The Investigation of the Idiosyncratic Volatility: Evidence from the Hong Kong Stock Market

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Abstract

There are two methods to estimate the idiosyncratic volatility (IV) for stocks; indirect decomposition and direct decomposition methods (Xu and Malkiel, 2003). Malkiel and Xu (1997, 2006) and Campbell et al (2001) find a positive IV effect and an upward trend of IV in the US stock market using the indirect decomposition method. However, Ang et al (2006, 2009) employ the direct decomposition method to estimate IV for the US stocks and report a negative IV effect in the US stock market. , Fu (2009) employs the EGARCH model to estimate IV for US stocks shows a positive IV effect in the US stock market. Bali and Cakici (2008) and Fu (2009) both argue that the data frequency in estimating IV for stocks might alter the IV effect in the stock market. This study employs Ang et al.'s (2006, 2009) method to estimate IV for Hong Kong stocks using weekly return data over the period 1980 to 2007. The study concludes three main findings. First, the result shows an upward trend of average IV in the Hong Kong stock market during the study period, which implies that the number of stocks increase to achieve a certain level of diversified portfolio. Second, we confirm a significant positive IV effect in the Hong Kong stock market during the study period and the positive IV effect cannot be explained by other firms' characteristics, such as size, BM, momentum and REV. Finally, the result reveals that the positive IV effect in the Hong Kong stock market is not due to either the model specification or the data frequency in estimating IV for stocks.

Key words: idiosyncratic volatility, Asset pricing model, Hong Kong stock market

1. Introduction

The debate of how idiosyncratic volatility (IV) relates to the expected stock return has been documented in recent financial literatures. The traditional asset pricing model asserts that the expected stock return should only be rewarded to the systematic risk, which is the market risk, but there should not be any relationships between the idiosyncratic risk and the expected stock return (Sharpe, 1964). However, Levy (1978) indicates that if investors are constrained from holding fully diversified portfolios, they would demand compensation for idiosyncratic risk, which is supported by Merton (1987). Malkiel and Xu (2006) further suggest that if one group of investors failed to hold the market portfolio, then it is impossible for other investors to hold market portfolios, thus the idiosyncratic risk should be priced. This study investigates what role idiosyncratic risk plays in the stock market.

A natural proxy for idiosyncratic risk in empirical studies is idiosyncratic volatility, which refers to the volatility of a firm's returns related to firm-specific events. There are two methods in estimating the IV for stocks in the literatures, called the indirect decomposition method and the direct decomposition method (Xu and Malkiel, 2003). The indirect decomposition method is widely used to estimate the IV for stocks before 2003, for example, Malkiel and Xu (1997, 2006), Campbell et al (2001), Xu and Malkiel (2003) and Goyal and Santa-Clara's (2003). Malkiel and Xu (1997 & 2006) and Campbell et al (2001) both find an upward trend of IV for US stocks in the past three decades. Furthermore, Malkiel and Xu (1997 & 2006) indicate that the firm level IV is positively related to the firm's expected return in the US stock markets, which is supported by Goyal and Santa-Clara's (2003) findings.

However, Xu and Malkiel (2003) report that the IV is often over estimated by the indirect decomposition method, thus most studies employ the direct decomposition method to estimate IV for stocks. Under the direct decomposition method, three models have been widely used to estimate IV for stocks, for example, the CAPM model, the Fama-French three-factor model (1993), and the EGARCH model. Bali et al (2005) and Bali and Cakici (2008) employ the CAPM model to estimate IV for US stocks and report that there is no relationship between IV and expected stock portfolios' returns in the US stock markets. Ang et al (2006, 2009) employ Fama-French three-factor model to estimate IV for US stock market and conclude that there is a negative relationship between IV and stock portfolios returns in the US stock market. On the other hand, Fu (2009) employs the EGARCH model to estimate IV for US stocks and reports that there is a significant positive relationship between IV and expected stock returns in the US stock market.

The Hong Kong stock exchange began formally in the late 19th century with the first establishment in 1891(Wikipedia.com, 2010). Today it is the Asian second largest stock exchange in terms of market capitalisation behind China stock exchange at the end of July 2010[1]. There were 1,241 stocks listed in the Hong Kong stock market with a market capitalisation of $2.7 trillion at the end of 2007. The Hong Kong stock market also provides a unique stock market to study the role of idiosyncratic volatility in asset pricing for a number of reasons. First, only 65% trading volume per year is contributed by institutional investors in the Hong Kong stock market (HKSE.com, 2010). This implies that institutional investors play weak roles in the Hong Kong stock market than investors in the US stock market. Individual investors are more likely holding underdiversified portfolios compared to institutional investors. Finance theory suggests that underdiversified investors would demand a premium for bearing idiosyncratic risk; hence, we should expect that high idiosyncratic portfolios generate high returns than low idiosyncratic portfolios in the Hong Kong stock market. Second, the Hong Kong stock market is also more volatile than the US stock market. We thus expect that the idiosyncratic volatility plays a more significant role in pricing the Hong Kong stocks. Finally, the existing literatures indicate that there are only few studies which

[1] By the end of July 2010, the total market capitalization of Hong Kong stock exchange is around USD$2,319,659.30 million (Hong Kong stock exchange, 2010); the total market capitalization of China stock market is around USD$3,321,162.07 million (CSRC.com, 2010), and the total capitalization of Tokyo stock exchange is around USD$2,007,771.06 million (TSE.com, 2010).

investigate the IV effects in the Hong Kong stock market, for example, Drew and Veeraraghavan's (2002), Brockman et al's (2009), and Pukthuanthong-Le and Visaltanachoti's (2009). However, our study employs Ang et al's (2006, 2009) method to estimate the IV for Hong Kong stocks, which has not been used by previous studies. Furthermore, all existing studies use daily stock return data to estimate IV for Hong Kong stocks. This study uses weekly stock return data to estimate IV for each Hong Kong stock, because Bali and Cakici (2008) and Fu (2009) both indicate that the IV effect in the stock market might be due to the data frequency on estimating IV for stocks.

This study contributes to the literature in three aspects. First, we find an upward trend of both equal-weighted and value-weighted average idiosyncratic volatility in the Hong Kong stock market over the study period. The results imply that the numbers of stocks need to achieve a given level of diversification would have increased over time (Malkiel and Xu, 1997; Campbell et al, 2001; & Hamao et al, 2003). Second, we find a statistically significant positive relationship between the IV and expected stock returns in the Hong Kong stock market and this positive IV effect cannot be explained by control variables, such as size, book-to-market ratio (BM), momentum, and short-term reversal (REV). Our results contradict Ang et al's (2006, 2009) findings in the US stock markets due to the differences in the level of market efficiency, price informativeness and investor under-diversification. Finally, our result of positive IV effect in the Hong Kong stock market qualitatively supports Drew and Veeraraghavan's (2002), Brockman et al's (2009), and Pukthuanthong-Le and Visaltanachoti's (2009) findings. We employ Ang et al's (2006, 2009) method and weekly return data to estimate IV for Hong Kong stocks to differentiate from previous studies. We assert that the positive IV effect in the Hong Kong stock market is not because of the model specification and data frequency on estimating IV for each stock, which reject both Bali and Cakici (2008) and Fu's (2009) hypotheses.

The rest of the paper is organized as follows: Section 2 provides a brief literature review. Section 3 presents the data and methodology of the study. Section 4 discusses the empirical results and Section 5 concludes the paper.

2. Literature Review

The literature identifies two methods in estimating the idiosyncratic volatility for stocks, indirect decomposition method and direct decomposition method. The indirect decomposition method estimates stock's idiosyncratic volatility through the difference between the individual stock's volatility and market index volatility (Malkiel and Xu, 1997). On the other hand, the direct decomposition method computes stock's idiosyncratic volatility according to either the CAPM model or the Fama-French three-factor model (Xu and Malkiel, 2003).

Malkiel and Xu (1997) employ the indirect decomposition method to compute the idiosyncratic volatility (IV) for stocks portfolios by using monthly return data. The authors report that there is a positive relationship between the value-weighted IV and stock return in the US stock market over the period 1963 to 1994. The authors further conclude that the IV showed an increasing trend for S&P 500 stocks since 1952, and this trend is statistically significant. Campbell et al (2001) confirm that there is an upward trend in the IV in the US stock market over the period 1962 to 1997, which is also confirmed by Bali et al's (2009) using the indirect decomposition method in estimating IV for stocks. Campbell et al state that the upward trend of the IV is not due to the increase in the number of stocks listed in markets or to changes on the serial correlation of daily data, but due to either a shock to expected future cash flow of the firms or shocks to discount rate for the whole market. Xu and Malkiel (2003) find that the IV increased in the1990s, although the 1970s' oil shock and the 1987 stock market crash caused the volatility to increase faster, and there is a positive relationship between the IV and stock returns in the US stock markets, which is also supported by Goyal and Santa-Clara's (2003) findings over the period 1927 to 1999. Furthermore, Xu and Malkiel (2003) argue that the increase in the IV is not due to the small stock effects, but large stocks. The authors provide two economic explanations to their findings, i.e. the increasing numbers of institutional investors in the market and a higher future earning growth rate (Xu and Malkiel, 2003). Moreover, Xu and Malkiel (2003) conclude that by using both approaches to estimate the idiosyncratic volatility the results exhibit similar outcomes, but the indirect approach seems to overstate the overall level of idiosyncratic volatility. Malkiel and Xu (2006) further explain that the IV of the portfolio is positively related to the beta, but is negatively related to the size over the period 1935 to 2000. This could be the reason why the positive relationship between IV and stock returns exists in the US stock market.

Drew and Veeraraghavan (2002) conclude that small and high IV stocks generate superior returns in Asian stock markets during the period 1995 to 1999. Drew and Veeraraghavan employ the indirect decomposition method to compute IV for stocks of four Asian stock markets separately, namely Hong Kong, India, Malaysia, and Philippine during the period of mid-1990s. However, Guo and Savickas (2006) employ quarterly data and the indirect decomposition method to estimate IV in the US stock market. The authors report a negative IV effect in the US stock market over the period 1926 to 2005. They argue that previous findings of positive IV effect might be due to the data frequency on estimating IV for stocks.

Since Malkiel and Xu (2006) prove that the indirect decomposition method overstates the firms' IV, recent researchers employ the direct decomposition to estimate IV for stocks. For example, Bali et al (2005) employ the CAPM model using daily return data to estimate the IV for stocks and report that there is no relationship between value-weighted IV and expected excess market return over the period of 1962 to 2001. Bali et al further conclude after controlling for size, liquidity, and price level, the positive relationship between IV and expected stock returns which are reported by Campbell et al (2001) disappeared. Bali and Cakici (2008) further confirm that there is no relationship between IV and equal-weighted expected stock portfolios' returns in US stock market during the period 1958 to 2004.

Ang et al (2006) employ the Fama-French three-factor model using daily stock returns to estimate IV in the US stock market over the period 1963 to 2000. Ang et al report that stocks with high IV generate a low average returns during the study period, which is also confirmed by Saryal's (2009) study. Ang et al further state that none of variables, i.e. size, BM, leverage, liquidity, volume, turnover, bid-ask spreads, coskewness, dispersion in the forecasts, or momentum could explain the negative IV effect in the US stock markets. Ang et al (2009) further confirm the negative IV effect in 23 international stock markets over the period 1980 to 2003. The authors raise six potential economic explanations on the negative IV effect in the international stock markets, including private information, transaction costs, analyst coverage, institutional ownership, delay, and skewness. Nartea et al (2010) find a negative IV effect in the Chinese stock market, but there is no trend of IV during 1993 to 2008. However, Nartea et al (2010[a]) report that there are strong positive relationships between IV and expected stock returns in the Southeast Asia stock markets, such as Singapore, Malaysian, Indonesia, and Thailand during the early 1990s to the end of 2007. On the other hand, Nartea and Ward (2009) discover a flat trend of IV and no relationship between the IV and expected stock portfolio returns in the Philippine stock market over the period 1992 to 2007. The authors argue that the IV effect in the Philippine stock market is due to the Fama-French's (1993) size and BM factors.

Fu (2009) employs an EGARCH model and out of sample data to estimate expected IV for stocks, called conditional IV. Fu argues that the lagged IV might not be a good estimate of expected IV. The author points out that the conditional idiosyncratic volatility not only captures the time-series properties of volatility, for example fat tails, clustering, and asymmetry, but is also less noisy than realized idiosyncratic volatility. Fu (2009) concludes that there is a statistically and economically positive relationship between the conditional IV and stock portfolios returns in U.S. stock market during the period 1963 to 2006. The author further argues that Ang et al's (2006) findings are driven by monthly return reversal and Ang et al's (2006) results could also be due to the data frequency used to estimate IV, weighting schemes used to compute average portfolio returns, and breakpoints utilized to sort stocks into quintile portfolios. Furthermore, Fu also indicates that variables of size, price, and liquidity might also are used to explain the negative IV effect which is reported by Ang et al (2006) in the US stock market. According to Fu's (2009) computation method of IV, Brockman *et al* (2009) confirm the statistically significant positive relation between the IV and expected stock returns around 36 international stock markets during 1980 to 2007, including the Hong Kong stock market. Pukthuanthong-Le and Visaltanachoti (2009) also report a positive relationship between the conditional IV and expected stock return across 36 countries from 1973 to 2007. Pukthuanthong-Le and Visaltanachoti (2009) also indicate that a stock in Hong Kong has an IV of one standard deviation higher than other stocks that generates a return of 1.89% higher than in a month. Fu and Schutte (2010) confirm the positive relationship between the conditional IV and stock returns during the period 1980 to 2007 in the US stock market and argue that the positive IV effect is due to the effect of investors' diversification, which the positive relation between IV and stock return and is significantly stronger in stocks that held by individual investors than stocks held by institutional investors.

3. Data and Methodology

The data for this study is obtained from the DataStream. The sample includes all stocks listed on both main board and Growth Enterprise Market (GEM market) of Hong Kong stock market from January 1980 to December 2007. Consistent to previous studies, the sample excludes the investment trusts, closed-end funds, exchange traded funds, and preferred shares. We also exclude stocks with negative book-to-market (BTM) ratio in order to reduce the noise in computing the IV for each stock. There are a total of 40 stocks in the sample in January 1980 and 1108 stocks in December 2007 with an average of 423 stocks per month. This study employs the weekly Hong Kong prime rate as the weekly risk free rate.

We employ an Ang et al's (2006, 2009) FF three-factor model to estimate the idiosyncratic volatility for Hong Kong stocks. The idiosyncratic volatility is the standard deviation of the residuals from the adopted FF three-factor model given in equation 1:

$$R_{i,t} - R_{f,t} = \alpha + \beta_{MKT,i,m} (R_m - R_{ft}) + \beta_{SMB,i,m} SMB_t + \beta_{HML,i,m} HML_t + \varepsilon_{i,t} \qquad (1)$$

where the $R_{i,t} - R_{f,t}$ is the excess return of every individual stocks at time t; $\beta_{MKT,i,m}$, $\beta_{SMB,i,m}$, $\beta_{HML,i,m}$ are coefficients of market premium, size premium, and BM premium respectively. R_m-R_f is the excess market return; SMB is the size factor defined as the excess return of small firms over big firms, and HML is the value factor defined as the excess return of high BM firms over low BM firms. Equation (1) is estimated for every individual stock. Therefore, the IV of each stock was computing at the beginning of every month as the standard deviation of the residuals ($\varepsilon_{i,t}$) from the Fama-French three-factor model *(1)* by using weekly data for the previous *t* trading weeks, which t equals to 26. The $\sigma_{\varepsilon i}$ is a weekly volatility measure that is computed monthly.

We employ a longer time period data to compute idiosyncratic volatility for each individual stock, because Guo and Savickas (2006) suggest that the long horizon data set might increase the stock return predictability. Moreover, Fu (2009) critic Ang et al's (2006, 2009) research findings due to the data frequency on estimating IV for each stock. Thus, this study is to use weekly data computing IV for each individual stock and provides out-of-sample empirical evidence on the IV effect in the Hong Kong stock market, which is the first study to use weekly data to estimate IV for stocks.

Following Ang et al's (2006, 2009) method, we first sort stocks into three portfolios according to stocks' IV at the beginning of every month to investigate the relationship between the idiosyncratic volatility and one-month ahead of the stock returns. Three stock portfolios contain similar number of stocks, called high-IV portfolio (HIV), medium-IV portfolio (MIV), and low-IV portfolio (LIV). The HIV portfolio composed of top third of all stocks with the highest IV; the MIV composed of the middle third, and the LIV the lowest third of all stocks with low IV. Both equal-weighted and value-weighted portfolios raw returns for the current month are computed.

To further investigate whether or not the IV effect can be explained by other known effects, we employ a double-sort procedure where we first sort by stock's characteristic (e.g., MV, BM, momentum, REV, etc.) and then again by IV. Stocks are first sorted into three portfolios according to the stocks' characteristic of the previous month (control variable) at the beginning of each month. Each portfolio contains the similar number of stocks. Following this, each stock portfolio with control variable is again sorted into three portfolios according to the stocks' IV. This procedure yields 9 stock portfolios that contain similar number of stocks.

4 Empirical Results and Discussion

4.1 Descriptive Results

Panel A of Table 1 reports the descriptive statistics for the equal-weighted (IV^{ew}) and value-weighed (IV^{vw}) idiosyncratic volatility across all firms, where IV is the standard deviation of residuals from equation (1). The mean of IV^{ew} is 0.0564, which is nearly doubled the mean of IV^{vw} (0.0286). This implies that smaller size firms are more volatile than big size firms in the Hong Kong stock market during the study period, which is consistent to previous findings in the US stock markets (Campbell et al, 2001). Moreover, the coefficient variations of both IV^{ew} and IV^{vw} are similar, which indicate they are equal variables (with low variance). Panel B initially shows that the IV^{ew} and IV^{vw} are positively correlated, which is 0.7150.

[Insert Table 1 Here]

4.2 Investigating the trend of idiosyncratic volatility

In this section, we investigate whether there is a trend of idiosyncratic volatility in the Hong Kong stock market using weekly return data. Most previous findings in the US stock market indicate that there is a upward trend of IV in the past, for example Malkiel and Xu (1997, 2006), Campbell et al (2001) and Xu and Malkiel (2003). However, Hamao et al (2003) indicate that the IV has a decreased trend in the Japanese stock market over period 1975 to 1999. On the other hand, Bekaert *et al* (2009) find no evidence of a trend of IV in 23 developed stock markets, including U.S. The debate remains in the literatures, thus we are going to further investigate whether or not there is a trend of average IV for Hong Kong stock market.

Figure 1 plots both the IV^{ew} and IV^{vw} respectively. Panel A shows IV^{ew} has a clear upward trend from early 1980s to the end of 1990s. However, the trend in IV^{ew} decreased after 2000. The IV^{vw} exhibits e similar shape with IV^{ew}, except IV^{vw} decreased more than the IV^{ew} trend after 2000, where IV^{vw} reaches its lowest level in November of 2005 (0.0174). The results are partly consistent to Bekaert *et al*'s (2009) findings. Bekaert *et al* (2009) conclude that the IV increased after 1995 and decreased after 2001 in 23 developed stock markets except for the U.S stock market. Moreover, Brandt et al (2009) point out that the IV fell back to the pre-1990 level after 2003 in the US stock market, which is also reported in our findings in the Hong Kong stock market (see Figure 1).

We note several key points in the behavior of the volatility series over the study period. First, the suddenly increased level of idiosyncratic volatility in November and December of 1987 could be due to the effect of New York stock market crash on 19th October, 1987. The stock market crash began in Hong Kong and then spread to all over the world (Wikipedia.com, 2011). By the end of October 1987, the Hong Kong stock market fell by 45.5%. This was the biggest market drop within a month in the history of the Hong Kong stock market. Second, the IV started to climb from the end of 1996 to the early of 1998 due the effects of the 1997 Asian financial crisis. The Hang Seng Index dropped 23% between 20 October and 23 October 1997, which increased the volatility of the market.

Third, the highest level of idiosyncratic risk appearing in the July of 2000 could be due to the burst of the High-Tech bubble. We also notice that the IV^{ew} is twice higher than IV^{vw} in the same period. We thus assume that the High-Tech bubble is mainly caused by the relative smaller firms, where most internet companies are small size stocks. When the High-Tech bubble burst, only prices of these small size firms are impacted. The prices of the big size firms remain stable. Fourth, an increased in the level of IV could be due to an increased in the number of institutional investors in the Hong Kong stock market. Malkiel and Xu (1997, 2006) suggest that the herding behavior among institutional investors leads to increased sensitive of stock prices to new information or changes in investors' sentiment. Nartea et al (2010) confirm this suggestion in the Chinese stock market. Finally, an increased in the number of H shares in the Hong Kong stock market might cause a decreasing trend of IV after 2000. As discussed above, the high IV is caused by small stocks rather than big stocks (Angelidis and Tessaromatis, 2005). There are only 110 H shares listed in the Hong Kong stock market at the end of 2008, which account for about 54.5% of total market capitalization of the stock exchange (Karrenman & Van der Knaap, 2010). These H shares are large capitalization stocks. Since more H shares are listed in the market, the volatility of the Hong Kong stock market could be lower.

To accurately estimate the trend of the IV in the Hong Kong stock market, we estimate the deterministic time trend model for both idiosyncratic volatility series using the following equation (2):

$$VOL_t = b_0 + b_1 t + \mu_t \qquad (2)$$

Where *VOL* represents IV^{ew} and IV^{vw}, and *t* is time. The estimated time trend b_1 parameter and its t-sand test statistics are reported in Table 2. Bunzel and Vogelsang (2005) indicate that the use of standard t-test rejects the hull hypothesis of no trend when errors in the trend regression are persistent. Thus, Bunzel and Vogelsang (2005) develop the t-sand test, which has better power than standard t-test while retaining its good size properties. Panel A in Table 2 shows that there are upward trends for both IV^{ew} and IV^{vw}, which is consistent to our observations according to weekly data results. Panel A in Table 2 also report a statistically significant decreased trend of market volatility during the full sample period. Both Malkiel and Xu (1997) and Campbell et al (2001) indicate that the IV increases in the US stock market recently with a flat trend of market volatility. Our results are partly consistent to their findings. Thus, our results indicate an upward trend in correlation among stocks and that benefit from diversification would have likely increased on average over the testing period. In other words, the numbers of stocks needed to achieve a given level of diversification would have increased over time (Malkiel and Xu, 1997; Campbell et al, 2001; & Hamao et al, 2003).

To further investigate how 1987 stock market crash affect the IV trend for Hong Kong stocks, we conduct a robustness test for our data from 1990 to 2007. The results show IV^{ew} still exhibits a statistically significant upward trend over the period 1990 to 2007 (see Panel A in Table 2). However, IV^{vw} exhibits no trend in the robustness test because of a statistically insignificant coefficient. The coefficient MV remains negative, but it is statistically insignificant. The results might indicate that the 1987 stock market crash does have some effect on the IV trend for stocks in the Hong Kong stock market.

Panel B in Table 2 reports the results of the IV trends according to monthly IV data. The results are qualitatively similar to those reported in the Panel A in Table 2.

[Insert Table 2 Here]

4.3 The cross-sectional relationship between the idiosyncratic volatility and stock returns

Table 3 shows the average monthly raw returns of stock portfolios sorted according to IV. It also shows average abnormal returns or Jensen's alpha. Panel A reports the equal-weighted average raw returns and Jensen's alpha while Panel B reports the corresponding value-weighted returns. Table 3 also presents the average size and book to market (BM) ratio of the three-IV sorted portfolios. Panel A in Table 3 indicates that high IV portfolio has lower raw return than low IV portfolio during the study period, which is -0.05% per month, but it is statistically insignificant. On the other hand, Panel B in Table 3 reports that high IV portfolio outperforms low IV portfolio by 1.49% per month in raw return with a weak statistically significance. However, the results of Jensen's alpha indicate that there is a strong positive relationship between the IV and expected returns in the Hong Kong stock market. The FF-3 alpha indicates that the high IV portfolio generates a higher return than low IV portfolio around 2.47% per month for equal-weighted returns or 3.14% per month for value-weighted returns. More importantly, the positive relationship between IV and expected stock returns is confirmed by a monotonic decrease in FF-3 alpha from high to low IV portfolios.

We summarize three points for findings in Table 3. First, our results corroborate most research findings in the Hong Kong stock market, such as Drew and Veeraraghavan (2002), Pukthuanthong-Le and Visaltanachoti (2009), and Brockman et al (2009). For example, Brockman et al (2009) report that the Jensen's alpha of high IV portfolios is 2.36% per month higher than low IV portfolios for the value-weighted portfolios or 2.99% per month of the equal-weighted portfolios in the Hong Kong stock market from early 1980 to the end of 2007 with a sample of 469 stocks per month on average. Their results are similar to our results in Table 3. Moreover, Pukthuanthong-Le and Visaltanachoti's (2009) indicate that a stock in Hong Kong has an IV of one standard deviation higher than other stocks, which generates a return of 1.89% higher than in a month. This is also qualitatively similar to our findings. We assumed that Pukthuanthong-Le and Visaltanachoti's (2009) sample does not cover the H shares which are also traded in the Hong Kong stock market. However, our results contradict Ang et al. (2009) findings, who report a negative IV effect in Hong Kong stock market. We argue that Ang et al's (2009) findings are biased by the small number of stocks in their sample over the period 1980 to 2003. They used 242 stocks on average when there are more than 1200 listed stocks in the Hong Kong stock market. Second, previous studies which investigate the IV effect in the Hong Kong stock market employ a variety of methods in computing the IV for stocks. For example, Drew and Veeraraghavan (2002) measure IV for stocks as the difference between the variance of returns for each stock and the variance of the index. Both Pukthuanthong-Le and Visaltanachoti (2009) and Brockman et al (2009) employ Fu's (2009) method to compute conditional IV for stocks rather than the realized IV used in our study. However, all these studies report a positive IV effect in the Hong Kong stock market similar to our findings. We thus argue that the methodology used to estimate IV for stocks might not alter the results of IV effect on qualitatively. Finally, Both Pukthuanthong-Le and Visaltanachoti (2009) and Brockman et al (2009) employ daily return data to estimate IV for Hong Kong stocks while Drew and Veeraraghavan (2002) use monthly return data estimate IV for stock portfolios. However, the data frequency in estimating IV does not influence the existence of the positive IV effect in the Hong Kong stock market. We thus reject both Bali and Cakici (2008) and Fu's (2009) research hypotheses, which they assert that the IV effect might be due to the data frequency in estimating IV for stocks.

Our result indicates that there might be around 2.5% per month adjusted risk premium for high IV portfolio than low IV portfolio in the Hong Kong stock market, which most studies show that the IV premium in the US stock market is around 1% per month over the period from early 1960s' to the beginning of 2000 (Goyal & Santa-Clara, 2003; Ang et al., 2006 & 2009; Fu, 2009). We argue that the difference of the IV premium between the Hong Kong stock market and the US stock market could be due to the level of market efficiency, price informativeness, and degree of investor underdiversification.

[Insert Table 3 Here]

To further investigate whether the positive idiosyncratic volatility effect can be explained by some other factors in the Hong Kong stock market, we employ Ang et al's (2006, 2009) method to control for four cross-sectional effects – size, BM, momentum, and short-term reversal (REV) and use the alpha to control for the standard set of systematic factors. The results are reported in Table

4[2]. Panel A shows the double-sorted on size and idiosyncratic volatility results. The result show the positive and highly significant equal- (value-) weighted alpha spread of 2.50% (2.76%) per month, when we averaged the alpha spreads within each idiosyncratic volatility category. This results in three portfolios with variation in idiosyncratic volatility but similar levels in the control variable. The evidence in Panel A also indicates that all alpha spreads are positive and statistically significant for both equal- and value-weighted portfolios. We notice that the alpha spread for the medium-size portfolios are higher than the other two size portfolios (big-size and small-size) for both equal- and value-weighted portfolios, which indicate that the IV effect is strongest for the medium-size portfolios. Therefore the size effect is not driving the positive relationship between idiosyncratic volatility and alpha.

Panel B in Table 4 shows the results when we double-sorted on BM and idiosyncratic volatility. Again, both average equal- and value-weighted alphas spreads are positive and highly significant at 2.32% and 2.84% per month, respectively. The result also shows that the average alpha spreads for both equal- and value-weighted LBM portfolios are higher than the other two portfolios, which are above 4% per month. This might indicate that the IV has a strong effect on LBM portfolios. The results suggest that the BM effect is not behind the relationship between idiosyncratic volatility and FF-3 alpha.

Panel C in Table 4 reports the results for portfolios double-sorted on momentum and idiosyncratic volatility. The alpha spreads are positive and highly significant for all equal- and value-weighted portfolios. The IV effect is stronger for loser portfolios than the other two portfolios, winner and medium, respectively. More importantly, both average equal- and value-weighted alpha spreads are positive and highly significant at 2.75% and 3.59% per month, respectively. The

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[2] We also control for three additional cross-sectional effect, value (lagged 6-month BTM), 11-month past return with one-month lag, and past month return with one-month lag in search of a possible explanation for the positive relationship of IV and alpha. The results are qualitatively similar to those reported in Table 4. We do not report these results but they are available from the authors upon request.

evidence suggests that the momentum is not behind the relationship between the idiosyncratic volatility and risk-adjusted returns.

Panel D in Table 4 reports the results when we control for short-term reversal (REV). First, both average equal- and value-weighted alphas spreads are positive and highly significant at 1.11% and 2.02% per month, respectively, where the alpha spread of equal-weighted portfolio is weakly significant. Second, the alpha spreads of the loser portfolios (*LSR*) for both equal- and value-weighted portfolios are negative and highly statistically significant, which suggests a negative instead of a positive idiosyncratic volatility effect for loser stocks. This finding is consistent with Nartea et al (2010[a]) who also report a positive IV effect in the Southern East Asian stock markets that disappears in the loser portfolios and turns to a negative IV. Third, only the results of alpha spreads for winner portfolios exhibit a positive relationship between idiosyncratic volatility and returns, which is consistent to the resulys in the Panel A, B, and C. For the medium portfolio, the equal-weighted alpha spread is negative but the value-weighted alpha spread is positive. None of them are statistically significant at any level. The results indicate a weak positive IV effect in the Hong Kong stock market after controlling for REV. For the medium REV portfolios there is no IV effect at all, which is partly consistent with Huang et al's (2010) findings. Huang et al (2010) conclude that the negative coefficient of IV is statistically insignificant after controlling for return reversal. Therefore, Huang et al concludes that the short-term reversal might be a primary reason for the negative relation between realized IV and stock returns in the US stock market over the period 1963 to 2004. Overall, our results suggest that REV does not explain the relationship between the idiosyncratic volatility and risk-adjusted returns.

Our results suggest that the positive IV effect in the Hong Kong stock market cannot be explained by size, BM, momentum, and REV based on weekly return data.

[Insert Table 4 Here]

4.4 Is idiosyncratic volatility priced?

In this section, we further test whether or not idiosyncratic volatility is priced in the Hong Kong stock market during the study period. Carhart (1997) used a multifactor pricing model to test existence and significance of risk factor which forms a mimicking risk portfolio. This method is very popular in the multi-factor asset pricing field. Drew et al. (2004) employ Carhart's (1997) idea and test whether IV is priced in the four-factor model in the Shanghai stock exchange. Drew et al.'s (2004) add additional factor on the FF three-factor model, called *HIVMLIV* which is the return of high IV minus the low IV portfolio. The *HIVMLIV* factor is the return of a zero-investment factor mimicking portfolio for idiosyncratic volatility. This study employs Drew et al's (2004) method to further confirm whether the IV has been priced in the Hong Kong stock market. We estimate the following equation for each of the double-sorted portfolios in the previous section:

$$R_t = \alpha + \beta_{MKT} MKT_t + \beta_{SMB} SMB_t + \beta_{HML} HML_t + \beta_{HIVMLIV} HIVMLIV_t + \varepsilon_{,t} \qquad (3)$$

According to Carhart's (1997) statement, if IV is a significant factor in determining asset returns, $\beta_{HIVMLIV}$ should be significantly different from zero. We also expect to see an increase monotonically coefficients of $\beta_{HIVMLIV}$ from low to high IV to confirm the positive relationship between IV and returns.

Table 5 reports the regression estimates for the value-weighted size-IV sorted portfolios. The result shows that $\beta_{HIVMLIV}$ increases monotonically from low to high IV portfolios for all size categories. For instance, $\beta_{HIVMLIV}$ in Panel A increases from -0.0939 to 0.5561 among the big size portfolios consistent with the positive relationship between IV and returns documented. Moreover, eight out of nine IV coefficients are highly statistically significant at all level, except for the coefficient IV for BIG-MIV (big size and medium IV) which is statistically insignificant.

Table 6 reports the regression estimates for the value-weighted BTM-IV sorted portfolios. Similarly, the $\beta_{HIVMLIV}$ increases monotonically from low to high IV portfolios for all BM categories. Moreover, eight out of nine $\beta_{HIVMLIV}$ are statistically significant at all level, only the IV coefficient of HBM-LIV (high BTM and low IV) is statistically significant at the 5% level.

Table 7 reports the regression estimates for the value-weighted momentum-IV sorted portfolios. The result shows $\beta_{HIVMLIV}$ increases monotonically from low to high IV portfolios for all momentum categories. More importantly, all nine $\beta_{HIVMLIV}$ are statistically significant at all level, and eight out of nine constant variables are statistically insignificant at 1% level, only constant variable of LSR-MIV (loser and medium IV) is statistically significant. This result indicates that IV is well priced in value-weighted momentum-IV double sorted portfolios.

Table 8 reports the regression estimates for the value-weighted REV-IV sorted portfolios. The result shows $\beta_{HIVMLIV}$ increases monotonically from low to high IV portfolios for all REV categories. Similarly, all nine $\beta_{HIVMLIV}$ are statistically significant at all level.

[Insert Table 5,6,7,8 Here]

Overall, the evidence suggests that IV should be priced in the Hong Kong stock market with high IV portfolios being compensated with high returns. Thirty-four out of thirty-six reported $\beta_{HIVMLIV}$ are statistically significant at 1% level, one $\beta_{HIVMLIV}$ is statistically significant at 5% level, and only one out of the thirty-six $\beta_{HIVMLIV}$ are insignificant at any level. Our results are broadly consistent with Wu and Nartea's (2011) findings in the Hong Kong stock market, where 86% of their $\beta_{HIVMLIV}$ are statistically significant at 1% level or around 8% lower than the current study. Our result indicates that IV effect in the Hong Kong stock market is not due to the data frequency in estimating IV for each stock. Wethus confirm that the positive IV effect is present in the Hong Kong stock market and reject Bali and Cakici (2008) and Fu's (2009) arguments[3].

5. Summary and Conclusion

In this paper, we investigate the role of idiosyncratic volatility in asset pricing in the Hong Kong stock market, which we use Ang et al's (2006, 2009) methodology according to weekly return data to compute IV for each stock. To differentiate previous studies in estimating IV for Hong Kong

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[3] We also compute the monthly premia associated with market, size, BM and idiosyncratic volatility for equal-weighted nine size-IV sorted portfolios, nine BM-IV sorted portfolios, nine momentum-IV sorted portfolios, and nine REV-IV sorted portfolios. Due to limited space, we do not report the results here, but the results are qualitatively similar to this study, where the IV premium decreases from high IV portfolios to low IV portfolios and the IV premium is bigger than the BM premium. The results are available upon request from the authors.

stocks, for example, Drew and Veeraraghavan (2002), Pukthuanthong-Le and Visaltanachoti (2009), and Brockman et al (2009), this study employs a new methodology in estimating idiosyncratic volatility for Hong Kong stocks. This study is the first study to use weekly stock return data in estimating IV for Hong Kong stocks., Both Bali and Cakici (2008) and Fu (2009) argue that the data frequency alter the IV effect in the US stock markets. The Hong Kong stock market is also an ideal market to study the IV effect since the institutional investors play a weak role in the market compared to those in the US stock markets. Finally, we test whether the wide disparity in the level of market efficiency, price informativeness, and degree of investors' diversification between the Hong Kong and US stock markets could determine the relationship between idiosyncratic volatility and returns and whether investors in these two markets exhibit similar behavioural biases.

The main finding of this study shows a significant positive relationship between the firm level idiosyncratic volatility and expected stock portfolios' returns in the Hong Kong stock market over the period 1980 to 2007. The idiosyncratic volatility of each firm is estimated using Ang et al's (2006, 2009) method with weekly stock return data. Our findings are consistent with previous research findings in the Hong Kong stock market, for example, Drew and Veeraraghavan's (2002), Brockman et al's (2009), and Pukthuanthong-Le and Visaltanachoti's (2009). We conclude that the positive IV effect in the Hong Kong stock market might not be due to model specification and data frequency in estimating IV for each firm. Further, previous studies did not employ the same method or weekly data in estimating IV for Hong Kong stocks. Our results support the traditional asset pricing theory, where high risk is associated with high returns in the stock markets. In as much as there exists wide disparities between the US and Hong Kong stock markets in terms of market efficiency, price informativeness and level of investor diversification, it appears that these factors could explain the difference in our findings with those in the US stock market. We also find the upward trends of both equal-weighted and value-weighted average idiosyncratic volatility in the Hong Kong stock market during the study period. The results indicate an upward trend in the correlations among the stocks and that benefit from diversification would have likely increased on average over the testing period. Finally, our results indicate that high idiosyncratic volatility portfolios generate higher returns than low idiosyncratic volatility portfolios in the Hong Kong stock market, which implies that investors could increase their portfolio returns by systematically by going long stocks with high idiosyncratic volatility and short stocks with low idiosyncratic volatility. We further confirm that the positive IV effect in the Hong Kong stock market cannot be explained by factors, such as size, BM, momentum, and short-term reversal.

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Table 1. Descriptive Statistics of the Idiosyncratic Volatility in the Hong Kong stock market (1980 – 2007)

Panel A: Summary statistics

	Mean	Median	Stdev	CV	Max	Min
IV^{EW}	0.0564	0.0512	0.0161	0.2855	0.1078	0.0325
IV^{VW}	0.0286	0.0269	0.0071	0.2483	0.0532	0.0174

Panel B: Correlation Table

	IV^{EW}	IV^{VW}	MV
IV^{EW}	1.0000	0.7150	0.2994
IV^{VW}	0.7150	1.0000	0.5617

Table 2. Time trend of the volatility series

Panel A Weekly Results

	1981:08-2007-12		1990:01-2007:12	
	Linear Trend (x 10 $^{-5}$)	t-dan	Linear Trend (x 10 $^{-6}$)	t-dan
IV^{EW}	2.80	17.1034	37.4	7.6870
IV^{VW}	0.33	3.7612	0.36	0.1225
MV	-1.40	-7.9160	-4.10	-1.3886

Panel B Monthly Results

	1981:08-2007-12		1990:01-2007:12	
	Linear Trend (x 10 $^{-5}$)	t-dan	Linear Trend (x 10 $^{-5}$)	t-dan
IV^{EW}	12.1	8.0209	16.3	3.6457
IV^{VW}	1.44	1.7832	0.18	0.0659

*The 5% critical value for t-dan is 1.726.

Table 3. Returns of portfolios sorted by idiosyncratic volatility

	Raw Return		Size[a]	B/M	Jensen's Alpha	
	Mean	Std. Dev			Mean	Std. Error
Panel A: Equal-Weighted						
High IV	0.0031	0.1291	691.6395	1.2410	0.0181	0.0039
	(0.4238)		(30.6485)	(47.2759)	(4.6858)	
Medium IV	-0.0012	0.0978	1894.199	1.2615	-0.0027	0.0025
	(-0.2180)		(29.1206)	(46.8523)	(-1.1103)	
Low IV	0.0036	0.0744	11760.22	1.1961	-0.0066	0.0017
	(0.8507)		(26.9086)	(48.6669)	(-3.9283)	
High- Low	-0.0005		-11068.58	0.0449	0.0247	
	(-0.0577)		(-25.292)	(1.2483)	(5.8057)	
Panel B: Value- Weighted						
High IV	0.0287	0.1391	4942.61	0.6981	0.0282	0.0054
	(3.6794)		(6.5774)	(30.0997)	(5.2040)	
Medium IV	0.0162	0.1012	18142.20	0.6986	0.0045	0.0024
	(2.8552)		(9.0894)	(46.7365)	(1.91**)	
Low IV	0.0139	0.0854	186571.4	0.7101	-0.0032	0.0007
	(2.8965)		(14.9945)	(75.2448)	(-4.4103)	
High- Low	0.0149		-181628.8	-0.0119	0.0314	
	(1.6798)		(-14.571)	(-0.4771)	(5.7666)	

[a] Market capitalisation in million HK Dollar.
Numbers in parenthesis are t-statistics.

Table 4. Alpha double sorted portfolios

	Equal-weighted				Value -weighted			
	LIV	*MIV*	*HIV*	*HIV-LIV*	*LIV*	*MIV*	*HIV*	*HIV-LIV*
Panel A. Double sort on size (market capitalisation) and IV								
BIG	-0.0066	-0.0044	0.0152	0.0218	-0.0032	-0.0021	0.0189	0.0221
	(-3.9708)	(-2.126*)	(3.4740)	(4.9116)	(-3.2223)	(-1.0149)	(4.5068)	(5.1188)
MED	-0.0050	0.0015	0.0270	0.0320	-0.0063	0.0015	0.0267	0.0330
	(-2.0523)	(0.4921)	(5.4792)	(5.8649)	(-2.7244)	(0.4921)	(5.1817)	(5.8985)
SMA	-0.0083	-0.0060	0.0128	0.0211	-0.0080	-0.0039	0.0197	0.0277
	(-2.9850)	(-2.1794)	(3.0428)	(4.1801)	(-2.9972)	(-1.3350)	(4.4580)	(5.3658)
AVE	-0.0066	-0.0030	0.0183	0.0250	-0.0058	-0.0015	0.0218	0.0276
	(-4.9005)	(-1.9325)	(7.1934)	(8.6516)	(-4.7488)	(-0.9634)	(8.2264)	(9.4612)
Panel B. Double sort on BTM and IV								
HBM	-0.0134	-0.0108	-0.0051	0.0083	-0.0160	-0.0085	0.0036	0.0196
	(-5.3562)	(-3.3115)	(-1.0899)	(1.5853)	(-5.7568)	(-2.2070)	(0.6309)	(3.0863)
MBM	-0.0072	-0.0030	0.0118	0.0190	-0.0089	-0.0009	0.0106	0.0195
	(-3.2677)	(-1.0444)	(2.6155)	(3.7932)	(-4.2132)	(-0.2692)	(2.0271)	(3.4772)
LBM	-0.0001	0.0109	0.0422	0.0423	0.0001	0.0134	0.0461	0.0460
	(-0.0406)	(3.6488)	(7.4989)	(7.1135)	(0.0655)	(4.4374)	(6.6547)	(6.4731)
AVE	-0.0069	-0.0010	0.0163	0.0232	-0.0083	0.0013	0.0201	0.0284
	(-5.3288)	(-0.5451)	(5.7323)	(7.4253)	(-6.3737)	(0.6752)	(5.8256)	(7.6958)
Panel C. Double sort on Momentum and IV								
WNR	-0.0057	0.0015	0.0140	0.0197	-0.0006	0.0052	0.0306	0.0312
	(-2.3332)	(0.4851)	(2.6958)	(3.4398)	(-0.2644)	(1.4388)	(4.0906)	(3.9621)
MID	-0.0062	-0.0032	0.0134	0.0196	-0.0057	0.0005	0.0205	0.0262
	(-3.0824)	(-1.2576)	(3.4162)	(4.4719)	(-2.6046)	(0.1987)	(4.3335)	(5.0487)
LSR	-0.0117	-0.0074	0.0314	0.0431	-0.0080	-0.0015	0.0422	0.0502
	(-4.3020)	(-2.1316)	(5.8431)	(7.1389)	(-2.4698)	(-0.3525)	(5.7302)	(6.2265)
AVE	-0.0079	-0.0030	0.0196	0.0275	-0.0048	0.0014	0.0311	0.0359
	(-5.7154)	(-1.7254)	(6.9582)	(8.7610)	(-3.1325)	(0.6795)	(8.0871)	(8.6723)
Panel D. Double sort on REV and IV								
WNR	0.0858	0.1095	0.1842	0.0984	0.0783	0.1124	0.2000	0.1217
	(16.569)	(18.240)	(22.192)	(10.047)	(25.952)	(27.066)	(23.621)	(13.501)
MID	-0.0107	-0.0105	-0.0113	-0.0006	-0.0072	-0.0053	-0.0067	0.0005
	(-2.553*)	(-2.3465)	(-2.5051)	(-0.0975)	(-4.0297)	(-2.4116)	(-3.0460)	(0.1759)
LSR	-0.0977	-0.1175	-0.1622	-0.0645	-0.0797	-0.1039	-0.1414	-0.0617
	(-17.127)	(-19.885)	(-21.674)	(-6.8470)	(-24.509)	(-28.552)	(-24.052)	(-9.1270)
AVE	-0.0075	-0.0062	0.0036	0.0111	-0.0029	0.0011	0.0173	0.0202
	(-2.5738)	(-1.9432)	(0.8874)	(2.2325)	(-1.7936)	(0.5375)	(4.9063)	(5.2064)

At the end of each month over the test period, stocks are double-sorted 3x3, first by the control factor (size, BTM, momentum, and short-term reversal) into three portfolios and then within each portfolio we sort stocks again by idiosyncratic volatility measured using with the Fama-French three factor model (FF-3) (Eq. 1). The alpha of each value- and equal-weighted portfolio is shown with t-statistics in parenthesis. Alpha refers to the FF-3 model (Eq. 1) alpha (α coefficient) using the full sample of monthly value- or equal-weighted returns for each portfolio. To control for a particular factor, we average the alpha within each idiosyncratic volatility category ending up with three portfolios with dispersion in idiosyncratic volatility but containing all values of the factor being controlled. Size is the firm's market capitalisation at the end of month *t,* BTM is firms' book-to market ratio at the end of month t. *LIV*, *MIV*, *HIV* refer to low, medium, and high idiosyncratic volatility portfolio, respectively; *BIG*, big size; *MED*, medium size; *SMA*, small size; *HBM*, *MBM*, *LBM* refer to high, medium, low book-to-market, respectively; *WNR*, winner; *MID*, middle; *LSR*, loser.

Table 5. Four-factor model for value-weighted size-IV sorted portfolios

$R_t = \alpha + \beta_{MKT} MKT_t + \beta_{SMB} SMB_t + \beta_{HM,} HML_t + \beta_{HIVMLIV} HIVMLIV_t + \varepsilon_{,t}$

Panel A: Big size portfolios						
	Coefficient			Probability		
	BIG/HIV	*BIG/MIV*	*BIG/LIV*	*BIG/HIV*	*BIG/MIV*	*BIG/LIV*
α	-0.0008	-0.0019	-0.0003	0.6925	0.3702	0.7388
β_{MKT}	0.9973	1.0554	0.9628	0.0000	0.0000	0.0000
β_{SMB}	-0.3351	-0.0589	-0.0298	0.0000	0.2031	0.1132
β_{HML}	-0.1404	-0.0002	0.0253	0.0000	0.9966	0.1023
$\beta_{HIVMLIV}$	0.5561	-0.0050	-0.0939	0.0000	0.7972	0.0000
Adj-R^2	0..9314	0.9073	0.9793			
BG-LM				0.0000	0.0000	0.0000
ARCH				0.0000	0.0000	0.0000
Panel B: Medium size portfolios						
	MED/HIV	*MED/MIV*	*MED/LIV*	*MED/HIV*	*MED/MIV*	*MED/LIV*
α	0.0070	-0.0061	-0.0069	0.0606	0.0172	0.0000
β_{MKT}	1.0411	0.9823	0.6724	0.0000	0.0000	0.0000
β_{SMB}	0.6451	0.4400	0.3032	0.0000	0.0000	0.0000
β_{HML}	0.2305	0.0236	0.1297	0.0000	0.5435	0.0000
$\beta_{HIVMLIV}$	0.6268	0.2564	0.0938	0.0000	0.0000	0.0000
Adj-R2	0.8647	0.8545	0.7975			
BG-LM				0.0000	0.0000	0.0000
ARCH				0.0000	0.0000	0.0000
Panel C: Small size portfolios						
	SMA/HIV	*SMA/MIV*	*SMAL/LIV*	*SMA/HIV*	*SMA/MIV*	*SMA/LIV*
α	0.0078	-0.0118	-0.0123	0.0047	0.0000	0.0000
β_{MKT}	1.1458	0.9483	0.5936	0.0000	0.0000	0.0000
β_{SMB}	1.6264	0.9958	0.6096	0.0000	0.0000	0.0000
β_{HML}	0.1140	0.1167	0.0977	0.0251	0.0134	0.0215
$\beta_{HIVMLIV}$	0.4402	0.2496	0.0971	0.0000	0.0000	0.0000
Adj-R^2	0.8769	0.8831	0.7536			
BG-LM				0.0000	0.0000	0.0000
ARCH				0.0000	0.0000	0.0000

Portfolios are first sorted by size (market capitalisation) and then sorted by idiosyncratic volatility (IV). Size categories are big (*BIG*), medium (*MED*) and small (*SMAL*). IV categories are high (*HIV*), medium (*MIV*) and low (*LIV*).
RP, portfolio return; *RF*, risk-free rate; *RM*, market return; *SMB*, return of small minus big size portfolio; *HML*, return of high minus low BTM portfolio; *HIVMLIV*, return of high IV minus low IV portfolio.
B-G LM, Breusch-Godfrey Serial Correlation LM test *p* value
ARCH, Autoregressive Conditional Heteroscedasticity test *p* value
Reported regression coefficients are re-estimated coefficients using M-L-ARCH for cases with significant serial correlation and/or heteroscedasticity.

Table 6. Four-factor model for value-weighted BTM-IV sorted portfolios

$R_t = \alpha + \beta_{MKT} MKT_t + \beta_{SMB} SMB_t + \beta_{HM,} HML_t + \beta_{HIVMLIV} HIVMLIV_t + \varepsilon_{,t}$

Panel A: High BTM portfolios						
	Coefficient			Probability		
	HBM/HIV	*HBM/MIV*	*HBM/LIV*	*HBM/HIV*	*HBM/MIV*	*HBM/LIV*
α	-0.0124	-0.0130	-0.0142	0.0040	0.0005	0.0000
β_{MKT}	0.9126	0.9932	0.9891	0.0000	0.0000	0.0000
β_{SMB}	0.2435	-0.1229	0.1027	0.0026	0.0245	0.0975
β_{HML}	0.4558	0.2834	0.3135	0.0000	0.0000	0.0000
$\beta_{HIVMLIV}$	0.5243	0.1791	-0.0564	0.0000	0.0000	0.0324
Adj-R^2	0.7347	0.7455	0.8278			
BG-LM				0.0000	0.0000	0.0000
ARCH				0.0000	0.0000	0.0000
Panel B: Medium BTM portfolios						
	MBM/HIV	*MBM/MIV*	*MBM/LIV*	*MBM/HIV*	*MBM/MIV*	*MBM/LIV*
α	-0.0056	-0.0035	-0.0058	0.1447	0.3031	0.0062
β_{MKT}	1.0742	1.0380	1.0526	0.0000	0.0000	0.0000
β_{SMB}	0.1159	-0.0024	-0.0010	0.0890	0.9741	0.9820
β_{HML}	0.2481	0.0978	0.1233	0.0001	0.1024	0.0000
$\beta_{HIVMLIV}$	0.5854	0.0831	-0.0970	0.0000	0.0000	0.0000
Adj-R2	0.8238	0.8009	0.9063			
BG-LM				0.0000	0.0000	0.0000
ARCH				0.0000	0.0000	0.0000
Panel C: Low BTM portfolios						
	LBM/HIV	*LBM/MIV*	*LBM/LIV*	*LBM/HIV*	*LBM/MIV*	*LBM/LIV*
α	0.0136	0.0083	0.0022	0.0000	0.0000	0.2028
β_{MKT}	0.8293	1.0047	0.9420	0.0000	0.0000	0.0000
β_{SMB}	-0.2158	-0.0656	-0.0796	0.0000	0.3084	0.0303
β_{HML}	-0.3499	-0.3299	-0.1774	0.0000	0.0000	0.0000
$\beta_{HIVMLIV}$	0.8774	0.1629	-0.0658	0.0000	0.0000	0.0000
Adj-R^2	0.8199	0.8349	0.9237			
BG-LM				0.0000	0.0000	0.0000
ARCH				0.0000	0.0000	0.0000

Portfolios are first sorted by book to market ratio (BTM) and then sorted by idiosyncratic volatility (IV). BTM categories are high (*HBM*), medium (*MBM*), and low (*LBM*).). IV categories are high (*HIV*), medium (*MIV*) and low (*LIV*).
RP, portfolio return; *RF*, risk-free rate; *RM*, market return; *SMB*, return of small minus big size portfolio; *HML*, return of high minus low BTM portfolio; *HIVMLIV*, return of high IV minus low IV portfolio.
B-G LM, Breusch-Godfrey Serial Correlation LM test *p* value
ARCH, Autoregressive Conditional Heteroscedasticity test *p* value
Reported regression coefficients are re-estimated coefficients using M-L-ARCH for cases with significant serial correlation and/or heteroscedasticity, otherwise OLS estimates.

Table 7. Four-factor model for value-weighted momentum-IV sorted portfolios

$$R_t = \alpha + \beta_{MKT} MKT_t + \beta_{SMB} SMB_t + \beta_{HML} HML_t + \beta_{HIVMLIV} HIVMLIV_t + \varepsilon_{,t}$$

Panel A: Winner portfolios						
	Coefficient			Probability		
	WIN/HIV	*WIN/MIV*	*WIN/LIV*	*WIN/HIV*	*WIN/MIV*	*WIN/LIV*
α	-0.0020	0.0013	0.0008	0.5497	0.6526	0.6709
β_{MKT}	0.9103	0.9701	1.0349	0.0000	0.0000	0.0000
β_{SMB}	-0.1595	0.0303	0.0874	0.0377	0.5917	0.0000
β_{HML}	-0.0124	0.1728	0.0993	0.8773	0.0000	0.0000
$\beta_{HIVMLIV}$	1.0305	0.2192	-0.0570	0.0000	0.0000	0.0000
Adj-R^2	0.8402	0.8013	0.8794			
BG-LM				0.0000	0.0000	0.0000
ARCH				0.0000	0.0000	0.0000
Panel B: Middle portfolios						
	MID/HIV	*MID/MIV*	*MID/LIV*	*MID/HIV*	*MID/MIV*	*MID/LIV*
α	0.0039	-0.0010	-0.0003	0.2882	0.6571	0.8024
β_{MKT}	1.0907	1.0734	1.0118	0.0000	0.0000	0.0000
β_{SMB}	0.3757	0.0025	0.0200	0.0000	0.9613	0.4457
β_{HML}	0.1786	0.0183	0.0029	0.0000	0.6581	0.8949
$\beta_{HIVMLIV}$	0.5280	0.1158	-0.1146	0.0000	0.0000	0.0000
Adj-R2	0.8521	0.8768	0.9017			
BG-LM				0.0000	0.0000	0.0000
ARCH				0.0000	0.0000	0.0000
Panel C: Loser portfolios						
	LSR/HIV	*LSR/MIV*	*LSR/LIV*	*LSR/HIV*	*LSR/MIV*	*LSR/LIV*
α	0.0121	-0.0121	-0.0081	0.0444	0.0018	0.0115
β_{MKT}	1.0206	0.9954	0.9109	0.0000	0.0000	0.0000
β_{SMB}	0.2577	0.0335	0.0486	0.0000	0.6319	0.3810
β_{HML}	0.1696	0.0134	-0.1024	0.0674	0.8310	0.0306
$\beta_{HIVMLIV}$	0.7859	0.3014	0.0723	0.0000	0.0000	0.0000
Adj-R^2	0.7316	0.7415	0.7667			
BG-LM				0.0000	0.0000	0.0000
ARCH				0.0000	0.0000	0.0000

Portfolios are first sorted by size (market capitalisation) and then sorted by idiosyncratic volatility (IV). Size categories are big (*BIG*), medium (*MED*) and small (*SMAL*). IV categories are high (*HIV*), medium (*MIV*) and low (*LIV*).
RP, portfolio return; *RF*, risk-free rate; *RM*, market return; *SMB*, return of small minus big size portfolio; *HML*, return of high minus low BTM portfolio; *HIVMLIV*, return of high IV minus low IV portfolio.
B-G LM, Breusch-Godfrey Serial Correlation LM test *p* value
ARCH, Autoregressive Conditional Heteroscedasticity test *p* value
Reported regression coefficients are re-estimated coefficients using M-L-ARCH for cases with significant serial correlation and/or heteroscedasticity.

Table 8. Four-factor model for value–weighted REV-IV sorted portfolios

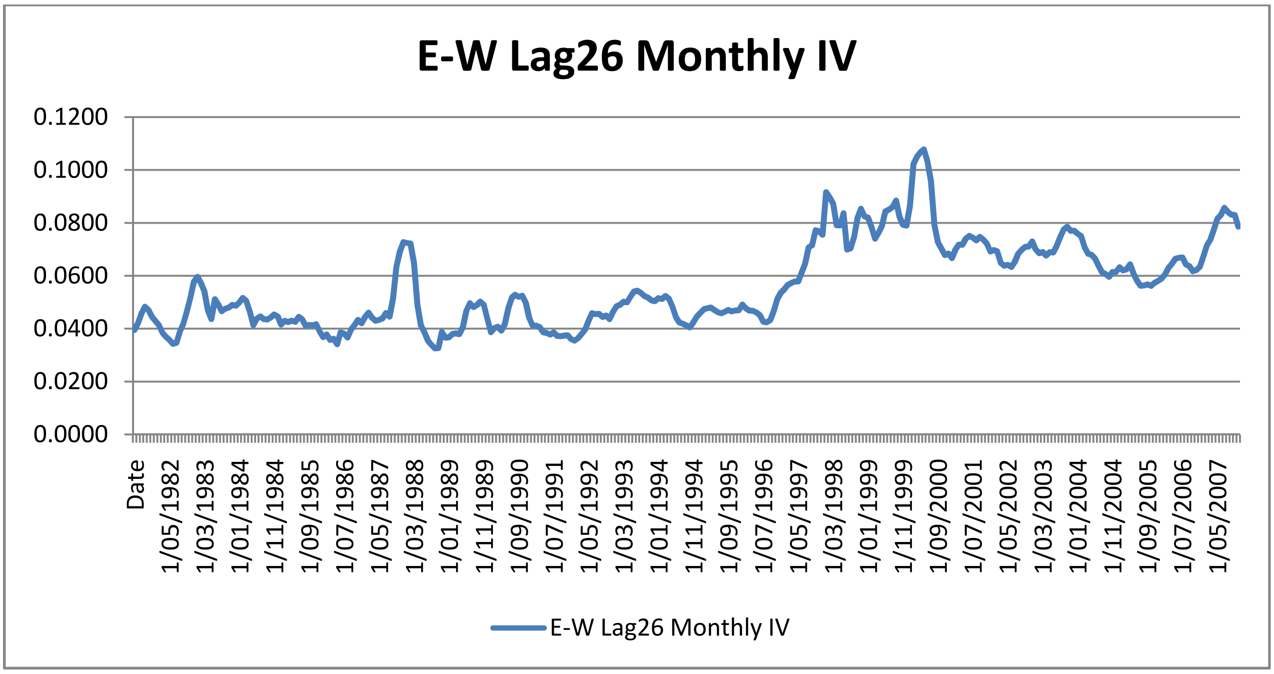
$$R_t = \alpha + \beta_{MKT} MKT_t + \beta_{SMB} SMB_t + \beta_{HML} HML_t + \beta_{HIVMLIV} HIVMLIV_t + \varepsilon_{,t}$$

Panel A: Winner portfolios						
	Coefficient			Probability		
	WIN/HIV	*WIN/MIV*	*WIN/LIV*	*WIN/HIV*	*WIN/MIV*	*WIN/LIV*
α	0.1691	0.0906	0.0708	0.0000	0.0000	0.0000
β_{MKT}	0.7904	0.9254	0.8459	0.0000	0.0000	0.0000
β_{SMB}	0.0773	0.1155	0.1488	0.5745	0.0401	0.0135
β_{HML}	0.3415	0.2443	0.1238	0.0000	0.0000	0.0123
$\beta_{HIVMLIV}$	0.9845	04533	0.2385	0.0000	0.0000	0.0000
Adj-R²	0.7062	0.8025	0.8265			
BG-LM				0.0000	0.0000	0.0000
ARCH				0.0000	0.0000	0.0000
Panel B: Middle portfolios						
	MID/HIV	*MID/MIV*	*MID/LIV*	*MID/HIV*	*MID/MIV*	*MID/LIV*
α	-0.0120	-0.0102	-0.0103	0.0000	0.0000	0.0000
β_{MKT}	0.8975	0.8943	0.9005	0.0000	0.0000	0.0000
β_{SMB}	0.4219	0.4004	0.3729	0.0000	0.0000	0.0000
β_{HML}	0.0970	0.0884	0.0677	0.0000	0.0169	0.0296
$\beta_{HIVMLIV}$	0.1666	0.1569	0.0987	0.0000	0.0000	0.0000
Adj-R2	0.8998	0.8963	0.9199			
BG-LM				0.0000	0.0000	0.0000
ARCH				0.0000	0.0000	0.0000
Panel C: Loser portfolios						
	LSR/HIV	*LSR/MIV*	*LSR/LIV*	*LSR/HIV*	*LSR/MIV*	*LSR/LIV*
α	-0.1501	-0.1082	-0.0838	0.0000	0.0000	0.0000
β_{MKT}	1.2348	1.0698	1.0183	0.0000	0.0000	0.0000
β_{SMB}	0.9879	0.8305	0.6401	0.0000	0.0000	0.0000
β_{HML}	-0.1856	-0.0175	-0.0330	0.0109	0.7898	0.5712
$\beta_{HIVMLIV}$	0.2117	0.1350	0.1319	0.0000	0.0000	0.0000
Adj-R²	0.6419	0.7931	0.8105			
BG-LM				0.0000	0.0000	0.0000
ARCH				0.0000	0.0000	0.0000

Portfolios are first sorted by size (market capitalisation) and then sorted by idiosyncratic volatility (IV). Size categories are big (*BIG*), medium (*MED*) and small (*SMAL*). IV categories are high (*HIV*), medium (*MIV*) and low (*LIV*).
RP, portfolio return; *RF*, risk-free rate; *RM*, market return; *SMB*, return of small minus big size portfolio; *HML*, return of high minus low BTM portfolio; *HIVMLIV*, return of high IV minus low IV portfolio.
B-G LM, Breusch-Godfrey Serial Correlation LM test *p* value
ARCH, Autoregressive Conditional Heteroscedasticity test *p* value
Reported regression coefficients are re-estimated coefficients using M-L-ARCH for cases with significant serial correlation and/or heteroscedasticity.

Figure 1. Idiosyncratic Volatility in the Hong Kong stock market

Panel A. Average equal-weighted IV across all firms
(Hong Kong Stock Market)



Panel B. Average value-weighted IV across all firms