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Alternative investments during turbulent times – a comparison of dynamic relationships

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Abstract. The COVID-19 pandemic, like the Russian aggression against Ukraine, had a significant impact on many financial markets and asset prices. The latter additionally led to large fluctuations on financial markets. In our paper, we try to compare the performance of 'safe haven' assets during turbulent times, such as the recent global financial crisis, the eurozone debt crisis, the COVID-19 pandemic and the Russian aggression against Ukraine. We investigate the dynamic relationship between indices from several European countries (Czech Republic, France, Germany, Great Britain, Poland, Slovakia and Spain), and popular financial instruments (gold, silver, Brent and WTI crude oil, US dollar, Swiss franc and Bitcoin). The study further estimates the parameters of DCC or CCC models to compare dynamic relationships between the above-mentioned stock markets and financial instruments. The results demonstrate that in most cases, the US dollar and Swiss franc were able to protect investors from stock market losses during turbulent times. In addition, investors from France, Poland, the Czech Republic and Slovakia saw gold as a 'safe haven' asset throughout all the above-mentioned crises. Our findings are in line with other literature which points out that 'safe haven' instruments can change over time and across countries. In the literature, we can find research performed for the USA, China, Canada, and Great Britain, but there is no such research for Poland, France, the Czech Republic or Slovakia. The purpose of this paper is to try to fill this research gap.

Keywords: safe haven instruments, gold, silver, Bitcoin, dynamic correlation, global financial crisis, eurozone debt crisis, COVID-19 pandemic.

JEL: C6, C10, C32, C58, G11

1. Introduction

The world has witnessed several financial crises since the early 2000s. During the COVID-19 pandemic, the eurozone debt crisis and the global financial crisis we could observe huge falls in stock indices and fast changes in prices of many financial instruments. Also, we could see that prices of some instruments, like gold, might rise very quickly. In addition, increased volatility in the financial markets occurred, which was connected with high uncertainty and reduced risk appetite.

The first of the series was the European debt crisis, which began in 2008 with the collapse of Iceland's banking system. In 2009 it spread – mostly to Portugal, Italy, Ireland, Greece, and Spain (PIIGS). That crisis led to the loss of confidence in

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European businesses and economies. By the end of 2009, peripheral eurozone member states like Greece, Spain, Ireland, Portugal, and Cyprus were unable to repay or refinance their government debt (European Stability Mechanism, n.d.). Also in 2009, it turned out that the previous government of Greece had grossly underreported its budget deficit, thus violating the EU policy. This spurred additional fears regarding the stability of the euro and its potential collapse via political and financial contagion (Council on Foreign Relations, n.d.).

The global financial crisis (GFC), which lasted between mid-2007 and the beginning of 2009, was the second financial calamity that ravaged the global financial system. It was caused by a downturn in the US housing market. Its consequence was a crisis which spread from the USA to the rest of the world through links within the global financial system. Many banks all over the world suffered substantial losses and had to use governmental support to avoid bankruptcy. Millions of people lost their jobs as the major advanced economies experienced deepest recessions since the Great Depression of the 1930s. In addition, the recovery from the GFC was slower than in the case of past recessions, because unlike them, it had a financial background.

The COVID-19 pandemic was the third blow to several financial markets and asset prices, which in February 2022 was additionally aggravated by the Russian invasion of Ukraine. As a result, capital markets declined (as demonstrated by their main stock indices), while the prices of gold soared. Most of the European stock indices, especially in Central and Eastern Europe, plummeted. The same happened to European currencies, which depreciated against the US dollar. The prices of Russia- or Ukraine-produced commodities like crude oil, natural gas or wheat rose very fast (Fiszeder & Małecka, 2022).

The European Union, USA, UK, Canada, Switzerland, Japan, Australia and Taiwan imposed several sanctions on Russia. On 8 March 2022, US President Joe Biden signed an executive order banning imports of Russian oil, liquefied natural gas and coal to the United States (Morgan, 2022).

Meanwhile, the Russian ruble reached all-time lows. The Russian stock exchange closed on 25th February 2022 and has not re-opened since then (as of the time of writing this paper). The price of crude oil amounted to 130 USD per barrel (for the first time since 2008), and the gas price climbed to 200 euro per megawatt hour (Dutch TTF Gas Futures) at the beginning of March 2022. Gold prices were boosted by a 'safe haven' demand, and reached the highest level since August 2020.

Let us now look at Baur and Lucey's (2010) definitions of some related terms. According to these researchers, a 'hedge' is an asset that is uncorrelated or negatively correlated with another asset or a portfolio. A 'strict hedge' is an asset strictly negatively correlated with another asset or a portfolio. A 'diversifier' is an asset that is positively (but not perfectly) correlated with another asset or portfolio, whereas a 'safe haven' is an asset uncorrelated or negatively correlated with another asset or portfolio in times of market difficulties.

In turbulent times, risk-averse investors turn to precious metals as 'safe haven' assets. Interestingly, during the COVID-19 pandemic, and more specifically between January and March 2020, precious metals market fell. Prices of silver and platinum went down by 22% and 26%, respectively. Gold prices did not start rising until the 3rd week of March 2022. Prices of silver and other precious metals began to rebound later in 2020.

Traditionally, investors have used gold as a 'safe haven' asset (Baur and Lucey, 2010; Ji et al., 2020). Other precious metals like silver, palladium or platinum have been chosen less often, as their 'safe haven' properties seemed to last only over a short time-horizon (Bredin et al., 2017; Lahiani et al., 2021). Some literature finds 'safe-haven' properties of gold time-varying (Akhtaruzzaman et al., 2021; Shahzad, Raza et al., 2019) and market-specific (Beckmann et al., 2015; Shahzad, Bouri et al., 2019), while other studies question gold's safe-haven properties at all (Baur & Glover, 2012; Dee et al., 2013; Klein, 2017).

According to Lucey and Li (2015), the ability of gold to play the role of a 'safe haven' asset changes over time. Baur and McDermont (2010) assert that gold can act as a 'hedge' or a 'safe haven' for major European and US stock markets, but not for other markets. Beckmann et al. (2015) also see 'hedge' and effective 'safe haven' properties in gold. According to Hood and Malik (2013), gold acts like a weak 'safe haven' and a strong 'hedge' asset on the US stock markets.

In addition to precious metals, currencies and commodities can also perform as 'safe haven' assets on financial markets. According to Ranaldo and Soderlind (2010), the Swiss franc and the Japanese yen often play that role during crises. Several other researchers agree with them regarding the Swiss franc, but also attribute 'safe haven' properties to the US dollar (Grisse & Nitschka, 2015; Kaul & Sapp, 2006; Ranaldo & Söderlind, 2010). Bouri et al. (2020) shows that the commodity index is a weak 'safe haven' for some stock indices. Commodities, such as crude oil (Xia et al., 2019), are reported to have been behaving differently since the 2008 global financial crisis (Wu et al., 2020). Będowska-Sójka and Kliber (2021) compare the 'safe-haven' properties of Ether and Bitcoin displayed during various market turbulences. Łęt and Siemaszkiewicz (2020) investigate the 'safe-haven' properties of Bitcoin, gold, and fine wine market against stocks.

This paper attempts to compare the performance of 'safe haven' assets during the global financial crisis, the eurozone debt crisis, and the period of the COVID-19 pandemic and the partially overlapping Russian aggression against Ukraine. The author investigates the dynamic relationship between the following European countries: the Czech Republic, France, Germany, Great Britain, Poland, Slovakia, Spain, and the popular instruments: gold, silver, Brent and WTI crude oil, US dollar, Swiss franc and Bitcoin.

2. Data and methodology

The research analysis was carried out using indices of the main stock exchanges, i.e. CAC40 (France), DAX (Germany), FTSE250 (Great Britain), IBEX35 (Spain), PX (Czech Republic), SAX (Slovakia) and WIG (Poland), as well as gold, silver, Brent and WTI crude oil, US dollar, Swiss franc and Bitcoin. We considered three periods: from 1st October 2007 to 31st of March 2009 (sample for the global financial crisis), from 1st January 2010 to 1st June 2012 (sample for the eurozone debt crisis), and from 3rd February 2020 to 30th June 2022 (sample for the COVID-19 pandemic and the Russian aggression against Ukraine). Price rates of metals and crude oil taken from the Thomson Reuters database are quoted in US dollars (continuous futures series). The rest of the data came from the Stooq portal (stooq.pl). We date-adjusted the time series for the observations of indices and metals for particular countries having taken into account holidays during which there was no trading. All the calculations used daily percentage logarithmic returns defined as $r_t = 100 \cdot \ln \frac{P_t}{P_{t-1}}$, where P_t denoted the price of an asset at time t.

Table 1 presents descriptive statistics for the rates of return series on gold, silver, Brent and WTI, US dollar, Swiss franc and Bitcoin, as well as for the CAC40, DAX, FTSE250, IBEX35, PX, SAX and WIG stock exchange indices, in all the studied periods. As regards the first sample (the global financial crisis), the mean value was close to zero: in three cases it was positive, and for the other ten instruments it was negative. The highest volatility as measured by the standard deviation was observed for WTI. The highest skewness was reported for SAX, and it was positive for six instruments. In the other seven cases it was negative, which indicates a long-left tail of the empirical distribution of returns. Surprisingly, the highest kurtosis was observed for SAX, which might be caused by a long period of observation.

In the case of the second period (the eurozone debt crisis), the mean value in eight instances was positive, and in six negative. The highest standard deviation was observed for silver. The highest skewness was reported for IBEX 35: in three cases it was positive, and for the other instruments it was negative. The highest kurtosis was observed for SAX.

As far as the last sample (the COVID-19 pandemic and the Russian aggression against Ukraine) is concerned, the mean value was close to zero: in four cases it was negative, and positive for the remaining instruments. The highest volatility as measured by the standard deviation was observed for WTI, the highest skewness for

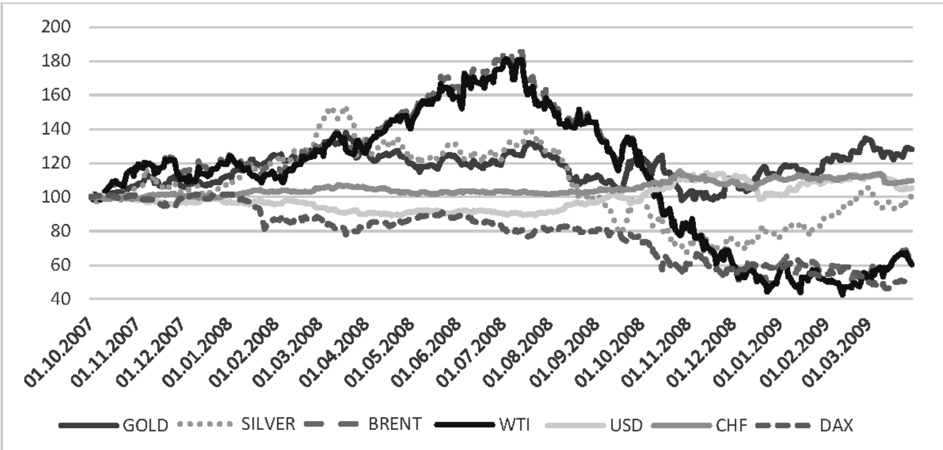
WIG, positive skewness for four instruments, and negative skewness in the remaining cases. The highest kurtosis was reported for WTI.

Table 1. Descriptive statistics for the rates of return series of the analysed instruments

Asset	Min	Max	Mean	St. dev.	Skewness	Kurtosis
Global financial crisis						
GOLD	−6.661	9.235	0.060	1.651	0.155	3.846
SILVER	−12.391	9.786	−0.002	2.473	−0.265	3.121
BRENT	−10.945	12.707	−0.118	3.375	−0.045	1.384
WTI	−12.959	18.587	−0.128	3.567	0.108	2.574
USD	−3.408	2.674	0.018	0.880	−0.355	1.732
CHF	−3.402	2.051	0.025	0.575	−0.691	5.895
CAC40	−9.472	10.595	−0.181	2.273	0.322	4.519
DAX	−7.433	10.797	−0.165	2.152	0.476	5.594
FTSE250	−6.735	7.462	−0.142	1.887	−0.020	1.232
IBEX35	−9.586	10.118	−0.156	2.210	0.145	4.053
PX	−16.186	12.364	−0.231	2.662	−0.337	7.819
SAX	−5.128	11.880	−0.066	1.167	2.403	33.396
WIG	−8.289	6.084	−0.239	1.840	−0.321	1.808
Eurozone debt crises						
GOLD	−5.390	3.568	0.063	0.968	−0.587	3.477
SILVER	−17.050	8.149	0.084	2.077	−1.309	9.164
BRENT	−8.790	5.465	0.032	1.699	−0.315	1.723
WTI	−8.700	5.928	0.003	1.867	−0.386	1.490
USD	−2.310	2.524	0.023	0.716	0.176	0.443
CHF	−8.450	3.035	0.033	0.741	−2.797	32.654
CAC40	−5.630	9.221	−0.046	1.586	0.046	3.056
DAX	−5.990	5.210	0.002	1.466	−0.215	2.124
FTSE250	−5.030	5.262	0.017	1.158	−0.402	1.976
IBEX35	−6.870	13.484	−0.108	1.765	0.508	6.007
PX	−6.130	7.249	−0.044	1.330	−0.272	3.352
SAX	−14.810	4.258	−0.053	1.283	−3.535	33.665
WIG	−6.240	4.579	−0.013	1.181	−0.658	3.851
COVID-19 pandemic						
GOLD	−5.114	4.961	0.020	1.047	−0.426	3.050
SILVER	−16.080	8.243	0.023	2.269	−0.873	7.645
BRENT	−27.976	19.077	0.112	3.395	−1.720	17.584
WTI	−56.859	22.394	0.121	4.728	−3.144	42.165
BITCOIN	−31.877	16.589	0.114	4.592	−0.842	5.989
USD	−1.527	2.485	0.007	0.451	0.173	1.523
CHF	−1.355	1.739	0.009	0.303	0.256	3.998
CAC40	−13.098	8.056	0.002	1.616	−1.013	10.798
DAX	−8.981	7.943	−0.003	1.649	−0.322	6.195
FTSE250	−9.820	8.039	−0.020	1.448	−0.687	8.482
IBEX35	−15.151	8.225	−0.024	1.653	−1.335	14.467
PX	−8.377	7.515	0.025	1.264	−1.176	9.923
SAX	−7.226	6.804	0.008	1.034	0.135	11.593
WIG	−11.347	7.433	−0.009	1.536	1.536	9.781

Source: author's calculations.

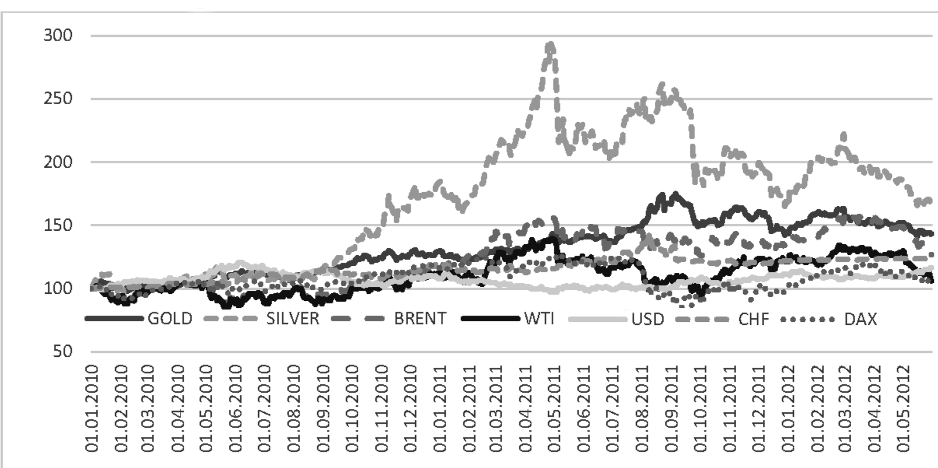
Figure 1. Normalised quotations of gold, silver, Brent, WTI, US dollar, Swiss franc and DAX during the global financial crisis



Source: author's calculations.

Figure 1 presents normalised quotations of gold, silver, Brent, WTI, US dollar, Swiss franc, and the DAX index in the period from 1st January 2007 to 31st March 2009. It shows that obtaining the highest value for investment in gold was possible at the end of the above-mentioned period. Also, the figure indicates the beginning of the downward trend in the value of the DAX index in early February 2008.

Figure 2. Normalised quotations of gold, silver, Brent, WTI, US dollar, Swiss franc and the DAX index during the eurozone debt crisis

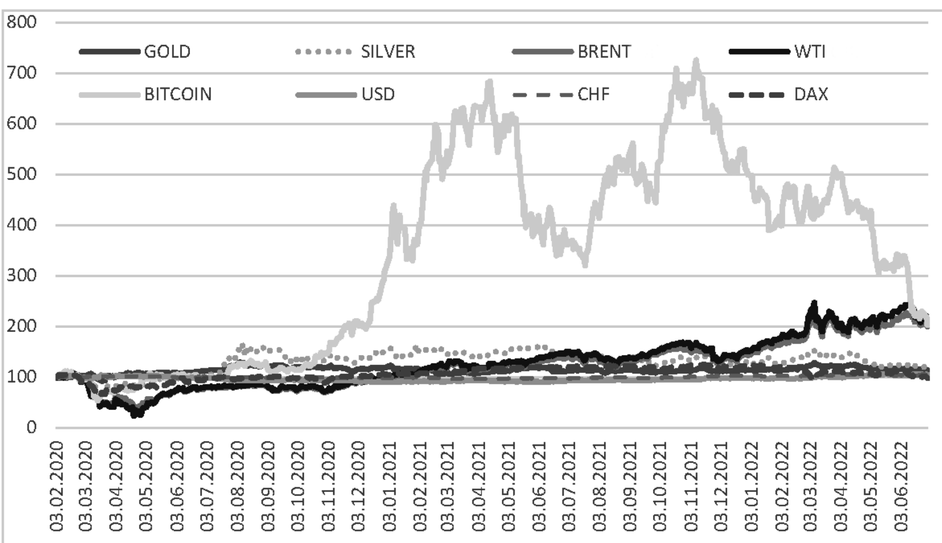


Source: author's calculations.

Figure 2 presents normalised quotations of gold, silver, Brent, WTI, US dollar, Swiss franc, and the DAX index in the period from 1st January 2010 to 1st June 2012. It shows that it was possible to obtain the highest value for investment in silver at the end of the studied period. The figure also indicates the fall in the value of the DAX index at the beginning of August 2011, caused by the European financial regulator's announcement of a ban on all forms of short selling among banks and other financial institutions. The ban was imposed as a result of growing instability on markets, initialled by rumors of French banks risking downgrades and by the concerns of various European banks linked to indebted economies such as Greece.

Figure 3 presents normalised quotations of gold, silver, Brent, WTI, US dollar, Swiss franc, Bitcoin, and the DAX index in the period from 3rd February 2020 to 30th June 2022. According to Figure 3, it was possible to obtain the highest value for investment in Bitcoin at the end of the studied period, and Bitcoin quotations were subject to the most substantial changes.

Figure 3. Normalised quotations of gold, silver, Brent, WTI, US dollar, Bitcoin, Swiss franc and DAX during the COVID-19 pandemic



Source: author's calculations.

2.1. Dynamic conditional correlation and constant conditional correlation models

Let $Y_t = (y_{1,t}, \dots, y_{k,t})$ be the k −sized vector of observation at time *t*. The total number of observations is $n \in \mathbb{N}$. We assume that $E_{t-1}[\varepsilon_{i,t}] = 0$ and $E_{t-1}[\varepsilon_{i,t}, \varepsilon'_{i,t}] = H_t$. The dynamic conditional correlation (DCC) model of Engle (2002) reads:

$$Y_t = \mu_t + \varepsilon_t, \text{with } \varepsilon_t = \boldsymbol{H}_t^{1/2}\mathbf{z}_t, \tag{1}$$

$$\boldsymbol{H}_t = \boldsymbol{D}_t \boldsymbol{R}_t \boldsymbol{D}_t \tag{2}$$

$$\boldsymbol{D}_t = \operatorname{diag}\left(\sqrt{h_{11,t}}, \dots, \sqrt{h_{kk,t}}\right), \tag{3}$$

where μ_t is the k-dimensional conditional mean structure, $\boldsymbol{H}_t$ denotes the $(k \times k)-$ sized conditional variance matrix, $\mathbf{z}_t$ is a k-dimensional vector of independent and identically distributed random variables with zero mean and unit variance, $\boldsymbol{R}_t$ is the dynamic correlation matrix of size $(k \times k)$ from which we obtain the time-varying correlation coefficient estimates, and $\boldsymbol{D}_t$ is the diagonal matrix of conditional standard deviations of ε_t. We assume that $\mathbf{z}_t \sim St - t_v(0, I_k)$. Let $z_{i,t}$ denote the standardised residual with respect to the idiosyncratic volatility given as $z_{i,t} = \varepsilon_{i,t}/\sqrt{h_{ii,t}}$. The dynamic correlation matrix then decomposes to

$$\boldsymbol{R}_t = (\operatorname{diag} \boldsymbol{Q}_t)^{-1/2} \boldsymbol{Q}_t (\operatorname{diag} \boldsymbol{Q}_t)^{-1/2}, \tag{4}$$

where $\boldsymbol{Q}_t$ denotes the covariance matrix of the standardised residuals $z_t = \left(z_{1,t}, \dots, z_{k,t}\right)$. Engle (2002) introduced a GARCH (1,1)-like structure on the elements of $\boldsymbol{Q}_t = [q_{ij,t}]_{i,j=1}^{k,k}$ with

$$\begin{aligned} q_{ij,t} &\coloneqq \bar{\rho}_{ij} + \alpha\left(z_{i,t-1}z_{j,t-1} - \bar{\rho}_{ij}\right) + \beta\left(q_{ij,t-1} - \bar{\rho}_{ij}\right) = \\ &= \bar{\rho}_{ij}(1 - \alpha - \beta) + \alpha z_{i,t-1}z_{j,t-1} + \beta q_{ij,t-1}, \end{aligned} \tag{5}$$

which is a mean reverting as long as $\alpha + \beta < 1$, and where $\bar{\rho}_{ij}$ is the unconditional expectation of $q_{ij,t}$ with $\bar{\rho}_{ii} = 1$ for all $i = 1, \dots, k$. An estimator for the dynamic correlation is then obtained by calculating:

$$\begin{aligned} \rho_{ij,t} &= \frac{q_{ij,t}}{\sqrt{q_{ii,t}q_{jj,t}}} = \\ &= \frac{\bar{\rho}_{ij}(1 - \alpha - \beta) + \alpha\xi_{i,t-1}\xi_{j,t-1} + \beta q_{ij,t-1}}{\sqrt{1 - \alpha - \beta + \alpha\xi_{i,t-1}^2 + \beta q_{ii,t-1}}\sqrt{1 - \alpha - \beta + \alpha\xi_{j,t-1}^2 + \beta q_{jj,t-1}}}. \end{aligned} \tag{6}$$

The difference between DCC and the constant conditional correlation (CCC; Bollerslev, 1990) models is shown in Equation (2), in which $\boldsymbol{H}_t$ is defined as

$$\boldsymbol{H}_t = \boldsymbol{D}_t \boldsymbol{R} \boldsymbol{D}_t, \tag{7}$$

where $\boldsymbol{H}_t$ is a conditional variance matrix and $\boldsymbol{R}$ is the constant conditional correlation matrix of process ε_t.

The vector GARCH (p, q) process of ε_t is defined as (Nakatani & Teräsvirta, 2008)

$$\boldsymbol{h}_t = \boldsymbol{a}_0 + \sum_{i=1}^{q} \boldsymbol{A}_i\, \varepsilon_{t-1}^{(2)} + \sum_{j=1}^{p} \boldsymbol{B}_j\, h_{t-j}, \tag{8}$$

where $\varepsilon_{t-1}^{(2)} = (\varepsilon_{1,t}^2, \dots, \varepsilon_{N,t}^2)', \boldsymbol{a}_0$ is a k-dimensional vector, and $\boldsymbol{A}_i$ and $\boldsymbol{B}_j$ are $(k \times k)$ matrices with elements such that $h_{ii,t}$ in $\boldsymbol{h}_t$ are positive for all *t*.

Equations (1), (2) and (8) jointly define the k-dimensional CCC-GARCH (p, q) model if $\boldsymbol{A}_i$ and $\boldsymbol{B}_j$ are diagonal for all *i* and *j*.

In 1986, Engle and Bollerslev proposed an integrated GARCH (IGARCH) model. Many studies have shown that the sum of the parameters in GARCH models is almost always close to unity. In the IGARCH model, we assume the sum of the parameters to be equal to one, which means that the return series is not covariance-stationary, and there is a unit root in the GARCH process (Jensen & Lange, 2007). Jensen and Lange pointed out that 'the conditional variance of the GARCH model converges in probability to the true unobserved volatility process even when the model is misspecified and the IGARCH effect is a consequence of the mathematical structure of a GARCH model and not the property of the true data-generating mechanism'.

The condition for IGARCH is $\sum_{i=1}^{q} \alpha_i + \sum_{i=1}^{p} \beta_i = 1$. For the IGARCH model, Equation (5) assumes then the following form:

$$q_{ij,t} = (1 - \lambda)\left(z_{i,t-1} z_{j,t-1} \right) + \lambda q_{ij,t-1}, \tag{9}$$

where $\lambda = 1 - \alpha = \beta$. Then the DCC model is called an 'Integrated DCC'.

The GJR-GARCH was proposed by Glosten et al. (1993). This model assumes the revelation of and taking into account the asymmetry properties of financial data by means of obtaining conditional heteroscedasticity (see Glosten et al., 1993). The general form of the GJR-GARCH (q, p) is

$$\sigma_t^2 = w + \sum_{i=1}^{q} (\alpha_i + \lambda_i\, I_{t-i})\varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2, \tag{10}$$

where I_{t-i} is an indicator function taking the value of one if the residual is smaller than zero and the value of zero if the residual is larger than or equal zero, i.e.

$$I_{t-i} = \begin{cases} 1 \text{ if } \varepsilon_{t-i} < 0 \\ 0 \text{ if } \varepsilon_{t-i} \geq 0 \end{cases}.$$

3. Results and discussion

This part of the paper presents the research results for the CAC40, DAX, FTSE250, IBEX35, PX, SAX, and WIG indices obtained using the methodology described earlier in the article. As mentioned before, we considered three periods: 1st October 2007 to 31st of March 2009 (sample for the global financial crisis), 1st January 2010 to 1st June 2012 (sample for the eurozone debt crisis), and 3rd February 2020 to 30th June 2022 (sample for the COVID-19 pandemic and the Russian aggression against Ukraine).

Table 2. Static correlation between the studied instruments for the period of 1 Oct 2007–31 March 2009

Instrument	GOLD	SILVER	BRENT	WTI	USD	CHF
SILVER	0.768	1				
BRENT	0.219	0.149	1			
WTI	0.177	0.137	0.817	1		
USD	–0.127	–0.099	–0.008	–0.006	1	
CHF	–0.065	–0.090	–0.231	–0.291	–0.057	1
DAX	**–0.150**	**–0.041**	0.024	0.028	**–0.027**	**–0.074**
FTSE250	**–0.093**	0.056	0.026	0.042	**–0.030**	**–0.080**
CAC40	**–0.173**	**–4.8E–05**	0.003	0.016	0.034	**–0.081**
IBEX35	**–0.163**	**–0.046**	**–0.003**	0.018	0.009	**–0.059**
WIG	**–0.016**	0.027	0.050	0.063	**–0.038**	**–0.091**
PX	0.132	0.015	0.341	0.283	**–0.051**	**–0.209**
SAX	0.027	**–0.003**	0.040	0.021	**–0.024**	0.006

Note. Numbers in bold indicate that the instrument can be considered as a 'safe haven' for a given asset.
Source: author's calculations.

Table 2 presents the static correlation between the studied financial instruments during the sample period for the global financial crisis. We can see that gold, the USD and the CHF were able to act like 'safe haven' instruments, and the correlation coefficient was negative (bold numbers).

Table 3. Static correlation between the studied instruments for the period of 1 Jan 2010–1 June 2012

Instrument	GOLD	SILVER	BRENT	WTI	USD	CHF
SILVER	0.727	1				
BRENT	0.130	0.234	1			
WTI	0.108	0.217	0.857	1		
USD	−0.109	−0.149	−0.431	−0.441	1	
CHF	0.070	−0.009	−0.214	−0.243	0.337	1
DAX	0.014	0.158	0.443	0.466	**−0.395**	**−0.205**
FTSE250	0.090	0.227	0.498	0.496	**−0.345**	**−0.178**
CAC40	0.019	0.158	0.467	0.470	**−0.409**	**−0.210**
IBEX35	**−0.028**	0.105	0.402	0.389	**−0.451**	**−0.245**
WIG	**−0.030**	**−0.034**	0.003	0.004	**−0.024**	0.029
PX	0.057	0.208	0.364	0.334	**−0.255**	**−0.164**
SAX	0.008	0.012	0.012	0.027	**−0.056**	0.008

Note. Numbers in bold indicate that the instrument can be considered as a 'safe haven' for a given asset.
Source: author's calculations.

Table 3 presents the static correlation between the analysed financial instruments during the sample period for the eurozone debt crisis. We can see that the USD and the CHF assume the role of a 'safe haven' here.

Table 4. Static correlation between the analysed instruments for the period of 3 Feb 2020–30 Jun 2022

Instrument	GOLD	SILVER	BRENT	WTI	BITCOIN	USD	CHF
SILVER	0.604	1					
BRENT	0.058	0.220	1				
WTI	0.008	0.191	0.837	1			
BITCOIN	0.054	0.250	0.198	0.162	1		
USD	−0.149	−0.126	0.081	0.078	−0.050	1	
CHF	0.086	0.056	−0.086	−0.051	−0.023	0.319	1
DAX	0.021	0.174	0.219	0.154	0.244	**−0.075**	**−0.094**
FTSE250	0.058	0.228	0.255	0.167	0.277	**−0.077**	**−0.113**
CAC40	**−0.022**	0.203	0.375	0.265	0.251	**−0.073**	**−0.150**
IBEX35	**−0.055**	0.127	0.290	0.202	0.292	**−0.028**	**−0.145**
WIG	0.087	0.155	0.120	0.075	0.268	**−0.063**	**−0.036**
PX	0.103	0.037	0.016	0.027	0.082	**−0.172**	**−0.112**
SAX	**−0.006**	0.019	**−0.024**	0.002	0.001	0.002	0.055

Note. Numbers in bold indicate that the instrument can be considered as a 'safe haven' for a given index.
Source: author's calculations.

Table 4 presents the static correlation between the studied instruments during the sample period for the COVID-19 pandemic. The USD and CHF were able to act like a 'safe haven' in that period. Gold displayed similar properties, but only for investors from France, Spain and Slovakia.

We obtained the estimation of DCC or CCC model parameters by means of OxMetrics professional program by Jurgen A. Doornik. Every consecutive table describes models which could be estimated.

Table 5. Parameter estimates of DCC or CCC models (the covariance part) of pairwise synchronised return data of a chosen instrument and the CAC40 stock index for the studied periods. Robust standard errors are available upon request

Instrument	**01.10-2007–31.03.2009**				
	Model	$\bar{\rho}$	α	β	ν
GOLD	DCC-IGARCH	**–0.855689**	0.435508	0.548063	35.437678
SILVER	DCC-IGARCH	0.864911	0.372007	0.610552	17.843321
BRENT	DCC-IGARCH	0.813531	0.363481	0.635019	28.651271
WTI	DCC-IGARCH	0.818750	0.356349	0.641856	27.722282
USD	DCC-GARCH	**0.007485**	0.167051	0.722181	5.217730
CHF					no model
	01.01.2010–01.06.2012				
	Model	$\bar{\rho}$	α	β	ν
GOLD					no model
SILVER					no model
BRENT					no model
WTI					no model
USD	DCC-GARCH	**–0.363442**	0.270696	0.729167	2.389826
CHF	DCC-GARCH	**–0.151098**	0.133705	0.866278	2.389103
	03.02.2020–30.06.2022				
	Model	$\bar{\rho}$	α	β	ν
GOLD	DCC-GARCH	**–0.011460**	0.011930	0.867722	5.278174
SILVER	DCC-GARCH	0.147659	0.013062	0.945512	4.323866
BRENT	DCC-GARCH	0.280304	0.027201	0.906151	4.820194
WTI	DCC-GARCH	0.258318	0.044729	0.835777	4.323945
BITCOIN	DCC-GARCH	0.115494	0.012011	0.938783	4.307042
USD	DCC-GARCH	**–0.091039**	0.010536	0.922120	6.868912
CHF	DCC-GARCH	**–0.104849**	0.040353	0.905463	5.556040

Note. Numbers in bold indicate that the instrument can be considered as a 'safe haven' for CAC40.
Source: author's calculations.

Table 5 presents the parameters of DCC or CCC models of pairwise synchronised return data of a chosen instrument and the stock exchange index from France in the studied periods. The analysis of the first sample shows that gold and the USD (the bold number of $\bar{\rho}$) acted like 'safe haven' instruments. If we had been able to estimate the CCC model alone, we would have obtained only the values of $\bar{\rho}$ and ν. In the first sample, we could not estimate the parameters of the model for the CHF (no model in Table 2). If the number $\bar{\rho}$ is written in bold, it means that the instrument can be considered as a 'safe haven' for a given financial market. We received such estimations for the second sample (the eurozone debt crisis). Here the USD and the

CHF performed as 'safe haven' instruments. For the third sample (the COVID-19 pandemic and the Russian aggression against Ukraine) it was gold, the USD and the CHF.

During all the studied periods, we were able to observe changes in the 'safe haven' instruments. Parameter ν is the Student-t degrees of freedom, which is also highly significant for all the analysed markets.

Table 6. Parameter estimates of DCC or CCC models (the covariance part) of pairwise synchronised return data of a chosen instrument and the DAX stock index for the studied periods. Robust standard errors are available upon request

Instrument	01.10–2007–31.03.2009				
	Model	$\bar{\rho}$	α	β	ν
GOLD					no model
SILVER	DCC-IGARCH	0.747367	0.339874	0.637354	42.714842
BRENT					no model
WTI					no model
USD	DCC-GARCH	**0.017794**	0.225868	0.717877	6.044658
CHF	DCC-GARCH	**–0.279713**	0.237167	0.762818	6.121240
	01.01.2010–01.06.2012				
	Model	$\bar{\rho}$	α	β	ν
GOLD	DCC-GJR	0.100388	0.456954	0.539041	17.435560
SILVER	DCC-GARCH	0.872968	0.403194	0.586336	21.966551
BRENT	DCC-GJR	0.214342	0.448220	0.546723	29.576535
WTI	DCC-GJR	0.561504	0.395476	0.596793	32.800047
USD	DCC-GARCH	**–0.601568**	0.430806	0.557005	49.887258
CHF	DCC-GARCH	**0.002928**	0.311602	0.307095	4.937210
	03.02.2020–30.06.2022				
	Model	$\bar{\rho}$	α	β	ν
GOLD	DCC-GARCH	**0.012609**	0.024982	0.884302	5.255967
SILVER	DCC-GARCH	0.100165	0.045367	0.884028	4.510034
BRENT	DCC-GARCH	0.218921	0.087742	0.766783	5.065991
WTI	DCC-GARCH	0.196299	0.095173	0.760282	4.488492
BITCOIN	DCC-GJR	0.172001	0.022321	0.630662	4.776805
USD	DCC-GARCH	**–0.042095**	0.014063	0.945218	7.509458
CHF	DCC-GARCH	**–0.044364**	0.006699	0.976591	5.405469

Note. Numbers in bold indicate that the instrument can be considered as a 'safe haven' for DAX.
Source: author's calculations.

Table 6 presents the parameters of DCC or CCC models of pairwise synchronised return data of a chosen instrument and the stock exchange index from Germany for the analysed periods. We can observe that for the first sample (the global financial crisis), the CHF acted as a 'safe haven' instrument, and the USD like a diversifier. We could not, however, estimate any model for gold, Brent or WTI crude oil, which means that the parameters were non-significant. For the second sample (the eurozone debt crisis), the USD and CHF played the role of 'safe haven' instruments. During the COVID-19 pandemic, German investors identified gold in addition to the USD and the CHF as 'safe haven' instruments.

Table 7 presents the parameters of DCC or CCC models of pairwise synchronised return data of a chosen instrument and the stock exchange index from Great Britain for the analysed periods. We can see that for the first sample gold, the USD and the CHF performed like 'safe haven' instruments. For the second sample, none of the analysed instruments were able to act as a 'safe haven'. In the last sample, it was the USD and the CHF that assumed that role. However, we could only estimate the CCC model for them.

Table 7. Parameter estimates of DCC or CCC models (the covariance part) of pairwise synchronized return data of a chosen instrument and the FTSE250 stock index for the analysed periods. Robust standard errors are available upon request

Instrument	**01.10-2007–31.03.2009**				
	Model	$\bar{\rho}$	α	β	v
GOLD	DCC-GJR	**–0.773008**	0.395823	0.592608	57.149371
SILVER	DCC-IGARCH	0.870617	0.417034	0.565477	55.851490
BRENT	DCC-IGARCH	0.974320	0.431575	0.548935	46.912669
WTI					no model
USD	DCC-GJR	**–0.777718**	0.415172	0.573252	133.804185
CHF	DCC-IGARCH	**–0.151108**	0.126566	0.873424	5.755777
	01.01.2010–01.06.2012				
	Model	$\bar{\rho}$	α	β	v
GOLD	DCC-GJR	0.922608	0.376621	0.603970	39.889827
SILVER	DCC-GJR	0.936172	0.421873	0.551708	38.252471
BRENT	DCC-GJR	0.905833	0.393996	0.589547	49.618297
WTI					no model
USD	DCC-GJR	0.408277	0.313151	0.686770	5.151887
CHF	DCC-GJR	0.202545	0.187833	0.812147	5.166961
	03.02.2020–30.06.2022				
	Model	$\bar{\rho}$	α	β	v
GOLD	DCC-GARCH	0.061356	0.012497	0.952665	6.429651
SILVER	DCC-GARCH	0.167862	0.027387	0.932724	5.121025
BRENT	DCC-GARCH	0.217322	0.037338	0.864430	5.414050
WTI	DCC-GARCH	0.191069	0.050345	0.822635	4.703665
BITCOIN	DCC-GARCH	0.191768	0.057980	0.444974	5.016487
USD	CCC	**–0.128980**			9.000909
CHF	CCC	**–0.112000**			6.465939

Note. Numbers in bold indicate that the instrument can be considered as a 'safe haven' for FTSE250.
Source: author's calculations.

Table 8 presents the parameters of DCC or CCC models of pairwise synchronised return data of a chosen instrument and the stock exchange index from Spain for the analysed periods. The table shows that for the first sample, the USD and the CHF were 'safe haven' instruments. For the second sample, all the considered instruments besides gold and silver acted like a 'safe haven'. We were not able to estimate any model for them, which means that the parameters were non-significant. As regards the last sample, gold, the USD and the CHF assumed the role of a 'safe haven'.

Table 8. Parameter estimates of DCC or CCC models (the covariance part) of pairwise synchronised return data of a chosen instrument and the IBEX35 stock index for the studied periods. Robust standard errors are available upon request

Instrument	**01.10–2007–31.03.2009**				
	Model	$\bar{\rho}$	α	β	ν
GOLD					no model
SILVER	DCC-IGARCH	0.864608	0.393670	0.586732	26.478605
BRENT	DCC-IGARCH	0.952832	0.342216	0.650269	69.919609
WTI	DCC-IGARCH	0.948066	0.392836	0.596922	72.438051
USD	DCC-IGARCH	**–0.140535**	0.144989	0.854918	6.435076
CHF	DCC-GARCH	**–0.153448**	0.136317	0.863666	5.802824
	01.01.2010–01.06.2012				
	Model	$\bar{\rho}$	α	β	ν
GOLD					no model
SILVER					no model
BRENT	DCC-IGARCH	**–0.823470**	0.350473	0.642149	18.957779
WTI	DCC-GARCH	**–0.721551**	0.368481	0.619947	20.007171
USD	DCC-GARCH	**–0.744959**	0.489767	0.479076	36.974216
CHF	DCC-GARCH	**–0.175427**	0.078289	0.921689	5.155858
	03.02.2020–30.06.2022				
	Model	$\bar{\rho}$	α	β	ν
GOLD	DCC-GARCH	**–0.027057**	0.014252	0.884740	5.737603
SILVER	DCC-GARCH	0.051029	0.035763	0.890887	4.889897
BRENT	DCC-GARCH	0.201075	0.013149	0.977917	5.794954
WTI	DCC-GARCH	0.190250	0.040868	0.886720	4.991259
BITCOIN	DCC-GARCH	0.141693	0.050887	0.562657	4.784661
USD	DCC-GARCH	**–0.065973**	0.009620	0.911343	8.038629
CHF	DCC-GARCH	**–0.115954**	0.031190	0.901819	6.147031

Note. Numbers in bold indicate that the instrument can be considered as a 'safe haven' for IBEX35.
Source: author's calculations.

Table 9. Parameter estimates of DCC or CCC models (the covariance part) of pairwise synchronised return data of a chosen instrument and the PX stock index for the studied periods. Robust standard errors are available upon request

Instrument	01.10.2007–31.03.2009				
	Model	$\bar{\rho}$	α	β	v
GOLD					no model
SILVER	DCC-IGARCH	0.461011	0.531922	0.447429	14.932472
BRENT	DCC-IGARCH	0.779160	0.354647	0.641090	19.581309
WTI	DCC-GJR	0.849292	0.458906	0.521793	69.450220
USD	DCC-GJR	**–0.833320**	0.451201	0.531993	83.810415
CHF	DCC-IGARCH	**–0.564010**	0.379333	0.620657	6.382970
	01.01.2010–01.06.2012				
	Model	$\bar{\rho}$	α	β	v
GOLD					no model
SILVER					no model
BRENT	DCC-IGARCH	**–0.383056**	0.500989	0.479729	41.086390
WTI	DCC-GARCH	**–0.645584**	0.336861	0.658189	67.495692
USD	DCC-IGARCH	0.448988	0.739845	0.259919	5.123791
CHF	DCC-GARCH	**0.002803**	0.090534	0.774052	3.152850
	03.02.2020–30.06.2022				
	Model	$\bar{\rho}$	α	β	v
GOLD	DCC-GARCH	**0.038179**	0.013889	0.925150	5.395398
SILVER	DCC-GARCH	**0.014474**	0.019279	0.915615	4.895346
BRENT	DCC-GARCH	0.175833	0.059475	0.863947	5.297923
WTI	DCC-GARCH	0.178175	0.066614	0.844744	4.727693
BITCOIN	CCC	0.116920			4.682146
USD	DCC-GARCH	**–0.008366**	0.030781	0.909490	8.121857
CHF	DCC-GARCH	**–0.063639**	0.035200	0.737096	5.818132

Note. Numbers in bold indicate that the instrument can be considered as a 'safe haven' for PX.
Source: author's calculations.

Table 9 presents the parameters of DCC or CCC models of pairwise synchronised return data of a chosen instrument and the stock exchange index from the Czech Republic for the analysed periods. The USD and CHF turned out to be 'safe haven' instruments for the first sample (the global financial crisis). For the second sample (the eurozone debt crisis sample) it was silver, Brent, WTI and the CHF. We could not, however, estimate any model for gold. The analysis of the last sample (the COVID-19 pandemic) identified the USD and the CHF as 'safe haven' instruments, while gold and silver acted like diversifiers.

Table 10. Parameter estimates of DCC or CCC models (the covariance part) of pairwise synchronised return data of a chosen instrument and the SAX stock index for the studied periods. Robust standard errors are available upon request

Instrument	01.10-2007–31.03.2009				
	Model	ρ	α	β	ν
GOLD	DCC-IGARCH	0.380580	0.532207	0.418066	14.480247
SILVER	DCC-IGARCH	0.872840	0.329076	0.649137	9.467602
BRENT	DCC-IGARCH	**–0.235311**	0.633031	0.292223	12.999959
WTI	DCC-IGARCH	**–0.112323**	0.692290	0.250241	10.650810
USD	DCC-IGARCH	0.824149	0.556674	0.443281	4.057933
CHF	DCC-IGARCH	0.693377	0.562151	0.437838	4.063121
	01.01.2010–01.06.2012				
	Model	ρ	α	β	ν
GOLD	DCC-GJR	**–0.643940**	0.268954	0.729471	9.192191
SILVER	DCC-GARCH	**–0.677970**	0.271991	0.726189	11.312298
BRENT	DCC-GJR	**–0.659567**	0.265811	0.731917	11.699329
WTI	DCC-GARCH	**–0.476157**	0.337293	0.657481	11.367734
USD	DCC-GARCH	**–0.698326**	0.507687	0.451662	14.047624
CHF	DCC-EGARCH	**–0.184411**	0.360978	0.631185	16.040608
	03.02.2020–30.06.2022				
	Model	$\bar{\rho}$	α	β	ν
GOLD	CCC	**–0.004145**			3.581142
SILVER	CCC	**0.010773**			3.377403
BRENT	CCC	**–0.013781**			3.771008
WTI	CCC	**0.008540**			3.466948
BITCOIN	CCC	**0.037810**			3.288803
USD	DCC-GARCH	**0.042724**	0.013815	0.946996	4.278525
CHF	CCC	0.073189			3.922210

Note. Numbers in bold indicate that the instrument can be considered as a 'safe haven' for SAX.
Source: author's calculations.

Table 10 presents the parameters of DCC or CCC models of pairwise synchronised return data of a chosen instrument and Slovakia's stock exchange index for the analysed periods. The first (GFC) sample indicated Brent and WTI as 'safe haven' instruments. Within the second (EDC) sample, all the studied instruments acted like a 'safe haven'. For the last (COVID-19 pandemic) sample, gold and Brent were identified as 'safe haven' instruments, while silver, WTI, Bitcoin and the USD behaved like diversifiers.

Table 11. Parameter estimates of DCC or CCC models (the covariance part) of pairwise synchronised return data of a chosen instrument and the WIG stock index for the analysed periods. Robust standard errors are available upon request

Instrument	**01.10-2007 – 31.03.2009**				
	Model	$\bar{\rho}$	α	β	v
GOLD	No model				
SILVER	DCC-GJR	**–0.018615**	0.286464	0.683628	6.580985
BRENT					no model
WTI	DCC-GARCH	**–0.845865**	0.248803	0.751086	32.588449
USD	DCC-GJR	**–0.423791**	0.436192	0.560037	32.740343
CHF	DCC-GARCH	**–0.862167**	0.605918	0.369927	3.950087
	01.01.2010 – 01.06.2012				
	Model	$\bar{\rho}$	α	β	v
GOLD	DCC-GJR	**–0.399642**	0.378022	0.619880	31.564120
SILVER	DCC-GJR	**–0.686526**	0.364487	0.632018	61.217814
BRENT	DCC-GJR	**–0.622894**	0.381311	0.615699	56.010843
WTI	DCC-GJR	**–0.305956**	0.323458	0.674095	28.673782
USD	DCC-GJR	0.412603	0.266950	0.731978	7.410154
CHF	DCC-EGARCH	**0.000015**	0.089062	0.910396	5.695479
	03.02.2020– 30.06.2022				
	Model	$\bar{\rho}$	α	β	v
GOLD	DCC-GARCH	0.072622	0.006643	0.905773	6.133009
SILVER	DCC-GARCH	0.153195	0.021415	0.850993	4.905963
BRENT	CCC	0.190343			5.632020
WTI	CCC	0.182339			4.904768
BITCOIN	CCC	0.198206			4.679099
USD	DCC-GARCH	**–0.045457**	0.013421	0.9222542	9.729939
CHF	DCC-GARCH	**–0.034920**	0.012046	0.790507	6.192595

Note. Numbers in bold indicate that the instrument can be considered as a 'safe haven' for WIG.
Source: author's calculations.

Table 11 presents the parameters of DCC or CCC models of pairwise synchronised return data of a chosen instrument and Poland's stock exchange index for the analysed periods. As regards the first sample, all the studied instruments except gold and Brent were able to act like a 'safe haven'. For the second sample, gold, silver, Brent, WTI and the CHF were considered as 'safe haven' instruments, while for the last one, it was the USD and CHF.

Table 12. Number of countries (stock exchanges) in which we were able to identify the analysed instruments as a 'safe haven'

Instrument	01.10–2007 – 31.03.2009	01.01.2010 – 01.06.2012	03.02.2020– 30.06.2022
GOLD	2	2	4
SILVER	1	3	1
BRENT	1	4	1
WTI	2	4	1
BITCOIN	–	–	1
USD	6	4	7
CHF	5	6	7

Source: author's calculations.

Table 12 presents the number of countries in which the studied instruments were able to act like 'safe haven' assets during all the analysed time samples. The USD and the CHF were the dominant 'safe haven' instruments throughout the studied crises. We were also able to observe that 'safe haven' instruments were changing during different downturn periods. The largest number of the analysed instruments were identified as a 'safe haven' during the eurozone debt crisis, probably because all the countries were sampled from Europe. Surprisingly, in only one country (Slovakia), Bitcoin was considered as a 'safe haven' instrument. This might be the result of the specific characteristics of Bitcoin: during the COVID-19 pandemic, its quotations were subject to sharp fluctuations, while it is common knowledge that only those financial instruments can be considered a 'safe haven' that are not risky themselves.

4. Conclusions

During turbulent times such as financial crises or pandemics, searching for safe haven instruments becomes an important task for financial market investors. Due to the recent Russian aggression against Ukraine, we witnessed substantial hikes in the crude oil and natural gas prices, while at the same time stock indices were falling. Difficult times bring about great uncertainty.

This paper examined the performance of gold, silver, Brent, WTI, the USD and CHF as 'safe haven' assets during the global financial crisis, the eurozone debt crisis, and the COVID-19 pandemic combined with the war in Ukraine.

The results demonstrate that it was the USD and the CHF that were best able to protect investors from stock market losses during turbulent times. However, we could observe changes in 'safe haven' instruments throughout these crises. For example, during the eurozone debt crisis, silver, Brent, WTI, the USD and the CHF acted like a 'safe haven' for most of the analysed countries. Bitcoin, on the other hand, was considered as a 'safe haven' only by investors from Slovakia.

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