# FORECASTING EXTREME EVENTS ON FINANCIAL MARKETS

## Ionuț Cosmin Năstase\*

The Academy of Economic Studies, Bucharest, Romania

#### Abstract

The events of the recent financial crisis from 2007-2008 were the basis for choosing this topic and justified the desire to deepen crises on financial markets. "Too big to fall" is a statement that this crisis has dismantled in just few months through the bankruptcy of US large-scale financial conglomerates such as Lehman Brothers, Bear Stearns, Merrill Lynch and others. September 2008 is a month that many will not forget, a "dark" month in which the entire global financial system froze, marked by huge creditors taken in collapse (Fannie Mae and Freddie Mac), by the buying of the bankrupted bank Bear Stearns by J.P Morgan for 2\$/share, the collapse of Lehman Brothers, followed by the bankruptcy and the collapse of the largest American Insurance Group (AIG), which has been taken by the government. This paper's objective is to determine if, based on historical events – last financial crisis – we can determine whether we can define certain methods or instruments which can be used as signals for anticipating future extreme events on financial markets and how accurate and applicable they are.

### Keywords

Financial crisis, Extreme events, Financial markets, Global financial system, Bankruptcy, Financial Engineering, Securities.

#### JEL Classifaction

G01, G17, G20

## Introduction

The last century has experienced a large number of financial crises in emerging market economies (EMEs), leaving behind, most often, economic, social and political devastating consequences. These financial crises were not, in many cases, limited to individual economies, but also were contagious in other capital markets. Especially the crisis from South America from 1994-1995 and the Asian crisis from 1997-1998 affected a large group

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<sup>\*</sup> Corresponding author, **Ionut Cosmin Nastase** – nastaseionutcosmin@gmail.com

of countries and had systemic repercussions over the whole international financial system. Over the past decade, we witnessed the worst financial crisis in the United States in 2007-2008 after the Great Depression of 1929, which spread globally, propagating in all the world's economies. This last financial crisis has shown us that the world in which we live is highly globalized and that economies are interconnected.

What is a financial crisis? The financial crisis is the result of events created on capital markets as a result of severe imbalances caused by different factors, such as: excessive lending, lack of regulation in different areas (certain securities), excessive and unjustified price increases in certain sectors ( eg. real estate prices in 2006). The financial crisis is becoming an economic crisis when the financial instability in an economy or globally marks a sharp decline in some economic performance indicators (GDP, interest rates, exchange rates and others). Frankel & Saravelos (2010) define the crisis as being when the limits or intervals of economic and financial variables have been breached.

Researching and deepening this topic has the purpose to identify the mistakes made by public and private financial institutions that have led to the strongest global financial crisis and to identify those signals which will predict, with good accuracy, future extreme events on financial markets. Through this paper, I intend to understand the major influences that led to the 2007 financial crisis, to describe the role that rating agencies and Wall Street's brokers have had for the development of mortgage-backed securities (MBS), collateralised debt obligation (CDO), credit default swaps (CDS) and to describe the timing events that took place during the financial crisis.

I believe that this issue is significant to the new generation of financial analysts, because the history repeats and, more than ever, we have to learn from mistakes made in the past. Regardless of how many new regulations have been introduced since 2008, how many agreements have been signed and implemented related to the risk and liquidity of financial institutions (Basel II, Basel III), financial markets are evolving fast, new banks are much larger and more complex, financial crisis will not cease to occur, but the economists must anticipate them early and be prepared to respond to schocks.

#### 1. The review of scientific literature and the context of the financial crisis

Over the years, the term "crisis" or "financial crisis" has received many definitions by the authors and can be defined in several ways, as Kaminsky, Lizondo and Reinhart (1996) said. Frankel and Saravelos (2002) in their work defined the crisis as being when there are breaches within economic or financial variables. Frankel and Rose (1996) define the crisis as a "collapse of the currency" when nominal exchange rates depreciate by at least 25% or the nominal depreciation ratio of last year's exchange rates increased by 10%.

Another proposal by Eichengreen, Rose and Wyplosz (1995) defines a "exchange market crisis" sustained when the speculative pressure index moved with at least two standard deviations above average.

Raghuram G. Rajan (2005), the pre-crisis IMF leader, defines the financial crisis as the cost paid by the company for the development and expansion of the financial sector through its ability to distribute the risk. In his paper, he predicted the exposure risk of the financial sector to potential distorsions and on this occasion, he proposed a closer scrutiny by the

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authorities for the financial transactions, a restriction of excessive lending and a regulation of "toxic assets" that were speculatively used on international exchanges.

In order to be able to follow the signs of a crisis, it is necessary to study the recent financial crisis, to identify the characteristics of the capital market at that time, the big players in the economic context and the decisions taken by the banks and state authorities. Therefore, the underlying causes of the collapse of the capital market and the devastating effects that have unleashed on the world's economies have been highlighted.

On setting the "foundation" of the 2007-2008 financial crisis contributed several factors as it follows. The cultural shift in the american people mentality was an important factor, which at the beginning they were sceptical in accessing loans, but in time, this mentality changed and they started to desire everything faster to the detriment of saving. Therefore, the mentality of "save now, spend later" was replaced by accessing loans (consumer and mortgage loans).

John C. Hull (2008) states that this mentality was encouraged by the Federal Reserve policy which, at the beginning of 2000, deliberately lowered the interest rates in order to encourage the consumption with the aim of boosting economic growth.

Changes in rules, probably politically motivated to encourage ownership, have led to the expansion of property owners and greater use of debt to finance housing acquisition. A particular aspect was the increase in sub-prime mortgage loans, which differ from others by the high level of risk. Lenders of this type offered mortgage loans to people with a small scoring or who do not meet the eligibility requirements of the income or who allow themselves to access the loan with a much lower advance.

Another concern in this period was the notoriety increase in mortgage loans with variable interest rates (ARM-adjustable rate mortgage). By mid-2005, over one third of new mortgages had variable interest rates which will reset with a new interest rate in 5-7 years – "balloon loans" (right about the time when real estate bubble burst and the financial crisis began). To help people qualify for loans, the mortgage industry has developed a series of risky credit plans designed for customers with low scoring quality. In the run for big bonuses and rewards, credit brokers started to grant NINJA loans (No income, no job, no assets) which added great risk on the loan portfolio.

"Balloon" loans had a series of mandatory installments with a final reimbursment of the principal in 5 or 7 years; the hope for the most debtors was that they could refinance the mortgage loan in order to pay the "balloon" principal, therefore both the debtor and the lender were exposed to credit risk. First of all, the interest rates could increase, therefore granting a new loan to refinance the original one is expense or not probable, if the income will be insufficient to sustain bigger monthly installments. Second, a change in personal life, such as loosing the job, could make the refinance impossible.

Real estate bubble was created when the government lowered the interest rates for mortgage loans simultaneously with the increase of property prices (evaluated in my study case through Case-Shiller index) as a result of high demand for housing. The bubble burst has occured through a reverse phenomenon: the interest rates on mortgages increased significantly (as a result of resetting variable interest rates under loan agreements) as house prices declined (as a result of the fall in demand for such loans and because most of the

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loans went into default, therefore it was a big offer/supply for properties and there were not enough buyers or they didn't have resources to buy).

The peak was touched by the Wall Street involvement in the securitization process of these mortgages through a financial enginneering. Financial engineering has led to securities like morgage-backed securities (MBS), new securities of much greater complexity, such as collateralised debt obligation (CDO), which in fact is a securization of MBS, and CDS (credit default swap) which are betting agains the previous securities. At this toxic process, has contributed the rating agencies (Moody's, S&P 500) which ranked these securities with great ratings like AAA rating, although these securities were created on "garbage" mortgages, and as a result, they tricked the investors from all around the world.

Charles R. Morris (2008) explained in his paper "The two trillion dollar meltdown" that, once the mortgage loans were bought by the investment banks, these were transformed in securities which they were selling them for the cash-flows expected from the principal and interest rate payments from the loans. This process, called securitization, created mortgage-backed securities. These securities provided liquidity and diversity for the mortgage market, because the investors could buy these titles from a diverse "pool" of mortgage loans. It was hoped that the credit risk of these securities would not affect significantly the cash-flows cummulated by the MBS investors.

Indeed, the securitization process increased the available capital on the market, through the selling of financial assets, the creditors eliminated the loans from balance sheet, recovering the money, money which could be used again for granting new loans. It could have been a win-win situation once the initial creditor was receiving commissions as long as the debtors were paying the installments (which were transferred to the morgage fund).

As long as the other third parties were investing in these new securities, the liquidity of the assets class was improved by these mortgage-backed securities. Oversees investors became more interested in the aquisition of these securities considering their characteristic and the risk vs return potential. Another advantage for the popularity of these securities was absence of the reinvestment risk – as long there were no reinvestment coupons, it was no reinvestement risk in interest rates smaller than those expected; therefore the return was "blocked" when the securities were purchased.

#### 2. Research metodology

In order to identify the signals which can help to anticipate extreme events on financial markets, I decided to perform an econometric analysis on the great financial crisis from 2007-2008 which started in United States of America and which infiltrated with speed in the global financial markets

In order to perform this study, 7 stock market indices were used from the US market (NYSE, DJIA, S&P 500, Russel 1000), japanesse market (Nikkei 225), chinese market (Hang Seng Index –HSI), european market (DAX) and romanian market (BET index). For the analysis we used the daily closing prices for each index, for 2000-2017 period, using Reuters base.

The econometric analysis was performed using and interpreting normality tests (Histograme, Jarque-Bera Test, Quantiles of Normal and Empirical Distribution Test for

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Normality) for 5-6 different time intervals (2000-2009, 2002-2009, 2004-2009, 2006-2009, 2007-2008 and 2008 in some cases) on each stock index in order to identify extreme events as we approach the crisis – 2007-2008 interval. The econometric analysis was performed both on daily closing price of the index and on its daily return calculated through the following formula: (Price1-Price0)/Price0.

In this paper we intended to have a different approach of the 2007-2008 financial crisis in comparison with the foreign authors. Therefore, the paper starts to present the cronological events of the crisis for a better understanding, we determined the causes of these extreme events (particular event – 2007-2008 crisis and also generally), followed by a econometrical analysis in order to determine those "triggers" of the extreme events on financial markets.

As a result, through this study we can measure the effects generated by a financial crisis and it was possible to ,,draw" normality levels of certain indicators which we can use them in the future in order to anticipate extreme events at the time they breach the thresholds.

The results certify that as we shorten the time span until the financial crisis, the probability of extreme events occuring (left negative tails characterized by negative skewness greater than 0.5 and kurtosis greater than 3 – leptokurtic distribution) is growing bigger.

These results are only obtained by the analysis of daily closing rates, not on the analysis of daily returns, which suggests that these extreme events could be predicted by observing the daily closing rates, not their return, which leads to a first conclusion of this paper – the evolution of stock exchange closing rates can be a tool for predicting extreme events in financial markets.

According to the literature, the extreme events can be identified if the distribution extend 3 times the average square deviation to the left and to the right from the center of distribution. Starting from this principle, we can establish with a satisfactory probability that by using the dynamics of closing rate (daily returns), at the right and left of distribution center, we can see tails at least 3 times of the average square deviation in the analysed period. However, this topic is debatable considering the positive skewness recorded by the daily return distribution, meaning that in this period there are good chances of recording profits.

The analysis is structured in 2 chapters. In the first chapter is graphically depicted the evolution of daily closing rates and returns to be able to show the impact of the financial crisis on these indices, followed by an annual risk vs return analysis for a period of 17 years for each index. The results were obtained using the mean and the standard deviation annually.

In chapter two, an econometric study for selected indices is conducted to identify the increase in the likelihood of extreme fat tails (left fat tails), characterized by negative returns, negative skewness greater than 0.5 and 1, and by kurtosis greater than 3 (leptokurtic distribution).

### 3. Results and discussions

In this study case, I analyzed and interpreted over 300 outputs and charts considering all the indices and periods analysed all leading to the same conclusion – the probability of extreme events occuring on financial markets increase if according to normality distribution analysis we obtain negative skewness values greater than 1 and kurtosis above 3.

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## 3.1 Graphic analysis

In chart no.1 we can observe the annual evolution of the return vs risk for Dow Jones Industrial Average Index in 2000-2017 period. It is obvious the moment of the real estate bubble burst from 2008, a period characterized by extreme high risk and negative return.



Figure no.1: Dow Jones annual return vs risk Source: Own processing in Excel

In chart no.2 it can be observed the annual evolution of the return and risk for S&P 500 index in 2000-2017 period. It can be easily observed the impact of the real estate bubble burst in 2008, a period characterized by high volatility of the market and losses.



Source: Own processing in Excel

Above we highlighted the crash of the daily closing rated for New York Stock Exchange Index during the financial crisis and we can see that in 2009 the index hit the bottom of the 17 years analysed (fig. no. 3).

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Figure no. 3. NYSE daily closing price evolution Source: Own processing in Excel

In chart no. 4 we analysed the daily return dynamic of the closing prices for NYSE index and it can be seen that the events generated by the capital market collapse produced an extreme volatility deepening the uncertainty between investors and transactions in 2007-2008 period.



Source: Own processing in Excel

Above we highlighted the crash of the daily closing rated for RUI Index during the financial crisis and we can see that in 2009 the index recorded the lowest price in the study period (fig. no. 5).

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Figure no. 5. RUI daily closing price evolution Source: Own processing in Excel

In Chart no.6 we can observe the daily return evolution for the german index DAX in 2000-2017 period. The increased variation in 2007-2009 confirm the extreme volatility of the european financial market.



Figure no.6: DAX daily return dynamic Source: Own processing in Excel

### 3.2 Probability distribution analysis

In this chapter we will only present the financial crisis timeframe (considering both daily closing price and daily return) which certify the presence of extreme events on financial markets.

The results show that as we shorten the time frame to the financial crisis, the probability of extreme events occurence (left tails identified with negative skewness greater than 0.5 and kurtosis greater than 3 – leptokurtic distribution) is increasing.

These results are only obtained through econometric analysis of daily closing rates, not on the daily return analysis, which suggests that the extreme events could be forecasted by observing the daily closing prices, not their daily return. Therefore, the result lead us to the conclusion of this paper – the evolution of the stock indices closing rates could be a forecasting tool of the extreme events occurence on the financial markets.

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Considering the topics mentioned above, in the next pages of the paper we will present the individual analysis for the selected indices, but considering the size constraint of this paper, we will only present one index for each significant market.

## New York Stock Exchange index (NYSE)

Figure no.7 below shows a comparison of the NYSE index over 2007-2008 period with 504 observations (daily frequency), both in terms of closing rates and closing rate returns. From both perspectives, the results show, according to Jarque-Bera Test and EDT (Empirical Distribution Test), that the time series are not normally distributed (the probability of a normal distribution is 0). Analyzing the index closing rate, we get a high negative skew of 1.6 and kurtosis of 4.6 suggesting that the distribution is leptokurtic (high peak) and indicates the presence of long left tails. In the case of index daily returns, we get a slightly positive skew of 0.01 and a kurtosis of 10.37, which emphasizes that the distribution is symmetrical and leptokurtic, but does not indicate the appearance of left tails.



Figure no.7: Analysis of the probability distribution of the index NYSE Source: Own processing in Eviews

In case of NYSE index, by analysing daily closing rates, not daily closing return, we can identify long left tails along the distribution, which indicate an increased probability for extreme events occurence (fig. no. 8).

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Figure no. 8. Normality Quantiles distribution for the index NYSE (2000-2009 above vs 2008-2009 below; closing rates in the right, daily returns in the left) Source: Own processing in Eviews

## Nikkei 225 (Tokio Stock Exchange)

Figure no.9 below shows a comparison of the Nikkei 225 index over 2007-2008 period with 490 observations (daily frequency), both in terms of closing rates and closing rate returns. From both perspectives, the results show, according to Jarque-Bera Test and EDT (Empirical Distribution Test), that the time series are not normally distributed (the probability of a normal distribution is 0).



Figure no. 9: Analysis of the probability distribution of the index Nikkei 225 Source: Own processing in Eviews

Analyzing the index closing rate, we get a moderate negative skew of 0.73 and kurtosis of 2.69 suggesting that the distribution is platikurtic (flat peak) and indicates the presence of long left tails. In the case of index daily returns, we get a slightly negative skew of 0.07 and a kurtosis of 10.5, which emphasizes that the distribution is symmetrical and leptokurtic, but does not indicate the appearance of left tails.

#### Hang Seng index

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Figure no.10 below shows a comparison of the HSI index over January-December 2008 period with 252 observations (daily frequency), both in terms of closing rates and closing rate returns. From both perspectives, the results show, according to Jarque-Bera Test and EDT (Empirical Distribution Test), that the time series are not normally distributed (the probability of a normal distribution is 0). Analyzing the index closing rate, we get a moderate negative skew of 0.65 and kurtosis of 2.14 suggesting that the distribution is platikurtic (flat peak) and indicates the presence of long left tails. In the case of index daily returns, we get a moderate positive skew of 0.55 and a kurtosis of 6.86, which emphasizes that the distribution is symmetrical and leptokurtic, but does not indicate the appearance of left tails, but right tails (good chances to record profit).

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Figure no.10: Analysis of the probability distribution of the index Hang Seng Source: Own processing in Eviews

#### DAX index (European index)

Figure no.11 below shows a comparison of the DAX index over 2007-2008 period with 508 observations (daily frequency), both in terms of closing rates and closing rate returns. From both perspectives, the results show, according to Jarque-Bera Test and EDT (Empirical Distribution Test), that the time series are not normally distributed (the probability of a normal distribution is 0).

Analyzing the index closing rate, we get a high negative skew of 0.98 and kurtosis of 3.4 suggesting that the distribution is leptokurtic (high peak) and indicates the presence of long left tails. In the case of index daily returns, we get a moderate positive skew of 0.69 and a kurtosis of 12.84, which emphasizes that the distribution is symmetrical and leptokurtic, but does not indicate the appearance of left tails, but right tails (good chances to record profit).

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Method	Value	Adj. Value	Probability		Method	Value	Adj. Value	Probability	
Lilliefors (D) Cramer-von Mises (W2) Watson (U2) Anderson-Darling (A2)	0.114688 1.935622 1.518414 15.12650	NA 1.937527 1.519908 15.14897	0.0000 0.0000 0.0000 0.0000		Lilliefors (D) Cramer-von Mises (W2) Watson (U2) Anderson-Darling (A2)	0.106283 2.356134 2.350783 14.42076	NA 2.358453 2.353097 14.44218	0.0000 0.0000 0.0000 0.0000	
Parameter Value Std Error a S			a Statistic	Deah	Parameter	Value	Std Error	z-Statistic	Prob
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Log likelihood No: of Coefficients	-4210.852	.852 Mean dependent var. 2 S.D. dependent var.		6828.717 964.0327	Log likelihood No. of Coefficients	1313.693 2	Mean dependent var. S.D. dependent var.		-0.000457 0.018243

Figure no. 11. Analysis of the probability distribution of the index DAX *Source:* Own processing in Eviews

#### **BET index (Romanian index)**

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Figure no.12 below shows a comparison of the BET index over 2007-2008 period with 500 observations (daily frequency), both in terms of closing rates and closing rate returns. From both perspectives, the results show, according to Jarque-Bera Test and EDT (Empirical Distribution Test), that the time series are not normally distributed (the probability of a normal distribution is 0).





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Analyzing the index closing rate, we get a moderate negative skew of 0.83 and kurtosis of 2.77 suggesting that the distribution is platikurtic (flat peak) and indicates the presence of long left tails. In the case of index daily returns, we get a slightly negative and symmetrical skew of 0.02 and a kurtosis of 8.56, which emphasizes that the distribution is symmetrical and leptokurtic, but does not indicate the appearance of left tails.

#### Conclusions

Following the analysis of some international stock exchange indices in United States, Europe, Romania and Asia, the results were the same and they tended to the same conclusion: the likelihood of extreme events on financial markets increases when, through econometric studies of certain shares or indices, negative skewness values greater than 1 and kurtosis above 3 are obtained.

Practically, these atypical values of the indicators testify to the existence of long left tails to the left of normal distribution, characterized by high negative skew and leptokurtic distribution (high peak). Therefore, it is significantly increasing the likelihood of extreme events occurring on financial markets and suggesting an increase in the uncertainty of investors acting with a snowball effect.

According to our study, the probability of extreme events on financial markets is greater on US financial markets, while the probability is smaller in Europe (DAX –Germany), Romania (BET), Japan (Nikkei 225) and in China where we can almost state that the crisis didn't occur.

The purpose of this paper was to understand the previous financial crisis from two perspectives that can serve as future forecasting signals for extreme events.

The first was from the perspective of excessive lending supported by the government authorities in the conditions of a lack of regulation on the capital market, which all the big players took advantage of and which led to the bankruptcy of the most irresponsible. This type of high-gain events, unsustainable growth in specific industries is the first trigger which announce the creation of new "financial bubbles".

The second perspective was the empirical study through which the occurrence of extreme events to the left of normal distribution was analyzed and which alert the existence of a potential new financial crisis.

Through this paper we managed to develop a short term model of forecasting the extreme events on financial markets by using and observing the signals previously determined which can predict with significant accuracy potential imbalances from financial markets.

Researching and deepening this topic has the purpose to identify the mistakes made by public and private financial institutions that have led to the strongest global financial crisis and to identify those signals which will predict, with good accuracy, future extreme events on financial markets.

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