USING INDEX OPTIONS AND FUTURES TO PREDICT FINANCIAL CRISES

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ABSTRACT

This paper examines the information flow from index option and futures markets to stock markets. More specifically, it investigates whether the information provided by index option and futures markets can help us predict financial crises. Binary logit and probit models are employed to examine the predictive power of each market. The evidence indicates that implied volatility, futures volume, changes in futures open interest, and options bid-ask spread have some predictive power. Overall, futures market is superior to option market in forecasting market volatility and provides useful warning signals.

INTRODUCTION

This study investigates whether the information provided by index option and futures markets can help us predict financial crises. If an investor can utilize and interpret the information conveyed from index option and futures markets, he/she can react quickly and rebalance his/her portfolios before the financial crisis. Further losses can be minimized.

In this paper, we examine whether the derivatives market can provide an early warning system to the stock market. The derivatives markets might have more and/or faster information flows than stock markets for the following reasons. First, derivatives markets provide greater financial leverage for hedgers, speculators, and arbitragers (Black, 1975, and Mayhew et al., 1995), thus providing great incentives for information recovery. Easley et al. (1998) confirm that as long as some informed traders choose to trade in the option market, the option market will carry more information than stock market. Second, transaction costs in options markets are lower than those in stock markets (Black, 1975, and Mayhew et al., 1995), which likely facilitates information discovery. Overall, futures and option markets are more liquid and might be more informative than stock markets. Moreover, because futures market tends to be associated with greater leverage and lower transaction costs relative to the options market, we expect a greater predictive power of the futures market.

We use binary logit and probit models to test for forecasting power of each potential leading indicator. The dependent variable is an indicator of the occurrence of a financial crisis. The explanatory variables include the implied volatility of S&P 500 index options (VIX), futures volume, change in futures open interest, and option bid-ask spread. The evidence shows that these four predictors are very effective and informative. Moreover, the futures market is superior to the option market in forecasting future market volatility. This indicates that portfolio managers and investors should utilize the information conveyed from futures markets before a financial crisis.

The rest of the paper is organized as follows. Section 2 reviews literature. Section 3 describes data and methodology. Section 4 provides empirically results. Section 5 concludes.

LITERATURE REVIEW

A number of studies has documented the early warning of the recent major financial crises, such as 1994 economic crisis in Mexico and Asian financial crisis in 1997 (Goldfajn and Valdes, 1998; Berg and Pattillo, 1999; Kaminshy, 1999; Distinguin et al., 2006; Chen, 2009.) These studies attempt to use macroeconomic and accounting variables as leading indicators, such as interest rate spreads, inflation rates, money stocks, aggregate output, unemployment rates, federal funds rates, federal government debt, and nominal exchange rates. In general, these macroeconomic and accounting variables possess predicting power of financial crises.

Coudert and Gex (2007) consider implied volatility as one of seven risk aversion indicators by employing a binary logit model and find these indicators are all statistically and economically significant leading indicators. One of the risk aversion indicators is the implied volatility on the S&P 500 index, which provides an indication of the amounts investors are willing to pay to protect themselves from the risk of market fluctuation. The implied volatility has been regarded as an important indicator of future market volatility. Moreover, Diavatopoulos, Doran, and Peterson (2008), Giot and Laurent (2007), Christensen and Hansen (2002), Christensen and Prabhala (1998), and Giot (2005) indicate that implied volatility is a trustable measure of future market volatility and outperform historical realized volatility. The higher the amount an investor is willing to pay for VIX, the more volatile of the future market. In addition, investor overreaction in stock market serves as another leading indicator which is supported by Sy (2004).

DATA AND METHODOLOGIES

To examine the information content of the S&P 500 index options and futures, we obtained data from the following sources. The S&P 500 index return was obtained from the Center for Research in Security Prices (CRSP). The closing price of CBOE volatility options (VIX) proxy for the implied volatility on the S&P 500 index was provided by the Chicago Mercantile Exchange (CME). The S&P 500 index futures data was obtained from Normas.com. S&P 500 index options prices are from the Chicago Board of Exchange (CBOE). The sample period is from August 2008 to October 2008. To use most representative prices, we construct the "most active contract" data series. Therefore, the three futures contracts with expiration date on September, 2008, December, 2008, and March, 2009 are included in the sample. As for options contracts, most actively traded out-of-money put options are selected, since these options are what hedgers most likely to use to hedge market risk. Bates (1991) finds that during crises the most active options contracts are the out-of-the money put options.

We use binary logit and probit models to find which futures or option variables possess the best predictive power for crises. We applied the following regression equations to estimating the predictive power in the futures markets.

$$Logit\ (Crisis_t = 1) = IV_t + \log(FVOL_{t-k}) + CHFOI_{t-k} \quad \text{(Eq. 1)}$$

$$\Pr obit\ (Crisis_t = 1) = IV_t + \log(FVOL_{t-k}) + CHFOI_{t-k} \quad \text{(Eq. 2)}$$

where IV_t is the implied volatility of S&P 500 index options, also called CBOT volatility index (symbol: VIX); $\log(FVOL_{t-k})$ is the logarithm of futures trading volume; $CHFOI_{t-k}$ is the change of the logarithm of futures open interest; and k represents the number of lags which is set to one, five, and twenty-one, respectively, to infer when a warning sign occurs. For the options market, the following regression equation is employed:

$$Logit\ (Crisis_t = 1) = \log(IV_t) + \log(IV_{t-1}) + Spread_t + Spread_{t-1} \quad \text{(Eq. 3)}$$

where $\log(IV_t)$ is the implied volatility of the S&P 500 index options from the CBOT volatility index (symbol: VIX). Spread is the difference between bid and ask prices of options.

The dependent variable is a dummy variable as an indicator of financial crises. We follow Patel and Sarkar's (1998) approach to identify extreme price levels over a given period. Patel and Sarkar define the $CMAX_t$ as the ratio of the current stock price (P_t) in a month over the maximum stock price in the past several years. We set the past 24 months in Patel and Sarkar's CMAX ratio.

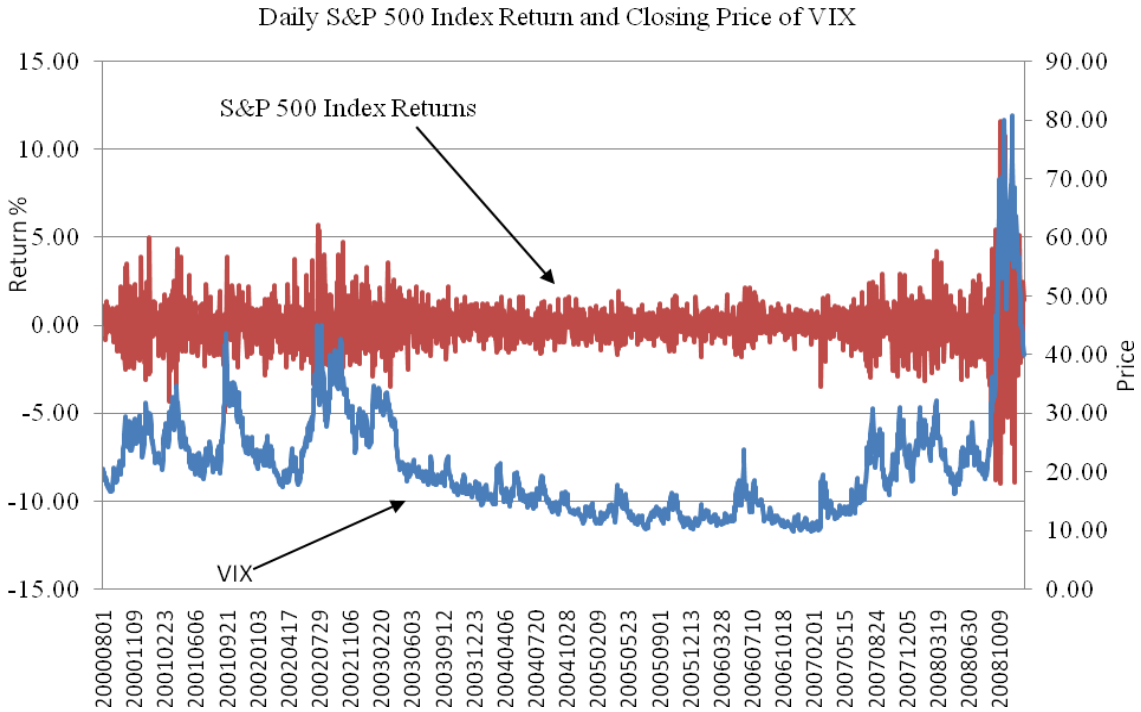
$$CMAX_t = \frac{P_t}{\max(P_t, \cdots, P_{t-24})}$$

If the ratio of the $CMAX_t$ in a month is lower than two standard deviation below the average of $CMAX_t$,that month is defined as the crisis period.

The rationale for including these explanatory variables in our estimation is motivated by past studies. Implied volatility of S&P 500 index options (VIX) is designed as a signal of future market volatility. It has been a widely used indicator of financial crises as shown in Fung (2007) and Coudert and Gex's (2007) papers. Moreover, a strong asymmetric relation between the S&P 500 index returns and the contemporaneous value of VIX is shown in Figure1. Negative returns for the S&P 500 index are associated with much greater relative increase of VIX (Canina and Figlewski, 1993). The relationship between the occurrence of the crisis and implied volatility is expected to be positive. Futures volume is a proxy for the size of information flow. Kawaller and Koch (2001) find an increase in futures volume due to active liquidity providers leads the market to experience lower volatility. Bessembinder and Seguin (1992) show that expected futures volume is negatively related to equity volatility but unexpected futures volume is positively related to equity volatility. Cheng, Fung, and Chan (2000) and Fung (2007) argue that futures volume is more informative than the options volume, especially during crises. A positive relationship between the occurrence of the crisis and futures volume is expected. Fung (2007) asserts that lagged implied volatility, lagged futures trading volume, and lagged futures open interest are useful to explain the current month realized volatility. The change in futures open interest serves as a proxy for new trader or information arrival. Finally, the spread of options prices can proxy for the degree of informed trading (Ahn, Kang, and Ryu, 2008; George and

Longstaff, 1993). Gwilym et al. (1998) demonstrate that the bid-ask spread is directly related to the future stock market volatility.

Figure 1. Daily S&P 500 index return and the closing price of volatility index options (VIX) during the period of August, 2000 to December, 2008



EMPIRICAL RESULTS

Table 1 summarizes descriptive statistics of the daily observations of S&P 500 index return, its level, implied volatility (IV), futures trading volume ($FVOL$), the logarithm of futures trading volume ($\log(FVOL)$), futures open interest (FOI), the logarithm of futures open interest ($\log(FOI)$), changes in futures open interest ($DFOI$), and changes in the logarithm of futures open interest ($CHFOI$) over the period, July, 2008 through December, 2008. The number of observations is 128. During this period, the daily S&P 500 index mean return is approximately -0.02% and the minimum is -9% while the closing price of VIX is as high as 80.86.

Table 2 provides the results from the binary logit model of the occurrence of crises on the contemporaneous implied volatility (IV_t), lagged futures trading volume ($FVOL_{t-k}$), and changes in futures open interest ($CHFOI_{t-k}$). The predictive ability is measured at horizons (k) of 1 and 5 days ahead. Models 1 and 2 examine the forecasting ability of futures market one and five days ahead (at time t-5) on the stock future market movement (at time t,) respectively. We identified 34 crises by the method of CMAX in the sample period from July, 2008 to December,

Table 1 Descriptive Statistics of the Futures Market
The table shows summary statistics of S&P 500 index level, its return, implied volatility (IV) from the S&P 500 volatility index option, futures trading volume, logarithem of futurs trading volume, futures open interest, logarithm of futures open interest, changes in futures open interest, and change in the logarithem of futures open interest. The sample includes daily data from July, 2008 to December, 2008.

	Mean	Min	Max	Std Dev	Skewness	Kurtosis
SP 500 Return	-0.002	-0.090	0.116	0.034	0.202	1.641
SP 500 Level	1080.401	752.440	1305.320	179.887	-0.120	-1.763
IV	41.983	18.810	80.860	18.708	0.289	-1.363
FVOL	61408.047	5662	267401	53253.230	2.240	4.564
Log(FVOL)	10.774	8.642	12.497	0.671	0.519	0.877
FOI	597458.047	478017	769377	59681.620	0.400	0.244
Log(FOI)	13.296	13.077	13.553	0.099	0.104	0.020
DFOI	-259.110	-291360	30082	31791.566	-7.635	64.169
CHFOI	-0.001	-0.476	0.044	0.052	-7.715	65.244

Table 2 Logit Regression of Crises on Futures Market Indicators
The dependent variable is an indicator of crises at time t which are defined by the CMAX. The sample period is from July, 2008 to December, 2008. The number of observations is 128. Models 1 and 2 examine the forecasting ability of futures market one and five days ahead (at time t-5) on the stock future market movement (at time t,) respectively. IV_t represents the contemporeneous effect of the implied volatility of S&P 500 index on the stock marekt movement. Log (VOL_{t-1}) and Log(VOL_{t-5}) are the one lag and five lags of logarithm of futures volume, respectively. $CHOI_{t-1}$ and $CHOI_{t-5}$ are the one lag and five lags of the change of the logarithm of futures open interest, respectively.

	Model 1		Model 2	
Variables	Estimate	P-value	Estimate	P-value
Intercept	-0.365	0.932	-14.334	0.012
Log(IV_t)	0.102	0.000	0.105	0.000
Log(VOL_{t-1})	-5.189	0.199		
Log(VOL_{t-5})			0.742	0.112
$CHOI_{t-1}$	-4.004	0.308		
$CHOI_{t-5}$			-6.061	0.125
Number of Crises	34		34	
R-squared	0.343		0.349	
Adj. R-squared	0.400		0.403	
Fraction of Correct Predictions	0.786		0.779	

2008. The current crisis started July 2007 and since then most daily stock returns have been negative. Overall, we find that the occurrence of crises is positively related to implied

volatility and futures trading volume as expected. Further, a negative association between the occurrence of crises and the change in futures open interest suggests a decrease in liquidity prior a crisis. The estimate of the logarithm of the implied volatility is significant at 1% level. This implies that futures trading activities conveys information regarding future market volatility or movement in the next week. Table 3 reports the statistics from the probit model to examine the likelihood of crises. The evidence is qualitatively the same as that of the binary logit model.

Table 3 Probit Regression of Crises on Futures Market Indicators
The dependent variable is an indicator of crises at time t which are defined by the CMAX. The sample period is from July, 2008 to December, 2008. The number of observations is 128. Models 1 and 2 examine the forecasting ability of futures market one and five days ahead (at time t-5) on the stock future market movement (at time t,) respectively. IV_t represents the contemporeneous effect of the implied volatility of S&P 500 index on the stock marekt movement. Log (VOL_{t-1}) and Log(VOL_{t-5}) are the one lag and five lags of logarithm of futures volume, respectively. $CHOI_{t-1}$ and $CHOI_{t-5}$ are the one lag and five lags of the change of the logarithm of futures open interest, respectively.

	Model 1		Model 2	
Variables	Estimate	P-value	Estimate	P-value
Intercept	-0.392	0.866	-7.652	0.013
Log(IV_t)	0.061	0.000	0.061	0.000
Log(VOL_{t-1})	-0.293	0.181		
Log(VOL_{t-5})			0.372	0.148
$CHOI_{t-1}$	-2.331	0.345		
$CHOI_{t-5}$			-3.538	0.157
Number of Crises	34		34	
R-squared	0.348		0.350	
Adj. R-squared	0.412		0.410	
Fraction of Correct Prediction	0.786		0.770	

Table 4 summarizes the descriptive statistics of the daily observations of S&P 500 index return, its level, implied volatility (IV), option bid prices, option ask prices, and option spreads during the period, August, 2008 through October, 2008. The number of observations is 65. The daily S&P 500 index mean return is approximately - 0.035% and the lowest is - 9% while the closing price of VIX is as high as 80.06. The maximum of spread jumps to 12.7 implying the market is very volatile and illiquid at a certain point of time.

Table 5 provides the results from the binary logit model of the probability of crises on the contemporaneous implied volatility (IV_t), lagged implied volatility (IV_{t-1}), spread $_t$, and lagged spread. 4 crisis periods are identified by the CMAX method. The predictive ability is measured at horizons (k) of 1 and 5 days. The contemperanous implied volatility and spread are all postively related to the occurrence of crises. Surpringly, the estimates are not significant at 5%, which mean these variables in the options marekts don't have predicitive power of forecasting the likelihood of financial crises. Table 6 presents results from the probit model to investigate the likelihood of crises. It presents similar evidence as that of the binary logit model.

Overall, the futures market is more informative than options market since the futures market can predict the stock market movement a week ahead.

Table 4 Descriptive Statistics of the Options Market
The table shows descriptive statistics of the S&P 500 index level, its return, implied volatility from S&P 500 volatility index option, and bid price, ask price, and spread of the S&P 500 index option. The sample period is from August, 2008 to October, 2008.

Variables	Mean	Min	Max	Std. Dev.	Skewnes	Kurtosis
SP 500 Level	1149.988	848.920	1305.320	147.179	-0.701	-1.132
SP 500 Return	-0.004	-0.090	0.116	0.032	0.474	2.380
Implied volatility	38.103	18.810	80.060	19.099	0.722	-0.930
Bid	9.879	0.000	64.600	16.852	1.645	1.913
Ask	12.095	0.050	69.500	18.276	1.523	1.292
Spread	2.216	12.700	0.050	2.885	1.499	1.777

Table 5 Logit Regression of Crises on Options Market Indicators
The dependent variable is an indicator of crises which are defined by the CMAX. The data period is from August, 2008 to October, 2008. IV_t and IV_{t-1} represent the contemporenous and lagged implied volatility of S&P 500 index. Spread is the difference between bid and ask of options prices. The number of observations is 65.

Variables	Estimat	P-value
Intercept	-10.39	0.0(
IV_t	0.12	0.2
IV_{t-1}	0.06	0.4
$Spread_t$	0.63	0.1(
$Spread_{t-1}$	0.01	0.9
Number of Crises		
R-squared	0.3(	
Adj. R-squared	0.2	
Fraction of Correct Predictions	0.93	

Table 6 Probit Regression of Crises on Options Market Indicators
The dependent variable is an indicator of crises which are defined by the CMAX. The data period is from August, 2008 to October, 2008. IV_t and IV_{t-1} represent the contemporenous and lagged implied volatility of S&P 500 index. Spread is the difference between bid and ask of options prices. The number of observations is 65.

Variables	Estimate	P-value
Intercept	-5.642	0.008
IV_t	0.065	0.264
IV_{t-1}	0.035	0.521
$Spread_t$	0.338	0.165
$Spread_{t-1}$	-0.012	0.963
Number of Crises	4	
R-squared	0.3028	
Adj. R-squared	0.2510	
Fraction of Correct Predictions	0.9375	

CONCLUSIONS

This study provides a test of the predicitive power of futures and options marekts in forecasting for the likelihood of financial crisis. The results show that implied volatility has some predictive power for crises. In general, the futures market is more informative than options marekt in this sample period. This result is consistent with the standpoint of leverage and transaction costs. Trading futures contracts typically involves a greater degree of leverage and lower transaction costs. The more information will convey from the futures markets and helps us predicting the probability of financial crises.

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