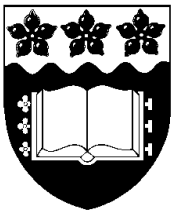

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Did Option Traders Predict the Korean Financial Crisis of 1997?

Abstract

This paper examines KOSPI200 options prices in order to investigate whether implied volatility implicit in options prices foreshadowed the 1997 financial crisis in Korea. A set of call and put implied volatilities are examined for evidence of expectations prior to October 23, 1997 of an impending financial crisis. It is shown that implied volatilities from out-of-the-money calls were relatively higher than those from otherwise identical puts during the period preceding October 23, 1997. Thereafter, however, put implied volatilities became extremely high relative to call implied volatilities. These results indicate no strong fears about the financial crisis during the three months immediately preceding the financial crisis, so KOSPI200 options prices indicate that options traders failed to detect the financial crisis prior to October 23, 1997.

Did Option Traders Predict the Korean Financial Crisis of 1997?

1. Introduction

The initial suddenness and the volatility of the Asian financial crisis caught many financial observers by surprise. An important question is whether a group of financial market participants whose main business is to predict volatility, options traders, were able to anticipate the potential influence of the Asian crisis on markets. The purpose of this paper is to examine whether options prices in the Korean capital market were informative in estimating future market movements leading up to the financial crisis.

When the trading of standardized index option contracts on an index of 200 stocks listed on Korea Stock Exchange (KOSPI200) commenced in Korea in July, 1997, Korea's economy was already suffering from the first effects of the Asian crisis.[1] A real sense of panic did not encompass market participants, however, until Standard & Poor downgraded Korea's foreign debt rating on October 23, 1997. Upon release of the information, the stock market index experienced its biggest single-day drop (-5.2%) in history. Since option prices are based on the collective assessment of market participants' about future market volatility, information contained in option prices could potentially provide clues regarding the impending crisis.

This study examines the informational content of KOSPI200 options prices traded between July 1997 and March 1998 in order to determine whether implied volatility implicit in options prices foreshadowed the 1997 financial crisis in Korea. The study examines the ability of an options market, that had existed only for a few months, to

[1] The KOSPI200 is a value-weighted index composed of 200 stocks from a broad range of industries which comprise nearly 70% of the total market capitalization in Korea.

predict significant events with potential to affect market prices, so the market could potentially exhibit different features from options trading in established market such as in the United States and United Kingdom. The primary question addressed in this paper is whether option traders detected the impending financial crisis prior to the release of the news on October 23, 1997.

It can be argued that a financial crisis can be thought of as an episode of extreme financial market volatility. A standard approach for determining whether options market participants predicted the Korean economic crisis in 1997 would therefore be to examine if implied volatility in the Korean options market predicted subsequent volatility.

Numerous studies have looked at the issue of whether implied volatility improves upon historical volatility when predicting subsequent volatility in general. Studies by Latane and Rendlemen (1976), Chiras and Manaster (1978), Fleming *et al* (1995), and Christensen and Prabhala (1998) support the use of implied volatility. In contrast, Day and Lewis (1992) as well as Canina and Figlewski (1993) found that implied volatility tended to be a biased and inefficient predictor of future volatility. Few studies have looked at the specific question of whether implied volatility can be used to predict individual financial crises, however, presumably due to the limited number of independent implied volatility observations which could be used for statistical testing and the potential non-stationarity of the data in a crisis.

Bates (1991) developed a technique that uses put and call option prices in order to determine whether stock index options market participants predicted the 1987 United States stock market crash. This approach was subsequently extended by Gemill (1996)

who used put and call option implied volatility in order to determine whether United States and United Kingdom option market participants predicted the 1987 crash. Bates (1991) and Gemmill (1996) build upon the observation that variations in put and call prices and implied volatility across different exercise prices can provide information about the market's beliefs concerning the entire probability distribution of future market events.

Gemmill (1996) compares implied volatility from out-of-the-money put options with implied volatility from otherwise identical call options. This is a potentially effective test of whether option traders predict a market crash because option traders correctly anticipating an impending crash would find it profitable to purchase out-of-the-money put options in anticipation of a large decline in stock prices. This increased demand should make out-of-the-money put options expensive relative to otherwise identical calls, leading to relatively higher put implied volatility than call implied volatility during the period preceding a market crash. In this paper we adopt the Gemill (1996) approach for determining whether variations in implied volatility in the Korean index options market provided evidence of expectations of an impending financial crisis in Korea prior to the most severe days of the crisis in late October, 1997.

Results show that there is no persistence in relatively higher put options prices than otherwise identical call options price over the sample period preceding October 23, 1997. This possibly suggests that option traders failed to detect the impending financial crisis from various economic woes. It is in fact interesting to notice that prices actually shifted in a direction contrary to prediction at each stage of the crisis.

The remainder of the paper is organized as follows: Section 2 provides an overview of the Korean economy, stock market performance during the Korean financial crisis, and features of KOSPI200 options. Methodology using market participants' aggregate subjective distribution of stock return, as measured by a set of out-of-the-money call and put option prices, is presented in section 3. Section 4 contains results and discussion while some concluding remarks contained in section 5 end the paper.

2. Genesis of the Korean crisis[2]

It is widely believed that the Asian financial crisis had its origin in Thailand and was precipitated by speculative attacks on the Thai baht peg when its value began to appear excessive given a weakening economy, a balance of trade deficit and banking sector problems related to excessive corporate leverage as well as property speculation. As a result the Thai central bank announced a managed float of the baht and called on the International Monetary Fund (IMF) for technical assistance on July 2, 1997. The Asian crisis quickly spread to other emerging South East Asian countries, including South Korea. At first Korea was considered to be immune from the financial turmoil buffeting the Thai and Indonesian economies, but a series of bankruptcies by a few leading Korean companies combined with the effects of the South East Asian economic turmoil help precipitate a financial crisis in Korea as well. Korea's economic problems became acute during the latter half of 1997, culminating in a bailout assistance from the IMF on December 3, 1997 just fifteen days prior to a presidential election.

[2] Sources for material in this section include the International Harold Tribune, Korea Politics Company Special Report (1997) and the Samsung Economic Institute.

It can be argued that the roots of Korea's economic problems began to emerge as early as 1993 when Korean companies used foreign borrowing to finance aggressive expansion via the building of factories for products such as automobiles, ships, petrochemicals, and steel. Companies in neighbouring countries such as China, Japan, and Malaysia were also expanding in similar areas, however, leading to a situation where supply outpacing demand caused a drop in prices of key exports. As a result, Korea's current account deficit grew to US$ 23.7 billion or 4.7% of GDP in 1996.

The first obvious sign of trouble in the Korean economy hit the market in January 1997 when Hanbo Group, the fourteenth largest conglomerate in Korea, collapsed, leaving US$ 6.7 billion in bad loans. Hanbo had accumulated debts that were nearly twenty times as much as the company's net assets, and had expanded into steel by building a steel mill in 1994 even though steel was not one of Hanbo's core business lines and the sector was suffering from over-capacity. The Hanbo case illustrated the difficulties facing Korea's largest firms which caused financial companies to panic and call in corporate loans. Liquidity thus disappeared, leading to a series of bankruptcies of over-leveraged companies which left financial companies with ever-increasing non-performing loans so that in early 1997 the level of non-performing loans was over 70% of banks' equity.

On July 15, 1997 the Kia Motor Company, the third largest car company in Korea, sought bankruptcy protection with US$10 billion in bad loans. The timing of the crisis could not have been worse as Korea was on the eve of a presidential election and the government was therefore not inclined towards controlling the impending financial collapse. The government's failure to resolve Kia's bankruptcy quickly or satisfactorily

deepened fears of an impending crisis. A deep sense of the impending crisis cristalized when, on October 22, 1997, the government instructed state-run Korean Development Bank to convert $3.2 billion of its loan to Kia Motors into an equity stake. It further intensified the following day when Standard & Poor's cut the rating of Korean foreign debt in response to the government's decision that day to nationalize Kia.

The compounding of events made foreign investors accelerate their exodus from the Korean capital market. The amount of money exiting the Korean stock market in October of 1997 was nearly three times the quantity in September, causing the exchange rate and stock market to drop significantly over this period (Samsung Economic Research Institute). Foreign banks slashed credit lines by more than US$30 billion in the fourth quarter of 1997, and net usable official foreign exchange reserves plunged to less than $5 billion in mid-December from more than $30 billion at the beginning of the year. This rapid deterioration meant Korea was on the verge of defaulting on its heavy foreign debt obligations that had been built up during half a decade of rapid corporate expansion. The government therefore announced on November 21, 1997, that it was discussing details of a bailout package with the IMF. After more than a week of intense negotiations, the IMF agreed to a US$57 billion package on December 3, 1997, the largest in the IMF's history.[3]

A turning point in the crisis came on December 24, 1997 when the newly elected president steadfastly pledged to follow the terms of the IMF agreement. This lead to an acceleration in the rate of implementation of the assistance programme which, consequently, resulted in Korea escaping the risk of a debt moratorium.

[3] Figures are obtained from "International Herald Tribune" and "Korea Country Risk Report(March 11, 1998)".

2.1 Financial Market Performance During the Korean Crisis

The Korean stock market initially ignored the Hanbo bankruptcy on January 23, 1997, and continued to rise until mid-February (see Figure 1). Thereafter the KOSPI200, Korea's stock market index, began to decline. The fall accelerated on March 19, 1997 when Sammi Steel Co., the twenty-sixth largest company in Korea, defaulted on a loan (see Table 1 for a chronology of important events in the Korean economic crisis). The KOSPI200 declined by 4.5% for three consecutive days in response to this news. The Korean won (unit of the Korean currency) also fell sharply and the Korea Central Bank used US$3 billion in official foreign exchange reserves by the end of March in an effort to support the currency (see Table 1).

Figure 1 and Table 1 about here

The value of the Korean currency and interest rates subsequently stabilized during the second quarter of 1997, and the stock market actually increased by nearly twenty per cent during the quarter. However, bankruptcies in the summer, especially that of Kia Motor Company on July 15, 1997, soon created renewed capital market suspicions as to the soundness of the Korean economy. When Kia failed to make some payments on its US$10 billion debt, Korea First Bank, the main creditor to Kia and Hanbo, required a bailout in August 1997. As Thailand entered into an agreement with IMF for bailout in August 1997, foreign investors began to distrust the soundness of Asian economies in general and consequently cut credit lines or demanded a higher premium on loans to most Korean banks. As a result, for the first time ever the Korean won exceeded 900 to the US dollar on August 19, 1997. Despite those early negative signs, the stock market did not react strongly until late August when the exchange rate hit a new record low.

A real sense of crisis engulfed market participants when Standard & Poor cut Korea's foreign debt rating on October 23, 1997 in response to the news that the Korean government would take over debt-ridden Kia Motors. The following day, the Korean currency plunged, with share prices taking their biggest single-day drop in history. On October 28, 1997, Korea's currency ended at 953 to the US dollar despite central bank intervention, and share prices fell by 6.5%. On November 17 the Korea Central Bank announced it would no longer defend the value of the Korean currency and the won immediately fell its daily limit from 986 won to the US dollar level to 1008.6.

The announcement by the Korean government on November 21, 1997 that it was discussing details of a bail-out package with the IMF in response to the rapid deterioration in its external financial position caused the stock market to drop by 3.3%. The IMF agreed to a $57 billion bail-out package on December 3, but the situation actually worsened due to political uncertainty because two presidential candidates announced that they would renegotiate the agreement if elected. This further undermined foreign investor confidence and the exchange rate collapsed to nearly 2000 won to the US dollar at the end of December and three-year corporate bond rates rose above thirty percent. Share prices fell a further twenty-five percent in December.

After the newly elected president pledged to meet the IMF agreement terms, Korea's capital markets finally began to recover and by early March 1998 the stock price index had returned to the same level as a year earlier. A gradual return to stability following the jump to an extreme level of volatility during the final quarter of 1997 is illustrated in Figure 2 which plots the annualized standard deviation of the daily return of the KOSPI200 index during 1997 and early 1998.

Figure 2 about here

2.2 The Korean Options Market

Options on the KOSPI200 stock index began trading on the Korean Stock Exchange in July 1997 just prior to the full onset of the Korean economic crisis. Trading was quiet at first but soon intensified as the economic crisis worsened. A daily average of only 1,246 contracts were traded in July 1997 whereas trading had peaked at a level of nearly 83,000 contracts per day by December 1997 (see Table 2 which displays daily trading volume of KOSPI200 options contracts from July 1997 through March 1998).

Table 2 about here

Table 2 also shows that the trading volume of call options increased significantly from October through December 1997 when serious financial turmoil enveloped Korea's capital market. During these three months, the average daily trading volume of call options was 46,365, which was nearly five times as many as that of put options. Thereafter, trading volume of call options dropped significantly. From January 1998 through March 1998, the average daily trading volume was 20,260 for call options and 19,747 for put options.

The KOSPI200 option contract size is set at 100,000 times the level of the index. The minimum tick size is 0.01 points of the index for an options contract with a premium of three points or more. The maturities of the options contracts are the three consecutive near-term months plus three additional months from a quarterly cycle (March, June, September, and December). KOSPI200 options are European. The last trading day of the options contracts is the second Thursday of each contract month. The expiration settlement price is the day's final KOSPI200 index level. Settlement is conducted on the

business day following the contract's expiration. The first trading day of a new contract is the first trading day following the last trading day for the expiring contract.

Options trading hours are from 09:00-11:30 for the morning session and 13:00-15:15 for the afternoon session, with the option market closing fifteen minutes after the stock market closes. Trading is executed through a computerised trading system. Precedence is given to orders with price priority followed by time priority.

3. Methodology and Data

Since options are agreements to buy or sell an underlying asset at some future date at a predefined exercise price, variations in options prices across exercise prices are useful in deriving the market's perception of future price volatility of the underlying asset. A basic insight into this belief is that option prices are determined by market participants' aggregate expectation regarding the likelihood of the price of the underlying asset finishing in-the-money. Variations in option prices across exercise prices could therefore incorporate information about the market's expectations for future movements in the underlying asset. Gemmill (1996) compares implied volatility from out-of-the-money put options with implied volatility from otherwise identical call options in order to test whether option traders in the U.S. and U.K. could predict the 1987 market crash. In this paper we adopt this methodology to examine variations in implied volatilities across exercise prices of puts and calls of KOSPI200 options to test whether option traders could foretell the financial crisis that afflicted Korea in October of 1997. Option traders anticipating a market crash would purchase out-of-the-money put options with the expectation that the large drop in stock prices will sharply increase the put option's value.

Thus an assessed risk of impending market crash would make out-of-the-money put options unusually expensive relative to otherwise identical calls, leading to relatively higher put implied volatility than call implied volatility during the period preceding the market crash.

3.1 Theoretical Framework

In the Black-Scholes framework, it is assumed that stock prices follow a constant variance diffusion process, where over any finite interval a log price is normally distributed with the mean centered at the risk-free rate. If markets were to price options according to the Black-Scholes model, the implied volatilities should not vary across exercise prices. Evidence shows that the Black-Scholes model performs reasonably well only for at-the-money-options. Discrepancies between the market and Black-Scholes prices are large and systematic.[4] For this reason, it is conceivable that different options on the same underlying asset might have different Black-Scholes implied volatilities. The pattern of implied volatility across exercise prices is known as a "volatility smile".

Under the risk neutral distribution hypothesis, the price of a European call or put option is the discounted expected payoff conditional upon the underlying asset value finishing in-the-money. Bates (1991) employs the insight that since the value of an option depends on the probability of the option finishing in-the-money, prices of European call options will reflect conditions in the upper tail of the risk neutral distribution while put option prices will reflect conditions in the lower tail. Under conditions of symmetric risk neutral distribution prices of out-of-the-money call options should be identical to

[4] For instance, Rubinstein (1985) examined option prices traded on the CBOE between August 1976 and August 1978. In his study, he divided the sample into two sub-samples, and showed that implied volatility was higher for options with lower exercise price in the first sample period but the reverse was found in the

otherwise similar out-of-the-money European put options. The prices would deviate only if the underlying distribution is skewed. Consequently, a shift in the skewness of the underlying distribution identified through an analysis of out-of-the-money put and call option prices can provide information about the market's perception of future movements in the underlying asset price. Gemmill (1996) extends the Bates methodology by observing that if the underlying distribution is skewed the volatility smile should also be skewed. An interesting question, therefore, is whether changes in the volatility smile reflect past movements in the underlying asset or are a prediction of the future.

Given that options are forward looking in nature, changes in the volatility smile could be attributed to changes in market participants' aggregate expectations about future events. For example, a bullish sentiment would result in a significant increase in the demand, and consequently the price, of deep out-of-the-money call options thus leading to relatively higher call implied volatility. Likewise, a bearish sentiment would result in a significant increase in the demand, and consequently the price, of deep out-of-the-money put options thus leading to relatively higher put implied volatility. While the former situation is likely to result in a positive skewness of the volatility smile and by extension the underlying distribution, the latter will have the opposite effect. Bates (1991) developed a skewness premium measure as the percentage deviation in the price of x% out-of-the-money call options from the price of otherwise similar put options in an effort to detect skewness in the risk neutral distribution prior to the 1987 market crash.[5] Bates'

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second sample period. These results suggest that systematic deviations from the Black-Scholes model appear to exist, but the pattern of deviations varies over time.

[5] $SK(x)= \left\{ \frac{C_t(+x\%) - P_t(-x\%)}{P_t(-x\%)} \right\} \times 100$ where SK(x) is the skewness premium, C is the call price, P is the put price, and x denotes an exercise price which is x% above and below the forward price.

skewness premium would be negative if the volatility of returns increases as the market falls, or if option traders forecast a downward movement in prices. Likewise, a positive premium would result if the volatility of returns increases as stock prices increase or traders collectively anticipate positive jumps in future stock prices.

Gemmill (1996) uses a modified version of the Bates (1991) skewness statistic by using implied volatilities of out-of-the-money call and put options rather than option prices. Since option prices are almost linear in volatility, there should be little difference between the price based skewness measure of Bates and a measure based on volatility. In this study, we adopt the Gemmill's skewness measure to capture the variation in the implied volatility across exercise prices.

$$\text{skewness measure}_t = \left\{ \frac{\sigma_t(+2\%) - \sigma_t(-2\%)}{\sigma_t(+2\%)} \right\} \times 100 \qquad (1)$$

where, $\sigma_t(+2\%)$: implied volatility from call option with exercise price, which is 2% above the forward price

$\sigma_t(-2\%)$: implied volatility from put option with exercise price, which is 2% below the forward price.

2% out-of-the-money options are chosen for analysing volatility smile because these options are most heavily traded over the sample period, thereby avoiding the problems of thin trading.[6] However, since finding an option with exercise price exactly 2% above the current forward price is difficult, the relevant implied volatilities are linearly interpolated.

3.2 Data

To ensure reliable analysis, a contemporaneous set of put and call option prices should ideally be used. Prices of call and put options from as close to the end of trading of the underlying shares in the KOSPI200 were used (3:00 pm).

Daily transaction data for call and put options on KOSPI200 as well as the closing spot price of the KOSPI200 were collected from the Korean Stock Exchange. On each day, implied volatilities for put and call options with up to four exercise prices are calculated. Implied volatility is computed from the last transaction of at-the-money call option with nearest time to maturity before 3:00 p.m. Since the KOSPI200 contains mostly dividend-paying stocks, call and put implied volatilities implicit in options prices are estimated using the dividend-adjusted Black-Scholes option pricing formula. In addition, the analysis is shifted to the next contract if the remaining time to maturity is five days or less because maturity less than five days could be too short to contain much information about future volatility.

Results indicate that the implied volatilities for KOSPI 200 options observed at a given point in time vary systematically across the different exercise prices. Figure 3 depicts the averages of implied volatility for call options across exercise prices.

Figure 3 about here

Regularity in implied volatility differences across the different exercise prices suggests the existence of systematic factors that lead investors to price particular options higher or lower relative to others. The figure also shows that traders pay relatively higher prices for call options with lower exercises prices than for those with higher exercise prices, suggesting that the risk-neutral distribution is negatively skewed relative to a normal

[6] Bates (1991) shows that results are not sensitive to use of alternative ranges, such as 2%, 4% or 6%.

distribution. In addition, it can also be detected from Figure 3 that the nearest at-the-money call options have higher implied volatility than in and out-of-the-money call options. One possible explanation for this result is that option traders pay liquidity premium for at-the-money options because in-the-money and out-of-the-money options are relatively illiquid and thus trade less frequently than those close to at-the-money.

4. Results and discussion

We first examine the levels of at-the-money put and call implied volatilities, shown in Figure 4, during the period leading up to the crisis and over the crisis period.

Figure 4 about here

The striking result from Figure 4 is that the level of call implied volatilities is systematically different from the level of put implied volatilities over the whole sample period. Dividing the sample into "pre-crisis" and "crisis" periods, however, paints a different picture. Despite a plethora of events pointing towards a potential crisis prior to the actual downgrade of Korea's sovereign debt the put implied volatilities remained significantly lower than call implied volatilities.

Four days before the news of the downgrade on October 23, 1997, the put implied volatility began to exceed call implied volatility, suggesting an increase in assessment of downside potential. However, the day before the news, fears subsided concurrently with the stock market rising 6.3% and the call implied volatility becoming higher than put implied volatility. This inexplicable improvement in the market just prior to the precipitation of the crisis suggests that the higher put implied volatility just a few days before October 23, 1997 might be a reflection of past continuous decline in stock prices

rather than a prediction of impending financial turmoil. The 21.23% decline in the stock market over the period from September 19 to October 18, 1997 was presumably a major contributor to this perception of downside risk.

Figure 4 shows that the put implied volatilities, during the crisis period, are significantly greater than call implied volatilities. This suggests that the onset of the financial crisis, as inferred by investors from S&P's downgrade of Korea's foreign debt, led investors to price put options significantly higher than otherwise identical call options. Table3 contains results for the call and put implied volatilities computed over the entire sample period as well as the two sub-periods. While the average of call and put implied volatilities for the full sample is 63.31%, there is significant variation over the two sub-periods: volatility increases from 27.42% in the pre-crisis period to 90.23% during the crisis period.

Table 3 about here

A surprising result over the pre-crisis period is that the put implied volatilities (24.99%) are, on average, nearly five percentage points lower than call implied volatilities (29.86%) even though the precipitation of the crisis was not a total surprise. This suggests that although there were events that foretold the onset of the crisis option traders misinterpreted the signals and were rather bullish about the immediate future. However, the average put implied volatility (106.69%) during the crisis period is nearly 33 percentage points higher than the average call implied volatility (73.78%), suggesting that traders interpreted the downgrade of Korea's foreign debt as the true onset of the crisis. Although this implication is difficult to prove, the increase in negative sentiment is supported by the significant increase in the trading volume of put options immediately

after the downgrade. The ratio of trading volume of put options to total volume increased from 0.203 during the pre-crisis period to 0.3254 during the crisis period (see Table 1).

Table 4 about here

Table 4 contains results for the volatility smiles for puts and call options. For the total sample period, 2% out-of-the-money puts have an average volatility of 72.0%, which is indistinguishable from 71.67% average for at-the-money. Similarly, at-the-money call implied volatility is 54.95%, which is hardly greater than the 54.65% average for 2% out-of-the-forward calls. These rather flat profiles observed in both the pre-crisis and the crisis periods suggest that the average volatility smile is small. Alternatively, in this study the average volatility smile is captured by the skewness measure computed using equation 1. The results for the skewness measures are contained
in the last column of Table 3. If investors detected the impending financial crisis for the pre-crisis period, then the average skewness measure would have negative a value. However, for the pre-crisis period the average skewness measure is 10.96%, suggesting an assessment of upside potential rather than risk of financial crisis. This, however, gets reversed with the downgrade of the Korean debt. The average skewness measure for the crisis sample period is –54.9% indicating that option traders paid extremely high prices for puts relative to otherwise identical call options during the crisis period reflecting a concern about further decline in stock prices.

In order to illustrate a more general relationship between the skewness measure and market movements, the six-day moving average of the skewness measure and the daily KOSPI200 levels over the whole sample period are plotted in Figure 5.

Figure 5 about here

It can be readily seen that there are systematic divergences between call and put option prices. Over the pre-crisis period, the six-day moving average of skewness measures were greater than zero almost every day. The most right-skewed period is around late August 1997, when the skewness measure reached +62.4%. This extremely high positive value of average skewness measure could possibly be due to an anticipation of a stock market rally following a period of continuous declin. Although negative skewness measures were seen around late September 1997, this disappeared immediately. In consequence, option traders did not appear to take into account the various economic woes over the pre-crisis period until at least the middle of October, 1997.

The skewness measures show a particularly significant negative value just before and immediately after the news of the downgrading of Korean foreign debt on October 23, 1997, suggesting a strong assessment of downside risk. The most left-skewed period for the whole sample period is around December 23, 1997, when the six day average reached –227.3%. Around that time period, the political concern was fuelling uncertainty about the future. Two presidential candidates had announced that they would renegotiate the agreement with the IMF if they got elected which further undermined foreign investor confidence. However, as the newly elected president pledged on December 24, 1997, to perform as per IMF agreement terms the KOSPI200 began to turn upward and attained a level of 65 points (which was almost 60% higher than the lowest level in late December, 1997) by late January, 1998. Although the skewness measure also began to increase from that day, it remained less than zero until February 23, 1998, over which time the KOSPI200 increased by nearly 60%. This inverse relationship between the skewness measure and the subsequent movement of the underlying market convincingly rejects the

hypothesis that negative skewness forecasts a falling market, a result consistent with Gemmill (1996).

5. Conclusions

The Korean financial crisis was a period of extreme financial volatilities which does not appear to have been anticipated by option traders. In fact traders seem to have reacted in exactly the wrong direction prior to each major shift in the market**.**

We initially show that the volatility implicit in option prices, over the period immediately preceding the crisis, follow a pattern which is contrary to expectations. If option prices are set based on investors' aggregate assessment of future market movements then, over the period preceding the crisis, the implied volatility of the puts should be significantly greater than that of otherwise similar call options. Results in this study show that, contrary to expectation, the implied volatility of calls is significantly greater than that of put options. Moreover, immediately after the downgrading of Korea's sovereign debt by Standard and Poors, put implied volatility exceeded the implied volatility of calls suggesting an impending worsening of the stock market. However, option traders were once again proven wrong when the market moved significantly in the opposite direction.

We next employed the methodology developed in Gemmill (1996) to compute a skewness measure of the volatility smile (see equation 1). Results once again point towards a total mis-judgement on the part of option traders despite the string of negative signals that preceded the onset of the crisis.

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Table 2.1

KOSPI200 options contracts volume by month for the sample period from July, 1997 through March, 1998

Month/Year	Trading Days	Call Volume	Put Volume	Total Volume	Daily Average
July/1997	21	14,876	11,281	26,157	1,246
Aug/1997	25	53,471	39,813	93,284	3,731
Sep/1997	23	162,727	64,127	226,854	9,863
Oct/1997	26	804,576	148,861	953,437	36,671
Nov/1997	25	1,170,215	242,010	1,412,225	56,489
Dec/1997	22	1,409,916	324,551	1,816,467	82,567
Jan/1998	22	450,326	447,751	898,077	40,822
Feb/1998	24	520,414	497454	1,017,868	42,411
Mar/1998	26	487,909	476,613	964,522	37,097

Source: Market Statistics, the Korea Stock Exchange

Table 2.3

Economic woes brewed for months around the currency bailout

Date	Economic woes	KOSPI200 (W / US$)
23-Jan-97	Hanbo, 14th largest company in Korea, defaults on loans	71.00 (852.7)
19-Mar-97	Sammi Steel Co., a unit of Korea's 26th largest company, defaults on loans	65.04 (883.1)
21-Apr-97	Jinro, Korea's largest distillery, collapses	70.60 (890.7)
2-Jul-97	Thai central bank announces a managed float of the baht and calls on the IMF for "technical assistance"	81.63 (885.7)
15-Jul-97	Kia Motors Co., Korea's eighth largest company, fails to make some payments on its US$ 10 billion debt	78.28 (889.9)
19-Aug-97	Won hits record low of 901 to the dollar	76.67 (901.0)
2-Oct-97	S&P Co. cut credit ratings for three Korean commercial banks	66.72 (912.0)
22-Oct-97	Korean government announces it would take over debt-ridden Kia Motors Co	63.12 (913.9)
23-Oct-97	S & P Co. cuts rating of Korean foreign debt in response to Kia bailout	63.44 (917.8)
24-Oct-97	Korean currency plunges and stock price takes biggest single-day drop in history following a cut rating by S&P	59.60 (927.1)
28-Oct-97	Won ends at 953 to US$ despite central bank intervention	51.57 (953.2)
7-Nov-97	Markets openly speculate that Korea will have to go to IMF to help defend won, which ends at 979.9 with traders targeting the 1,000 barrier. KOSPI 200 ends down 7.39% at 53.75	53.75 (974.7)
10-Nov-97	Won closes at 999 to the dollar	54.6 (999.0)
17-Nov-97	Korea central bank announces it will no longer defend 986 to US$. Won immediately falls its daily limit down to 1008.6.	51.21 (1008.6)
18-Nov-97	Korea central bank suggests to finance ministry that Korea should seek an IMF bailout loan	51.02 (1010.0)
20-Nov-97	Won plunges to its new limit-down level of 1139	50.88 (1139.0)
21-Nov-97	Finance ministry official announces Korea discussing details of bailout package with IMF	53.49 (1051.0)

3-Dce-97	Korea and IMF sign agreement to provide $57 billion bailout loan	41.38 (1195.0)
19-Dec-97	Presidential election and the first shift of power by vote to the opposition	44.65 (1576.5)
23-Dec-97	Won hit the record low of 1952.7	40.91 (1952.7)
24-Dec-97	New elected president pledges to perform IMF agreements	39.08 (1822.7)

Table 4.1

Summary Statistics on Implied Volatility and Skewness

The table reports summary statistics for implied volatilities (ISD) calculated from at-the-forward call and put options with nearest contract month. OBS denotes number of observation in each sample period. Bracked numbers are standard deviations, except where denoted as t values. [a]denotes t value (calculated assuming unequal variances) significant at the 1% level. Skewness measures are calculated from puts 2% below the forward price and calls 2 % above the forward price, using the equation (4.3)

		For at-the-forward options				
Period	OBS	Average of Put & Call ISD %	Put ISD %	Call ISD %	Difference in Put-Call	Skewness Measure %
10/Jul/97 - 7/Mar/98	182	63.31	71.67	54.95	16.72	-26.67
(Whole Period)			(53.57)	(26.63)	(t = 3.89)[a]	
10/July/97- 22/Oct/97	78	27.42	24.99	29.86	-4.87	10.96
(Pre-Crisis)			(9.29)	(6.45)	(t = 3.53)[a]	
23/Oct/97 – 7/ Mar/98	104	90.23	106.69	73.78	32.91	-54.9
(Crisis)			(45.57)	(20.38)	(t = 6.93)[a]	

Table 4.2

Comparison of volatilities at and out-of-the-money

The table compares the implied volatility from at-the-forward options with that from 2% out-of-the-forward options by subsample. (±2%) denotes an option which has an exercise price 2% above or below the forward price. Bracketed numbers are standard deviations, except where denoted as t values. The differences between 2% out-of-the forward and at-the-forward options are insignificant in all three subsamples at 0.01 level.

Period	No of OBS	Puts (-2%)	Puts (0%)	Difference	Calls (0%)	Calls (+2%)	Difference
10/Jul/97-7/Mar/98	182	72.0	71.7	-0.33	55.0	54.7	-0.3
(Whole Period)		(53.0)	(53.8)	(t=0.059)	(28.2)	(27.3)	(t=0.101)
10/Jul-22/Oct/97	78	25.6	25.0	-0.65	29.9	29.1	-0.79
(Pre-Crisis)		(8.5)	(8.52)	(t=0.475)	(6.45)	(5.82)	(t=0.80)
23/Jul/97-7/Mar/98	104	106.8	106.7	-0.09	73.8	73.6	-0.02
(Crisis)		(45.1)	(46.4)	(t=0.016)	(23.1)	(20.5)	(t=0.03)

Table 4.3

Distributional Statistics for Daily returns for KOSPI200

The table shows the breakdown of daily log return on KOSPI200 between July 10, 1997, and March 7, 1998, into two groups on the news that S&P downgrade Korea's foreign debt rating on October 23, 1997. [a] denotes that skewness is significant at 5% level (expected values for a distribution is skewness = 0). Normality of daily return distribution is tested using the Lillifos table with α=0.05, and variances are estimated. Sd denotes standard deviation and annualised standard deviation is calculated multiplying Sd by square root of number of trading days per annum.

Period	No of OBS	Mean (%)	Sd (%)	Annualised Sd (%)	Skewness
10/Jul/97-22/Oct/97 (pre-crisis)	78	-29.8	1.64	28.40	0.707[a]
23/Oct/97-3/Mar/98 (crisis)	104	-2.0	4.06	70.32	-0.022

Table 4. 4

Skewness measure regressed on daily return

The table reports regression results from equation (4.4) for skewness measures between July 10, 1997 and March 7, 1998, for each of two subsamples. The coefficients are fitted by OLS. (SE) denotes standard error. DW denotes the Durbin-Watson values. OBS is the number of observation. $SKEW_t$ is the skewness measure defined as percentage deviation of 2% out-of-the-forward call implied volatility from 2% out-of-the-forward put implied volatility on given day t. KOR_t is the $\ln(S_t/S_{t-1})$, where S_t is closing KOSPI200 level.
than two with p-value close to zero in both Pre-Crisis and Crisis sample, indicate positive

Group	α (p-value)	β (p-value)	R^2	DW	N
Pre-Crisis	0.1163	0.1318	0.0193	0.885	78
	(0.0003)	(0.2247)		(0.0001)	
Crisis	-0.5472	0.4189	0.1409	0.6946	104
	(0.0001)	(0.0001)		(0.0001)	

Table 4.5

Autocorrelogram of Skewness measure and Daily return series

Skewness measures are calculated from 2% out-of-the-forward call and put options implied volatilities, using the equation (4.3). Daily returns are computed by multiplying square root of number of trading days per annum by $\ln(S_{t+1}/S_t)$

	Skewness measure		Daily return	
Lag Length	Autocorrelation	Partial Autocorrelation	Autocorrelation	Partial Autocorrelation
1	0.6807(0.0741)	0.6807	0.2594(0.0743)	0.2594
2	0.5368(0.1028)	0.1369	-0.1014(0.0791)	-0.1808
3	0.5216(0.1172)	0.2147	-0.0509(0.0798)	0.0299
4	0.5329(0.1293)	0.1787	-0.1829(0.0800)	-0.2153
5	0.4138(0.1409)	-0.1051	-0.1997(0.0823)	-0.1019
6	0.3685(0.1474)	0.0423	-0.1018(0.0849)	-0.0840
7	0.4233(0.1524)	0.1625	0.1843(0.0856)	0.2186
8	0.4003(0.1587)	-0.0025	0.2328(0.0878)	0.0818
9	0.3298(0.1642)	-0.0161	0.0500(0.0911)	-0.0260
10	0.2478(0.1678)	-0.1155	0.0300(0.0913)	0.0172
11	0.2753(0.1698)	0.0513	-0.0039(0.0913)	0.0115
12	0.2395(0.1722)	-0.0308	-0.0810(0.0913)	0.0167
13	0.1838(0.1740)	-0.0264	-0.0549(0.0913)	0.0451
14	0.1576(0.1751)	-0.0018	-0.0352(0.0917)	-0.0449
15	0.1762(0.1759)	0.0089	0.1576(0.1751)	-0.0095
16	0.1573(0.1768)	-0.0029	0.1762(0.1759)	0.0035
17	0.1029(0.1776)	-0.0257	0.0433(0.0921)	0.0318
18	0.0687(0.1779)	-0.0536	0.0342(0.0922)	-0.0009
19	0.1168(0.1781)	0.1062	0.0540(0.0923)	0.0705
20	0.2045(0.1785)	0.2051	0.0732(0.0925)	0.0639
21	0.2348(0.1798)	0.1433	-0.0546(0.0928)	-0.0707
22	0.2174(0.1815)	0.0041	-0.1180(0.0930)	-0.0603
23	0.1959(0.1829)	-0.0801	-0.0787)0.0938)	-0.0487
24	0.1754(0.1840)	-0.0821	-0.0004(0.0942)	0.0449

Table 4.6

Regression results of skewness of volatility smile ($SKWE_t$) against return on KOSPI200

The table reports regression results from equation (4.5) by subsamples defined as Pre-Crisis and Crisis. The coefficients are fitted by maximum likelihood method. Bracketed numbers are p values. N denotes the number of observation in the sub sample.

Period	AR order	α (SE) (p-value)	β (SE) (p-value)	DW (p-value)	Regression R^2	Total R^2	N
Pre-Crisis	1	0.1120 (0.0566) (0.0515)	0.1800 (0.0846) (0.0365)	2.0686 (0.6211)	0.0573	0.3236	78
Crisis	1	-0.5421 (0.1503) (0.0005)	0.4164 (0.0765) (0.0001)	2.3163 (0.9498)	0.2293	0.5057	104

Table 4.7

Daily Return regressed on one day lagged skewness measure

The table reports ordinary least squares estimates from equation (4.10): $KOR_t=\alpha+\beta SKEW_{t-1}+\varepsilon_t$. SE denotes standard error. All Durbin-Watson d statists (DW) are significant at 0.01 level. OBS is the number of observations in the subsample.

Group	α (SE) (p-value)	β (SE) (p-value)	R^2	DW (p-value)	OBS
Pre-Crisis	0.1061	-0.06137	0.0042	0.8835	77
	(0.0316)	(0.1092)		(0.0001)	
	(0.0012)	(0.5759)			
Crisis	0.1021	0.1939	0.0469	1.4678	103
	(0.0819)	(0.0865)		(0.0023)	
	(0.2152)	(0.0272)			

Table 4.8

Regression results of Daily return on KOSPI200 on day t (KOR_t) against Skewness measure on day t-1($SKEW_{t-1}$)

The table reports regression results from equation (4.11) by subsamples defined by Pre-Crisis and Crisis. The coefficients are fitted by maximum likelihood method. SE denotes standard error. OBS denotes the number of observation in the subsamples.

Period	AR Order	α (SE) (p-value)	β (SE) (p-value)	DW (p-value)	R^2	Total R^2	OBS
Pre-Crisis	1	0.0933	0.0949	1.6997	0.0172	0.3252	77
		(0.0662)	(0.0901)	(0.0818)			
		(0.1624)	(0.2958)				
Crisis	1	0.1024	0.1951	1.9404	0.0390	0.1143	103
		(0.1032)	(0.1006)	(0.3667)			
		(0.3232)	(0.0551)				

Figure 1

Daily levels of the KOSPI 200 over the sample period

KOSPI200 level during the period from January 3, 1997, through March 8, 1998.

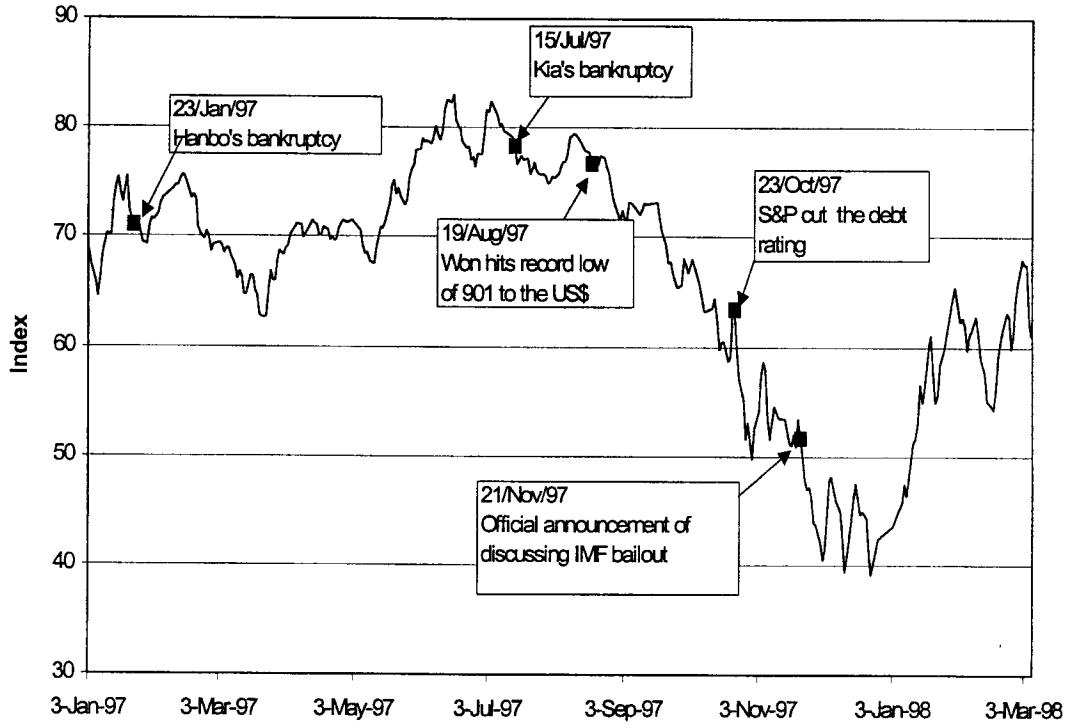

Figure 2

Actual and implied volatility levels over the sample period

Actual volatility is an annualised standard deviation of the daily log return of KOSPI 200 over the remaining life of the option. Implied volatility is calculated from at-the-money options with nearest time to maturity because the trading volume is heavily concentrated on those options so that the bias resulting from bid-ask spread can be diminished. volatility). Diamonds (◊) indicate maturity shift.

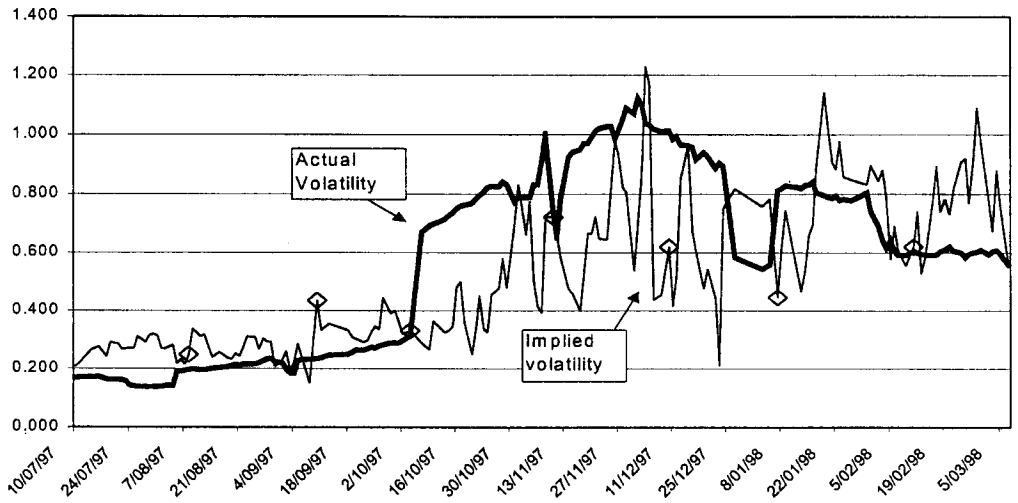

Figure 3

Average of call implied volatility versus intrinsic value

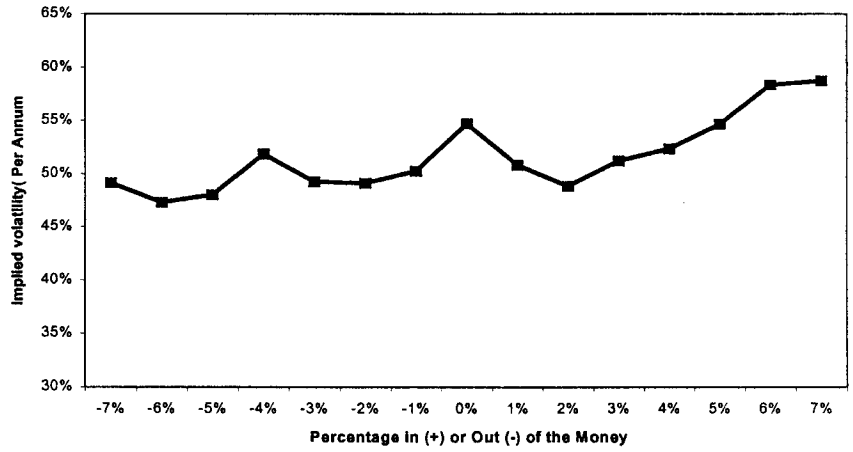

Figure 4

The level of at-the-forward call and put implied volatility, July 10, 1997-March 7, 1998

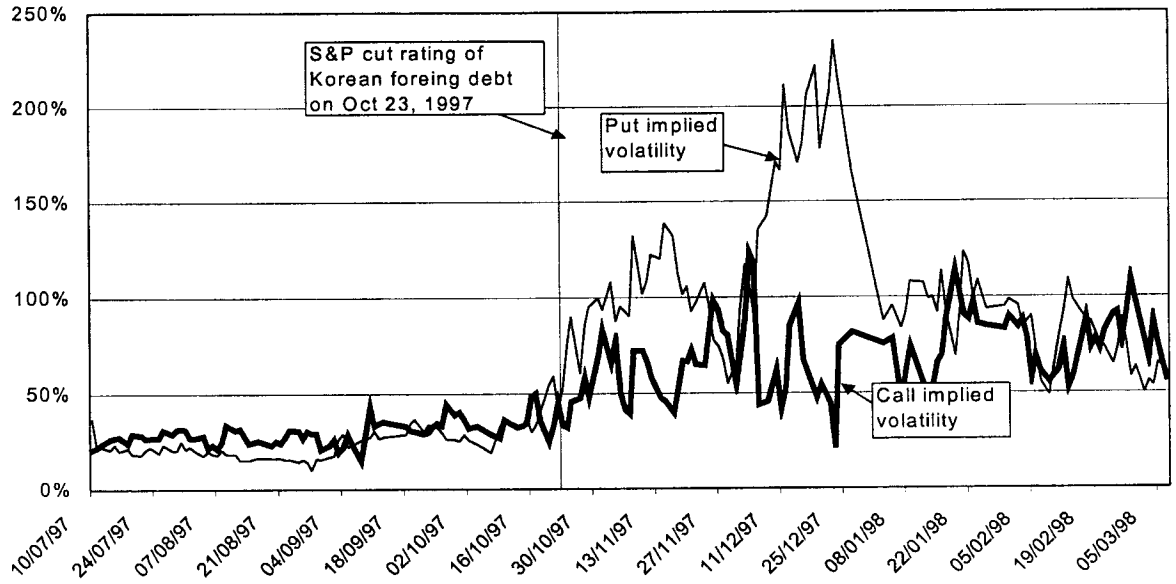

Figure 5

The level of KOSPI200 and six-day moving average of skewness measure