

The influencing factors of VIX in the 2008 Financial Crisis—Based on Quantitative Methods

Xianghuizi Peng^{*+}, Zhixuan Ouyang⁺

*Corresponding author. Email: 1320251236@qq.com, 2563768255@qq.com

Department of Finance, Wuhan Textile University, Wuhan, 430200, China

+These authors contributed equally to this work and should be considered co-first authors.

Abstract. This article aims to investigate the influencing factors of VIX index during the financial crisis in the United States. Specifically, the research is based on quantitative methods. The empirical analysis utilizes a multiple linear regression model to examine the relationship between several factors and VIX index. Based on the empirical analyses, three conclusions are drawn regarding the factors influencing VIX index. These findings contribute to understanding the dynamics of the financial crisis and shed light on the importance of investor sentiment in shaping financial markets.

Keywords: CBOE Volatility Index, Gross Domestic Product, Economy Policy Uncertainty, Investment sentiment.

1 Introduction

1.1 Background of the study

In 2007, cooling housing market and continuously rising interest rate led to a heavier burden on subprime borrowers who, resulting in widespread losses and triggering the subprime mortgage crisis. Also, the overabundance of high leverage structure by numerous investment banks and real estate companies seriously damaged the whole financial system. In 2008, excessive housing prices, loose monetary policy and lax regulation led to an overheated subprime market and the investment panic in this market. The U.S. government also introduced some policies during the crisis to alleviate capital market. Therefore, the paper, taking the subprime crisis as the background, firstly explores the influencing factors of the market panic index during the financial crisis.

1.2 Research Significance and Research methodology

In terms of theoretical significance, this paper selects the 2008 financial crisis as the research background to explore the influencing factors of the VIX in this period, and applies three different methods. Although there have been many studies on the influencing factors of the VIX, few empirical analyses used time series data, especially in the context of the financial crisis. In terms of practical significance, the 2008 financial crisis had a striking global impact on capital markets. In response to the growing market panic, the United States introduced a series of capital opening policies, which were positively reflected in VIX. Therefore, for most regulators and

investors, this study can help enhance the understanding of the economic impact of the financial crisis, better understand the influencing factors of investor sentiment, and provide theoretical support for proposing policy responses.

This paper mainly adopts three research methods: literature research, event analysis and empirical econometric analysis to demonstrate the research problem.

(1) Literature research method: this paper adopts the literature research method to present relevant literature about the impact of the financial crisis on the global economy, the impact of investor sentiment on financial market, and causes of 2008 financial crisis, which lays a theoretical foundation for the empirical analyses of the article.

(2) Event analysis method: This paper analyses the enactment of major U.S. policies through the timeline of the financial crisis, and considers the lag of the policies, which enhances the credibility of the study.

(3) Econometric analysis method: To explore the transmission effect of macroeconomic indicators on the panic sentiment of capital market in the U.S., this paper constructs OLS model and FGLS model in the empirical analysis, and further conducts White's heteroskedasticity test, autocorrelation test, and Granger causality test.

2 Literature review

2.1 The Impact of financial crises on the global economy

In recent years, there have been frequent financial crises around the world. Lou pointed out that the risky assets and the safe havens in the financial market fell at the same time, and the correlation between the two types of assets was close to 1, which featured evaporating liquidity [1]. In the 2008 financial crisis, the function of banks as financial intermediaries was destroyed, which led to a greater impact of the financial crisis on the real economy and more difficult economic recovery [2]. Farrukh Suvankulov suggested that excessive deleverage policies led to a downturn in economic markets, which then triggered the volatility of the international oil market, with plummeting oil price [3]. After the 2008 financial crisis, the U.S. financial markets experienced significant volatility and several market indicators moved at historic peaks. In terms of the stock market, in mid-October 2008, the absolute value of the highest one-day rise and fall of the United States Dow Jones Industrial Average Index, the Nasdaq Index and the S&P 500 Index all exceeded 7%.

2.2 The impact of investor sentiment on financial markets

Wu Yang argued that the contagion of early financial crises was mainly carried out through the real economy channel [4]. However, modern financial crises were more often realized through financial channels, which meant that financial crises were transmitted to other countries through fears. Cai also pointed out that exogenous shocks would inevitably affect the panic of investors, and fear will be the main cause of financial crises[5]. Lou said the confidence and sentiment of the market subject was the trigger for the large fluctuations in the US financial market [1].

De long believed that fluctuations in sentiment would lead to fluctuations in stock prices. Gao Yang used the Bi-LSTM technique to prove that investor sentiment affects the stock return rate

of Chinese Sci-Tech innovation board. Corredor showed that local investor sentiment has a significant impact on the overall future return expectations of the Spanish stock market. He also demonstrated that both local and global sentiment factors have a significant impact on returns.

All the above studies showed that investor sentiment had a certain impact on the financial market, including the effect of policy implementation, market yield, market liquidity and other aspects. And the implied volatility index (VIX) represents the market dynamics. Therefore, the study of the VIX index is helpful to understand how to recover financial markets by involving investor sentiment.

2.3 Causes of the 2008 financial crisis

About the causes of this disastrous financial crisis, Taylor pointed out that the excess money caused by the unusually loose monetary policy of Federal Reserve was the main factor that triggered the financial crisis in 2008[6]. Wang also believed that the cause of the international financial crisis should be mainly attributed to the economic development model, monetary policies, and financial regulatory links. Meanwhile Ross identified the massive issuance of subprime mortgages aimed at low-credit households was an important cause of the collapse of the mortgage market. Shi found that one of the important factors contributing to the international financial crisis was the structured financial derivatives based on subprime mortgages, such as CDOs. As a synthetic loan and default protection, CDS could replace the real assets such as mortgages. In addition, CDS can be used to protect against the default of the underlying assets under the ABS or CDO structure. And this irrational structure largely contributed to the financial crisis [7,8]. However, there are researchers who put forward a different point of view. According to Chang, CDO, CDS and other subprime derivatives are only financial instruments, so they cannot be the source of the international financial crisis at all, and the real cause of the international financial crisis should be the real economic crisis.

According to the literature, financial crises affect macroeconomics, capital market, investor confidence and other aspects, and it can be transmitted to the international level through real economy, investor sentiment and other channels, causing heavy damage to the global economy. Unstable investor sentiment during financial crises can significantly affect the stock market, and the VIX is an important indicator of investor sentiment. However, we find that the quantity of literature on VIX index in financial crisis is relatively small, and most of relevant literature about the 2008 financial crisis focused on monetary policies, subprime mortgages, and financial derivatives. Therefore, the innovation of our paper is to find the influencing factors of VIX index in the 2008 financial crisis to effectively control investor sentiment.

3 Empirical analysis

3.1 Analysis of factors affecting the market panic index

This chapter will explore the influencing factors of VIX during the financial crisis and provide policy recommendations to stabilize investor sentiments and prevent the occurrence of systemic financial crisis. In fact, macroeconomic indicators reflect changes in the VIX index.

GDP: Gross domestic product (GDP), is the value of the goods and services produced by the nation's economy less the value of the goods and services used up in production. GDP has always been considered to have a significant correlation with the volatility index of various countries. Zhou analyzed the volatility of the stock market in China and found that there has been a negative correlation between changes in Chinese stock market prices and GDP growth since 1995.

EPU: The macroeconomic impact on market panic is mainly transmitted through economic policies, and the market tends to be more panicky when economic policy uncertainty is relatively high. The market panic index is significantly positively correlated with economic policy uncertainty. Baker proposed the Economic Policy Uncertainty Index (EPU), which is constructed based on the heat of news coverage. For example, the EPU index in the U.S. is to calculate the frequency of articles that contain specific words in the top 10 U.S. newspapers each month.

3.2 Sample selection and descriptive statistics

Through extensive literature review, this paper selects several variables that have been proven to have a certain influence on the VIX index as control variables, and uses the monthly data from January 2006 to December 2010 as the data sample period, and uses the U.S. GDP and EPU as the core explanatory variables to conduct regression tests with the VIX to verify whether the hypotheses are valid or not.

Table 1 shows the descriptive statistics of the U.S. VIX index, the value of the U.S. GDP and U.S. economic uncertainty index, with a sample size of 60.

Table 1. Descriptive statistical analysis [Owner-draw].

Research variables	Observations	mean value	standard deviation	minimum value	maximum values
VIX	60	23.5013	10.7960	10.42	59.89
GDP	60	97.7565	33.5898	48.9512	204.751
EPU	60	115.8218	39.7703	57.2026	189.9173

The following are other exogenous variables related to the VIX that are used as control variables in the regressions. Table 2 and Table 3 explain the specific meaning of these variables.

Table 2. Variable selection for GDP regression [Owner-draw].

variables	typology	Meaning
VIX	Explained variable	represents the market's expectations for the relative strength of near-term price changes of the S&P 500 Index
The U.S. GDP	Explaining variable	total market value of the goods and services produced by a country's economy during a specified period of time
The U.S. unemployment rate	Control variable	the number of unemployed as a percentage of the labor force
The U.S. CPI	Control variable	the monthly change in prices paid by U.S. consumers
The U.S. inflation rate	Control variable	the rate at which prices increase over time

Table 3. Variable selection for EPU regression [Owner-draw].

variables	typology	Meaning
VIX	Explained variable	represents the market's expectations for the relative strength of near-term price changes of the S&P 500 Index
The U.S. EPU	Explaining variable	Economic Policy Uncertainty Index
The U.S. treasury rate	Control variable	the effective annual interest rate that the U.S. government pays on one of its debt obligations
The U.S. M2 growth rate	Control variable	The growth rate of money supply in a broad sense

4 Research hypothesis and model construction

Based on the previous researches, this paper chooses two main indicators to respectively explain the VIX index, namely Gross Domestic Product (GDP) and Economic Policy Uncertainty (EPU). Other control variables are influencing factors, based on the results of the previous researches, such as inflation rate, M2 monetary policy liquidity, unemployment rate, treasury yields, and consumer price index.

Hypothesis I: The U.S. GDP is negatively correlated with VIX.

Figure 1 shows the time series of GDP and VIX. The trend of the two variables is similar, and there may be a certain causal relationship between the two.

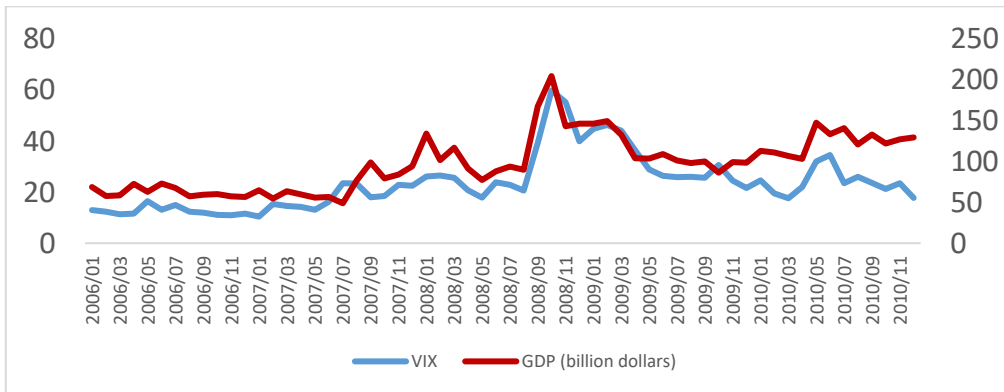


Fig. 1. Value of GDP [Owner-draw].

Hypothesis II: The U.S. economic policy uncertainty indicator is positively correlated with VIX.

Figure 2 shows the time series of EPU and VIX, since the instability of economic policy will bring more drastic price fluctuations, such fluctuations are easy to affect investor sentiment, so hypothesis 2 is made.

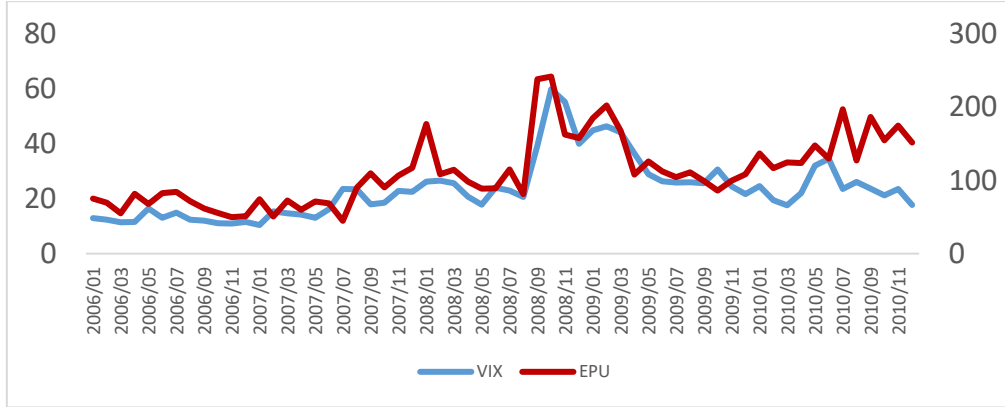


Fig. 2. Economic policy uncertainty index [Owner-draw].

This paper constructs the following model for empirical analysis based on previous research results and theoretical analysis assumptions:

$$VIX_t = \alpha + \beta GDP_t + \lambda_1 unemployment\ rate_t + \lambda_2 CPI_t + \lambda_3 inflation\ rate_t + \varepsilon_t \quad (1)$$

$$VIX_t = \alpha + \beta EPU_t + \lambda_1 treasury\ rate_t + \lambda_2 M2\ growth\ rate_t + \varepsilon_t \quad (2)$$

5 Empirical analyses

5.1 Stationarity test

Since the study uses time series, it is necessary to conduct the stationarity test of time series first. This paper uses the unit root test (ADF) method to test its stationarity, and its regression equation is as follows:

$$\Delta Y_t = \alpha + \beta T + \sum_{i=1}^q \phi_i \Delta Y_{t-1} + \varphi Y_{t-1} + \varepsilon_t \quad (3)$$

Where Y_t is the observed value of the time series, Y_{t-1} is the lagged period of the time series, T denotes the time trend, ΔY_t denotes the difference between the observation and the previous moment, and ε_t is the error term. The core of the ADF test expression is to test whether the coefficient β is not equal to zero, if it is not equal to zero, it means that the time series data has a unit root, otherwise it means that the time series data is stationary. The null hypothesis of the test H_0 is that Y_t has a unit root and the time series is non-stationary. The non-stationary variables need to be differentiated to verify the stationary of the first-order difference. If the first-order difference variable is stationary, the variable is a first-order single integration variable. Table 4 shows the unit root test results of the variables, all the variables pass the ADF test at a significance level of 1%. The type of test for each variable is with intercept, no trend and no lag term. The overall conclusion is that the time series is stationary.

Table 4. Unit root test for variables [Owner-draw].

Variables	Type of variable	Type of test	ADF statistic	conclusion
VIX Index	Explained variable	(1 st difference)	-6.369	Stable

GDP	Explaining variable	(1 st difference)	-8.690	Stable
EPU	Explaining variable	(1 st difference)	-10.303	Stable
CPI	Control variable	(1 st difference)	-3.751	Stable
Inflation Rate	Control variable	(0 difference)	-4.058	Stable
Unemployment Rate	Control variable	(1 st difference)	-4.820	Stable
M2 growth rate	Control variable	(1 st difference)	-6.446	Stable
Treasury Yield	Control variable	(1 st difference)	-5.669	Stable
S&P 500	Control variable	(1 st difference)	-5.431	Stable

After all the variables required for the regression are stable, this paper will be divided into two regressions to explore the correlation between the two core variables and Volatility Index.

5.2 Empirical analysis of GDP

5.2.1 Heteroscedasticity and autocorrelation tests

Before conducting multiple regression, further heteroskedasticity and autocorrelation tests are needed to be conducted to make the OLS regression method estimation effective by avoiding the problem of pseudo-regression. So this paper uses the White heteroscedasticity test method, and the results are shown in the Table 5. This verification uses the data after stationary processing. The P-value is 0.3035, which is greater than 0.05, and the results indicate that the assumption of homoskedasticity is not rejected, so heteroscedasticity correction is not necessary.

Table 5. White Heteroskedasticity hypothesis for GDP [Owner-draw].

Source	Chi2	df	P
Heteroskedasticity	16.16	14	0.3035
Skewness	3.41	4	0.4909
Kurtosis	0.35	1	0.5548
Total	19.93	19	0.3990

The autocorrelation test adopts DW, BG, Q test methods, as shown in the Table 6, and combines with the residual plot to determine the lag order. The P value of the BG test result of GDP is 0.1309, which is greater than 0.1, indicating that the model does not have autocorrelation, and the statistic of the DW test is 2.1919, which is close to 2, and there is a negative serial correlation. Overall, the model has a slight autocorrelation problem. Therefore, this paper uses the CO estimation in FGLS to reduce the model autocorrelation, and the revised DW value 2.02, which is much closer to 2. So autocorrelation problem is eliminated and the regression results of this FGLS will be presented in the robustness test section.

Table 6. Autocorrelation test for GDP [Owner-draw].

1 lag (GDP Index)	BG test	DW test	Q test
Statistics	2.282	2.1919	15.0831
significance	0.1309	/	0.9683

5.2.2 Granger causality test

In the process of hypothesis, this paper speculates that there is a significant causal relationship between GDP and VIX. Therefore, Table 7 shows that VIX is not the Granger cause of GDP,

while GDP is a Granger cause of VIX, that is, the fluctuation of GDP affects the fluctuation of the VIX index.

Table 7. Granger test of GDP and VIX [Owner-draw].

Conclusion on causality	Sample (n)	F distribution		Chi-square distribution		Lag order
		p-value	Statistic	p-value	Statistic	
GDP is the Granger cause of VIX	56	0.0092	4.29	0.0021	14.69	Lags (3)
VIX isn't the Granger cause of GDP	55	0.1481	1.78	0.0738	8.54	Lags (4)

5.2.3 Analysis of regression results

Table 8 shows the regression results between the GDP as core explanatory variable and VIX for the time sample from January 2006 to December 2010, with a frequency of monthly data. The results show that the regression coefficient of GDP is 0.1388 with a statistic of 3.31, which is significant at the significance level of 1% , indicating a significant positive correlation between GDP and VIX. The Huber-White Robust Standard Errors method used to correct for heteroskedasticity is 2.09, and the correlation is still significant at the significance level of 5%; the statistic of FGLS test after correcting the autocorrelation of the model is 3.97, which is significant at the significance level of 1%, so the model is robust. Hypothesis I of this paper is not supported by empirical test, and hypothesis I is not valid. The regression results for the other control variables are not very significant, but their correlation directions are similar with those of previous studies.

Table 8. Analysis of GDP regression results [Owner-draw].

Variables	OLS		Robust OLS		FGLS(CO)	
	p-value	t-Statics	p-value	t-Statics	p-value	t-Statics
DVIX	0.002	3.31	0.042	2.09	0.000	3.97
DGDP	0.914	0.11	0.913	0.11	0.857	-0.18
Dunemployment rate	0.736	0.34	0.658	0.45	0.677	0.42
Ln inflation rate	0.763	-0.30	0.726	-0.35	0.730	-0.35
DCPI	0.939	-0.08	0.946	-0.07	0.782	-0.28
Intercept						
N	56		56		54	
Adj R ²	0.1173		0.1815		0.1974	
F-Statics	2.83		1.39		4.26	

Due to the large gap between the regression results and the initial assumptions, this paper conducts a multiple regression on the S&P500, the benchmark of VIX construction, and finds GDP is still significantly correlated with the VIX, while the S&P500 is negatively correlated with the VIX. The VIX is the annualized implied volatility of S&P500 index, which measures the volatility of the S&P500 after 30 days in the market and annualizes this 30-day volatility. The VIX is essentially a measure of the expected percentage of the S&P500 rising or falling from its current prices over the next 12 months, reflecting the market's expectations of the future stock market volatility. Many studies have shown a strong negative correlation between the VIX and the S&P 500. In general, the VIX declines when the stock market is on a solid rising on good news. When the stock market plunges on negative news, the VIX rises rapidly. This supplementary regression as shown in Table 9 indicates that the regression results of positive causality

between GDP and the VIX is accurate. The VIX, as an indicator of short-term market volatility expectations, has a strong guiding effect on the stock market.

Table 9. Supplementary regressions of S&P500 and VIX [Owner-draw].

Variables	OLS	
	p-value	t-Statics
DVIX	0.008	2.75
DGDP	0.000	-7.73
DSP 500	0.974	-0.03
Intercept	59	
N	0.6006	
Adj R ²	44.61	
F-Statics		

After testing the correctness of the regression results, this paper also conducts regression tests between the GDP of other countries and the U.S. market panic index VIX (the control variables are the CPI and the unemployment rate of each country). As shown in Table 10, it is found that the influence of GDP of various countries on VIX during the 2008 financial crisis is mostly positive, contrary to the negative correlation conclusion of other literature. This indicates that the relationship between the VIX and the GDP during the financial crisis may be different from that during economic stability period [9].

Table 10. Results of OLS regressions of countries' GDP as an explanatory variable on the explanatory variable VIX from 2006 to 2010 [Owner-draw].

Phase	Nations	P-value	T-value	Relevant Direction
2006-2010	the U.S.	0.035	2.28	Positive
2006-2010	the U.K.	0.012	2.80	Positive
2006-2010	French	0.015	2.68	Positive
2006-2010	Canada	0.037	2.25	Positive
2006-2010	Japen	0.023	-2.49	Negative

5.3 Empirical analysis of EPU

5.3.1 Heteroscedasticity and autocorrelation tests

For the heteroskedasticity test of EPU, the White heteroskedasticity test is also used and Table 11 shows its results, and the p-value is 0.2590, which is greater than 0.05. The result shows that the hypothesis of homoskedasticity is not rejected, which indicates that there is no heteroskedasticity in the model.

Table 11. White's heteroskedasticity test for EPU [Owner-draw].

Source	Chi2	df	P
Heteroskedasticity	11.25	9	0.2590
Skewness	6.08	3	0.1077
Kurtosis	1.84	1	0.1750
Total	19.17	13	0.1179

Table 12 shows the autocorrelation test results of EPU. The P-value of BG test result is 0.6691, which indicates that the model does not have first-order autocorrelation problem, the statistic of DW test is 1.8760, which is close to 2, indicating a slight positive serial correlation, and the P-value of Q test is 0.0773, which is greater than 0.05, not significant. It means the model does not have a first-order autocorrelation problem. Overall, the model has a slight autocorrelation problem. It can be eliminated by CO estimation in FGLS, and the corrected DW value is 1.9336, extremely close to 2, without autocorrelation problem. The regression results of FGLS will be presented in the robustness test section.

Table 12. EPU Autocorrelation test. [Owner-draw].

1 lag (EPU)	BG test	DW test	Q test
Statistics	0.183	1.8760	38.0361
significance	0.6691	/	0.0773

5.3.2 Granger causality test

The results of the Granger test are shown in Table 13, due to the large p-values of the F and chi-square distributions, the VIX is not a Granger cause of the EPU. Instead, EPU is the Granger causal cause of VIX, the numerical fluctuation of EPU will affect the volatility of VIX. Through this causal relationship, the hypothesis of this paper is more likely to be valid, so the regression results are analyzed.

Table 13. Granger test between EPU and VIX [Owner-draw].

Conclusion on causality	Sample	F distribution		Chi-square distribution		Lag order
		p-value	Statics	p-value	Statics	
EPU is the Granger cause of VIX	57	0.0317	3.18	0.0123	10.89	Lags (3)
VIX isn't the Granger cause of EPU	57	0.2955	1.27	0.2274	4.34	Lags (3)

5.3.3 Analysis of regression results

Table 14 shows the regression results between EPU as the core explanatory variable from January 2006 to December 2010 and the fear index VIX. The results show that the regression coefficient of EPU is 0.0854, with a statistic of 2.50, which is significant at the significance level of 5%, indicating that the U.S. economic policy uncertainty index EPU is significantly positively correlated with the fear index VIX. The Huber-White Robust Standard Errors method used to correct for small heteroskedasticity has a statistic of 1.70, the correlation is significant at significance level of 10%; the statistic of FGLS test for correcting the autocorrelation of the model is 2.24, which is significant at the significance level of 5%, so the model is robust, and hypothesis II of this paper is theoretically supported by empirical test. Hypothesis II is valid from the statistical point of view. The regression results for the other control variables are not very significant and may have been affected by interactions between the other variables.

Table 14. Analysis of EPU regression results [Owner-draw].

Variables	OLS		Robust OLS		FGLS(CO)	
	p-value	t-Statics	p-value	t-Statics	p-value	t-Statics
DEPU	0.015	2.50	0.095	1.70	0.029	2.24
DTreasury Yield	0.446	0.77	0.589	0.54	0.406	0.84
DM2	0.787	-0.27	0.842	-0.20	0.707	-0.38
Intercept	0.868	0.17	0.866	0.17	0.810	0.24
N	59		59		58	
Adj R ²	0.1161		0.3247		0.1042	
F-Statics	2.41		1.18		2.09	

5.4 Summary of this chapter

This chapter introduces the relationship between macroeconomic indicators and the panic index under the background of the financial crisis. Based on literature research, this chapter selects some variables that affect VIX, including GDP, economic uncertainty index, unemployment rate, consumer price index and so on, and conducts descriptive statistical analysis. This paper discusses the time series characteristics of GDP and economic uncertainty index, and uses them as the core explanatory variables. And based on the theoretical analysis and literature review, this chapter proposes two hypotheses, Hypothesis I: The U.S. Gross Domestic Product is negatively correlated with Market Panic Index; Hypothesis II: The U.S. Index of Economic Policy Uncertainty is positively correlated with Market Panic Index. After that, the multiple regression model is constructed for empirical analyses. In the empirical analysis section, the chapter conducts stationarity tests, heteroskedasticity and autocorrelation tests, Granger causality tests, OLS regression and FGLS robustness test, according to the econometric method. The regression results show that GDP of the U.S. is positively correlated with the market panic index. Hypothesis I is not supported by the empirical results. Another result shows that the U.S. Economic Policy Uncertainty Index is positively correlated with the Market Panic Index, so hypothesis II is supported.

6 Conclusion

6.1 Empirical conclusion

This paper takes the 2008 financial crisis as the background of the event study, examines the influencing factors of the VIX index during the financial crisis, and studies the correlation between the U.S. GDP and EPU indices and the VIX index. The following main conclusions are drawn:

(1) U.S. gross national product GDP showed a positive correlation with the VIX during the financial crisis. This is somewhat different from our hypothesis and previous research results, as Bianchi (2018) stated in his study that GDP of all countries was negatively correlated with stock volatility, which means GDP is negatively correlated with VIX [10]. The main reason for this abnormal result might be that under the influence of the financial crisis, Lehman Brothers, one of the four major investment banks, and other investment banks went bankrupt, and the

market panic grew rapidly. The combined effects of this sentiment and the Federal Reserve's "zero-interest-rate policy" led investors would not face the risk of bank bankruptcy and inflation. Instead of putting their savings in the bank at the risk of bank failure and inflation, investors were more willing to consume or invest in assets with a low-risk coefficient, which led to an increase in consumption and investment, resulting in an increase in GDP.

(2) The GDPs of all countries were all significantly correlated with the VIX index during the financial crisis, and the GDPs of the UK, Canada and France were positively correlated with the VIX index, while the GDP of Japan was negatively correlated with the VIX index. This shows that when the subprime crisis broke out in the United States and caused market panic, the economies of the above countries were affected to a certain extent, but the GDPs of all the countries except Japan fluctuated abnormally.

(3) The EPU index of macroeconomic stability variables showed a positive correlation with the VIX index during the financial crisis. It shows that policy stability affects investor sentiment to a certain extent, and when governments implement market-friendly monetary policies, investors' confidence will be restored, which is conducive to the country's economic recovery. However, the EPU index is based on the textual analysis of macroeconomic policy keywords in mainstream newspapers and media to estimate the stability of economic policies, and it has a certain hysteresis effect, which means the market's reaction to the stability of macroeconomic policies is earlier than the portrayal of the EPU index. It is one of the reasons why the correlation between this variable and the VIX index is not very significant.

6.2 Policy recommendation

In 2008 and 2009, VIX declined significantly in three periods—January to April 2008, September to November 2008, and January to June 2009. Since the part of empirical analysis has demonstrated the positive correlation between the uncertainty of economic policies and the VIX in the previous section, this part will analyze the policies announced in the US during these three time periods and give policy recommendation.

Based on the Fed officer policy, between December 2007 and April 2008, firstly, on December 12, five central banks announced a joint bailout to stabilize the market and boost investor confidence in the aftermath of the crisis. And then the Federal Reserve (Fed) and New York regulators continuously injected short-term liquidity into different market through issuing Term Auction Facility (TAF) instrument. And in the end of this first period, U.S. Regulatory officials and Treasury Secretary Paulson proposed stricter regulations on bank capital and hybrid market successively. In the second period from August 2007 to November 2007, the Fed announced for the first time that it would buy agency debt and MBS in 25th November 2008, marking the beginning of the first round of quantitative easing(QE1), which aims at purchasing state-guaranteed troubled financial assets to rebuild the creditworthiness of financial institutions. Then, in 26th November 2008, the Fed Bank of New York announced some additional modest, temporary changes to the SOMA securities lending program, which were designed to further relax the limitations on borrowing Treasury securities and to improve the functioning of the Treasury market. In the third period, between January and June 2009, importantly, on June 17, 2009, U.S. Department of the Treasury submitted <Financial Regulatory Reform: A New Foundation> to Congress, which is known as the "White Paper on Financial Reform" and is widely regarded as

the most comprehensive restructuring of the financial regulatory system since the Great Depression of the 1930s.

Based on the analysis, this paper proposes the following policy recommendations:

(1) Continuous market liquidity injection helps market confidence recovery.

The VIX index went down when the federal reserve started to inject massive capital into the market. The Federal Reserve injected liquidity into financial institutions by implementing massive monetary policy stimulus measures, such as cutting interest rates, purchasing bonds and other financial assets, and providing emergency loans.

(2) Short-term liquidity stimulus could not constantly ease the liquidity shortage.

In January 2008, the VIX index rose sharply again after the Federal Reserve implemented short-term liquidity stimulus measures such as the TAF and the provision of emergency loans in December 2007 to alleviate the liquidity shortage in financial markets. Even if short-term stimulus measures provide some liquidity support, liquidity problems in the overall financial market cannot be fundamentally solved. Sometimes, Long-term policy initiatives can improve the risk management capacity and transparency of financial institutions and enhance the confidence of market participants.

(3) It is necessary for governments to reinforce financial regulatory system and stabilize investor confidence in the first place when a financial crisis occurs.

When governments improved financial regulations, the VIX dropped dramatically. Also, after the announcement of the joint bailout by the five major central banks, the VIX index dropped significantly, which was a sign of regaining investor confidence. Therefore, governments should be aware of the importance of strengthening the financial regulatory system. This requires governments to improve the regulatory framework and ensure that regulatory rules are more stringent and effectively enforced.

Acknowledgement: Xianghuizi Peng and Zhixuan Ouyang contributed equally to this work and should be considered co-first authors.

References

- [1] Lou F.P.(2020) COVID-19, financial market shocks and financial crisis [J]. Southwest Finance, (05): 25-35
- [2] Wan C, Zhou B, Jin Y.Y.(2017) The Mechanism and Recovery Characteristics of the Impact of Financial Crisis on the Real Economy [J]. Southwest Finance, (03): 26-29.
- [3] Farrukh S., Fatma O.(2012) Have firms with better corporate governance fared better during the recent financial crisis in Russia? [J] Applied Economics Letters, 19 (8): 1135-1151.
- [4] Wu Y.(2023) The Impact, Early Warning, and Response to Contemporary Financial Crises [D]. Shanghai University of Finance and Economics, 2021-002117.
- [5] Cai Y.F.(2016) Short term Capital Flow, Economic Policy Uncertainties and VIX Evidence from a Time varying Analysis Framework MPRA Paper.
- [6] Taylor J.(2023) The Financial Crisis and the Policy Responses: An Empirical Analysis of What Went Wrong [J].
- [7] Ross, L. M.,&Squires, G. D. (2011) The personal costs of prime lending and the foreclosure crisis: a matter of trust, security, and institutional detail Social Science Quarterly, 92 (1), 140-163.

- [8] Arner, D.W.(2009) The global credit crisis of 2008: Causes and sequences Int'l Law 2009:43:91.
- [9] Ye W.Y., Zeng H., Miao B.Q.(2018) Empirical Study on the Impact of VIX Index on the Linkage between Stock Markets [J]. Statistical Research, 35 (06): 68-76.
- [10] Cesa Bianchi A., Pesaran M.H., Rebacci A.(2018) Uncertainties and Economic Activity: A Multi Country Perspective [J]. CESifo Working Paper Series.