Stock market decision-making in the light of prospect theory

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SUMMARY: One of the main insights of prospect theory is that investment decisions are often irrational, following certain trends, and this is particularly true for individual investment decisions. The theory's main proponents and its developers have described the phenomenon of risk seeking over losses and risk aversion over gains, mainly by looking at stock market trends. One of the hypotheses of our paper is that investors become risk averse in times of crisis. The other hypothesis is that the hummingbird effect can be detected in stock market trading.

Using linear regression, we have been able to show that investors become more risk averse in times of crisis, which can also be seen in stock market trading, through the shift in the index. In addition, we have also been able to show that the hummingbird effect can also be detected in stock market trading

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Introduction

The main focus of this paper is to examine how the stock market index evolves in a crisis and what relationship can be established between investors' behaviour and their perceived crisis situation. Indirectly, we consider the prospect theory of D. Kahneman and A. Tversky (Kahneman, Tversky, 1979), a basic theory of behavioural economics, which states that at the level of individual decision making, most people avoid risk in the case of a profit or a trend in that direction, but when the trend turns loss-making, the propensity to take risk increases in order to avoid or reduce the loss. Anchoring is also a consequence of prospect theory because it provides

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a benchmark in the relative world. Kahneman and Tversky's prospect theory identifies three types of bias: errors affecting the evaluation of conjunctive cases, errors affecting disjunctive cases, and anchoring bias (Baddeley, 2019a: 45).

Prospect theory, similar to the behaviour of the rational homo economicus of classical economics, starts from rationality, but adds to this the potential for deviance, where decision making is carried out under the psychological pressure of risk (Corr, Plagnol, 2019: 85-86). Prospect theory did not approach the behavioural prospect from a normative and descriptive perspective, but put it in the perspective of uncertainty.

Of its two elements, the principle of risk aversion was formulated in 1738 by Daniel Bernoulli. Knowing that marginal utility increases gradually but decreases at the same time as the rate of increase, that individual happiness increases as wealth increases but the perception of it decreases as the degree of sensitivity decreases (Thaler, 2015: 71). And loss aversion as an element of prospect theory has been discussed in the works of Adam Smith and Charles Darwin (Corr, Plagnol, 2019: 90). In our study, we tried to test some hypotheses using quantitative econometric methods (regression, correlation) of stock market index analysis and correlation calculation.

One of our hypotheses is that the two main opposing ideas of the outlook theory may become even more prevalent in times of crisis, and this can be seen in the movement of indices. We should note that some general trends can be detected in stock market indicators, which provide evidence of a generalised trend in investor behaviour, but at the same time there are those who buck the trends and do not always do badly. Good illustrations of this are given, for example, by André Kostolany in his book „The Wonder World of Money and the Stock Market" (Kostolany, 1990), but the case of Taleb is also an excellent example. However, those who buck the trend are not always right, and although their success in doing so is a testimony to the success of others, they do not have a statistically significant impact on the trend indicators.

Our second hypothesis is that, although the hummingbird effect is present in the global system of stock markets, the extent of its propagation is not always the same: the smaller markets are affected by the larger waves of the larger ones than the reverse, and therefore a global crisis or phenomenon is felt when the trends of the smaller markets follow those of the larger ones, even with a certain phase lag.

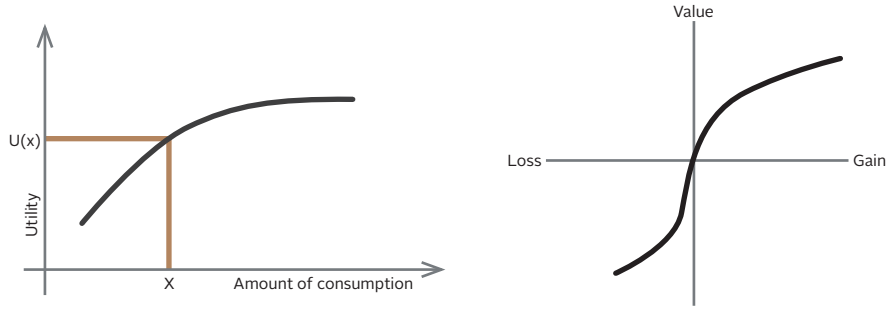
In the sense of the hummingbird effect or butterfly effect, the ringing of simple, banal actions can have a powerful effect in another part of the world. According to the classic example of the mathematician-meteorologist Edward Lorenz, the flapping wings of a butterfly in Brazil can cause a tornado in Texas (Lorenz, 1972) The butterfly effect was born as part of the broader chaos theory, which Gustáv Götz wrote: „The discovery of chaos fundamentally changed the way we see the world, and therefore many people, along with Einstein's theory of relativity and Heisenberg's quantum mechanics, have called it the ‚20th century'. „It is considered the third revolutionary scientific achievement of the 20th century." (Götz, 1993: 487).

Although the butterfly effect is mainly used in the natural sciences, it also has a strong literature in economics. Rajagopal's book (Rajagopal, 2015) details how

markets respond to the butterfly effect, noting, among other things, that improving corporate culture and response time makes firms competitive to avoid the negative consequences of the butterfly effect. (Rajagopal, 2015: 256). Wei-Bin Zhang applied the theory of the butterfly effect to the economic development of the Chinese economy (Zhang, 2021). In our study, we link the presence of the butterfly effect in the world of stock markets to the further spread of crises. Independently of the butterfly effect, the type of investor behaviour described by the prospect theory emerges. However, in a crisis, the two different phenomena tend to occur simultaneously.

Prospect theory is very similar to classical utility theory in that it too aims to determine the utility function of wealth. The difference, however, is that it is not the absolute level of wealth but the rate of change in wealth before investment that is relevant. It is also worth noting that the degree of utility is also perceived through subjective biases. To illustrate this difference, the authors propose the use of the value function instead of the classical utility function (Figure 1).

Figure 1: Value and classical utility function



(Source: Zsolt Bálint Nagy; Own editing)

The classical utility function shows the amount of consumption (U(x)) associated with a given quantity/good („x"). The meeting of the two values is represented by the utility function. In contrast, the value function shows the direction in which the rate of change in wealth shifts from the initial, origin point. However, moving away from the origin point reduces the relevance of the change in value. At the profit stage, the value function is concave, at which point the size of investors is risk averse, at the loss stage it is convex, with investors more likely to take risk.

„The loss stage is steeper than the gain stage, the convexity is greater than the concavity, simply put, the grief of loss is greater than the joy of gain. The sharp distinction between loss and gain is what Thaler (1980, 1999) called „mental accounting" of the effects." (Nagy, 2007)

Main approaches of Tversky and Kahneman

In their experiments, Kahneman and Tversky concluded (Kahneman – Tversky, 1979) that people prefer to choose a certain gain even if its expected value is lower than that of an uncertain gain (this phenomenon was analysed as early as 1953 by a French economist, Maurice Allais, and is therefore also called the Allais paradox, although he used different numbers) (Hamar, 2013: 45).

Kahneman and Tversky describe the possibility of a bet. At a risk of £450, you can lose, but you can win £1,000 if the bet goes through. Option A, the utility function of winning, has a higher value:

$u(1000)\times0.5 + u(0)\times0.5 = 1000\times0.5 + 0\times0.5 = 500$m whereas the utility of option B is $u(450) = 450$; together, risk averse individuals choose option B. (Orrell, 2021: 92). The initial coordinate of the graph of the prospect theory is 0. Subjective probability, however, is not the same as using weighted functions (Baddeley, 2019a:40). The utility function is affected by the change in the value of property (Mullainathan, 2007: 105).

According to the theory, gains and losses are determined by a reference point, but this reference point varies from situation to situation (Levine, 2009: 13). The perspective has two roots: the relevant risk and its utility (Baddley, 2019a: 54).The certainnity effect reduces the phenomenon of loss aversion, with investors taking risks according to the framework in which their perspectives are placed (Ayroza, Iwamoto, Rodrigues, 2018: 49).

Two elements are used to objectively quantify prospect theory: a weighted probability function and a value function. Subjective value judgements also play a role: individuals are generally averse to risking their prospective gains, but will take the risk if they stand to lose. The loss of a certain amount of money or other value – let's call it x – is bad, and the harm of losing x affects them more negatively, worse than the utility of gaining x of the same size. Hence, the phenomenon of loss aversion (Camerer, Loewenstein, 2004: 20-21). The reflection effect is felt in the betting theory of gain, loss and inactivity (Just, 2013: 215).

Kahneman was well versed as a psychologist in intuitive and reflective thinking. „The central idea of prospect theory is that there is no absolute utility, our decisions are always relative to a reference point, and in comparison, we can have positive or negative evaluations of utility (Hamar, 2013: 58). We judge our gains and losses in different ways, and we feel loss more strongly. We make our decision relative to our reference point, which gives rise to a bias called status quo bias (Baddeley, 2019b: 9). The practice of asymmetric decision making is summarised by Zsolt Nagy Bálint as follows:

„– Asymmetry – the reactions of the decision maker to a shift from a given state are not symmetric: we are more sensitive to a decrease in wealth than to an increase in wealth, a unit loss of wealth causes a greater decrease in utility than a unit increase in wealth. The traditional ‚risk aversion' is then replaced by ‚loss aversion'" (Nagy, 2007:5).

The derivation of the theory has been understood by several generations of economists, and its limitations have been reflected upon (Dhami, 2016: 130-138). Several critics of Kahneman argue that it is not possible to draw probabilities from

individual cases, since, as Gigerenzer says, „norms are always statistically valid, they can never apply to individual cases; if an individual case deviates from the norm, this is not in itself an anomaly, it does not escape the theoretical framework" (Hámori, 2003: 794). Graham Loomes and Robert Sugden contrast regret theory with prospect theory, which contrasts prospect theory's two possibilities with the perspective of multiple possibilities, since regret or pleasure over our decisions at a given moment influences our decision at that moment, but without knowledge of the subsequent conjuncture (Baddeley, 2017: 49).

A synthesis of behavioural economics published in 2013 summarises the weaknesses of the theory as follows: ‚The main limitation of prospect theory is its inability to provide insights into general price formation theory. At the same time, it is explicitly dynamic, due to the implicit predication principle. No one has yet managed to build a satisfactory asset pricing theory based on the utility functions of prospect theory" (Burton, Shah, 2013: 100).

At the same time, the workings of prospect theory can be verified not only by mathematical models and experiments, but also by everyday observations. For example, the phenomenon of loss aversion can be observed in financial markets: stock market turnover increases when prices rise (Orrell 2021: 95). In the world of insurance, a certain trend can also be observed, where the reference point is the current status quo, against which stakeholders weigh potential future risks (Kunreuther, Paully, McMorrow, 2013: 96). Subjective, intuition-based economic thinking can become particularly salient in times of crisis.

There is a rich literature on both the historical and econometric study of economic crises, and we would like to recall just a few ideas. One of these is the theory of the butterfly or hummingbird effect, in the light of which we can assess the global spread of crisis phenomena, whether their causes are real or speculative. According to Niall Ferguson, the butterfly effect can be summarized in the following way: both the weather and the economy are complex systems, and in the case of the economy this is increasingly the case since the industrial revolution. A complex system is made up of a very large number of interacting components arranged asymmetrically and operating somewhere between order and disorder, or to use the term of computer scientist Cristopher Langton, ‚on the edge of chaos'. The system works well over a long period of time, seemingly in equilibrium, but in fact constantly adapting. However, there may come a moment when the system enters a „self-generated critical state". A small stimulus (the flapping of a butterfly's wings or the infamous last grain of sand that knocks a whole pile over) can trigger a „transient transformation" from one state to another. (Ferguson, 2023: 99).

Predicting the unpredictable?

The different types of global, large-scale crises are distinguished by different code names in the literature. Among these, the term black swan has become known since Taleb's book and, using an analogy from Tchaikovsky's ballet, refers to unforeseen,

unsettling crises with mostly negative consequences (Taleb, 2010). The grey rhinoceros is a later concept and is much more predictable than the black swan in terms of the visibility of its antecedents. According to the concept's creator, Michele Wucker, it is a probable and imminent threat: something we should see coming...' (Wucker, 2016: 26 0).

The 2008 financial crisis was one of them. Also, according to its creator, the grey rhino has five stages: denial, obfuscation, diagnosis, panic and action (Wucker 2016: 43-46). The recently introduced concept of the dragon king is a metaphor for crises that are more unexpected than the black swan and much more powerful than the grey rhino. The creator of the traffic, Didier Sornette, found examples of it in six areas, one of which, a financial downturn, manifests itself specifically in the field of finance (Ferguson, 2021: 97). The dragon king is so unlikely, sudden and large in scale that it falls outside the distribution of power law. Sornette's study, after analysing crisis phenomena in the context of a few models, in particular the characteristics of the 2008 economic crisis, is very positive in its conclusion: crises and bubbles are and will be with us, but they are also perhaps the most constructive and collective phenomena, because there is a reaction to them, i.e. both adaptation and preparation (Sornette, 2009: 15-16). In other words, our world will not be destroyed by dragon kings, at least not in the stock market.... That being said, in fact, in the event of a global crisis, not only negative crisis phenomena and panic can spread, but also intervention measures to promote solutions, or even just spontaneous normalisation.

André Kostolany writes about the intertwining of buy-sell and human attitudes in the stock market as follows: ‚The factor of money and psychology is much more decisive for stock market tendencies than fundamental conditions. But man can only follow the money factor in an exact way, because the psychological factor is unpredictable." (Kostolany, 1990: 61-62) Prospect theory describes the peculiar behaviour where investors do not look at the final level of their investment, but relate their gains and losses to some subjective reference point, more sensitive to the sense of loss than to the sense of gain (Schleifer, 2000: 11).

There has been a considerable literature on this over the past decades, in particular in the light of case study-like analyses of indices of some major stock markets. For example, a 2009 study on the stock turnover of the Chicago Board Option Exchange from 1991-1995 derived the application of prospect theory to this S&P100 index (Gurevich, Kliger, Levy, 2009). Haim Levy and Moshe Levy examine the application of prospect theory in the context of Markowitz portfolio theory, using mean variance (MV) analysis, and suggest the possibility of applying the MV optimization algorithm to the case of porpholio returns (Levy, Levy, 2004). Sinha (1994) examines the veracity of prospect theory in the context of a regression model, reanalyzing the work of Avi Figenbaum published in 1990. In his analysis, Kaustia (2010) concludes that:

An investor with outlook preferences becomes more risk averse after experiencing a gain and more risk averse after experiencing a loss. Two Pakistani authors have analysed the phenomenon of financial leverage in the case of

Pakistani stock market movements, 2007-2019, their analysis is based on theories of expected and market efficiency, in addition to the propositions of prospect theory (Akhtar, Shah, 2021). Sibanda (2020) has examined investor behaviour in the context of the Zimbabwe stock market and identified eight thought biases known in behavioural economics. Foo, Wahihudin and Chie (2020), following their survey study, concluded that if an investor can choose between two positive options, he chooses the less risky one, and if he can choose between two negative options, he chooses the risky one if it minimizes his own losses. Hasan, Kayani, and Choudhury (2023) used prospect theory to analyze the relationship between risk and dividend changes using a database constructed from index data from 24 countries over the period 2000-2021.

In addition to this, we should mention the recent article by Ylin Wi (2023), in which he lists and analyses four relatively new analytical models for the application of prospect theory to the stock market. These are the BSV (Barberis and so on), DHS (Danial and so on), HS (Hong and Stein) and BHS (Barberis and so on) models.

As the literature review shows, it is relevant to examine stock market decision making in the light of prospect theory, so we have taken some historical data from some stock exchanges and performed some tests on them, as will be presented in the next section. We have tried to examine periods that are relevant to the literature and are well known as periods of crisis, e.g. the 2008 crisis as a black swan or the crown virus crisis, which can also be understood as a dragon king.

At the same time, we note that prospect theory is not the only approach to the psychological drivers of stock market investors' behaviour. Indeed, the disposition effect, i.e. the expectation of loss, contradicts the prospect theory, as Cartwright has deduced (Cartwright, 2011: 124-128). This is also confirmed by the recently published survey research of Singh, Adil and Haque (2023), who conducted a psychological study on Indian investors and found the presence of different thought biases for different types of investors, leaving open the potential for research in this area.

Hypotheses

I. In times of crisis, the two opposing ideas of the outlook theory, „risk seeking" and „risk aversion", prevail.
II. The global stock market system is also subject to the „hummingbird effect, which spreads with varying intensity."

Methodology

In total, we examined data from 6 different indices over the period 2006-2022 in relation to the VIX index. The indices are: Standard and Poor's 500, or S&P500 for short, which, tracks the weighted average of share prices of 500 large companies listed on US stock exchanges; Deutscher Aktien Index, DAX for short, which tracks the

stock market condition of 40 large German companies in one index; the Hungarian stock market index, BUX, which currently has 17 companies; and the Romanian BET, which has 20 companies; Financial Times Stock Exchange 100 Index, or FTSE100 for short, which is a share index of the 100 companies with the highest market capitalisation listed on the London Stock Exchange, the main stock market index of France, the CAC40, which has 40 French companies.

The index data were then processed, time-series adjusted, historical exchange rates and cross-rates were calculated in order to present the exchange rates in a uniform dollar amount. We then isolated 11 periods based on the VIX index data, alternating between quiet and crisis periods. As we have focused only on the crisis periods in this study, these are:

- 2.09.2008 – 30.06.2009 – crisis period
- 3.05.2010 – 30.06.2010 – crisis period
- 1.08.2011 – 30.11.2011 – crisis period
- 3.02.2020 – 30.06.2020 – crisis period
- 1.09.2020 – 30.11.2020 – crisis period

The periods were based on data from the VIX Volatility Index. In periods when the index value rose persistently above 40 points, we can talk about a crisis situation instead of the average range of 15-25. One good example is the penultimate crisis period, which was marked by the emergence and widespread spread of the coronavirus. During this period, the VIX was consistently between 60 and 80 points, clearly representing an extreme crisis situation.

The CBOE Volatility Index (VIX) is a real-time index that reflects expectations of the relative strength of short-term price movements in the S&P 500 Index (SPX). Because it is derived from the prices of options with short-term expiration dates on the SPX index, it generates a 30-day projection of volatility. Volatility, i.e. how quickly prices change, is often seen as a measure of market sentiment, and in particular of the degree of fear among market participants.

To process the correlation values, we use the Guilford (1950) system, which includes the following intervals:

0: no linear relationship
0-0.20: very weak, almost negligible relationship
0.20-0.40: secure but weak link
0.40-0.70: medium correlation, significant relationship
Above 0.70: high correlation, strong relationship

Another factor that we examine is the slope of the line. Since the VIX index inherently moves in the opposite direction to the indices, the slope of the line will be negative in most of the cases we examine. A positive slope of the line indicates an unnatural relationship. Another statistical slope that appears in the analysis is the coefficient of determination, or R^2, which refers to the strength of the relationship, so its interpretation is also important. The R-squared (R^2 or coefficient of determination) is therefore a statistical measure of the proportion of variance in the dependent variable explained by the independent variable. In other words, the r-square shows how well the data fit the regression model (goodness of fit).

Research results

In this chapter, the research findings are developed. A total of 11 periods have been identified. Of these 11 periods, 5 are crisis periods, and the evaluation of these periods follows. The first period was the financial crisis of 2008, followed by the Greek debt crisis and the Eurozone crisis in 2010 and 2011, and then the COVID panic in 2020.

In interpreting our results, we have tried to present graphs and tables that are understandable and interpretable, and from which it is possible to draw clear conclusions about the behaviour of the indices under study. Accordingly, the illustrative graphs have been selected to ensure that their data are relevant to the crisis being discussed.

The 2008 financial crisis

The financial crisis of 2008 is a prime example of the black swan phenomenon that we discussed in the introduction. The crisis basically originated in the US because of the bubble in the housing credit market. In 2006, 40% of borrowers were sub-prime borrowers. In a study by Iván Bélyácz, he summarised the main features of the onset of the 2008 crisis as follows: it occurred after a period when financial crises and risk levels in emerging economies appeared to be abating, and after a period of sustained high growth and low income volatility and sustained low inflation, with a high degree of tranquillity and relative stability in advanced economies (Bélyácz, 2014: 39).

This meant a turn to real estate loans for small people – in the United States of America, the hotbed of the crisis, but also in Europe – because, firstly, in the dynamism of the global world, owning property gives individuals a sense of inner peace and financial security, secondly, it is supposed to be one of the most time-proof investments, and thirdly, banks themselves, when granting real estate loans, felt their money was secure.

The sector continued to grow on hopes that house prices would rise. More and more loans were issued, and debt levels increased. Short-term profits for the banks, and the maintenance of the illusion of a prosperous economy by the Americans, triggered irrational behaviour on both sides, which was a straight road to collapse (Győrffy, 2009). Fear of default (FOMO) had a major impact on the development of the crisis. Everyone was afraid of missing out on a great investment opportunity in the real estate sector, which is entirely an irrational market behaviour and attitude. Just because one sector of the economy takes off at a particular time doesn't mean that everyone will just profit from it. There are always losers in such a situation.

The US state had to intervene several times during this period in the form of various financial bailouts. However, in September 2008, an arbitrary decision was taken not to bail out Lehman Brothers, one of the largest investment banks. That was when the crisis really erupted. The financial system was so interconnected that within a short period the effects of the crisis were felt everywhere. Millions of

people were out of work, the financial system was in tatters. Seeing this, the US state decided to try to rescue the other banks as best it could. The breakdown we use is September 2nd, because the VIX index had already started to rise, but it was only on the 15th that it really started to rise explosively. Table 2 shows the correlation values we calculated for the indices during the 2008 crisis period.

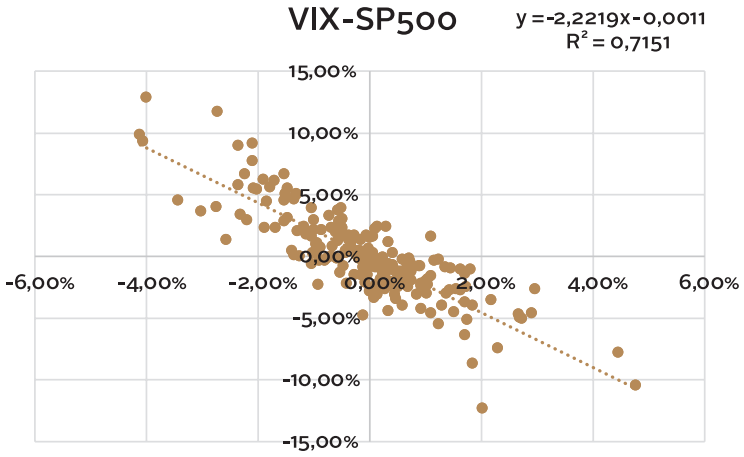
Figure 2: Correlation of the VIX index with other indices

	SP500	VIX	DAX	BET	BUX	FTSE 100	CAC 40
SP500	1						
VIX	-0,84632	1					
DAX	0,665116	-0,56313	1				
BET	0,379484	-0,30995	0,618426	1			
BUX	0,024464	-0,03454	0,218591	0,31033	1		
FTSE 100	0,586679	-0,5248	0,862918	0,605192	0,254206	1	
CAC 40	0,61072	-0,53313	0,926733	0,627981	0,222442	0,91635563	1

(Source: Own editing)

At that time, the correlation of the VIX index with the SP500 index was negative, but the value was 0.84632, indicating a significant relationship. The close relationship between the S&P500 and the VIX index is not surprising, as the VIX index is calibrated to be highly sensitive to changes in the S&P500.

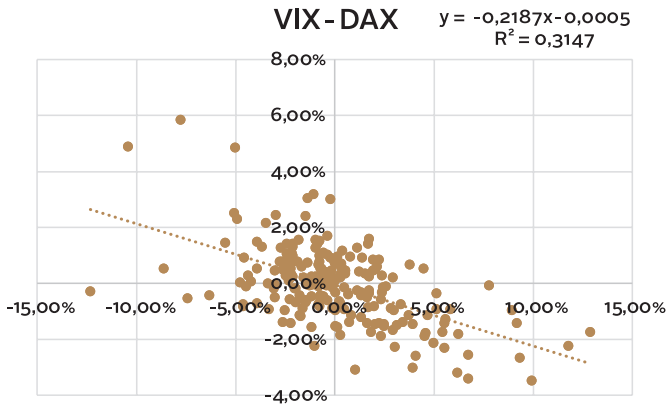
Figure 3: VIX-SP500 connection



(Source: Own editing)

As shown in Figure 3, the slope of the line is negative, indicating that the relationship between the two variables is negative. The value of R^2 is also high, 0.71, which also indicates the strength of the relationship. From the second half of September onwards, the value of the index fell from 1300 to 800-900 points, but in mid-2009 it also reached values between 700-800. This situation continued until mid-2009. From then on, markets started to moderate and the index returned to its normal range.

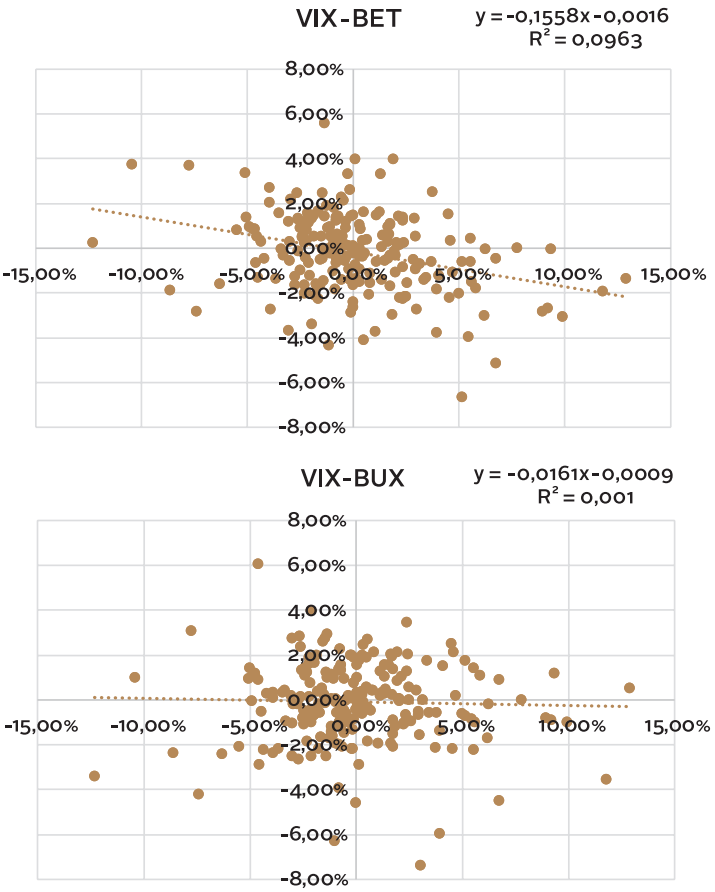
Figure 4: The VIX-DAX relationship



(Source: Own editing)

There was also a relatively strong relationship between the VIX and the German DAX index at this time, with the VIX index also reflecting the change in this index. The index has fallen from 10-11,000 points the previous month to almost half that level. Here the correlation level is lower, with many more outliers (Figure 4), but nevertheless also a strong relationship. The equation of the line also indicates that the relationship between the two variables is negative.

Figure 5: Romanian and Hungarian index values



(Source: Own editing)

The Romanian and Hungarian indices had almost no correlation with the VIX index movements, as shown in Figure 5. Although both indices fell during this period, this is due to the general panic and cannot be directly related to the VIX index movements. The change in the London Stock Exchange index, as well as the change in the French index, was also fed back by the VIX index, there was a significant relationship.

On the margins of the 2008 crisis, we can say that the crisis that started in the US quickly devastated other stock markets, as the regression data show. It could be seen as a kind of hummingbird effect. In the US, the easing of credit conditions was the ‚hummingbird's wing', which then escalated to the point where it spread to the US stock market, which then affected all the others.

The increase in the closeness between indices also reflects the risk aversion of investors. In a crisis situation, investors withdraw their money from the market

and sell their options, causing the value of the index to fall. Since the VIX index is calibrated to the SP500 data, it is clear that when the SP500 starts to fall, the VIX index starts to rise.

In this way, the US crisis was a good opportunity to prove the prospect theory. Risk seeking occurs after the crises have passed, when the markets recover.

The Greek debt crisis

Figure 6: Correlation of the VIX index during the Greek crisis

	SP500	VIX	DAX	BET	BUX	FTSE100	CAC40
SP500	1						
VIX	-0,9314	1					
DAX	0,61132	-0,6071	1				
BET	0,34123	-0,2876	0,6783	1			
BUX	0,24266	-0,2249	0,2093	0,44573	1		
FTSE100	0,67766	-0,6682	0,78441	0,60374	0,46887	1	
CAC40	0,64041	-0,6555	0,97999	0,67575	0,23264	0,80196	1

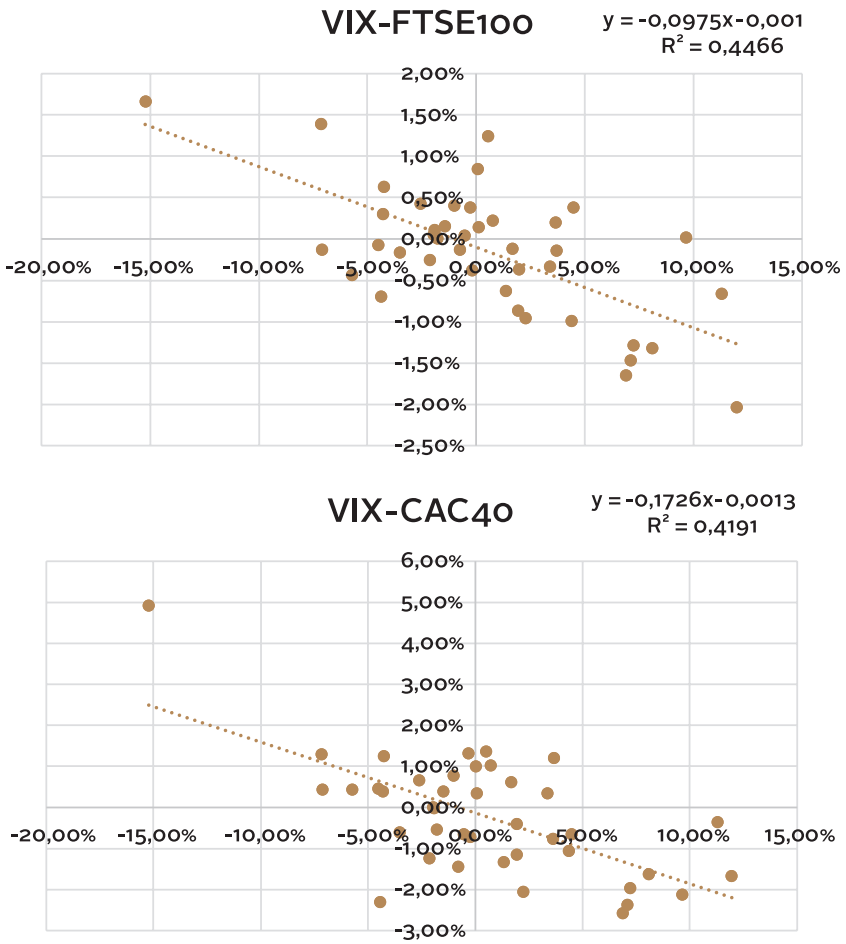
(Source: Own editing)

Another major global economic event that had a major impact on stock market trading was the Greek debt crisis that peaked in 2010. Before Greece joined the European Union, its public debt-to-GDP ratio was 104%, which was pushed up to around 130% by events in the US.

This deficit gave him an unfavourable debt rating, which meant he had to pay a premium on the loans he had taken out. Unable to repay the loans due, the government applied for a major bailout in April 2010 to cover its expenditure.

The first rescue package arrived at the end of April and was already reported back by the stock exchange in early May. It is worth noting, however, that while the VIX index showed a fall in the S&P500, the DAX in the FTSE100 and the CAC40, the Romanian and Hungarian indices did not. There are clear reasons for this. The countries lending to Greece were mainly Germany and France, which is why they were highly correlated with the VIX index to the same extent.

Figure 7: Correlation between the London index and the French index



(Source: Own editing)

Both the London and French indices were significantly correlated with the VIX index. Again, the slope of the line shows that the relationship between the two indices is negative

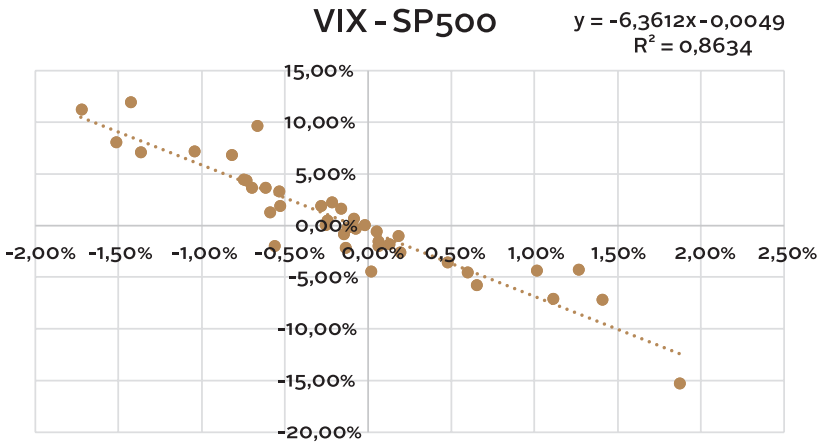
The correlation level also indicates a significant interconnection. Investors seem to have been temporarily uncertain about the fact that a member of the Eurozone is on the verge of default and that the core countries will have to provide financial support to Greece.

This uncertainty also caused a fall in the SP500, which led the VIX index to rise. Core country indices started to fall systematically. This uncertainty and price falls were well confirmed by the fear index, which explains the high correlation level.

As Romania and Hungary were not among the core countries and the euro was not used as official currency, there was no significant fall in the values of the two indices and therefore no relevant relationship between them.

The relationship between the S&P500 and the VIX index has risen to near-record levels (Figure 8).

Figure 8: Relationship between the VIX and the S&P 500

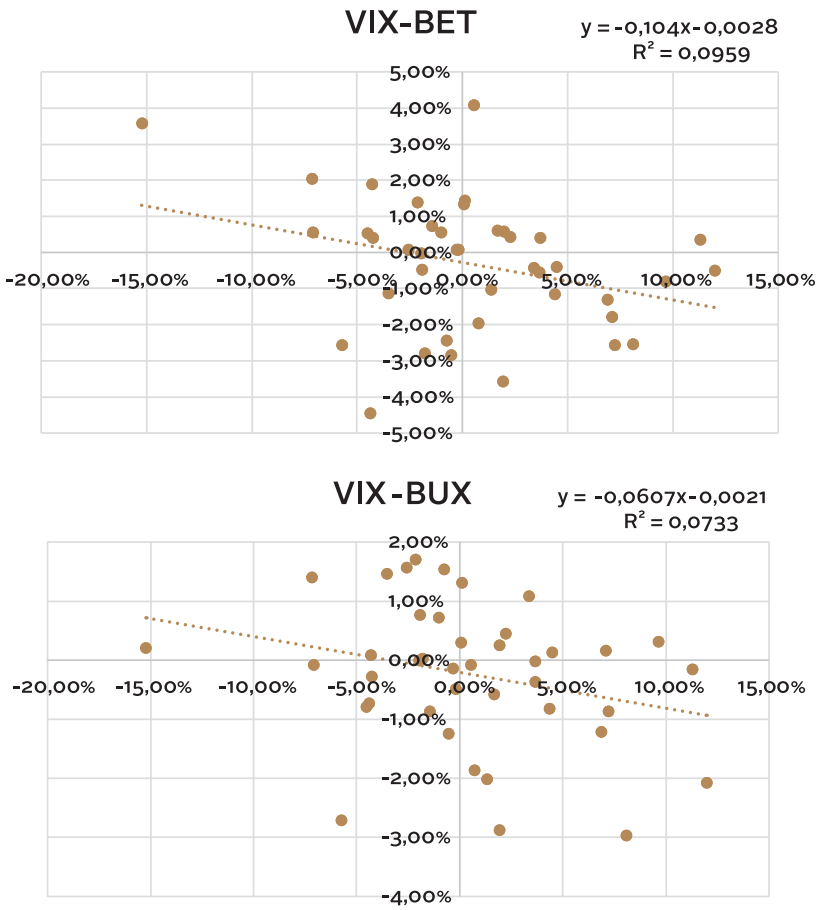


(Source: Own editing)

In terms of values and exchange rate depreciations, the Greek debt crisis is not comparable in magnitude to the events of 2008. It only had a minor impact on stock market trading for a month and a half and, as I have already mentioned, it did not cause a big fall in exchange rates. However, it was sufficient to make investors hesitate, and the fall in trading volumes and the rise in the VIX index are proof that crisis situations are accompanied by panic, which also affects stock market trading.

The correlation values of BET and BUX, as well as the regression coefficient, show that the debt crisis has not affected the two indices to a significant extent (Figure 9).

Figure 9: Relationship between the Hungarian and Romanian indices



(Source: Own editing)

In the wake of the Greek debt crisis, the stock markets of the major countries moved with the VIX index, but the Hungarian and Romanian stock markets were not affected.

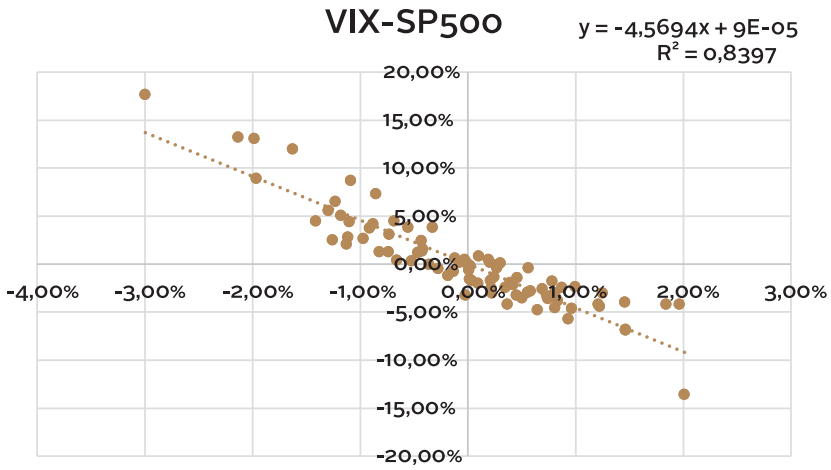
Figure 10: Correlations of the VIX index

	SP500	VIX	DAX	BET	BUX	FTSE100	CAC40
SP500	1,0						
VIX	-0,9130	1,0					
DAX	0,2849	-0,1853	1,0				
BET	0,4730	-0,4882	0,3178	1,0			
BUX	0,1866	-0,1933	0,1590	0,5342	1,0		
FTSE100	0,6566	-0,5490	0,3781	0,5974	0,4353	1,0	
CAC40	0,6990	-0,6296	0,2580	0,6087	0,4177	0,8476	1,0

(Source: Own editing)

On 8 August 2011, an event similar to Black Monday 1987 occurred. US and global equity markets fell as the weakening US economy and the widening European debt crisis reduced investor confidence. Prior to this event, the United States was downgraded for the first time in history by Standard & Poor's (S&P) from AAA to AA+. Investors' fears were illustrated by the fact that the VIX index almost doubled in value in 2 days and correlations with the VIX index increased.

Figure 11: The VIX-SP500 relationship



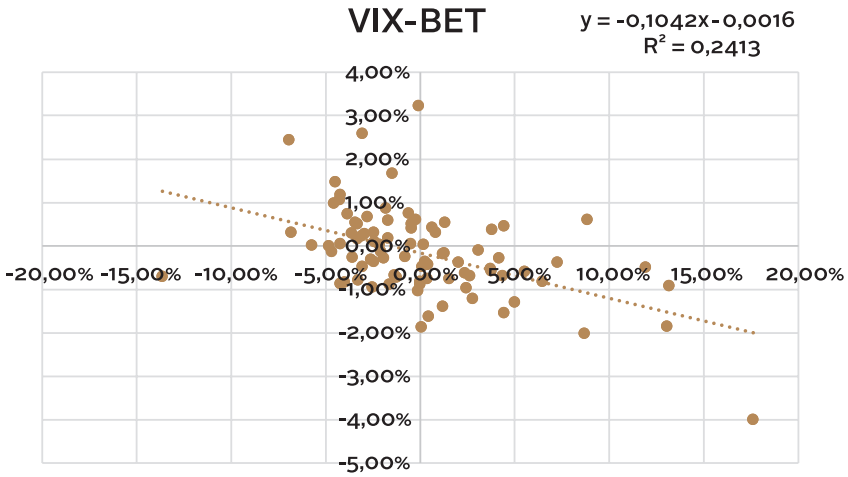
(Source: Own editing)

The relationship between the VIX and the S&P500 has also risen to near-record levels during this period. As the trigger for the fall was the US stock market, this is clearly shown in Figure 11. The slope of the regression line, as well as the distance of the points from the line, shows that the VIX as an explanatory factor is a good proxy for the change in the explained factor, the S&P500.

The German DAX and the BUX index of the Hungarian stock exchange were not so much affected by this large shock, and the VIX index did not necessarily explain their movements. The degree of correlation did not necessarily reach the expected value, nor did the slope of the regression line, the density of the point set, the R^2 value.

The Romanian BET index, changes at a low level but explained by the VIX index, with a medium correlation value.

Figure 12: Relationship between the Romanian index and the VIX index

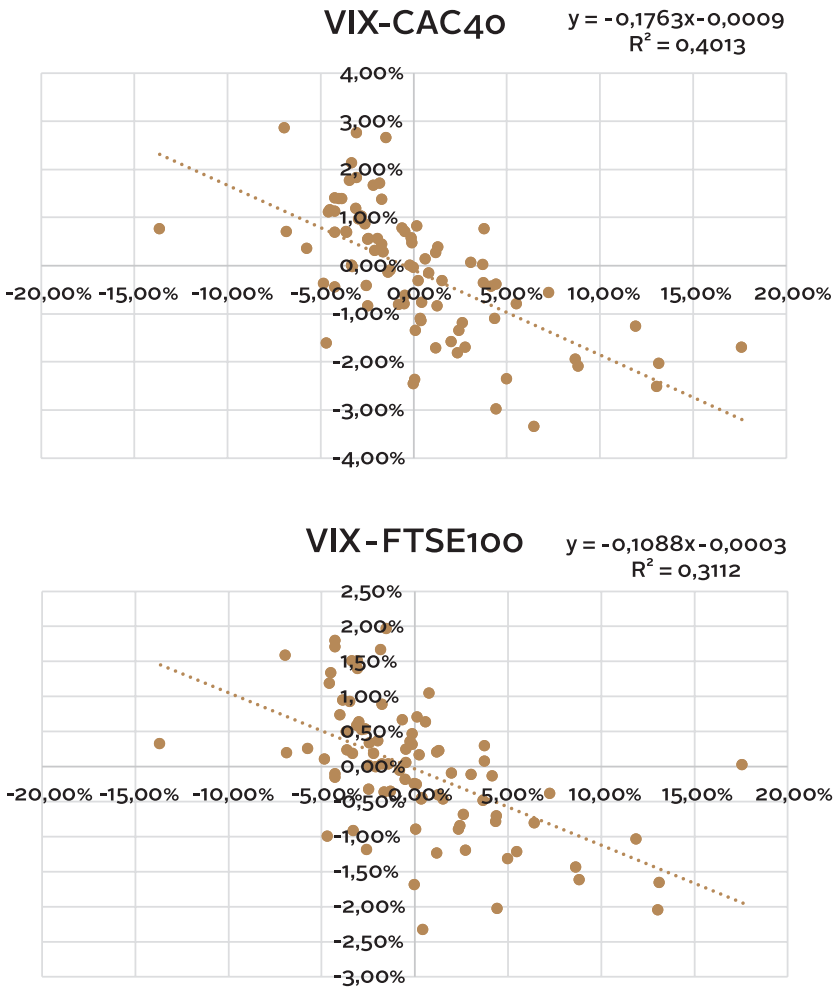


(Source: Own editing)

As can be seen in Figure 12, the value of R^2 is not very high, but the slope of the line and the location of the point cloud confirm that there is a minimal explained-explained relationship between the two indices.

However, the change in the London and French indices was well explained by the VIX index.

Figure 13: Relationship between the London and French indices



(Source: Own editing)

The age of the coronavirus

Figure 14: First wave of the coronavirus

	SP	VIX	DAX	BET	BUX	FTSE100	CAC40
SP	1,0						
VIX	0,2359	1,0					
DAX	0,0348	-0,1618	1,0				
BET	0,6972	0,0265	0,074	1,0			
BUX	0,6204	-0,1663	0,002	0,625	1,0		
FTSE100	-0,0063	-0,1482	0,161	0,186	0,047	1,0	
CAC40	-0,0045	-0,0517	-0,003	0,193	0,757	0,094	1,0

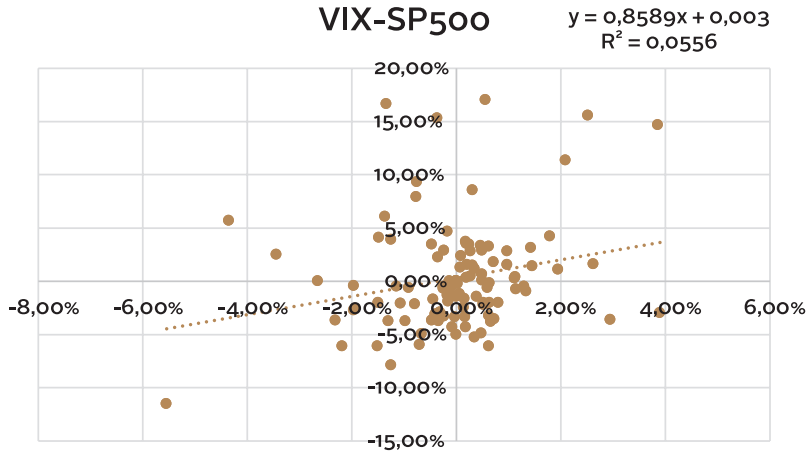
(Source: Own editing)

There is no need to go into much detail on the crisis caused by the crown virus this time. Everyone and every sector has suffered from it to a greater or lesser extent in all walks of life. It was not only the economy that suffered.

The WHO declared the coronavirus a health emergency on 30 January 2020. The stock exchange echoed this declaration on the second of February. The major leading indices have seen huge falls. The S&P500 fell more than 200 points in less than 1 hour. This has not happened since the stock market crash of ,87. The FTSE 100 fell almost 11%, similar to the DAX which fell 12.24%, but the French CAC40 closed down -13%. On 16 March the VIX index closed at a record high of 82.69.

However, an interesting phenomenon can be observed for the VIX index. Although it showed a high degree of volatility in terms of values, the correlation was completely divorced from all indexes. There is an unnatural positive correlation with the US index, but no significant relationship at all, and the regression model does not indicate any relationship. The slope of the lines is close to zero. and the location of the point clouds shows that the VIX has lost its explanatory function.

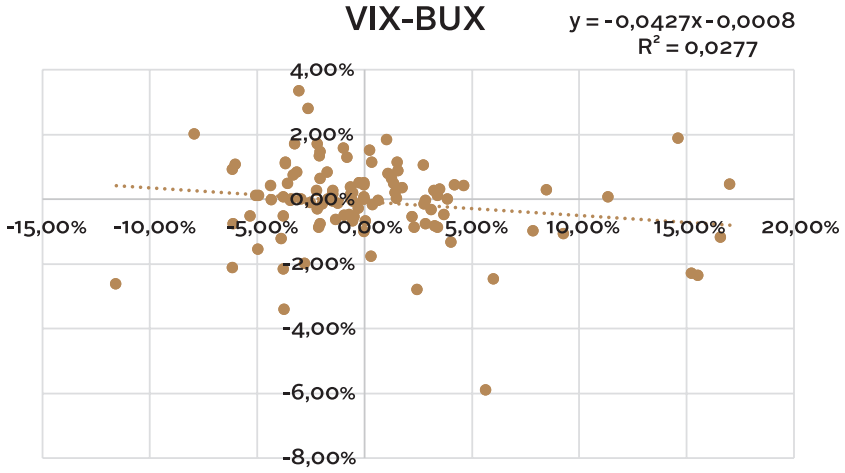
Figure 15: Relationship between VIX and SP during the first wave

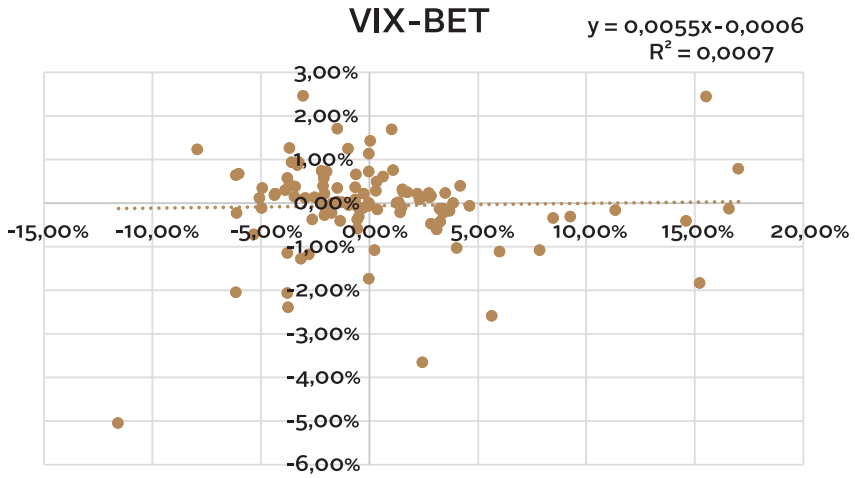


(Source: Own editing)

It can be observed in Figure 15 that instead of the usual high level of R^2 and negative correlation, there is a very low positive correlation.

Figure 16: Relationship with the Hungarian and Romanian indices





(Source: Own editing)

Figure 16 represents the relations between the Hungarian and Romanian indices. It can be clearly seen that the slope of the line is close to 0, and the point cloud location is very scattered, with many outliers. It can be seen that the value of R^2 approaches 0, so the VIX index as an independent variable does not explain the two dependent variables. This was no different in the second shock period.

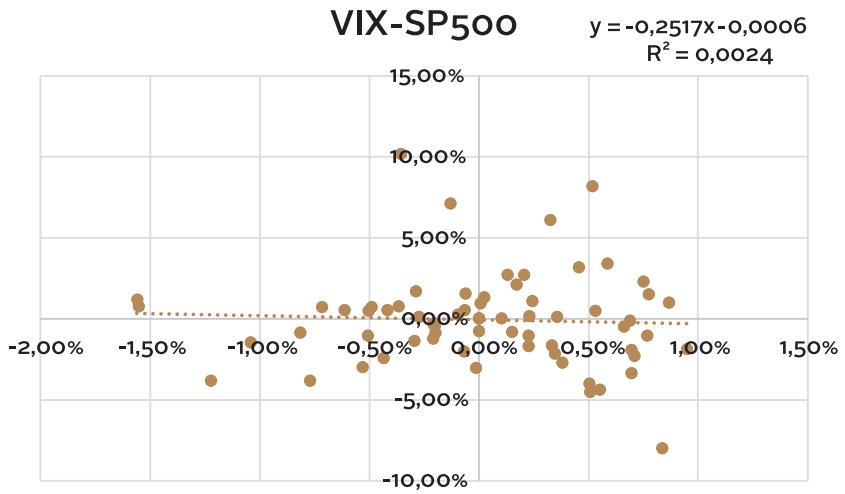
Figure 17: The second shock period

	SP500	VIX	DAX	BET	BUX	FTSE100	CAC40
SP500	1						
VIX	-0,0490	1					
DAX	0,2392	-0,1218	1				
BET	0,3032	-0,0856	0,0529	1			
BUX	0,3592	-0,2597	0,0996	0,5796	1		
FTSE100	-0,0052	-0,0312	0,1508	0,1523	0,2931	1	
CAC40	0,1435	-0,3069	0,1633	0,2187	0,6004	0,2487	1

(Source: Own editing)

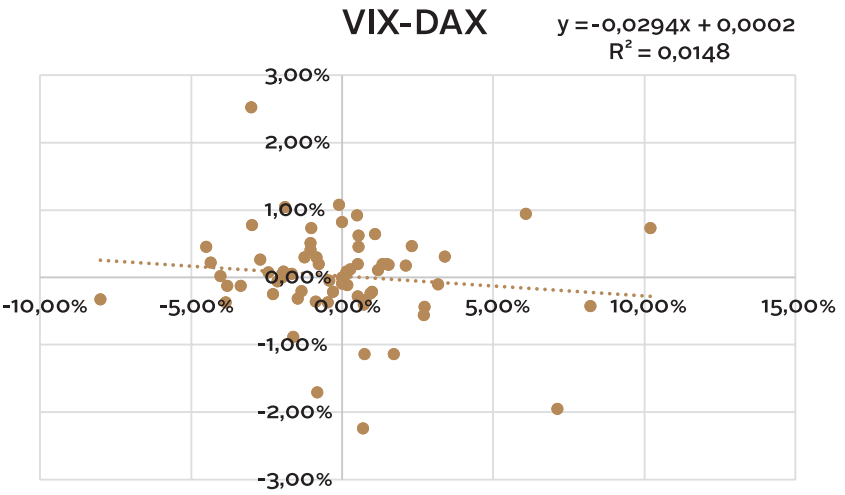
During the second shock period, the correlation values did not change much. The relationship between the VIX index and the SP500 was still not restored, and the explanatory function of the VIX did not recover. There was a low level of correlation with the French index, but this cannot be described as too close.

Figure 18: Relationship between the VIX and the S&P500



(Source: own editing)

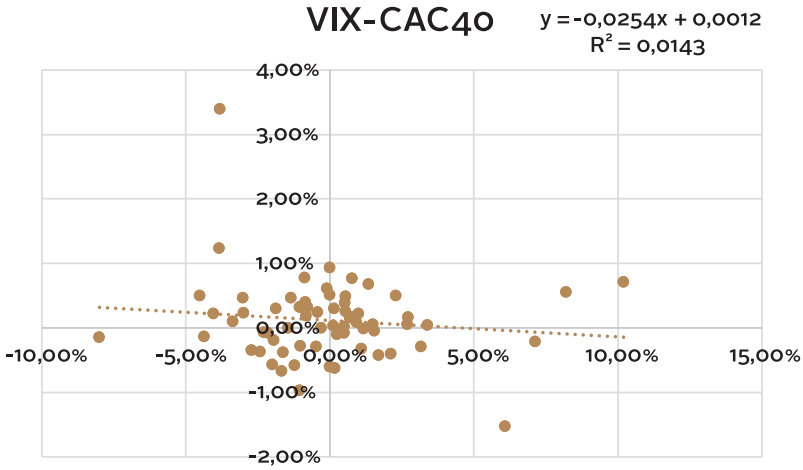
Figure 19: Relationship between the VIX and the German DAX



(Source: Own editing)

It can be clearly seen in Figures 19 and 20 that the relationships are not significant at all, the value of R^2 converges towards 0, and the regression line and point cloud do not indicate a relevant relationship.

Figure 20: Relationship between VIX and CAC40



(Source: Own editing)

Conclusions

One of the hypotheses of the thesis was that in times of crises, two counterpart ideas of the outlook theory, „risk seeking" and „risk aversion", prevail, which was confirmed by our statistical method. The obtained R^2 values, as well as the negative slope line, clearly indicated that investors become risk averse during crisis periods. This risk aversion is reflected in the fact that they start to withdraw money from the market, which causes the value of the index to decrease and the VIX index to increase.

The second hypothesis of the paper, that the hummingbird effect can also be observed in stock trading, is also supported by evidence. In particular, the 2008 crisis was a good example of how the loosening of borrowing criteria in the US had a strong impact on the German, French, London, and in some cases Romanian and Hungarian stock markets. But the Greek debt crisis has also had this further ringing effect, which can be interpreted as a kind of hummingbird effect.

Another important conclusion that has been drawn relates to the behaviour of the VIX index during the period of the coronavirus. During this period, research on a sample basis revealed that the VIX index even diverged from the SP500, which has no precedent in its existence.

Some say that the VIX index is „broken" and no longer a good measure of volatility, as the shock of the coronavirus has completely decoupled it from the rest, especially the US SP index. Another group of analysts believe the VIX index will recover over time based on options on the US index. ■

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