Idiosyncratic Volatility and Expected Return in the Australian Market

School of Business and Law

Candidate: Thomas Seok Hur

Supervisor: Alireza Tourani-Rad

2010

A dissertation submitted to Auckland University of Technology in fulfillment of the requirements for the degree of Master of Business

Table of Contents

List of Figures

List of Tables

Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning

Acknowledgements

This dissertation would not have been possible without the support of many people. First of all, I especially wish to express my sincere appreciation and gratitude to my supervisors, Professor Alireza Tourani-Rad and Associate Professor Bart Frijns. They have been abundantly helpful and offered invaluable assistances, supports, motivations and guidance during my research and study at Auckland University of Technology. This study would not have been successful without them. I would also like to convey thanks to Doctor Pat Strauss and Doctor David Parker for their thoughtful revision of my writing and encouragement. My friends deserve special credits as they always have been supportive. Finally I thank to my parents, Chan-Woo Hur and Soon-Yeol Nam, my brother, Min Hur and my love, Hye-Sun Chang for their endless love and support during my study. Without them, I would have given up this study long time ago.

Abstract

After Ang, Hodrick, Xing and Zhang (2006) found a negative relationship between idiosyncratic volatility and return, researchers have extensively debated the relationship between the two. Previous literature however has been limited to cross-sectional analyses which can be biased if firm and time effects exist in data. This research adopts the two-dimensional clustered standard errors approach, recommended by Petersen (2009) and Thompson (2009) and finds a negative relationship between idiosyncratic risk and expected return in the Australian market over the period of August 1999 to February 2010. The negative relationship is even clearly shown among the above average size equities. In addition, the Australian equities returns are positively related to size and book-to-market ratio on the two-dimensional clustered standard errors approach.

1. Introduction

One of the most popular pieces of financial wisdom is that higher risk investment yields higher return. However the risk needs to be acceptable Brigham and Daves (2004) say that, "No investment should be undertaken unless the expected rate of return is high enough to compensate the investor for the perceived risk of the investment" (p. 29). Based on this approach, Capital Asset Pricing Model (CAPM) and the Fama-French three factor model (1993) were established for risk analysis. The former considers only market risk while the latter takes account of market, size and growth risk. If the models hold well, investors are able to diversify stocks' idiosyncratic risk and adjust their return with acceptable risk level. However, investors cannot be fully diversified for many reasons, for example, transaction costs and low liquidity stocks. Holding and rebalancing stocks in a portfolio are costly practices and some stocks are not readily available. For those reasons, most investors allow for both market risk and idiosyncratic stock risk in their portfolio. Idiosyncratic stock risk is also called individual stock risk and measured by idiosyncratic volatility. Finding a relationship between idiosyncratic volatility and return is a concern for investors.

Idiosyncratic volatility has been extensively debated in recent times (Brockman, Schutte and Yu, 2009). Merton (1987) established a model that illustrates that higher idiosyncratic volatility yields higher return. Based on his model, researchers have found a positive relationship between idiosyncratic risk and expected return. A number of researchers have found a positive relationship in the U.S. market (Malkiel & Xu 1997, 2004; Campbell, Lettau, Malkiel & Xu, 2001; Spiegel & Wang, 2005; and Brandt, Brav, Graham & Kumar, 2008). A positive relationship was also found in the Australian market (Dempsey, Drew & Veeraraghavan, 2001; Balachandran, Durden, Juthani & Velayutham, 2009; Bollen, Skotnicki

& Veeraraghavan, 2009). Characteristics of idiosyncratic volatility were in a negative relationship to size; (Malikiel & Xu, 1997) and liquidity; (Spiegel & Wang, 2005). Idiosyncratic volatility demonstrated a tendency to increase in the 30 year period between 1962 and 1997; (Campbell *et al.,* 2001) and dropped back to pre-1990s level in 2007 (Brandt *et al.,* 2008).

However, the research of Ang, Hodrick, Xing and Zhang (2006) indicated a negative relationship. They found that the lowest idiosyncratic volatility portfolio earned approximately 1% more than the highest idiosyncratic volatility portfolio per month. In other words, investors cannot be compensated by idiosyncratic risk. The negative relationship was not explained by their robust tests so for this reason, they called it a 'substantive puzzle'. Their findings resulted in wide spread criticism: Malkiel and Xu (2004) criticised the small number of their sample size; Bali and Cakici (2008) pointed to the need to control size, price and liquidity in their sample; Fu (2009) argued for auto-correlation of idiosyncratic volatility and Saryal (2009) found that noise around announcement days boosted the negative relationship. In 2009, Ang *et al.* published their worldwide results of the negative relationship and Brockman, Schutte and Yu (2009) countered this with Fu (2009)'s methodology.

Most researchers criticised Ang *et al.* (2006) using cross-sectional analysis. However, Petersen (2009) criticised these widely used methodologies. One of his criticisms is that while cross-section analysis considers only a time effect with a 1 x T (time) data set, a panel data set considers firm and time effects with an N (firm) x T (time) data set. In other words, the former considers only one aspect of a data set, the time effect, while the latter also considers the firm effect. Petersen (2009) and Thompson (2009) proved that the Fama-MacBeth regression (1973), which most idiosyncratic volatility studies adopted, effectively removes a time effect but the methodology is biased when there is a firm effect in the data set. They recommend the two-dimensional clustered standard error set to remove the two effects. Brandt *et al.* (2008) interestingly adopted Petersen (2009)'s advice and tested panel data set analyses to remove possible serial and cross correlation in their robustness test. Although they did not report their methodology in detail, employing panel data analysis is a unique approach in the asset pricing model world.

Faff (2004) found that the Fama-French three factor model's coefficients vary across the Australian industry. His result stressed the existence of industry effect in the market. In addition, Campbell *et al.* (2001) and Brandt *et al.* (2008) reported that industry volatility affected idiosyncratic volatility. Idiosyncratic volatility also varies across companies. For example, Saryal (2009) found increased idiosyncratic volatility around announcement days led to a negative relationship between idiosyncratic volatility and return. This dissertation, therefore, seeks to establish whether a negative relationship exists when both firm and time effects are considered.

Firstly, this research employs the logic of Ang *et al.* (2006) to find whether the aggregate volatility is priced in stock return. Ang *et al.* (2006) argued if aggregate volatility is negatively priced then idiosyncratic volatility is also negatively priced. In this research, once aggregate volatility has been established then idiosyncratic volatility is tested. Using 1,915 Three approaches, *ex-post* portfolio analyses, the Fama-MacBeth regression (1973) and the two-dimensional clustered standard error approach are employed over the period from July 1999 to February 2010. These approaches analyse aggregate and idiosyncratic volatilities to find the negative relationship.

The outline of the dissertation is as follows; Chapter 2 introduces the literature review. Firstly, a positive relationship between idiosyncratic volatility and return, and characteristics of idiosyncratic volatility are introduced. The findings and methodology employed by Ang *et al.* (2006) are analysed. Criticisms of the negative relationship follow next. Lastly, the methodology suggested by Petersen (2009) and Thompson (2009) in this study is introduced. Chapter 3 summarises data. Chapter 4 describes methodologies employed in this research. Calculation of idiosyncratic volatility, comparison of the Fama-MacBeth regression (1973) and the two-dimensional clustered standard errors approach are included in Chapter 4. Chapter 5 reports the results of the empirical tests; *ex-post* portfolio analyses, the Fama-MacBeth regression (1973) and the two-dimensional clustered standard error approach. Lastly, Chapter 6 concludes this dissertation.

2. Literature Review

2-1. Introduction

Asset pricing models have been developed to diversify individual stock risk or idiosyncratic risk by identifying risk factors and diversifying them. CAPM developed by Sharpe (1964), Lintner (1965) and Black (1972) considers market risk and the Fama-French three factor model (1993) takes into account market, size and growth risks. If the models hold well and investors are able to form a well-diversified portfolio, then investors' only concern would be market risk, non-diversifiable risk, or systematic risk. According to Statman (1987), investors can reduce portfolio risk by 40 percent by diversification and 30 stocks, at least, are needed to have a well-diversified portfolio. However, it is hard to form a well-diversified portfolio for many reasons. Merton (1987) argued that it is not easy to form a well-diversified portfolio for investors due to the transaction costs and unavailability of short-sell of small firms with few stockholders. Malkiel and Xu (1997) also noted that it is impractical to remove all idiosyncratic risk from an investor's portfolio. Goetzmann and Kumar (2008) found that, based on their sample of 62,387 household investors in the U.S., average investors held a portfolio of four stocks and less than 10 percent of the household had a portfolio of more than ten stocks over the period of 1991 to 1996. Therefore, idiosyncratic risk analysis has become an important field of study for investors.

This chapter discusses the characteristics of idiosyncratic volatility. Then, the negative relationship is analysed as well as critiques of the relationship. Finally, a brief review of the two-dimensional clustered standard error follows.

2-2. Idiosyncratic Volatility

2-2-1. Definition of Idiosyncratic Volatility

Definitions of idiosyncratic volatility vary. Malkiel and Xu (1997) defined variance of stock return minus variance of the S&P 500 index. Campbell *et al.* (2001) and Brandt *et al.* (2008) used difference of individual stock return and industry return. Recently, the residual of asset pricing model has been used as idiosyncratic volatility. Malkiel and Xu (2004) and Bali and Cakici (2008) adopted both CAPM and the Fama-French three factor model (1993). The latter model was used by Spiegel and Wang (2005), Ang *et al.* (2006, 2009), Fu (2009), Brockman *et al.* (2009), and Saryal (2009). Although these definitions differ from each other, all idiosyncratic volatility represents a part that cannot be diversified. Therefore, idiosyncratic volatility is a useful measure for the idiosyncratic risk.

2-2-2. Positive Relationship between Idiosyncratic Volatility and Return

Merton (1987) introduced a model that investors require a higher expected return to compensate higher idiosyncratic volatility as investors cannot be fully diversified. Asset pricing models assumed that investors can acquire readily available information. However this is hardly possible with small or concentrated ownership stocks. When information is not readily available, this information cost increases and investors expect a higher return for greater cost (Merton, 1987). In addition, the existence of transaction costs in the real world makes holding and rebalancing stocks in a portfolio a costly practice (Merton, 1987). In other words, higher costs raise idiosyncratic risk in an investor's portfolio and investors want to be compensated for their costs with higher returns. Many researchers have found evidence of Merton (1987)'s theory and characteristics of idiosyncratic volatility. Firstly, Malkiel and Xu (1997) found that idiosyncratic volatility had a positive relationship with average annual return and a negative relationship with market capitalisation using the U.S. stocks in the S&P 500 index between 1963 and 1994.

Secondly, an upward trend over the period of 1962 to 1997 was observed by Campbell *et al.* (2001). They plotted idiosyncratic volatility against time and the plot showed an upward trend. They compared the volatility with market and idiosyncratic volatilities, and idiosyncratic volatility was greater than market levels. The upward trend has decreased in the 21st century to pre-1990s levels (Brandt, Brav, Graham, & Kumar, 2008). Based on Campbell *et al.*'s study (2001), the authors calculated that idiosyncratic volatility was the sum of the square root of the daily individual firm volatility minus industry level volatility. According to Brandt *et al.* (2008), the volatility level from 1997 to 2007 has decreased.

Thirdly, idiosyncratic volatility had a positive relationship with expected return, and a negative relationship with liquidity (Spiegel & Wang, 2005). In their sample between 1962 and 2003, the highest idiosyncratic volatility deciles had 1.33% more average return than the lowest deciles. In addition, the highest deciles had the smallest size and the least liquidity in their result.

Lastly, Malkiel and Xu (2004) found a positive relationship using CAPM and the Fama-French three factor model (1993). The idiosyncratic volatility was not only positively related to the return but also a more powerful explanatory variable than the market return, size and book-to-market ratio (Malkiel & Xu, 2004).

So far, Merton's theory (1987) had seemed on solid ground before the negative relationship was identified by Ang *et al.* (2006).

2-2-3. Negative Relationship

Ang *et al.* (2006 and 2009) found the opposite result to the previous studies that a stock with a higher idiosyncratic risk had a lower expected return using the Fama-French three factor model (1993). Firstly, they adopted the volatility index (VIX) from the Chicago Board Option Exchange as an innovation proxy to estimate price of the risk and found the aggregate market volatility was negatively priced in the stock return. The innovation estimated approximately -1% and it was statistically significant. The results were robust for their value, size, liquidity, volume, dispersion of analysts' forecasts, and momentum effects. Following their logic, if the volatility index is priced in the asset pricing model, then idiosyncratic volatility should also be priced.

The second finding was that the idiosyncratic volatility had a negative relationship with expected return. In their cross-section test, the standard deviation of the Fama-French three factor model (1993)'s residual was defined as idiosyncratic volatility. The stocks were sorted into 5 portfolios by the previous month's idiosyncratic risk. The highest idiosyncratic risk quintile brought in -0.02% per month and the lowest risk portfolio earned 1.06% per month more than the highest risk portfolio (Ang *et al.*, 2006). Controlling value, size, liquidity, volume, dispersion of analysts' forecasts and momentum effect did not affect the negative relationship (Ang *et al.*, 2006). It was also found in outside of the U.S. in their following study (Ang *et al., 2009).* The authors constructed local, geographical, G7 as well as world portfolios and the finding was consistent in all the sample groups (Ang *et al.*, 2009). However, the authors were not able to identify the reason behind their finding and called it 'a substantive puzzle' (Ang *et al.*, 2006).

2-2-4. Efforts to Solve the Puzzle

Researchers have put their efforts to solve the puzzle. Fu (2009) found an auto-correlation issue in the idiosyncratic risk and confirmed that the series was not a random walk as Ang *et al.* implicitly assumed. The Fama-French three factor model (1993) was adopted in the regression as Ang *et al.* (2006) did. As the idiosyncratic risk was the standard deviation of the regression residuals, if the risk is not constant, the basic assumption of linear regression collapses and the standard regression cannot be applied. Fu (2009) applied the exponential generalized autoregressive conditional heteroskedasticity (EGARCH) model to remove the heteroskedasticity of the series. He, indeed, showed the return reversal can explain a large part of the anomaly. Negative abnormal returns followed after positive abnormal return for stocks with high idiosyncratic risk. In addition, small firms with a higher idiosyncratic volatility explain a large part of the negative relationship. He did not, however, explain the first finding of Ang *et al.* (2006), or why stocks with high sensitivity to aggregate market volatility had lower returns.

Brockman *et al.* (2009) applied the Fu's EGARCH model (2009) in the world sample to counter the Ang *et al.*'s world study (2009). The results were that idiosyncratic volatility of countries had a positively significant relationship with return, consisted with the Fu (2009), or a negative and not significant relationship (Brockman *et al.,* 2009). Taking a different approach, Bali and Cakici (2008) identified the data frequency, weighting scheme, breakpoint, and the use of a screen for size, price and liquidity, which were important to establish a relationship between the idiosyncratic volatility and expected return. The authors found a significant and positive relationship after control the above factors (Bali & Cakici, 2008). However, Saryal (2009) confirmed Ang *et al.* (2006)'s finding and discovered that it is due to the increased volatility near announcement or event days. There is a positive relationship between idiosyncratic volatility and return after the event days. Nevertheless, she did not perform a cross-sectional analysis (Saryal, 2009).

2-3. Methodologies Employed to Investigate Puzzle

2-3-1. Methodologies in Previous Literature

The above researchers have tried to solve the substantive puzzle and have shown a positive relationship between idiosyncratic volatility and expected return. Now a question has been raised from their methodologies. Some have used cross-section of return analysis; the Fama-MacBeth regression (Ang *et al.*, 2006, 2009; Fu, 2009; Brockman *et al.*, 2009; Saryal, 2009) and the others adopted the Newly-West approach (Bali & Cakici, 2008). The researchers presumed there is a time effect in the relationship; by using the cross-section analysis they removed the time effect. It is not hard to imagine that the economic situation affects the volatility of securities and volatility varies over time. In addition to the time effect, a firm level effect should be considered. Campbell *et al.* (2001) and Brandt *et al.* (2008) assumed idiosyncratic volatility includes industry level volatility. Moreover, Spiegel and Wang (2005) explained idiosyncratic volatility with liquidity and Saryal (2009) found firm events impacted on the risk. Faff (2004) studied the Fama-French factors (1993) in the Australian market and the factors varied on the industry sectors. Beta of market, size and growth factors varied from 0.65 to 1.41, from -0.43 to 0.79, and from -1.22 to 1.14, respectively (Faff, 2004). If the relationship is affected by a firm effect, liquidity, firm event and industry characteristics, cross-section analysis is not enough to conclude the relationship.

Therefore, the above researches' findings came from inadequate regression method selection. Neither the Fama-MacBeth regression (1973) nor the Newly-West approach can reveal the true relationship between idiosyncratic risk and stock return; thus, another methodology which reflects a firm effect should be used to find the relationship.

2-3-2. Clustered Standard Error Approach

Interestingly, Brandt *et al.* (2008) adopted Petersen's advice (2009) and their panel data analysis had a similar result to a cross-sectional analysis. According to Petersen (2009), the Fama-MacBeth regression (1973) is biased if a firm effect or both firm and time effects exist. In addition, the Newly-West approach is biased if the firm effect exists. The firm effect occurs when the residuals of a given firm are correlated across year while the time effect exists when the residuals are correlated across different firms (Petersen, 2009). Petersen (2009)'s simulations showed biasness of the two regression method. Therefore, panel data analysis, which can remove both time and firm effects, should have been used to solve the puzzle. Petersen (2009) suggests the clustered standard error approach is the best approach to avoid both time and firm effects. Thompson (2009), also, suggests the Two-dimensional clustered standard approach and stresses that the Fama-MacBeth regression (1973) allows "firms to be correlated with one another at a moment in time."

2-4. Idiosyncratic Volatility Researches in the Australian Stock Market

The Australian market would be an acceptable place to imitate the Ang *et al.* (2006)'s methodology. There is an active options market; thus, a volatility index is available. The Australian stock market is one of the fastest growing stock markets in the world. According to the CIA World Factbook, the total value of the market was US$ 1.3 trillion at the end of

2007, an increase of 18 percent from 2006 and it was the 12th largest stock market in the world ("Australia", n.d).

Brockman *et al.* (2009) proved the Fu (2009)'s finding in 44 countries includes Australia. In the Australian sample over the period of July 1983 to October 2007, the idiosyncratic volatility was not a random walk and the highest minus the lowest idiosyncratic volatility quintile strategy earned 2.50 percent per month. However, their Fama-MacBeth regression (1973) found that there was a negative relationship between EGARCHed idiosyncratic volatility and expected return in the Australian market. According to the result of Brockman *et al.* (2009), 1 percent increase in the volatility caused a decrease in the expected return of 0.06 percent. They argued the slope was very small to be important explanatory variable. Similar to Ang *et al.* (2009), Brockman *et al.* (2009) adopted the 30-day U.S. Treasury bill as a risk free rate for all of the 44 countries. This is the U.S. investors' point of view and this dissertation will adopt the Australian investors view by choosing the Australian bill rate.

Some local researchers studied volatilities in the Australian market. Frijns, Tallau and Tourani-Rad (2008) studied the Australian market volatility and the S&P/ASX 200 index return. They constructed the volatility index with the S&P/ASX 200 index option and the changes in the volatility index were negatively and asymmetrically related to the S&P/ASX 200 index return. Dempsey, Drew and Veeraraghavan (2001) followed Malkiel and Xu (1997) and found a positive relationship between the idiosyncratic volatility and portfolio returns in Australia. In addition, consistent with Malkiel and Xu (1997), they detected an inverse relationship between the volatility and size. Balachandran, *et al.* (2009) found that stock split is positively related to the idiosyncratic volatility in the Australian market over the period of 1991 to 2008. Their idiosyncratic volatility, limited to near split announcement was calculated by CAPM. Bollen, Skotnicki and Veeraraghavan (2009) found the idiosyncratic volatility was not priced in the Australian market over 1980 to 2003 using Campbell *et al.* (1997)'s methodology.

2-5. Summary

In summary, investors cannot fully diversify their portfolio due to the information and transaction costs. Therefore, idiosyncratic volatility is the one of their concerns as well as market risk and investors want to be compensated for a higher idiosyncratic volatility with a higher return. A model describes a positive relationship between idiosyncratic volatility and expected return was established by Merton (1987) and researchers have found evidences of the Merton's model. Ang *et al.* (2006) however found an opposite result, a negative relationship between idiosyncratic volatility and expected return, and it has been extensively debated. The criticisms of the negative relationship have considered only a time effect in their methodologies. Petersen (2009) and Thompson (2009) criticised that considering only a time effect can be biased if a firm effect is existed as well as a time effect in data. The evidences of existing industry effect and increased volatility around announcement days point the existence of a firm effect. This research analyses the relationships between aggregate volatility and expected return and between idiosyncratic volatility and expected return with the two-dimensional clustered standard errors model to remove the both time and firm effects.

3. Data

Chapter 3 analyses the market and relevant data. This dissertation adopts the Australian Stock Exchange (ASX hereafter) All Ordinaries Index as a market return and the 30 day bank accepted bill as a risk-free return. The stocks are categorised to 9 industries and calculation of the monthly and daily Fama-French three factors (1993) follows. Australian volatility index (VIX), represents aggregate volatility is collected from Frijns, Tallau and Tourani-Rad (2008).

3-1. Market Data

Australian securities data is collected from Datastream for the period from July 1999 to February 2010. After filtering non-industrial companies, e.g. fixed-income securities, delisted stocks before July 1999 and financial companies, 1,915 Australian securities are selected to find a relationship between idiosyncratic volatility and expected return. To calculate the Fama-French factors (1993), monthly stock returns, stock market returns (ASX All Ordinary stock index), market capitalisation, and their price-to-book ratio are downloaded. Market capitalisation is collected for the size factor. Inversion of price-to-book ratio is book-to-market ratio which measures the growth factor used in this study. In each month, stocks with no data on both market capitalisation and book-to-market ratio are excluded from analyses. Individual stock returns are calculated using the return level. The return level is adjusted price index for stock split, dividend payments and other capital issues. The natural log difference of the return level is defined as the individual stock return. The data includes non-trading days such as, Christmas day, Boxing Day, New Year's Day, Good Friday, Easter Monday, Australia Day, Anzac Day, and Queen's Birthday. They are removed manually.

Figure 1 Monthly All Ordinary Stock Index from July 1999 to February 2010

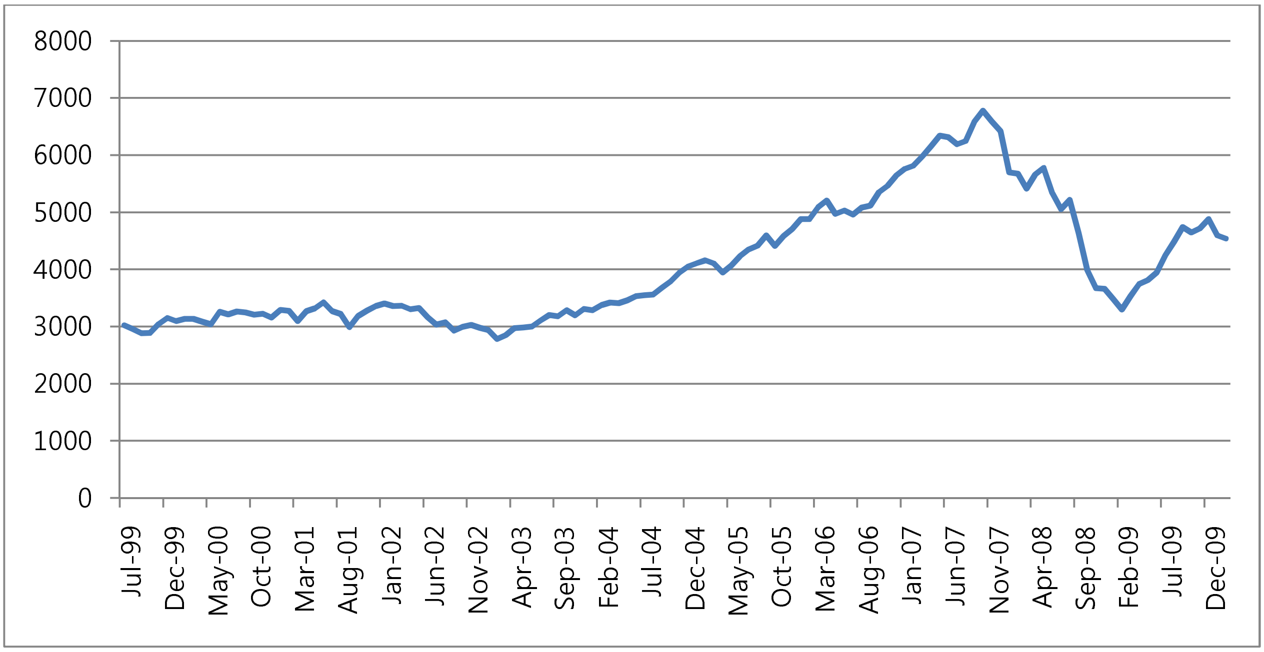
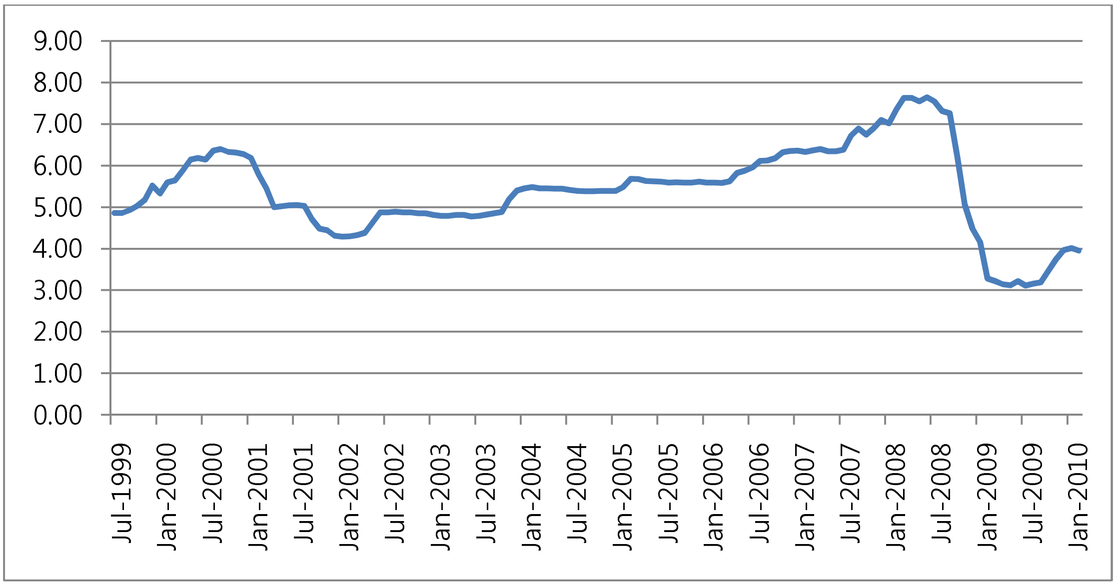


Figure 1 shows the stock price index throughout the selected time period. The market index of July 1999 was 3019 and it had been calm and stayed at around 3000 until mid 2003. Since then the index has increased up to 6,779.1 to the highest in October 2007. After the sharp drop, approximately 50% loss of the index, during the credit crunch crisis started from the U.S., the market has recovered to the 2006 level of approximately 4,500 in February 2010.

The risk free rate is based on the 30 day Australian Bank Accepted Bill Rate from the Reserve Bank of Australia[1]. Similar to Ang *et al.* (2006, 2009), this research has a month observation period; thus, the 30day bill is the most appropriate risk free rate. Figure 2 shows the annualized daily bill rate. The rate was 4.86 % in July 1999 and had increased until 6.40 % in September 2000. It had dropped until 4.29 % in January 2002 and had gradually increased until July 2008 to 7.64 %. Then, there was a huge drop in the second half of 2008 as result of

1 http://www.rba.gov.au/statistics/tables/index.html#interest_rates

Figure 2 30days Bank Accepted Bills from July 1999 to February 2010



the credit crunch crisis. The rate was the lowest at 3.11 % in July 2009 and it rebounded up to 3.95 % in February 2010. The rate is converted to daily and monthly then used to calculate excess market return and stock return for analyses in the later chapters.

Stocks are sorted to 9 industries according to Datastream's Level 2 sector name, excluding financial industry. Table 1 shows a summary of equal-weighted industries portfolios. The basic material industry earns highest return of -1.02 % per month and the telecommunications industry earns the lowest at -3.03% per month in the period. The basic material industry's standard deviation is the highest at 24.82%, while the consumer goods industry has the lowest at 15.96%.

Table 1 Summary of Industry Portfolios from July 1999 to February 2010

	number	average	std dev
Oil & Gas	165	-0.0161	0.2473
Basic Materials	810	-0.0102	0.2482
Industrials	266	-0.0117	0.1842
Consumer Goods	142	-0.0134	0.1596
Healthcare	165	-0.0203	0.2214
Consumer Services	182	-0.0125	0.1847
Telecommunications	40	-0.0303	0.2273
Utilities	27	-0.0152	0.2019
Technology	118	-0.0280	0.2366
Total	1,915		

3-2. Fama-French Factors

The calculation of daily and monthly Fama-French three factors (1993) is available on Kenneth French's website[2]. First of all, stocks without both market capitalisation and book-to-market ratio are excluded as well as negative book-to-market ratios. The factors are calculated based on the previous year's December market capitalisation and book-to-market ratio. For instance, December 1998's market capitalisation and book-to-market ratio are used to sort the returns of July 1999 to June 2000 into one of six portfolios, small-growth, big-growth, small-value, big-value, small-neutral and big-neutral portfolios. The Fama-French's size factor is the average return of the three small portfolios minus the average return of the three big portfolios. Average return of the two value portfolios, high book-to-market ratio, deduct average return of the two growth portfolios, low book-to-market, are defined to the growth factor in each period, either day or month.

[2] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

Table 2 Summary of Fama-French Factors from July 1999 to February 2010. 128 of monthly observations and 2,701 of daily observations

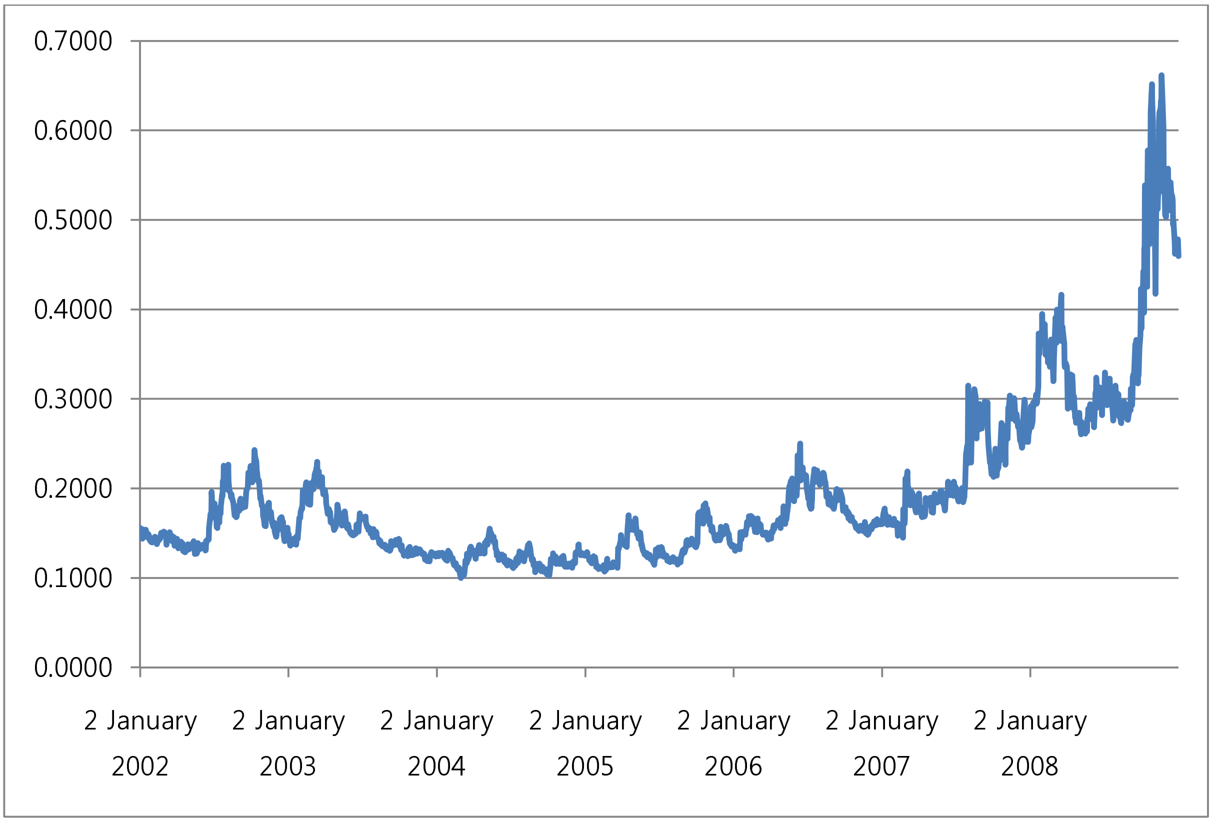
	Monthly			Daily		
Date	**MKT**	**SMB**	**HML**	**MKT**	**SMB**	**HML**
Average	-0.0012	0.0012	0.0188	-0.0003	0.0006	0.0089
Standard deviation	0.0395	0.0388	0.0305	0.0102	0.0053	0.0055
Maximum	0.0745	0.1152	0.1035	0.5342	0.2409	0.3215
Minimum	-0.1626	-0.1504	-0.0604	-0.8577	-0.7975	-0.2431

Table 2 summarises the Fama-French factors. Firstly, average excess market return of the period is -0.12% per month or -0.03% per day. The smallest one-third companies earn 0.12% per month or 0.06% per day more than the largest one-third and the high book-to-market companies earn 1.88% per month or 0.89% per day more than the low book-to-market companies. This research's the Fama-French factors (1993) are slightly different from other researchers' result. O'Brien, Brailsford and Gaunt (2008) reported the Fama-French factors (1993) in Australia from 1982 to 2006. In their result, the average monthly MKT, SMB and HML were 0.39%, 0.35% and 0.75%, respectively. They composed 25 portfolios instead of this research's 6 portfolios and covered longer time period which might make a difference. Faff (2004) stated a negative size premium had been often found in late 1990s in the Australian stock market among academics. He found -0.03% and 0.02% of daily SMB and HML factors, respectively over the period of 1 May 1996 to 30 April 1999. Chai, Faff and Gharghori (2009) found 0.39%, 3.21% and 0.65% of the MKT, SMB and HML factors, respectively from 1982 to 2006. They sorted securities into 6 portfolios like this research.

3-3. Volatility Index

Volatility index, VIX, represents the aggregate volatility of the stock return. Australian implied volatility index is collected from Frijns, Tallau and Tourani-Rad (2008). The index is

Figure 3 Daily Australian Volatility Index from 02 January 2002 to 31 December 2008



based on S&P /ASX200 index options. The daily data is consisted of 1,722 observations from 02 January 2002 to 31 December 2008. Figure 3 is a plot of the daily volatility index. Mean and standard deviation of VIX are 19.08% and 9.08%, respectively. Its peak was on 20th November 2008 at 66.15%.

4. Methodology

This section describes empirical tests of the volatilities and stock returns. Firstly, idiosyncratic volatility is calculated based on the Fama-French three factor model (1993). Then, the Fama-MacBeth regression (1973) and the two-dimensional clustered standard errors approach are compared. Lastly, empirical models are described.

4-1. Idiosyncratic Volatility

Idiosyncratic volatility is not an easily observable parameter. One probable assumption for the volatility would be a residual that cannot be explained by the existing factors as in Fama and MacBeth (1973) (Malkiel & Xu, 2004). The Fama-French three factor model (1993) is commonly adopted to calculate idiosyncratic volatility as in Malkiel and Xu (2004), Spiegel and Wang (2005), Ang *et al*. (2006, 2009), Bali and Cakici (2008), Fu (2009), Brockman *et al*. (2009) and Saryal (2009). Monthly idiosyncratic volatility is calculated using the daily Fama-French factors (1993), shown in Table 2 in the Chapter 3. Following Ang *et al*. (2006), the equation below is used to calculate idiosyncratic volatility:

$$\mathrm{r_{i,t}} = \alpha_{\mathrm{i,t}} + \beta 1_{\mathrm{i,t}}\mathrm{MKT_t} + \beta 2_{\mathrm{i,t}}\mathrm{SMB_t} + \beta 3_{\mathrm{i,t}}\mathrm{HML_t} + \varepsilon_{i,t}, \qquad (1)$$

where $\mathrm{r_{i,t}}$ is the daily excess return of individual stock, α is the constant, βs are the coefficients of each variables, MKT, SMB, and HML are the Fama-French three factors (1993) and $\varepsilon_{i,t}$ is the residual. Daily Individual stocks returns are regressed with the daily Fama-French three factors and each stock's daily residual is saved for the whole sample period. The standard deviation of the daily residual, $\sqrt{\mathrm{var}(\varepsilon_{i,t})}$, is multiplied by the square root of the number of trading days in the month. This is the monthly idiosyncratic volatility calculation adopted by Ang *et al*. (2006) and most researchers recently.

Figure 4 Average Idiosyncratic Volatility from July 1999 to February 2010

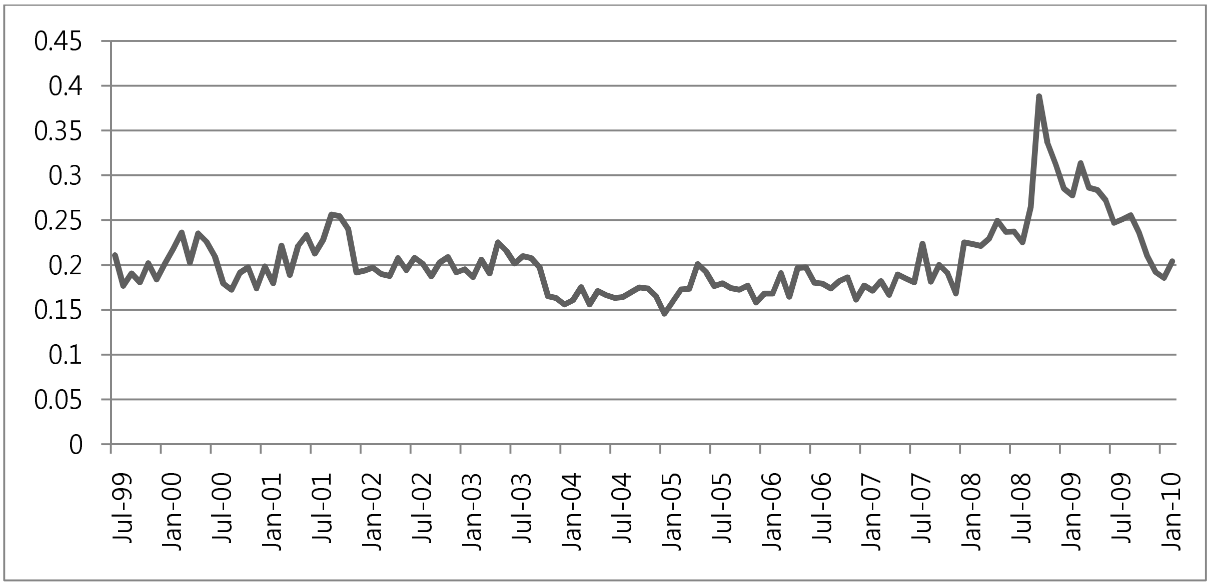


Figure 5 Distribution Graph of Idiosyncratic Volatility from July 1999 to February 2010

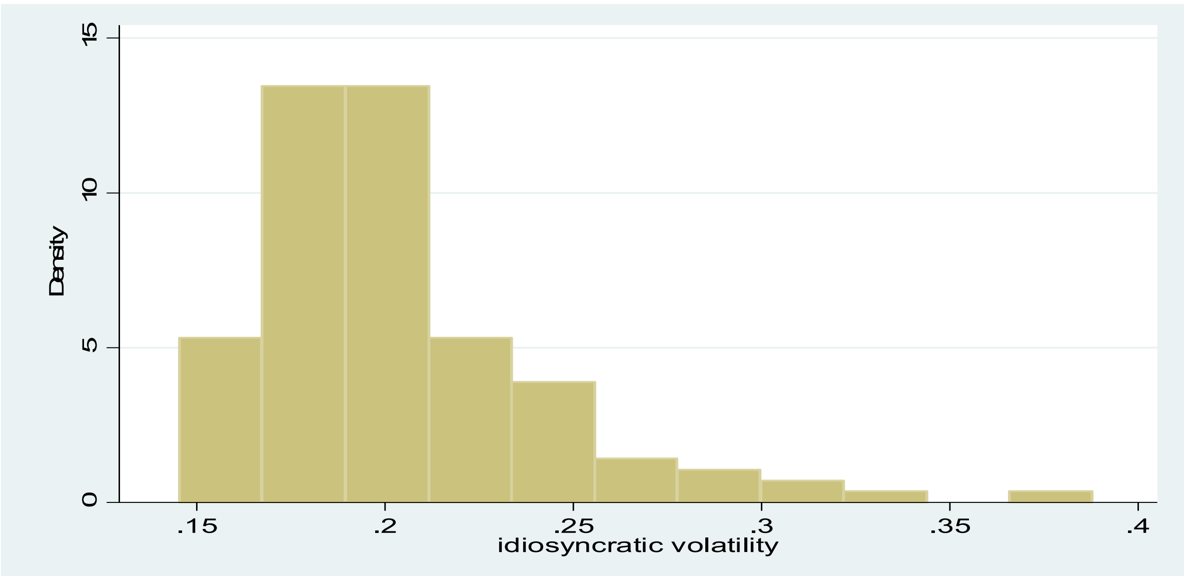


Table 3 Auto-correlation of Idiosyncratic Volatility from July 1999 to February 2010

lags	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
auto-correlation	0.84	0.75	0.68	0.63	0.61	0.52	0.46	0.42	0.35	0.30	0.26	0.24

Figure 4 and 5 and Table 3 are characteristics of idiosyncratic volatility over time. Idiosyncratic volatility has an average value of 0.2034 in the whole period. During the credit crunch crisis, it reached 0.3880 in October 2008 and decreased to an average level of 0.2042 in February 2010. Figure 5 shows the distribution of the idiosyncratic volatility which has a right skewness. The most idiosyncratic volatility is clustered around the average. As the main part of this research uses panel data analysis, the idiosyncratic volatility from time-series analysis, Equation (1) may not be a good proxy. Fu (2009) found an auto-correlation in idiosyncratic volatility and adjusted the issue with the EGARCH model. Table 3 shows an auto-correlation issue in the Australian stock market between July 1999 and January 2010 and this finding is consistent with Brockman *et al*. (2009)'s finding. They found that idiosyncratic volatility is highly auto-correlated in Australia from July 1982 to October 2007 (Brockman *et al.*, 2009). Fu (2009) and Brockman *et al.* (2009) pointed out the negative relationship stemmed from the auto-correlation. The auto-correlation should not be ignored and be treated by a technique such as the two-dimensional clustered standard errors approach should be used.

4-2. *Ex-post* Portfolio Formation

To find prices of aggregate and idiosyncratic volatilities on stock returns, firstly the *ex-post* approach is adopted. This approach is a commonly used technique to compare the effects of a parameter in the next period. Although it only considers time-series, it forms a useful comparison with results of the other researchers. Since their studies are based on the *ex-post* analysis. If the returns of the first and fifth quintile portfolio show a significant difference, sorting by aggregate or idiosyncratic volatilities would be a profitable strategy. First of all, daily individual stock returns are regressed on the daily change of VIX, ΔVIX, in the following regression:

$$r_{i,t} = \alpha_{i,t} + \beta_{i,\Delta VIX}\,\Delta VIX_t + \varepsilon_{i,t}, \qquad (2)$$

where $r_{i,t}$ is the daily excess return of individual stock, α is the constant, $\beta_{i,\Delta VIX}$ is the coefficients of ΔVIX, ΔVIX is the daily change of VIX and $\varepsilon_{i,t}$ is the residual. Then, stocks are sorted by previous month's $\beta_{i,\Delta VIX}$ and formed into 5 portfolios. In the next analysis, stocks are sorted by idiosyncratic volatility and also formed into 5 portfolios. The two portfolio sets are analysed with basic data; simple return, size and book-to-market ratio. Then CAPM and the Fama-French three factor model (1993) are applied in the following regressions:

$$r_{i,t} = \alpha_{i,t} + \beta 1_{i,t} MKT_t + \varepsilon_{i,t}, \qquad (3)$$

$$r_{i,t} = \alpha_{i,t} + \beta 1_{i,t} MKT_t + \beta 2_{i,t} SMB_t + \beta 3_{i,t} HML_t + \varepsilon_{i,t}, \qquad (4)$$

where $r_{i,t}$ is the daily excess return of each portfolio, α is the constant, β1 is the coefficients of MKT, MKT is the market excess return β2 and β3 are the coefficients of SMB, and HML, and $\varepsilon_{i,t}$ is the residual.

4-3.Cross-section and Panel Data Analyses

The Fama-MacBeth regression (1973) is employed before the two-dimensional clustered standard errors analysis to show the different results of the two analyses. Standard error calculations of both methods clearly show a difference. The standard error calculation of the Fama-MacBeth regression (1973) as follows:

$$S^2(\beta) = \frac{1}{T}\sum_{t=1}^{T} \frac{\left(\hat{\beta}_t - \widehat{\beta_{FM}}\right)^2}{T-1}, \qquad (5)$$

where $S^2(\beta)$ is the standard error of β, T is the number of time period, and $\hat{\beta}$s are the estimates. The most previous studies on idiosyncratic volatility and return have used

Equation (5) on the cross-section analysis. As only T, time, controls standard error in Equation (5), the Fama-MacBeth regression (1973) does not consider a firm effect. Petersen (2009) and Thompson (2009) criticise the limitation of the Fama-MacBeth analysis (1973). This dissertation assumes that idiosyncratic volatility is affected by both firm and time effects in the data set. Spiegel and Wang (2005) said that individual companies can be subject to the negative relationship due to their liquidity; and Saryal (2009) argued that high idiosyncratic volatility near event day; Industry is also selected as to be a firm effect according to the results of Campbell *et al.*(2001), Brandt *et al.*(2008) and Faff (2004). Therefore, the data has a variance-covariance matrix, suggested by Thompson (2009), as follows;

$$V_{Firm\&Time} = V_{Firm} + V_{Time} - V_{White}, \qquad (6)$$

where Vs are the variances. If both firm and time effects exist in data set, V_{White} should be removed in analysis and the two-dimensional clustered standard approach can easily solve the problem (Thompson, 2009). Therefore, the two-dimensional clustered standard error approach is adopted in this research to remove both firm and time effects. The standard error calculation of the two-dimensional clustered standard errors estimate on firms (*i*) across months (*t*) by Petersen (2009) follows;

$$S^2(\beta) = \frac{\mathrm{N\ (NT-1)} \sum_{i=1}^{N}\left(\sum_{t=1}^{T} X_{i,t}\varepsilon_{i,t}\right)^2}{\mathrm{(NT-k)\ (NT-1)} \sum_{i=1}^{N}\left(\sum_{t=1}^{T} X_{i,t}\varepsilon_{i,t}\right)^2}\ , \qquad (7)$$

where $S^2(\beta)$ is the standard error of β, T is the number of time cluster, N is the number of firm cluster, X is the independent variable, and $\varepsilon_{i,t}$ is the error term. While N is the number of companies or industry, 1,915 and 9 respectively, in this study and T is the total number of month, 127. The clustered standard errors approach is designed to correct the problem which occurred in the correlation of the residuals within cluster, V_{White} in Equation (6) (Petersen, 2009). Compared to the Equation (5), the two-dimensional clustered estimates the standard error based on both time and firm effects. Considering two clusters reveals a more accurate relationship of idiosyncratic volatility and expected return. This research uses a statistical programme called STATA and the programme code was downloaded from Petersen's website[3].

4-3-1. Aggregate Volatility and Return

Monthly excess returns of each stock in period t are regressed with ΔVIX, the log market capital and the log book-to-market ratio of period t-1. The time period of the test is February 2002 to January 2009 where the VIX data is available. To compare the Fama-MacBeth regression and the two-dimensional clustered standard approach, Equation (9) is applied to both approaches. Additionally, Equation (8) is used in the two-dimensional clustered standard approach to see whether there is a direct relationship between aggregate volatility and excess return or whether other factors dilutes in the relationship:

$$r_{i,t} = \beta 1_{\,i,t} \Delta VIX_{i,t-1} + \varepsilon_{i,t} \qquad (8)$$

$$r_{i,t} = \beta 1_{\,i,t} \Delta VIX_{i,t-1} + \beta 2_{\,i,t} Ln\,(Mkt\ cap)_{i,t} + \beta 3_{\,i,t} Ln\,(BtoM)_{i,t} + \varepsilon_{i,t}\ , \qquad (9)$$

where $r_{i,t}$ is the excess return of individual stock, β1, β2 and β3 are the coefficient of variable ΔVIX, the log market capitalisation and the log book-to-market ratio, respectively, and $\varepsilon_{i,t}$ is the error term.

4-3-2. Idiosyncratic Volatility and Return

Monthly idiosyncratic volatility and excess return of the next period are analysed following Equation (10) and (11). As per Chapter 4-3-1, these equations are fitted into the Fama-MacBeth regression (1973) and the two-dimensional clustered standard errors approach covers the period of Jul 2000 to February 2010:

---

[3] Detailed discussion of how parameters are estimated can be found from Petersen (2009). Petersen guides on STATA programming code to help researchers on his website, http://www.kellogg.northwestern.edu/faculty/petersen/htm/papers/se/se_programming.htm

$$r_{i,t} = \beta 1_{\,i,t} IVOL_{i,t-1} + \varepsilon_{i,t} \qquad (10)$$

$$r_{i,t} = \beta 1_{\,i,t} IVOL_{i,t-1} + \beta 2_{\,i,t} Ln\,(Mkt\ cap)_{i,t} + \beta 3_{\,i,t} Ln\,(BtoM)_{i,t} + \varepsilon_{i,t}, \qquad (11)$$

where $r_{i,t}$ is the excess return of individual stock, β1, β2 and β3 are the coefficient of variable idiosyncratic volatility, the log market capitalisation and the log book-to-market ratio, respectively, and $\varepsilon_{i,t}$ is the error term.

5. Result

Chapter 5 shows the result of empirical tests. ΔVIX is analysed in time series, cross-section and panel data set. The result indicates ΔVIX is negatively priced in expected return. Next, idiosyncratic volatility is analysed in the same test set. Idiosyncratic volatility is also negatively priced in expected return.

5-1. Aggregate Volatility and *ex-post* Return

Firstly, daily stock return is regressed on the excess market return and ΔVIX, in daily frequency within a month. Then the monthly coefficient of ΔVIX is used and stocks are sorted into 5 portfolios by the previous month's ΔVIX. Table 4 shows the result of *ex-post* formation of the stocks from February 2002 to January 2009. The lowest portfolio has beta of -3.09 and the highest portfolio has 2.65. Panel A shows the characteristics of each portfolio, and Panels B and C report the regression result of CAPM and the Fama-French three Factor model (1993), respectively.

Unlike Ang *et al.* (2006)'s study that found *ex-post* simple returns of the portfolio are negatively related to their coefficient of ΔVIX, Table 4 shows no trend. The lowest portfolio and the highest portfolio earn -1.66 % and -1.28% respectively, per month for the period. The second portfolio has the largest return of -0.62% per month. The book-to-market ratio and the size have a U-shape pattern across the portfolios similar to Ang *et al.* (2006). The middle portfolios have a lower book-to-market ratio than the first and fifth portfolios. The third portfolio has the largest size, an average 1.04 billion of Australian dollars, where the average size of portfolio 1 and portfolio 5 are 121 million and 145 million Australian dollars, respectively.

Table 4 Equal-weighted Portfolios Sorted by Exposure to Aggregate Volatility from February 2002 to January 2009. Stocks are sorted by the previous month's beta of the aggregate volatility change. Simple r is the total return, not excess and std ev is the standard deviation of simple r. ΔVIX is the change of Australian volatility index from Frijns, Tallau and Tourani-Rad (2008). BTM reports the average book-to-market ratio of portfolio and size reports the average market capitalisation in million Australian dollars term. Panel B reports CAPM regression of each portfolio. r = α + β x MKT (market excess return) + ε. R2 is the R-squared. Panel C is the results of the Fama-French three factor model (1993) regression. r = α + β1 x MKT + β2 x SMB + β3 x HML + ε. adj-R2 is the adjusted R-squared. The bracket [] is the t-statistic.

		Panel A					**Panel B**			**Panel C**				
	Ranks	**simple r**	**std ev**	**beta of Δ VIX**	**BTM**	**size**	**CAPM α**	**CAPM β**	**R2**	**FF α**	**FF β1**	**FF β2**	**FF β3**	**adj-R2**
lowest	**1**	-0.0166	0.0799	-3.0933	0.6772	121	-0.0094	1.5321	0.5906	-0.0071	1.2572	1.4277	-0.0193	0.8912
							[-1.66]	[10.88]		[-1.74]	[13.76]	[13.68]	[-0.11]	
	2	-0.0062	0.0639	-0.7655	0.6441	653	-0.0002	1.2498	0.6138	0.0040	1.0076	0.9598	-0.1707	0.8445
							[-0.05]	[11.42]		[1.03]	[11.53]	[9.61]	[-1.05]	
	3	-0.0078	0.0609	-0.0058	0.6476	1038	-0.0018	1.2549	0.6812	0.0034	1.0229	0.7669	-0.2421	0.8571
							[-0.48]	[13.24]		[0.95]	[12.81]	[8.40]	[-1.63]	
	4	-0.0072	0.0709	0.7315	0.6448	665	-0.0002	1.4614	0.6827	0.0067	1.1761	0.8797	-0.3305	0.8606
							[-0.05]	[13.28]		[1.63]	[12.82]	[8.39]	[-1.94]	
highest	**5**	-0.0128	0.0800	2.6530	0.6633	145	-0.0057	1.4866	0.5545	0.0042	1.0637	1.3395	-0.4715	0.8780
							[-0.97]	[10.10]		[0.98]	[10.98]	[12.10]	[-2.62]	
	(5-1)	0.0039					0.0036	-0.0455	0.0054	0.0113	-0.1935	-0.0882	-0.4522	0.0712
							[1.34]	[-0.67]		[3.08]	[-2.34]	[-0.93]	[-2.95]	

Panels B and C of Table 4 are the time series analyses. Ang *et al.* (2006) found the lowest portfolio's CAPM alpha and FF alpha were significantly higher than the highest portfolio's alphas similar to the average return. Their alphas decreased monotonically with the change of VIX ranking. Although the highest portfolios earned more than the lowest portfolio, a no trend is shown across portfolios in Panels B and C. Coefficients of market factor are a strongly explanatory variable of all portfolios except the fifth portfolio. In the small portfolios, the first and fifth quintiles, coefficient slopes of the size factor are bigger than one. Significant and positive coefficients of the size factor are consistent with the findings of O'Brien, *et al.* (2008) and Chai, *et al.* (2009). They have studied the Fama-French factors of the Australian market over a longer period and size factors in most portfolios have significant and positive characteristics as can be seen in Panel C. However, their coefficients of the growth factor reported are mixed. Unlike Panel C which reports consistent and negative coefficients, their portfolios have mostly positive coefficients although only half of them are significant. Overall, based on the time series analysis in Table 4, ΔVIX is not a significant explanatory variable of return in the next period and market and size have great explanatory power of return.

5-2. Aggregate Volatility and Expected Return in Cross-section and Panel Data Analyses

Table 5 is the examination of a relationship between return and ΔVIX using the Fama-MacBeth regression (1973) and the two-dimensional clustered standard errors approach. The first column is the list of variables and the first three rows are the description of methods. Regression 1 is the Fama-MacBeth regression (1973), and the rest is the two-dimensional clustered standard errors approach. Individual expected excess stock returns are regressed on

Table 5 Fama-MacBeth regression and the Two-dimensional Clustered Standard Approach of Aggregate Volatility. Excess return is regressed on beta of VIX change of the previous month, the log market capitalisation and the log book-to-market ratio. This table shows the results from 99,975 obserbations from February 2002 to January 2009. ΔVIX represents the monthly change in the Australian volatility index from Frijns, Tallau and Tourani-Rad (2008). FM is the Fama-MacBeth regression (1973) and CLUSTER is the two-dimensional clustered standard errors approach. IV is the idiosyncratic volatility, Ln Mkt Cap is the log of the market capitalisation, Ln BtoM is the log of the book-to-market ratio and R2 is the R-squared. Coefficients of each variable are reported, and the bracket [] is the t-statistic.

Time	**Feb 2002 to Jan 2009 number of obs = 99975**				
Method	**FM**	**CLUSTER**		**CLUSTER**	
Firm cluster		**INDUSTRY**	**COMPANY**	**INDUSTRY**	**COMPANY**
Regression	**1**	**2**	**3**	**4**	**5**
Constant	0.5379611	-0.016629	-0.016629	-0.020601	-0.020601
	[0.44]	[-1.77]	[-1.46]	[-2.94]	[-2.44]
Beta ΔVIX	0.0011395	-0.000542	-0.000542	-0.000597	-0.000597
	[0.21]	[-2.02]	[-1.50]	[-2.18]	[-1.66]
Ln Mkt Cap	0.1006872	0.0026164	0.0026164		
	[0.20]	[3.01]	[2.32]		
Ln BtoM	0.2483249	0.0172816	0.0172816		
	[0.49]	[7.23]	[7.41]		
R2	0.0046	0.0059	0.0059	0.0001	0.0001

the beta of ΔVIX, the log of market capitalisation and the log of book-to-market ratio.

In regression 1, the Fama-MacBeth regression (1973) is applied and no independent variables are priced. The beta of ΔVIX has a t-statistic of 0.21 and it is a poor explanatory variable. This is opposite to the finding of Ang *et al.* (2006). They found the price of VIX is -0.080 which has the t-statistic of -2.49. Regression 1 also does not find a price of the market capitalisation and the book-to-market ratio. As the results of Panel C of Table 4 reveal coefficients of the size factor are significant in the all portfolios, therefore the regression should find some degree of the coefficient relationship. In contrast to regression 1, the two-dimensional clustered standard errors results capture the price of the variables. Regressions 2 and 4 consider the industry level, and 3 and 5 consider the number of individual companies as a firm cluster. The coefficient of ΔVIX is negatively and significantly priced at the 5% level when the industry level is considered as a firm effect. Once the number of companies is considered as a firm effect, the t-statistics go down to -1.50 and the coefficient is almost significant at the 10% level.

The log market capitalisation and the log book-to-market ratio are positively significant variables in explaining returns. In other words, larger and value companies have performed well in the Australian market. 1% increases in the market capitalisation bring 0.26% in return and 1% increases in the book-to-market ratio earn 1.72% in return. The log book-to-market is the most significant variable among the three variables. While larger N in Equation (7) has lowered the t-statistics of ΔVIX and the size, the t-statistics of the book-to-market ratio improved under the individual company level. In other words, the relationship between the book-to-market ratio and the expected return is clearly priced at the individual company level. The R-squared of the two-dimensional clustered standard errors approach is higher than the Fama-MacBeth regression (1973)'s R squared. In other words, considering both firm and time effects explains more return than when only a time effect is considered.

Overall, aggregate volatility is negatively priced in the period which is consistent with the finding of Frijns *et al.* (2008). They found that VIX was negatively priced in S&P 200 return. When the industry level is considered, the aggregate volatility is significant at the 5% level. It is almost significant at the 10% level when the individual company is considered as a firm effect. Although clustering individual companies drives the significance down, the results consistently indicate the significant and negative relationship.

5-3. Idiosyncratic Volatility and *ex- post* Return

According to Ang *et al.* (2006), when aggregate volatility is negatively priced, idiosyncratic volatility should also be negatively priced. Table 5 shows a negative coefficient of ΔVIX thus a negative relationship between idiosyncratic volatility and return is found consistent with Ang *et al.* (2006) logic.

Table 6 is *ex-post* portfolio analysis based on the idiosyncratic volatility. It is calculated based on Equation (1) and converted to monthly figures. Then, stocks are sorted into quintile portfolios based on the idiosyncratic volatility. Characteristics of the portfolios are shown in Panel A. CAPM and the Fama-French three factor model (1993) regression results on each portfolio are reported in Panels B and C, respectively. The last row reports the difference of quintile 5 and quintile 1. Average idiosyncratic volatilities of the portfolios are 0.0611, 0.1129, 0.1647, 0.2327, and 0.4080 from the lowest to the highest, respectively. Portfolio 1 has 74.55% of the market share and the market share gradually decreases as idiosyncratic volatility increases. The lowest idiosyncratic volatility portfolio has the highest next month simple return of 0.42% per month and the highest portfolio has the lowest return of -1.67%. The simple return difference of the two portfolios is 2.09% per month. The return gradually decreases with the idiosyncratic volatility ranking. The alphas of Panels B and C show the same pattern. The difference of alphas in quintile 5 and 1 is -2.02% in Panel B and -1.07% in Panel C. These phenomena are not consistent with Ang *et al.* (2006) and Saryal (2009). Although the difference of their highest portfolios and lowest portfolios were statistically significant, their middle portfolios had the highest return. One distinctive pattern is that the size decreases from the lowest to the highest. The lowest portfolio has the largest size stocks

Table 6 Equal-weighted Portfolios Sorted by Idiosyncratic Volatility from August 1999 to February 2010. Stocks are sorted by the previous month's idiosyncratic volatility. Simple r is the total return, not excess and std ev is standard deviation of simple r. IV represents the idiosyncratic volatility. BTM reports the average book-to-market ratio of portfolio and size reports the average market capitalisation in million Australian dollars term. The bracket () in size column represent the market share of each portfolio. Panel B reports CAPM regression of each portfolio. r = α + β x MKT (market excess return) + ε. R2 is the R-squared. Panel C is the results of the Fama-French three factor model (1993) regression. r = α + β1 x MKT + β2 x SMB + β3 x HML + ε. adj-R2 is the adjusted R-squared. The bracket [] is the t-statistic

		Panel A					Panel B			Panel C				
	Ranks	**simple r**	**std ev**	**IV**	**BTM**	**size**	**CAPM α**	**CAPM β**	**R2**	**FF α**	**FF β1**	**FF β2**	**FF β3**	**adj-R2**
lowest	**1**	0.0042	0.0444	0.0611	0.6692	2011	0.0054	0.9533	0.7240	0.0033	0.9526	0.2127	0.1062	0.7487
						(74.55%)	[2.61]	[18.11]		[1.35]	[17.37]	[3.91]	[1.43]	
	2	0.0014	0.0627	0.1119	0.6985	480	0.0030	1.2772	0.6533	0.0044	1.1585	0.5480	-0.0998	0.7679
						(17.8%)	[0.92]	[15.35]		[1.35]	[15.59]	[7.43]	[-0.99]	
	3	-0.0044	0.0777	0.1647	0.7229	133	-0.0026	1.4275	0.5311	0.0020	1.1698	1.0428	-0.2918	0.8265
						(4.92%)	[-0.54]	[11.90]		[0.57]	[14.68]	[13.19]	[-2.71]	
	4	-0.0096	0.0945	0.2327	0.7496	50	-0.0077	1.5048	0.3994	-0.0028	1.1497	1.5708	-0.3338	0.8376
						(1.80%)	[-1.18]	[9.12]		[-0.67]	[12.27]	[16.90]	[-2.63]	
highest	**5**	-0.0167	0.1092	0.4080	0.7630	23	-0.0148	1.5328	0.3100	-0.0074	1.0730	1.9377	-0.4815	0.8193
						(0.86%)	[-1.83]	[7.49]		[-1.46]	[9.39]	[17.09]	[-3.11]	
	(5-1)	-0.0209					-0.0202	0.5795	0.0674	-0.0107	0.1203	1.7250	-0.5877	0.7157
							[-2.65]	[3.00]		[-2.08]	[1.04]	[14.96]	[-3.74]	

with an average of 2 billion Australian dollars. The most volatile portfolio has the smallest size with 23 million Australian dollars. It is also consistent with Ang *et al.* (2006)'s result that the lowest idiosyncratic volatility ranking quintile has the largest size. Malkiel and Xu (1997) and Spiegel and Wang (2005) have also found a negative pattern in return and size. Column BTM shows that portfolio 5 has the highest book-to-market ratio. Ang *et al.* (2006) also reported that the highest idiosyncratic volatility portfolio has the highest book-to-market ratio. Their book-to-market ratio, however, did not show the pattern of Table 6. Portfolio 1 has the lowest ratio of 0.6692 and the ratio increases gradually to 0.7630 of portfolio 5.

In Panels B and C, the market beta is a powerful explanatory variable. However, it loses its power as the idiosyncratic volatility increases. The coefficient of the size and growth factors get more powerful in higher idiosyncratic portfolios. The reason is that the highest portfolio contributes only 0.86% of market share and has the highest book-to-market ratio. Meanwhile, Portfolio 1's large market share, 74.55%, explains the highest t-statistic of $\beta1$ and the lowest t-statistic of $\beta2$ in Panel C. Portfolio 1's $\beta3$ is the only positive coefficient of the growth factor among 5 portfolios. Low book-to-market ratio securities in the other portfolios earn more than high book-to-market ratio securities.

Based on Table 6, the lowest idiosyncratic volatility portfolio is a winner in terms of the average portfolio return and the regression alphas. The size is negatively correlated to idiosyncratic volatility while the book-to-market ratio is positively correlated. The smallest portfolio is the most volatile and earns the least return.

5-4. Idiosyncratic Volatility and Expected Return in Cross-section and Panel Data Analyses

The negative relationship between idiosyncratic volatility and expected return in Table 6 is also found in the following tests. Table 7 reports the result of regressions. Panel A covers from February 2002 to January 2009, the same time period as ΔVIX analyses, and the whole sample period is tested in Panel B. The first column lists the variables and the first three rows describe of the methodologies. Regressions 1 and 6 are the Fama-MacBeth regression (1973), and the rest of the regressions are the two-dimensional clustered standard errors approaches. Consistent with ΔVIX analysis of Table 5, the difference between the two methodologies is reported.

In the cross sectional analysis, regression 1, the slope of idiosyncratic volatility is -0.0600 and statistically significant at the 1% level. If both firm and time effects are considered, the coefficient slightly decreases to -0.0553 but is still significant at the 1% level. The market capitalisation is not a significant variable in all the regressions. Meanwhile, the price of the log book-to-market ratio is not significant in regression 1 where the results of regressions 2 and 3 capture statistically significant coefficients of the log book-to-market ratio. R-squared of the two-dimensional clustered standard errors approach is more than double that of the Fama-MacBeth regression (1973). In other words, the firm effect, whether it is clustered by industry or company, is an significant factor in the regressions.

The results are similar in the whole time period as reported in Panel B. The two methods capture the negative and significant coefficients of idiosyncratic volatility. The Fama-

Table 7 Fama-MacBeth regression and the Two-dimensional Clustered Standard Approach of Idiosyncratic Volatility. Excess return is regressed on idiosyncratic volatility of the previous month, the log market capitalisation and the log book-to-market ratio. Panel A shows the results from 99,972 observations from February 2002 to January 2009, and the whole peiord, 144,064 observations is covered in Panel B. The first column is the list of the variables and the first three rows are the description of the methods. Regressions 1 and 2 are the Fama-MacBeth regression (1973), and the rest of the regressions are the two-dimensional clustered standard errors approach. FM is the Fama-MacBeth regression (1973) and CLUSTER is the two-dimensional clustered standard errors approach. IV is the idiosyncratic volatility, Ln Mkt Cap is the log of the market capitalisation, Ln BtoM is the log of book-to-market ratio and R2 is the R-squared. Coefficients of each variable are reported and bracket [] is the t-statistic.

Time	**Panel A Feb 2002 to Jan 2009 number of obs = 99972**						**Panel B Aug 1999 to Feb 2010 number of obs = 144064**				
Method	**FM**	**CLUSTER**		**CLUSTER**			**FM**	**CLUSTER**		**CLUSTER**	
Firm cluster		**INDUSTRY**	**COMPANY**	**INDUSTRY**	**COMPANY**			**INDUSTRY**	**COMPANY**	**INDUSTRY**	**COMPANY**
Regression	**1**	**3**	**4**	**5**	**6**		**7**	**8**	**9**	**10**	**11**
Constant	-0.2819	0.0011	0.0011	-0.0097	-0.0097		0.2593	0.0062	0.0062	-0.0083	-0.0083
	[-0.30]	[0.15]	[0.13]	[-1.74]	[-1.50]		[0.76]	[0.80]	[0.82]	[-1.78]	[-1.59]
IV	-0.0600	-0.0553	-0.0553	-0.0557	-0.0557		-0.0433	-0.0254	-0.0254	-0.0220	-0.0220
	[-4.81]	[-5.03]	[-3.54]	[-4.61]	[-3.47]		[-5.16]	[-1.90]	[-1.63]	[-1.34]	[-1.33]
Ln Mkt Cap	0.3853	0.0006	0.0006				-0.0447	0.0003	0.0003		
	[1.04]	[0.70]	[0.54]				[-0.47]	[0.27]	[0.29]		
Ln BtoM	0.5389	0.0169	0.0169				0.0872	0.0218	0.0218		
	[1.46]	[6.75]	[7.15]				[0.91]	[7.93]	[8.87]		
R2	0.0029	0.0072	0.0072	0.0018	0.0018		0.0041	0.0091	0.0091	0.0003	0.0003

MacBeth regression (1973) estimates the coefficient of -0.0433 which is significant at the 1% level. The slope coefficients of the other approach are -0.0254 and significant at the 10% level in regression 7, and almost significant at the 10% level in regression 8. Clustering by individual company lowers the t-statistics of the idiosyncratic volatility while it raises the t-statistics of the log of market capitalisation and the log of book-to-market ratio variables. Based on the mixed results of Panels A and B, it is hard to tell which clustering improves the quality of data. Meanwhile, the R-squared of regressions 7 and 8 is more than twice that of regression 6 which is consistent with Panel A. This is, again, due to the higher explanatory power of the book-to-market ratio. Its coefficient is 0.0218 and it is significant at the 1% level. The market capitalisation impacts little on the expected return in the whole period.

5-5. Robustness Test

Idiosyncratic volatility is significantly and negatively priced in the next month's return as in Table 7. The book-to-market ratio is significantly priced, while the market capitalisation is not a significant variable. The size and the return show a similar pattern; both decrease as the idiosyncratic volatility increases in Table 6 and the size difference between portfolio 1 and 5 of Table 6 is large. It is worth observing that all the regressions in Table 7 do not capture the significance of the size variable. One concern is that small stocks may drive the coefficient of the size variable and may disturb the relationship between idiosyncratic volatility and expected return. Fu (2009) argued that small firms with higher idiosyncratic volatility drive the negative relationship of Ang *et al.* (2006). Table 8 summarises the correlation between the size and book-to-market ratio. They are highly and negatively correlated. In other words, the high book-to-market stocks are mostly small stocks. Therefore the next examination filters small and high book-to-market ratio stocks which may cloud results. Table 9 shows the results of the two-dimensional clustered standard errors approach after filtering under three

Table 8 Correlation Table between Size and Book-to-market Ratio. Ln MKT CAP is the log market capitalisation and LN BTM is the log book-to-market. The correlation reported in this table covers monthly data of the whole sample from August 1999 to February 2010.

	LN MKT CAP	LN BTM
LN MKT CAP	1	
LN BTM	-0.8602	1

Table 9 The Two-dimensional Clustered Standard Approach with Selected Sample. Excess return is regressed on idiosyncratic volatility of previous month, log market capitalisation and log book-to-market ratio. This table covers the whole sample period of August 1999 to February 2010. Panel A is the result after filtering below average size stocks. Panel B reports the result after deleting above average book-to-market ratio stocks. In Panel C, below average size and above average book-to-market ratio stocks are deleted. CLUSTER is the two-dimensional clustered standard errors approach. IV is the idiosyncratic volatility, Ln Mkt Cap is the log of the market capitalisation, Ln BtoM is the log of book-to-market ratio and R2 is the R-squared. Coefficients of each variable are reported and bracket [] is the t-statistic.

Time	**Panel A Above average size**		**Panel B Below average BtoM**		**Panel C Above average size and Below average BtoM**	
Method	**CLUSTER**		**CLUSTER**		**CLUSTER**	
Firm cluster	**INDUSTRY**	**COMPANY**	**INDUSTRY**	**COMPANY**	**INDUSTRY**	**COMPANY**
Regression	1	2	3	4	5	6
Constant	-0.0008	-0.0008	-0.0011	-0.0011	0.0010	0.0010
	[-0.13]	[-0.12]	[-0.14]	[-0.12]	[0.11]	[0.09]
IV	-0.0941	-0.0941	-0.0415	-0.0415	-0.0924	-0.0924
	[-3.26]	[-2.87]	[-2.70]	[-2.40]	[-3.18]	[-2.74]
Ln Mkt Cap	0.0029	0.0029	0.0027	0.0027	0.0039	0.0039
	[3.46]	[2.93]	[2.61]	[2.58]	[4.25]	[3.53]
Ln BtoM	0.0168	0.0168	0.0203	0.0203	0.0209	0.0209
	[6.23]	[6.02]	[12.19]	[9.58]	[8.39]	[7.87]
R2	0.0117	0.0117	0.0084	0.0084	0.0142	0.0142

categories; below average size stocks, above average book-to-market ratio stocks, and below average size and above average book-to-market ratio stocks. The t-statistics of the idiosyncratic volatility and the market capitalisation variables are improved as a result.

Panel A of Table 9 shows the results after removing below average size stocks. The coefficient of the idiosyncratic volatility is -0.0941 which has dropped from -0.0254 in regression 8 in Table 7 and became statistically significant at the 1% level. The negative relationship becomes clearer without small stocks. The slope of the size variance has improved to 0.0029 and became statistically significant at the 1% level. Among the above average size stocks, the market capitalisation is a significant variable in return. The log of book-to-market ratio is still positively significant as in Table 7. The same improvements are shown in Panels B and C. High book-to-market stocks also lower the significance of the idiosyncratic volatility and the size in returns. Hence, the negative relationship between idiosyncratic volatility and expected return in Table 7 is not driven by small stocks or high book-to-market ratio stocks. Meanwhile, these stocks cloud size impact on expected return.

5-6. Limitation

There are some limitations in this study. Firstly, this is a single country study and this makes it hard to generalise. More countries, or a larger number of securities, will reduce the possible small scope problem that Malkiel and Xu (2004) pointed out as a limitation of Ang *et al.* (2006). Secondly, the time frame of this study is relatively shorter than Ang *et al.* (2009) and Brockman *et al*. (2009). Their results span more than 20 years. As idiosyncratic volatility is affected by a time effect, a different time period may impact on the results. However, a longer time horizon study in the Australian market should overcome the lack of company data. Datastream data does not have sufficient company information for the 1980s. Thirdly, momentum and liquidity effects are not considered in this research's asset pricing model as Ang *et al.* (2006) found them to be of no significance with regard to the negative relationship. Australian studies of momentum and liquidity in the asset pricing model have produced mixed results. For example, Chai, *et al.* (2009) found that momentum was not a significant variable in their 25 portfolio time-series analyses. They also stated that liquidity effect on asset pricing model in the Australian market has shown mixed results (Chai, *et al.* (2009). However, Spiegel and Wang (2005) reported liquidity is negatively related to the idiosyncratic volatility in the U.S. market thus, it may be worth considering liquidity in the idiosyncratic volatility analysis in the Australian market.

5-7. Summary

The results of this study are consistent with Ang *et al.* (2006) showing that ΔVIX, aggregate volatility and idiosyncratic volatility are negatively priced in equity returns in the Australian market. ΔVIX is not a significant factor in the *ex-post* analysis as reported in Table 4 and the Fama-MacBeth regression (1973) in Table 5. Clustering firm and time effects however captures a significant and negative coefficient of the ΔVIX. Idiosyncratic volatility is also priced negatively. It is significant and negative in all the tests and shows higher t-statistics among above average size firms. The market capitalisation and the book-to-market ratio are positively priced in return. Although Table 7 shows negative and insignificant coefficients of the market capitalisation, a positive and significant relationship is shown after filtering small firms.

The two-dimensional clustered standard errors approach shows differences to the Fama-MacBeth regression (1973). The latter fails to capture the price of the ΔVIX, the market capitalisation and the book-to-market ratio as reported in Table 5. Although the Fama-

MacBeth regression (1973) finds a negative and significant price of idiosyncratic volatility as reported in Table 7, the coefficients of the market capitalisation and the book-to-market are far from significant. In contrast, the results of the two-dimensional clustered standard errors approach show the price of the book-to-market ratio, and the higher R-squared value.

6. Conclusion

This dissertation has sought to establish whether a negative relationship existed between idiosyncratic volatility and expected return in the Australian market during the period of August 1999 to February 2010. Ang *et al.* (2006) found a negative relationship in the U.S. market in contrast to the previous research. Some academics have countered Ang *et al.*'s finding (2006) by using different methodologies. However, they were limited by using time series and cross-section analysis. Unlike previous studies, this dissertation adopted the two-dimensional clustered standard errors approach to test the relationship.

The evidence from this research is consistent with Ang *et al.* (2006)'s result, the negative relationships between ΔVIX and expected return, and idiosyncratic volatility and expected return. Investors cannot be compensated for higher idiosyncratic volatility. The result of this research is free from time and firm effects. Moreover, the Fama-MacBeth regression (1973) fails to capture the price of ΔVIX. In addition, the two-dimensional standard errors approach, suggested by Petersen (2009) and Thompson (2009), shows that the market capitalisation and the book-to-market ratio have positive and significant coefficients in the return analysis, while the Fama-MacBeth regression (1973) cannot find prices of them in Table 5. In Table 7, the Fama-MacBeth regression (1973) failed to estimate the price of the book-to-market ratio. It also observed that its R-squared is greater than one of the Fama-MacBeth regression (1973).

The presence of 'the puzzle' is a noticeable feature in the Australian stock market. Although this research focused only on the past decade in the Australian market and disregarded momentum and liquidity effects, the significant variables and higher R-squared of the two-dimensional clustered standard errors approach are striking features. The two-dimensional clustered standard errors approach proves that it is superior to the Fama-MacBeth regression (1973).

The presence of a negative idiosyncratic volatility price in the asset pricing model indicates that the Fama-French three factor model (1993) is incomplete as idiosyncratic volatility is calculated as the residual of the model. If investors can diversify risks by using the model in the Australian market, idiosyncratic risk should not be priced in the asset pricing model. Therefore, idiosyncratic volatility should be treated as an important factor in addition to the market, size and growth factors of the Fama-French three factor model (1993).

7. References

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

Ang, A., Hodrick, R., Xing,Y., & Zhang,X. (2009). High idiosyncratic volatility and low returns: International and further U.S. evidence. *Journal of Financial Economics, 91*, 1–23.

Australia. (n.d.). *CIA world factbook*. Retrieved October 31, 2009, from https://www.cia.gov/library/publications/the-world-factbook/geos/as.html

Balachandran, B., Durden, G., Juthani, V. H., & Velayutham, V. (2009). Stock splits, signalling and liquidity (2009). *Working Paper.* Retrieved December 9, 2009, from SSRN: http://ssrn.com/abstract=1460143

Bollen, B., Skotnicki, A., & Veeraraghavan, M. (2009). Idiosyncratic volatility and security returns: Australian evidence. *Applied Financial Economics, 19*, 1573–1579.

Bali, T., & Cakici, N. (2008). Idiosyncratic volatility and the cross-section of expected returns. *Journal of Financial and Quantitative Analysis, 43*, 29–58.

Black. F. (1972). Capital market equilibrium with restricted borrowing. *Journal of Business, 45*, 444-455.

Brandt, M. W., Brav, A., Graham, J. R., & Kumar, A. (2008). The idiosyncratic volatility puzzle: Time trend or speculative episode? *McCombs Research Paper Series No. FIN-02-09*.

Brigham, E. F., & Daves, P. R. (2004). *Intermediate Financial Management*, *8/e*. Mason, Ohio: South-Western, Thompson.

Brockman, P., Schutte, M. G., & Yu, W. (July 11, 2009). Is idiosyncratic risk priced? The international evidence. *Unpublished Working Paper*. Retrieved December 10, 2009, from SSRN: http://ssrn.com/abstract=1364530

Campbell, J. Y., Lettau, M., Malkiel, B. G., & Xu, Y. (2001). Have individual stocks become more volatile*?* An empirical exploration of idiosyncratic risk. *Journal of Finance, 56,* 1-43.

Chai, D., Faff, R., & Gharghori, P. (2009). Liquidity in asset pricing: New evidence using low frequency data. *Monash University Working Paper.*

Dempsey, M., Drew, M., E., & Veeraraghavan, M. (2001). Idiosyncratic risk and Australian equity returns*, No 096, School of Economics and Finance Discussion Papers and Working Papers Series, School of Economics and Finance, Queensland University of Technology*. Retrieved December 14, 2009, from http://econpapers.repec.org/RePEc:qut:dpaper:096

Faff, R. (2004). A simple test of the Fama and French model using daily data: Australian evidence, *Applied Financial Economics, 14,* 83-92.

Fama, E., & French, K. (1993). Common risk factors in stock and bond returns. *Journal of Financial Economics, 33*, 3-56.

Fama, E., & MacBeth, J. (1973). Risk, return and equilibrium: Empirical tests. *Journal of Political Economy, 81*, 607-636.

Frijns, B., Tallau, C., & Tourani-Rad, A. (2008). The information content of implied volatility: Evidence from Australia. 2*1st Australasian Finance and Banking Conference 2008 Paper.* Retrieved December 14, 2009, from SSRN: http://ssrn.com/abstract=1246142

Fu, F. (2009). Idiosyncratic risk and the cross-section of expected stock return. *Journal of Financial Economics, 91,* 24–37.

Goetzmann, W. N., & Kumar, A. (2008). Equity portfolio diversification. *Review of Finance, 12,* 433–463.

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

Malkiel, B., & Xu, Y. (1997). Risk and return revisited. *Journal of Portfolio Management, 23,* 9-15.

Malkiel, B., & Xu, Y. (2004). Idiosyncratic risk and security returns. *AFA 2001 New Orleans Meetings.* Retrieved October 24, 2009 from SSRN: http://ssrn.com/abstract=255303 or doi:10.2139/ssrn.255303

Merton, R. (1987). A simple model of capital market equilibrium with incomplete information. *Journal of Finance, 42*, 483–510.

O'Brien, M., Brailsford, T. J., & Gaunt, C. (2008). Size and book-to-market factors in Australia. *21st Australasian Finance and Banking Conference 2008 Paper*. Retrieved January 19, 2010, from SSRN: http://ssrn.com/abstract=1206542

Petersen, M. A. (2009). Estimating standard errors in finance panel data sets: Comparing approaches, *Review of Financial Studies, 22,* 435-480.

Saryal, F. S. (2009). Rethinking idiosyncratic volatility: Is it really a puzzle? *Unpublished Working Paper* Retrieved October 7, 2009, from SSRN: http://ssrn.com/abstract=1341930

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

Spiegel, M. I., & Wang, X. (2005). Cross-sectional variation in stock returns: liquidity and idiosyncratic risk. *Yale ICF Working Paper No. 05-13*; *EFA 2005 Moscow Meetings Paper*. Retrieved October 15, 2009, from SSRN: http://ssrn.com/abstract=709781

Statman, M. (1987). How many stocks make a diversified portfolio? *Journal of Financial and Quantitative Analysis, 22,* 353-363.

Thompson, S. B. (2009). Simple formulas for standard errors that cluster by both firm and time. *Unpublished Working Paper.* Retrieved February 10, 2010, from SSRN: http://ssrn.com/abstract=914002