−5C−7S	−0.009	−0.003	0.002 ***	0.000		0.115	−0.003	0.002	−0.004	−0.006	−0.009	−0.003	−0.001	0.016	−0.054	0.038	0.086	0.062	0.033	−0.033	0.371	0.282
	(0.110)	(0.114)	(0.002)	(0.818)		(0.267)	(0.694)	(0.714)	(0.501)	(0.292)	(0.305)	(0.738)	(0.937)	(0.892)	(0.628)	(0.745)	(0.454)	(0.684)	(0.818)	(0.791)		
Momentum																						
FF4−6A−7S	0.006 *				0.010 *		0.001	0.001	0.001	0.002	−0.002	0.002	0.001								0.129	0.079
	(0.062)				(0.064)		(0.787)	(0.472)	(0.800)	(0.394)	(0.683)	(0.578)	(0.855)									
FF4−6B−7S	0.007 **	−0.001			0.010 **		0.001	0.001	0.000	0.001	−0.002	0.001	0.001								0.161	0.106
	(0.024)	(0.743)			(0.038)		(0.823)	(0.666)	(0.903)	(0.483)	(0.588)	(0.717)	(0.818)									
FF4−6C−7S	−0.009 *	−0.004 *	0.002 ***	0.000	0.007 *	0.118	−0.004	0.001	−0.004	−0.006	−0.010	−0.002	0.000	0.008	−0.037	0.029	0.079	0.063	0.008	−0.047	0.386	0.294
	(0.097)	(0.082)	(0.003)	(0.912)	(0.059)	(0.277)	(0.625)	(0.924)	(0.539)	(0.315)	(0.277)	(0.822)	(0.961)	(0.947)	(0.752)	(0.812)	(0.508)	(0.685)	(0.958)	(0.715)		

Average slope (p−value) from month−by−month regressions
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

Figure 1: Time path of idiosyncratic risk

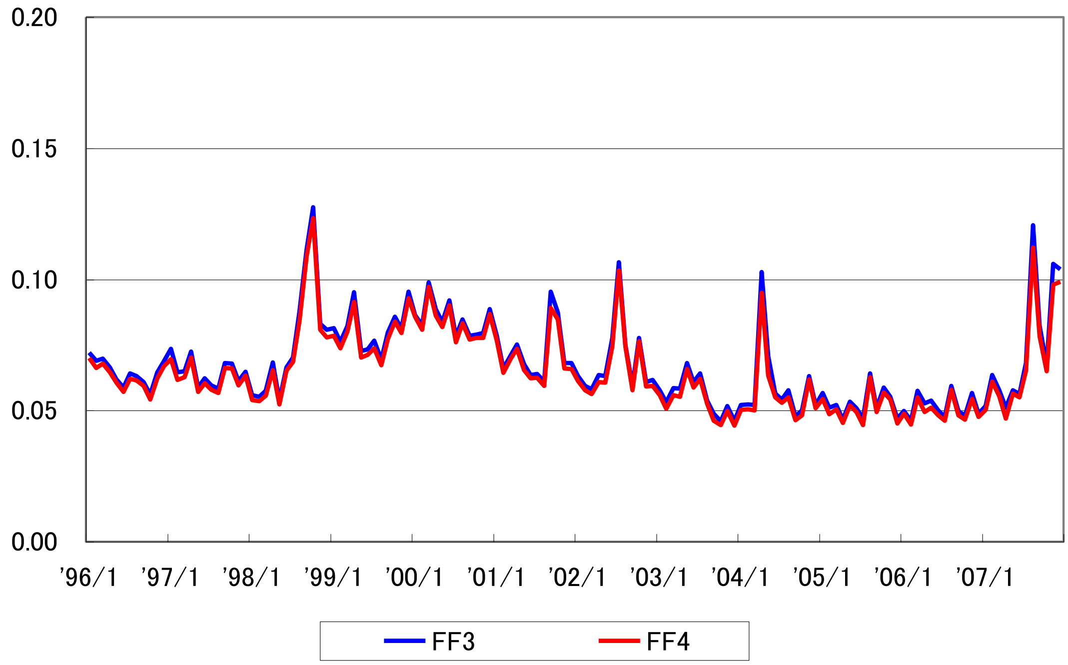
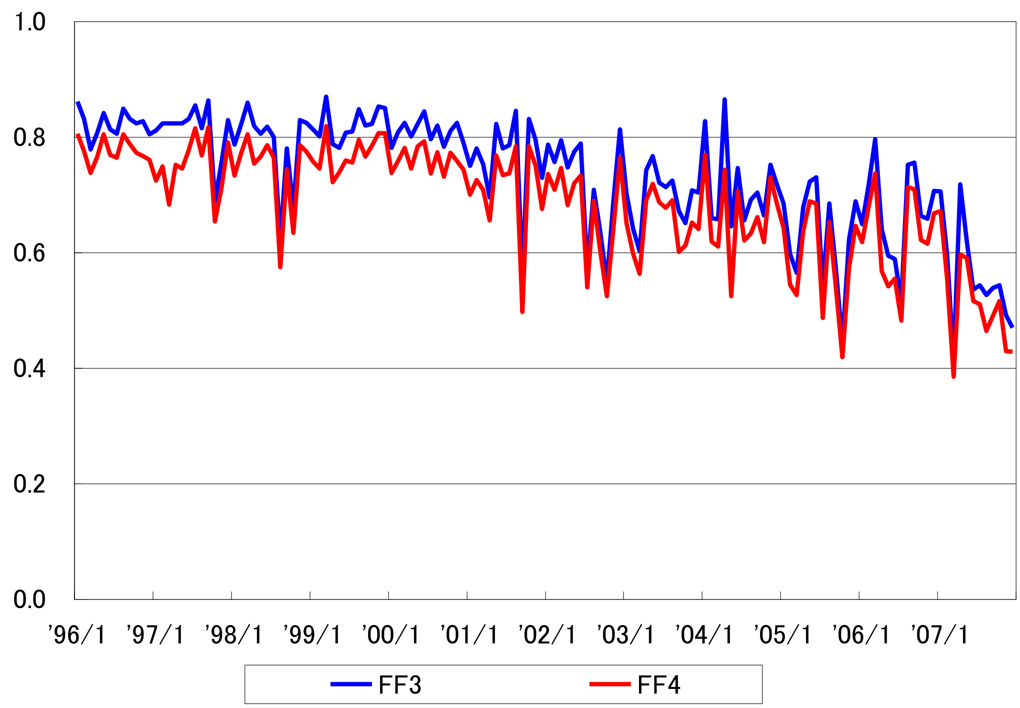


Figure 2: Idiosyncratic risk as a proportion of total volatility



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