Idiosyncratic volatility risk premium

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Abstract

This study examines whether investors also impose negative volatility risk premiums on individual options when the IVOLs of their underlying stocks increase. In addition, this study examines whether idiosyncratic volatility risk premiums explain the discrepancy between implied and historical volatilities and the extent to which idiosyncratic volatility risk premiums are independent from the market volatility risk premium. In our empirical results, the examination of idiosyncratic volatility risk premium shows that, as IVOL increases, DHGs monotonically decrease and, for the portfolios with the two highest IVOLs, are highly significant and negative. Because options with high vega, in general, have high liquidity, our argument that negative DHGs IVOL are caused by IVOL is in contrast with the interpretation of Cao and Han (2013) concerning the negative DHGs of individual options. To examine whether idiosyncratic volatility risk premiums explain the difference between implied and historical volatilities, we examine the distribution of DHGs of portfolios sorted not only by IVOL but also by the difference between implied and historical volatilities. Since the difference between implied and historical volatilities also increases as IVOL increases, the trend of DHGs according to IVOL and to the difference between implied and historical volatilities provides evidence that idiosyncratic volatility risk premium causes implied volatility to be higher than historical volatility. Lastly, we examine the extent to which the negative DHGs for stocks with high IVOL are attributed to MVOL. Consequently, it can be conjectured that investors may not worry about idiosyncratic volatility in the period with the highest MVOL, but they do in the situation where IVOL is relatively greater to MVOL.

Keywords: Idiosyncratic volatility, Individual options, Delta-hedged gains, The difference between implied and historical volatilities, Market volatility

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1. Introduction

Options provide investors with unique and various hedging strategies against volatility risk. A number of recent studies have examined the extent to which investors perceive volatility risk by investigating the performances of options. As argued in traditional asset pricing literature, if investors are concerned about a risk, then they will reflect the risk premium on assets related to this risk. Because they can avoid volatility risk by using options, just as stock prices depreciate in compensation for the expected price risk, option prices will appreciate in compensation for the expected volatility risk. With market volatility (hereafter MVOL), Bakshi and Kapadia (2003 a) show S&P 500 index option prices indeed include negative volatility risk premiums. Their results seemed to completely explain the phenomenon concerning volatility risk premiums imposed by investors on option prices. However, Ang, Hodrick, Xing, and Zhang (2006, 2009; hereafter AHXZ), by showing idiosyncratic volatility (hereafter IVOL) is also negatively associated with the following month's stock returns, open up the possibility that a risk premium due to IVOL may also exist in options markets. If investors require hedging against increase in IVOL as they do against increase in MVOL, analysis of individual option prices should take into account the price impact of these hedging trades. Therefore, this study examines whether investors also impose negative volatility risk premiums on individual options when the IVOLs of their underlying stocks increase. In addition, this study examines whether idiosyncratic volatility risk premiums explain the discrepancy between implied and historical volatilities and the extent to which idiosyncratic volatility risk premiums are independent from the market volatility risk premium.

Firstly, we examine whether investors utilize individual options for hedging against an increase in IVOL. By presuming that MVOL is the only factor that generates the effective changes in future stock returns and that risk-averse investors want to hedge against the changes with S&P 500 index options, Bakshi and Kapadia (2003 a) show the delta-hedged gains (hereafter DHGs) are significantly negative. However, AHXZ (2006, 2009) observe that an idiosyncratic volatility increase is also related to a significant decrease in the following month's stock return. Accordingly, we can infer that there may be also a negative idiosyncratic volatility risk premium imposed on individual options. Secondly, we investigate whether this idiosyncratic risk premium can account for the difference between implied and historical volatilities of individual options. Canina and Figlewski (1993) and Jackwerth and Rubinstein (1996) report that implied volatilities of individual options are frequently different to historical volatilities of their underlying stock returns. Even though the negative volatility risk premium for MVOL observed in Bakshi and Kapadia (2003 a) partially explains the discrepancy between implied and historical volatilities of the S&P 500 index options, the discrepancy between implied and historical volatilities of individual options has rarely been examined. By comparing the relation between IVOL and DHGs as the difference between implied and historical volatilities increases, this paper gives the evidence indicating that idiosyncratic volatility risk premiums account for the discrepancy between implied and historical volatilities. Finally, we examine how the idiosyncratic volatility risk premium relates to the market volatility risk premium. Traditionally, the market has been assumed as a complete market and thus only systematic risk is priced. However, in light of Fu (2009), many investors are indeed exposed to idiosyncratic volatility risk because they are restricted from diversifying their portfolios due to limits of arbitrage and wealth constraints. Therefore, in an incomplete real market, individual options will be crucial in asset management, especially when the ratio of IVOL to MVOL is large. By classifying portfolios according to IVOL and MVOL and examining various characteristics of their DHGs, we can ascertain whether and to what extent idiosyncratic volatility risk premiums and market volatility risk premiums are associated with each other.

We examine the U.S. stocks and options markets from January 1996 to December 2010. Our sample shows the negative relation between IVOL and the following month's stock returns just as that of AHXZ (2006). Even though our sample only includes firms that list their options, which are mostly large-size companies, because the stock returns of our portfolios with high IVOLs are significantly negative, it is enough to proceed with our experiment.

In our empirical results, the examination of idiosyncratic volatility risk premium shows that, as IVOL increases, DHGs monotonically decrease and, for the portfolios with the two highest IVOLs, are highly significant and negative. This is consistent with our argument that the negative relation between IVOL and the following month's stock returns causing DHGs to be negative represents the negative idiosyncratic volatility risk premium. Noteworthily, DHGs become more negative as options' moneyness approaches to at-the-money and as options' maturities become shorter. In light of Bakshi and Kapadia (2003 a), volatility risk premium, which is proxied by DHGs, increases as the vega of options increases. Because options with high vega, in general, have high liquidity, our argument that negative DHGs IVOL are caused by IVOL is in contrast with the interpretation of Cao and Han (2013) concerning the negative DHGs of individual options. They also observe negative returns of delta-hedged portfolio constructed with individual options, but they attributed these negative DHGs to the illiquidity of individual options. Therefore, the distribution of DHGs in our results can be regarded as evidence that shows an idiosyncratic volatility risk premium.

To examine whether idiosyncratic volatility risk premiums explain the difference between implied and historical volatilities, we examine the distribution of DHGs of portfolios sorted not only by IVOL but also by the difference between implied and historical volatilities. In three groups of ten portfolios, which are sorted first by the difference between implied and historical volatilities and then sorted again by IVOL, DHGs become more negative as the difference between implied and historical volatilities becomes greater. Specifically, for the ten portfolios in the group with the highest difference between implied and historical volatilities, all DHGs are negative and significant. In particular, among all three groups, DHGs monotonically decrease as IVOL increases. Since the difference between implied and historical volatilities also increases as IVOL increases, the trend of

DHGs according to IVOL and to the difference between implied and historical volatilities provides evidence that idiosyncratic volatility risk premium causes implied volatility to be higher than historical volatility. Consistent with Goyal and Saretto (2009), the DHGs of the portfolios with a low difference between implied and historical volatilities are shown to be significantly higher than those of the portfolios with a high difference between implied and historical volatilities. However, this result implying that investors over (under)-react in options markets to the negative (positive) stock returns in the previous month does not undermine our argument that the idiosyncratic risk premium causes the difference between implied and historical volatilities because the trend of DHGs sorted by IVOL are independent with that of DHGs sorted by the difference between IV and HV.

Lastly, we examine the extent to which the negative DHGs for stocks with high IVOL are attributed to MVOL. Interestingly, in the examination of DHGs by categorizing the whole sample period into five sub-periods according to the level of MVOL, DHGs of portfolios sorted by IVOL are all insignificant for the period with the highest MVOL. In contrast, DHGs for the rest of the sub-periods with lower MVOL become more negative and significant as the ratio of IVOL to MVOL becomes greater. Moreover, in the regression result that regress monthly DHGs of portfolios on MVOL, IVOL, or the ratio of IVOL to MVOL, MVOL is found to affect DHGs positively while IVOL affects negatively. However, after controlling for the Fama-French three factors and the momentum factor, only the ratio of IVOL to MVOL significantly and negatively affects DHGs. Consequently, it can be conjectured that investors may not worry about idiosyncratic volatility in the period with the highest MVOL, but they do in the situation where IVOL is relatively greater to MVOL.

The remainder of the paper is organized as follows. Section 2 develops testable hypotheses concerning the relation among DHGs, IVOL, MVOL, and the difference between implied and historical volatilities. Section 3 describes data and variable measurements. Section 4 presents the empirical results and Section 5 concludes the paper.

2. Development of Hypotheses

Even thouh Bakshi and Kapadia (2003 a) firstly modeled and showed that negative DHGs in the S&P 500 index options are attributed to the volatility risk in the stock market from the increase in MVOL, volatility risk affecting stock price dynamics is not limited to MVOL. Indeed, AHXZ (2006, 2009) observe the negative relation between IVOL and future stock returns. Thus, whether investors also hedge against IVOL becomes an important question to be resolved in order to analyze individual option price dynamics. Accordingly, in our study, the following reasoning is raised:

> H1 (1): DHGs from taking a long position in a call option and a short position in its underlying stock of an amount that corresponds to the delta of the call decrease as the IVOL of the stock increases.

In addition, because Bakshi and Kapadia (2003 a) argue that, if DHGs indeed represent a volatility risk premium, DHGs should be proportional to the sensitivity of options to volatility (vega), we hypothesize as follows:

> H1 (2): Delta-hedged portfolios with an ATM and short-term maturity call option generate a lower performance than those with an OTM and longer-term maturity call option.

Secondly, we investigate the performances of delta-hedged portfolios according to the difference between implied and historical volatilities as well as to IVOL. Canina and Figlewski (1993) and Jackwerth and Rubinstein (1996) report that in many cases implied volatility is different to historical volatility. If H1 (1) and H1 (2) are confirmed, we can infer that it is the increase in a firm's IVOL that causes implied volatility from the firm's options to be greater than historical volatility of this firm's stock returns. Based on this reasoning, we hypothesize as follows

> H2 (1): The negative relation between DHGs and IVOL predicted in H1 (1) is more evident in the portfolios with stocks having a greater difference between implied and historical volatilities.

On the other hand, in contrast to our point of view, Goyal et. al (2009) document that it is the over- and under-reaction of investors in options markets to the stock returns in the previous month that causes the difference between implied and historical volatilities. In their results, over (under)-expectation about the future volatility of stock returns due to the decrease (increase) in stock prices in the previous month is shown to raise (lower) option prices and implied volatilities and thus DHGs become negative (positive). Therefore, to distinguish our negative IVOL risk premium from the impact of over (under)-reaction to stock returns on DHGs, we examine the distribution of gains of delta-hedged portfolios sorted by the difference between implied and historical volatilities as well as by IVOL. In this examination, we set our hypothesis as follows:

> H2 (2): The decrease in DHGs sorted according to the increase in the difference between implied and historical volatilities is independent from the decrease in DHGs sorted according to the increase in IVOL.

In addition, to ascertain whether it is high IVOL that causes that implied volatility becomes greater than historical volatility, we examine the distribution of the difference between implied and historical volatilities of the delta-hedged portfolios sorted by the difference between implied and historical volatilities and by IVOL and hypothesize the trend of the difference between implied and historical volatilities as follows:

> H2 (3): The difference between implied and historical volatilities becomes greater as IVOL becomes higher.

When the market volatility increases, what concerns investors will be the market volatility - not idiosyncratic volatility because the systematic comovements of asset prices due to the market volatility will more greatly affect investors' portfolios than idiosyncratic volatility. On the other hand, during the period with low market volatility, the importance of hedging against idiosyncratic volatility risk will increase. Therefore, we can conjecture as follows:

> H3: The negative relation between DHGs and IVOL predicted in H1 (1) is more evident when when MVOL is low.

3. Data and Methodology

We examine the U.S. stocks and options markets from January 1995 to December 2010. The stocks are listed on the New York Stock Exchange or the NASDAQ stock market. The stock data are provided by CRSP (Center for Research in Security Prices) and the option data are from OptionMetrics. The option data contain the daily closing bid and ask prices. Besides the closing and bid-ask prices, the data give each option's maturity, its exercise price, its put-call indicator, and its implied volatility that is calculated by the binomial tree model. Because the option's moneyness can change as the stock price changes, we select ATM, OTM, and DOTM options based on the stock price of the first trading day of the delta-hedged portfolio formation month. We define the moneyness as the ratio of the exercise price to the current stock price and ATM calls are defined as calls with moneyness from 0.975 to 1.025. OTM and DOTM calls are from 1.025 to 1.075 and are from 1.075 to 1.125, respectively. Additionally, we classify the selected options into short, intermediate, and long-term maturity options. Short-term options have a time-to-maturity of less than 60 days and that of intermediate-term options is from 61 to 182 days. The long-term maturity options have a time-to-maturity of between 183 and 365 days. With the chosen calls, we calculate monthly delta-hedged gains as follows:

➔ Equation for DHG

In addition, because we analyze cross-sectional DHGs over sixteen years, we scale each DHG with the stock price of the first trading day of the delta-hedged portfolio formation month.

To calculate a monthly idiosyncratic volatility of a firm, following AHXZ (2006), every month, we regress daily stock returns on the Fama-French three factors and then proxy IVOL for that month by calculating the standard deviation of the residuals from the regression.

Because we examine the idiosyncratic volatility risk premium by classifying all stocks into ten portfolios according to IVOL, Table 1 shows the summary statistics for IVOL, DHGs, implied and historical volatilities, market capitalizations, book-to-market ratios, and the stock returns in the previous month of these ten portfolios. Consistent with our hypotheses, DHGs become more negative as IVOL increases. Although book-to-market ratios decrease as IVOL increases, the difference between the book-to-market ratios of the portfolio with the highest IVOL and the portfolio with the lowest IVOL is not as remarkable as the difference between their IVOLs. The median value of market capitalizations of the portfolio with the lowest IVOL is $4,745,112 million dollars, which is about seven times larger than that of the portfolio with the highest IVOL. Implied and historical volatilities become greater as IVOL increases and their difference also increases as IVOL increases. To briefly examine the relation between the stock return in the previous month and the difference between implied and historical volatilities, we report the stock returns in the previous month of the portfolios sorted by IVOL at the lowest raw of the Table. Unlike in Goyal and Sarreto (2009), there is no significant trend between the stock returns in the previous month and the difference between implied and historical volatilities.

Table 2 shows one month ahead stock returns of portfolios constructed according to IVOL. To examine whether our sample that include firms with options exhibits the negative relation between stock returns in the previous month and IVOL as AHXZ (2006) shows the relation. In Table 2, there are three kinds of ten portfolios sorted by IVOL. In the first row, the results of portfolios constructed with all stocks in NYSE and NASDAQ are presented and the stock returns in the previous month become lower as IVOL increases. The first two returns of the portfolios with the lowest IVOL are significantly positive and the last three returns of the portfolios with the highest IVOL are significantly negative. In the second and the third rows, the stock returns of the previous month of the portfolios that consist of firms without options and of the portfolios that consist of firms with options are shown. Like the first rows, these two groups also show the negative relation between the stock returns in the previous month and IVOL. Moreover, if we look at the level of stock returns and their significances, all three groups do not have significant different. Therefore, we may think that examining idiosyncratic volatility risk premium based on the findings of AHXZ (2006) does not have any problem.

4. Empirical Results

In our empirical experiments, firstly, on a monthly basis, we classify all stocks into ten portfolios according to their previous month's IVOL. Then, we confirm whether the negative relation observed in AHXZ (2006, 2009) between IVOL and the following month's stock returns is still observed in our sample. Secondly, we calculate DHGs of all portfolios and average DHGs for each portfolio. Like Bakshi and Kapadia (2003 a), to conduct time-series and cross-sectional analysis, we standardize these gains by scaling them with stock prices because trading gains are affected by stock and option values. In addition, we examine whether DHGs of portfolios sorted by IVOL become more negative as vegas of their options increases. To do this, according to moneyness and maturities of options, we classify the ten portfolios sorted by IVOL further. Thirdly, to investigate whether the difference between implied and historical volatilities is attributed to the idiosyncratic volatility risk premium, we examine the distribution of DHGs of portfolios sorted by IVOL as well as those sorted by the difference between implied and historical volatilities. Finally, the impacts of the market and idiosyncratic volatilities on DHGs are compared. By dividing the whole sample period into five sub-periods according to the market volatility, DHGs for the ten portfolios sorted by IVOL are calculated for each sub-period. All monthly DHGs of each portfolio are also regressed onto the Fama-French three factors, the momentum factor, the market volatility, and the mean value of IVOL of the portfolio.

4.1 Idiosyncratic volatility risk premium

According to Bakshi and Kapadia (2003 a), when market volatility increases, investors tend to hedge against the market down turn by using index options. Indeed, in their results, DHGs of portfolios constructed using S&P 500 index options become negative and significant as market volatility increases. This performance of their delta-hedged portfolios is consistent with their theoretical verification of the existence of a negative market volatility risk premium in an option pricing model with stochastic volatility. Because many previous studies argue that market return decreases when market volatility increases, i.e., the volatility feedback effect, their theory and empirical findings about the market volatility risk premium in index options may be intuitive. Inspired by this research, Bakshi and Kapadia (2003 b) further examine whether the market volatility risk premium exists in individual options. However, in their results, individual options do not appreciate in compensation for hedging against the increase in market volatility. Because the correlation between market volatility and returns of individual stocks is lower than that between market volatility and index returns, the insignificant impact of market volatility on individual option prices is not strange. However, with the recent studies showing that idiosyncratic volatility affects returns of individual securities significantly and negatively and that the risk from idiosyncratic volatility cannot be diversified due to wealth constraints, Bakshi and Kapadia (2003 b) becomes a starting point for our study to examine whether an idiosyncratic volatility risk premium exists in individual options.

AHXZ (2006, 2009) document that stocks with high idiosyncratic volatility perform worse in the following month than stocks with low idiosyncratic volatility. They also show that the abnormal returns of stocks with high idiosyncratic volatility are not related to the Fama-French three factors. As predicted in AHXZ (2006, 2009), Jiang, Xu, and Yao (2009) disclose that high idiosyncratic volatility is associated with negative information by showing the negative relation between idiosyncratic volatility and future earnings surprise. We also confirm this relation in our sample. In Table 3, the future earnings surprise, which is calculated by the difference between actual earnings and the median value of analyst forecasts about future earnings divided by the stock price at the earnings announcement date, of monthly portfolios sorted by their idiosyncratic volatilities becomes lower as idiosyncratic volatility increases. Therefore, we can infer that investors tend to hedge against the decrease in individual security's return by using its individual options just as they do against the market down turn by using index options. Following Bakshi and Kapadia (2003 a), we ascertain whether an idiosyncratic volatility risk premium exists in individual options by investigating the performances of delta-hedged portfolios consisting individual options. In addition, if it is idiosyncratic volatility that raises individual option prices, options with high vegas, which are close to being ATM options and/or short-term maturity options, will be more affected by idiosyncratic volatility. Thus, we examine the idiosyncratic volatility risk premium by categorizing options according to their moneyness and maturities.

Table 4 shows the distribution of DHGs of monthly portfolios sorted by the idiosyncratic volatility of their underlying stocks, moneyness and maturities of their options. Consistent with our prediction, all DHGs monotonically decrease as idiosyncratic volatility increases. Moreover, DHGs become more negative and significant as the options' moneyness becomes closer to being ATM and as their maturities become shorter. Because, in general, ATM and short-term maturity options have higher liquidity than other options, our results are in contrast with Cao and Han (2013) arguing that negative DHGs of individual options are caused by their low liquidity. In their results, transaction costs, such as bid-ask spreads and fees, explain only 34% of DHGs of individual option portfolios. Even though we do not replicate their results, because our way of classifying delta-hedged portfolios is independent of their way, based on the distribution of DHGs in our study, we can say that idiosyncratic volatility causes individual options to appreciate. In light of the investigation of Goetzman and Kumar (2008) that shows over 80% of investors hold only one or two individual securities, our results provide evidence supporting the argument of Merton (1987) that the risk from idiosyncratic volatility is unavoidable like systematic volatility.

4.2 The difference between implied and historical volatilities

Studies about the difference between implied and historical volatilities have focused on their predictabilities concerning future stock volatilities. Canina and Figlewski (1993), based on the assumption that option investors reflect their expectation about the future volatility of underlying stock returns on options, show that implied volatility is superior to historical volatility in forecasting future volatility. Given that stock returns, in general, are negatively associated with their volatility, high (low) idiosyncratic volatility indicating the decrease (increase) in returns may be positively (negatively) related to the increase (decrease) in future volatility. Thus, we may think that the predictability of implied volatility about future volatility in the previous studies is consistent with our idiosyncratic volatility risk premium. Form this point of view, in this section, we examine whether the difference between implied and historical volatilities is caused by idiosyncratic volatility. By doing this, we can support more strongly our argument that negative DHGs are attributed to an idiosyncratic volatility risk premium because it will provide evidence that investors predicting the increase in future volatility and the decrease in future returns require a negative risk premium by reflecting their expectation on option prices and implied volatilities.

Panel A of Table 5 exhibits the distribution of DHGs of monthly portfolios sorted not only by idiosyncratic volatility but also by the difference between implied and historical volatilities. As predicted in our hypotheses in Section 2, DHGs monotonically decrease as the difference between implied and historical volatilities becomes greater, regardless of the level of idiosyncratic volatility. In addition, given a certain level (High, Medium, Low) of the difference between implied and historical volatilities, DHGs become more negative as idiosyncratic volatility increases. If we see Panel B of Table 5 showing the difference between implied and historical volatilities in the same portfolios as Panel A, it becomes much clearer that the difference between these two volatilities is caused by idiosyncratic volatility risk premium. For the ten portfolios with the highest difference between implied and historical volatilities, as idiosyncratic volatility increases, the difference between the two volatilities becomes greater and positive. Because, except the portfolio with the highest idiosyncratic volatility and the medium difference between implied and historical volatilities, produce significantly negative DHGs, only these ten portfolios, we can say that risk from idiosyncratic volatility raises the implied volatilities of options to be higher than the historical volatilities of their underlying stocks.

In contrast to our interpretation, following Goyal and Saretto (2009), Panel A and B of Table 5 could be conceived as the result of the over- and under-reaction of investors to the stock returns in the previous month. They argue that investors over (under)-estimate a future stock volatility when the stock was poorly (greatly) performed in the previous month. As a result, the implied volatilities of options of the stock is over (under)-valued so that a delta-hedged portfolio with these options and its stock produces a significantly negative return. To ascertain whether our results are not driven by the misreaction of investors to the stock returns in the previous month, we examine the previous month's returns of the portfolios classified by the same criteria as Panel A and B. The distribution of the previous month's return of the portfolios is reported in Panel C of Table 5. Even though the returns in the mid range of idiosyncratic volatility are shown to decrease as the difference between implied and historical volatilities increases, in the portfolios with the lowest and the highest idiosyncratic volatilities, there is no distinctive pattern in those returns according to the difference between implied and historical volatilities. More importantly, among the ten portfolios with the highest difference between implied and historical volatilities, the returns do not show a significant correlation with idiosyncratic volatility. Bearing in mind the significantly negative relation between DHGs and idiosyncratic volatility of these ten portfolios in Panel A, the impact of the misreaction of investors to the stock returns in the previous month does not seem to be associated with the trends of DHGs or with the trend of the difference between implied and historical volatilities.

4.3 The impact of market volatility on idiosyncratic volatility risk premium

In the previous sections, we confirm that idiosyncratic volatility risk premium raises option prices and their implied volatilities. As argued in Merton ( ), investors with undiversified portfolios will require a risk premium for idiosyncratic volatility in the stock market. Thus, we argue that because they can avoid this risk in options markets, options will appreciate in compensation for hedging against the risk. However, the hedging demand for options concerning idiosyncratic volatility can vary according to the level of market volatility. As stated in Schwert (1989), the more the market volatility, the stronger correlation among all individual securities. In other words, we hypothesize that the ratio of idiosyncratic volatility to market volatility will be more associated with idiosyncratic volatility risk premium than idiosyncratic volatility itself is. To verify our hypothesis, we first examine the distribution of DHGs of portfolios sorted by idiosyncratic volatility in five sub-periods classified by the level of market volatility, which is measured by the volatility of S&P 500 index returns. In addition, we conduct regression analyses to examine how the ratio of idiosyncratic volatility to market volatility better explains the DHGs of portfolios sorted by idiosyncratic volatility and the difference between implied and historical volatilities of these portfolios.

Table 6 reports DHGs of monthly portfolios sorted by idiosyncratic volatility as well as by market volatility. In the period with the lowest market volatility, except the portfolio with the lowest idiosyncratic volatility, all DHGs are negative and significant. These DHGs also monotonically decrease as idiosyncratic volatility increases. For the rest of the periods, DHGs become greater and less significant as market volatility increase, until finally, in the period with the highest market volatility, all DHGs are positive and insignificant. If we look at Table 7 showing the distribution of the ratio of idiosyncratic volatility to market volatility, we can clearly notice the impact of market volatility on the idiosyncratic volatility risk premium. For the portfolios with negative and significant DHGs in Table 6, the ratios of idiosyncratic volatility to market volatility in Table 7 are mostly greater than those for the portfolios with insignificant DHGs. Among the portfolios with significant and negative DHGs, the more negative the DHG, the greater the ratio of idiosyncratic volatility to market volatility.

Table 8 shows the regression results of regressing DHGs of monthly portfolios sorted by idiosyncratic volatility on market volatility, idiosyncratic volatility or the ratio of idiosyncratic volatility to market volatility. In addition, to consider a firm's characteristics, we control for the Fama-French three factors and the momentum factor in the regression analyses. In the results of equation (1) and (3), consistent with our expectation, market volatility and idiosyncratic volatility affect DHGs positively and negatively, respectively. However, in the regression controlling for the traditional risk factors (eq. (2) and (4)), the impacts of these two volatilities become insignificant. On the other hand, the ratio of idiosyncratic volatility to market volatility is significantly negative even after controlling for the conventional risk factors (eq. (5) and (6)).

Table 9 exhibits the regression results of regressing the difference of implied and historical volatilities of monthly portfolios sorted by idiosyncratic volatility. Like Table 8, market volatility and idiosyncratic volatility affect the difference between implied and historical volatilities significantly, but in the opposite direction. Their power of explanation does not decrease even after controlling for the Fama-French three factors and the momentum factor. Also, the ratio of idiosyncratic volatility to market volatility affects the difference of the two volatilities negatively and significantly. Therefore, this result completes the results in Table 5 of Section 4.2 in that some DHGs not explained by idiosyncratic volatility itself are shown to be related to market volatility or to the ratio of idiosyncratic volatility to market volatility.

In summary, our idiosyncratic volatility risk premium is manifested when idiosyncratic volatility is high. In particular, the premium affects option prices and their implied volatilities more significantly in the period when market volatility is low. Therefore, our results provide evidence that investors require an idiosyncratic volatility risk premium in options markets, not only in the stock market. Moreover, the existence of an idiosyncratic volatility risk premium proves that the stock and options markets are cohesively connected.

5. Conclusion

Option price dynamics have been developed in two ways: one investigating which features of stocks affect option prices and the other investigating what characteristics of options provide new investment opportunities to investors. Focusing on the latter point of view, our study examines whether options appreciate due to their hedging ability against idiosyncratic volatility risk. We base our hypotheses about the relation between delta-hedged gains, which proxy the negative volatility risk premium, and idiosyncratic volatility on Baksi and Kapadia (2003 a). They theorize and show that investors raise index option prices as a compensation for hedging against the increase in market volatility. AHXZ (2006, 2009) document that stocks with high idiosyncratic volatility underperform stocks with low idiosyncratic volatility in the following month. In light of the findings of Bakshi and Kapadia (2003 a), we hypothesize that individual option prices appreciate in compensation for providing hedging against the idiosyncratic volatility risk of AHXZ.

We examine the U.S. stock and options markets from January 1996 to December 2010. In our empirical results, monthly delta-hedged portfolios sorted by their idiosyncratic volatilities generate more negative and significant returns. Because our delta-hedged gains become more negative as options have higher vegas, which imply they are closer to being ATM and are nearer-term maturities, we confirm that this negative delta-hedged gain from individual options is attributed to the appreciation of individual options in compensation for providing hedging against idiosyncratic volatility risk, not to high bid-ask spreads due to the illiquidity of these options. In addition, we show that the difference between implied and historical volatilities is caused by this idiosyncratic volatility risk premium. The performances of delta-hedged portfolios sorted not only by the difference between implied and historical volatilities but also by idiosyncratic volatility become more negative as both idiosyncratic volatility and the difference between implied and historical volatilities increase. Lastly, we find that the idiosyncratic volatility risk premium is affected by the ratio of idiosyncratic volatility to market volatility, not just by idiosyncratic volatility itself. Among the five sub-periods of our sample period classified by the level of the volatility of S&P 500 index returns, in the period with the highest market volatility, no delta-hedged portfolios produce significantly negative returns. In the analysis of regressing delta-hedged gains on the ratio of idiosyncratic volatility to market volatility, the ratio affects delta-hedged gains significantly and positively even after controlling for the Fama-French three factors and the momentum factor. This finding that what affects idiosyncratic volatility risk premium is both idiosyncratic volatility itself and the ratio of idiosyncratic volatility to market volatility also clarifies more clearly the relation between the idiosyncratic volatility risk premium and the difference between implied and historical volatilities. In a regression analysis of regressing the difference between implied and historical volatilities on idiosyncratic volatility, the explained sum of squares significantly increases by adding the ratio of idiosyncratic volatility to market volatility as an independent variable.

In this study, we provide evidence that idiosyncratic volatility is perceived as a risk to investors. Indeed, we find individual options appreciate in compensation for providing hedging against idiosyncratic volatility risk. Furthermore, the curious discrepancy between implied and historical volatilities can be partially explained by this idiosyncratic volatility risk premium. Our results contribute to the literature examining factors that affect option price dynamics and will fertilize the studies about the relation between stock and option markets.

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Table 1. Summary statistics

This table shows the summary statistics of our sample period from January 1996 to December 2010. Because, throughout the paper, we investigate portfolios sorted by IVOL, we present IVOL, DHGs, implied and historical volatilities, market capitalization, book-to-market ratio, and stock returns in the previous month of these portfolios. Portfolios are monthly constructed based on firms' idiosyncratic volatility in the previous month.

	Monthly portfolios sorted by idiosyncratic volatility									
	1	2	3	4	5	6	7	8	9	10
Idiosyncratic volatility	0.035	0.045	0.054	0.062	0.072	0.084	0.097	0.114	0.138	0.190
Delta-hedged Gains	-18.134	-19.613	-18.966	-18.289	-20.000	-17.310	-18.781	-19.271	-20.530	-20.123
Implied volatility	0.254	0.282	0.315	0.346	0.371	0.411	0.463	0.512	0.587	0.644
Historical volatility	0.246	0.287	0.324	0.351	0.389	0.430	0.497	0.564	0.630	0.725
Market capitalization (Mil.)	4,745,112	3,871,685	3,276,855	2,798,357	2,141,816	1,717,881	1,428,593	1,132,090	877,896	750,281
Book-to-market	0.424	0.403	0.395	0.387	0.381	0.374	0.366	0.356	0.359	0.340
Stock returns in the previous month	0.012	0.013	0.012	0.012	0.012	0.012	0.018	0.017	0.021	0.010

Table 2. One month ahead stock returns of portfolios constructed according to IVOL

This table exhibits the average stock returns in the previous month of the portfolio sorted by IVOL. In addition, we conduct two-sided t-test for examining the significance of these returns. * and ** represent 5% and 1% significance level, respectively.

stocks	IVOL									
	Low	2	3	4	5	6	7	8	9	High
All	1.210**	0.869**	0.938	0.990	0.826	0.524	-0.018	-0.799**	-1.561**	-6.653**
without options	0.864**	0.841**	0.762	0.758	0.856	0.763	0.544	-0.218**	-0.613**	-8.233**
with options	1.033**	0.635	0.939	0.893	0.500	0.398	-0.212	-1.074**	-1.867**	-7.039**

Table 3. Earnings surprises of portfolios sorted by IVOL

This table shows the earnings surprise at the nearest future earnings announcement after constructing the portfolios sorted by IVOL. Earnings surprise is calculated by dividing the difference between the actual earnings per share and the median value of the estimated earnings per share by the stock price at the earnings announcement date. In general, earnings surprises are negative because analysts estimate future earnings optimistically. Therefore, to provide more information about the future earnings surprises, we also report the absolute value of these earnings surprises. With earnings surprise and the absolute value of earnings surprise, it will be much easier to the negative relation between future negative information and IVOL.

	IVOL									
	Low	2	3	4	5	6	7	8	9	High
ES	-0.179**	-0.223**	-0.217**	-0.162**	-0.259**	-0.273**	-0.303**	-0.446**	-0.520**	-0.956**
|ES|	0.420**	0.457**	0.457**	0.495**	0.576**	0.574**	0.652**	0.820**	0.885**	1.382**

Table 4. Distribution of DHGs

This table reports delta-hedged gains of monthly portfolios sorted by IVOL, moneyness and maturity of options. * and ** indicate 5% and 1% significance of delta-hedged gains with the two-sided t-test.

Moneyness	Maturity	IVOL									
		Low	2	3	4	5	6	7	8	9	High
ATM	Short	-0.329	-0.423	-0.494	-0.652	-0.691**	-0.778**	-1.087**	-1.047**	-1.366**	-1.424**
	Intermediate	0.088	-0.269	-0.230	0.373	-0.377	0.264	-0.247	-0.397	-0.117	-0.176
	Long	-0.653	-0.229	-0.216	-0.300	-0.079	-0.653	-0.588	-0.588	-1.470	-0.795
OTM	Short	-0.104	-0.257	-0.247	-0.404	-0.432	-0.588	-0.454**	-0.769**	-0.726**	-1.344**
	Intermediate	-0.116	-0.003	0.129	-0.373	0.102	0.133	-0.349	-0.441	-0.300	-0.290
	Long	0.155	0.628	0.275	0.587	0.138	0.274	-0.315	0.706	-0.021	-0.042
DOTM	Short	-0.011	-0.081	-0.101	-0.247	-0.291	-0.229	-0.551**	-0.548**	-0.411**	-0.846**
	Intermediate	-0.112	0.030	-0.007	0.053	-0.109	-0.164	-0.090	-0.308	-0.349	-0.345
	Long	-0.031	-0.009	0.083	0.165	0.101	-0.066	-0.025	0.051	0.338	-0.030

Table 5. Portfolios sorted by IVOL as well as by the difference between implied and historical volatility

Panel A of this table shows DHGs of the portfolios sorted by idiosyncratic volatility in the previous month as well as the difference between implied and historical volatilities. Panel B shows the difference between implied and historical volatilities of the same portfolios in Panel A. Panel C exhibits the stock return in the previous month of the same portfolios in Panel A. * and ** indicate 5% and 1% significance of delta-hedged gains, the difference between implied and historical volatilities, or the stock returns in the previous month with the two-sided t-test.

Panel A. Delta-hedged gains										
The difference between IV and HV	IVOL									
	Low	2	3	4	5	6	7	8	9	High
High	-0.857**	-1.069**	-0.975**	-1.208**	-1.086**	-1.446**	-1.478**	-1.662**	-1.869**	-2.535**
Medium	0.232	0.159	0.180	0.096	-0.094	0.069	0.042	-0.056	-0.166	-0.649**
Low	0.478**	0.546**	0.351	0.309	0.442	0.104	0.161	0.196	0.157	-0.221
Panel B. The difference between implied and historical volatilities										
High	4.044**	4.855**	5.266**	5.686**	5.848**	6.224**	7.094**	7.388**	7.877**	9.677**
Medium	-1.593**	-1.737**	-1.703**	-1.957**	-1.851**	-2.180**	-2.131**	-2.488**	-2.521**	-2.588**
Low	-27.219**	-24.659**	-23.596**	-23.528**	-24.209**	-22.746**	-23.282**	-23.322**	-22.840**	-30.778**
Panel C. The stock return in the previous month										
High	0.791	0.331	0.386*	0.273*	0.016*	0.126*	0.720*	-0.045*	0.260*	-0.562*
Medium	1.066	1.346	1.149	1.496**	1.663	1.458*	1.577*	1.647*	1.293*	1.859
Low	-0.096*	0.785	1.229	0.645	1.598**	1.748**	2.013**	3.098**	2.644**	-1.978**

Table 6. DHGs of portfolios sorted by IVOL as well as by MVOL

This table reports delta-hedged gains of the portfolios sorted by idiosyncratic volatility as well as by market volatility that is calculated by the volatility of the S&P 500 index daily returns. We classified the whole sample period into five sub-periods with the market volatility. . * and ** indicate 5% and 1% significance of delta-hedged gains with the two-sided t-test.

MVOL	IVOL									
	Low	2	3	4	5	6	7	8	9	High
Low	-0.503	-0.821**	-0.832**	-1.112**	-1.243**	-1.191**	-1.419**	-1.542**	-1.856**	-1.987**
2	-0.351	-0.194	-0.377*	-0.360*	-0.491*	-0.510*	-0.560*	-0.915**	-1.028**	-1.447**
3	-0.537	-0.481	-0.825*	-0.782*	-0.748*	-0.768*	-0.810*	-1.245**	-1.063**	-1.413**
4	-0.429	-0.369	-0.392	-0.594*	-0.557*	-0.840*	-0.990*	-0.798*	-1.062**	-1.437**
High	0.539	0.374	0.502	0.304	0.474	0.457	0.417	0.259	0.302	0.047

Table 7. Proportion of idiosyncratic volatility to market volatility

This table shows the ratio of idiosyncratic volatility to market volatility of portfolios sorted by IVOL as well as by MVOL. In the first two columns shows the level of market volatility and the rest of columns shows the ratio of each portfolio.

MVOL		IVOL									
Quintile	Value	Low	2	3	4	5	6	7	8	9	High
Low	0.088	0.295	0.411	0.491	0.572	0.661	0.762	0.885	1.039	1.272	2.264
2	0.122	0.264	0.368	0.440	0.511	0.588	0.675	0.778	0.912	1.114	1.935
3	0.157	0.225	0.311	0.372	0.432	0.497	0.569	0.653	0.762	0.925	1.634
4	0.204	0.191	0.264	0.313	0.359	0.407	0.462	0.526	0.611	0.735	1.212
High	0.331	0.147	0.200	0.235	0.269	0.303	0.342	0.388	0.447	0.533	0.839

Table 8. Regression analysis

This table shows the results of regression of the following six equations. The dependent variable is delta-hedged gains of monthly portfolios sorted by IVOL. Among independent variables, SML and HML stand for the return difference between portfolios with small firms and portfolios with large firms and the return difference between portfolios with high book-to-market ratios and portfolios with low book-to-market ratios. MOM is the concurrent momentum factor. MVOL and IVOL are market volatility and idiosyncratic volatility. IVOL/MVOL is the ratio of idiosyncratic volatility to market volatility. * and ** indicate 5% and 1% significance of delta-hedged gains with the two-sided t-test.

Independent variables	Dependent variable					
	Monthly DHGs of each portfolio					
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	-0.409**	0.041	-0.023	0.076	0.070**	0.081**
market excess return		-0.160**		-0.158**		-0.156**
SML		-0.086**		-0.084**		-0.084**
HML		-0.035**		-0.032**		-0.029**
MOM		0.028**		0.029**		0.031**
MVOL	1.713**	-0.262				
IVOL			-0.007*	-0.008		
IVOL/MVOL					-0.003**	-0.001**
Adj. R^2	0.018	0.496	0.001	0.498	0.010	0.499

Table 9. The impact of the ratio of IVOL to MVOL on the difference between implied and historical volatilities

This table shows the results of regression of the following six equations. The dependent variable is the difference between implied and historical volatilities of monthly portfolios sorted by IVOL. Among independent variables, SML and HML stand for the return difference between portfolios with small firms and portfolios with large firms and the return difference between portfolios with high book-to-market ratios and portfolios with low book-to-market ratios. MOM is the concurrent momentum factor. MVOL and IVOL are market volatility and idiosyncratic volatility. IVOL/MVOL is the ratio of idiosyncratic volatility to market volatility. * and ** indicate 5% and 1% significance of delta-hedged gains with the two-sided t-test.

Independent variables	Dependent variable: The difference between implied and historical volatilities of monthly portfolios sorted by IVOL					
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	4.669**	3.548**	-2.514**	-2.530**	-2.792**	-3.311**
market excess return		0.060		0.067		0.117*
SML		0.383**		0.371**		0.376**
HML		0.555**		0.540**		0.596**
MOM		-0.075		-0.090*		-0.053
MVOL	-16.187**	-11.519**				
IVOL			0.064**	0.061**		0.245**
IVOL/MVOL					0.441**	0.034**
Adj. R^2	0.037	0.091	0.141	0.198	0.124	0.211