Looking for Alternatives in Times of Market Stress: A Tail Dependence between the European Stock Markets and Bitcoin, Gold and Fine Wine Market*

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Abstract

This study investigates relations between returns from the traditional stock markets and alternative investments over different investment horizons. Using a quantile coherency, we verify whether an occurrence of the extreme negative returns calculated over several frequencies in the stock exchange coincides with the occurrence of high positive or negative returns in the Bitcoin, gold and fine wine market. We found that in most cases considered alternative investments may act as a weak hedge in normal market conditions. In times of market stress, for all investment horizons only gold is a safe haven for examined stock markets. Results for Bitcoin and fine wines depend on the investment horizon, but in both cases, we found that there is a contagion effect for long-term investments.

1. Introduction

Heterogeneous market hypothesis (Müller, Dacorogna, Davé, Pictet et al., 1993; Müller, Dacorogna, Davé, Olsen et al., 1997) stands that market participants can have different investments horizons, dealing frequencies, geographical location, degree of risk aversion, institutional constraints, or transaction costs. A heterogeneity between investors leads to an own reaction time to news, related to their time horizon and characteristic dealing frequency. When an investor struggles with a bad market situation that causes a fall in their portfolio value, they should make decisions that will allow them to reduce losses. The moment when it happens will depend, however, on the investment horizon and the amount of acceptable loss, which is in fact a value related to a certain quantile from the distribution of a portfolio value.

There are many ways for market participants to invest their capital and expand their portfolio composition. Over the last few years, the alternative investments sector has become an important part of the worldwide financial market. Investing in alternatives plays a substantial role in diversification, reducing investor portfolio risk and increasing a portfolio risk-adjusted return. Moreover, they offer access to a wider range of investment opportunities.

There is still no consensus on the exact definition of the alternative investment. It is sometimes considered as an investment that is not simply a long position in a traditional asset (Chambers et al., 2015). Alternatives offer investors a set of characteristics that are not commonly found in traditional investments, such as public stocks or government and corporate bonds. They usually contain one or more of the following characteristics: long term, high risk, illiquidity associated with higher returns, low correlation with traditional assets to deliver diversification benefits, inflation-hedging benefits, and scalability (the ability to absorb large investment sums) (World Economic Forum, 2015). The fact, that alternative investments usually have a lower correlation with standard asset classes, makes them a useful tool for portfolio diversification, since it reduces the overall risk or volatility of a portfolio.

In this paper, we consider three types of alternative investments with completely different characteristics: gold, Bitcoin and fine wines. By selecting them for analysis, we will be able to compare, how they behave in different market conditions for investors with a certain investment horizon.

In the last ten years, we can observe a growing number of cryptocurrencies, such as Bitcoin, Ethereum, Ripple's XRP, Litecoin, and Tether. Bitcoin changed the area of digital currencies in 2009 and since that time it now plays a meaningful role in the present financial market. Bitcoin remains a leader among other cryptocurrencies in terms of market capitalization and popularity. However, since even for a single day, its price can rise and fall several times dramatically, investing in Bitcoin is subject to large risk and volatility. With the rise of Bitcoin, there has been a debate among economists about whether it can be treated as a currency and a medium of exchange or speculative investment. In this study, similar to Yermack (2015) and Baur et al. (2017), we treat Bitcoin as a one of the alternative ways to invest capital.

Gold, like other precious metals, can be classified as a tangible investment. It is commonly used to produce jewelry, electronics, coins, and others. Historically, gold was used as a currency. Gold is generally considered by investors as a safe alternative investment, particularly during a time of crisis. This is partly due to tradition, but it is undeniably important that, unlike any currency, gold has an intrinsic value. Nowadays, gold is still considered as the backup of currency for governments and central banks. According to Wang (2012), investors see more value on gold when they lose confidence in government bonds and the returns in the stock markets are negative.

Another type of tangible, alternative asset in this study is investing in fine wines. Wine is physical asset and therefore its supplies are rather limited. A growing demand for fine wine, in particular in the Far East, leads to support of its price. Fine wines have attracted widespread interest, especially after the financial crisis. Events in the global financial markets forced investors to find a way towards diversifying a portfolio and reducing the risk. The wine market is more available for investors thanks to the development of the London International Vintners Exchange (Liv-ex), which is the most known fine wine exchange (Bouri, 2015).

All above mentioned alternative investments can be treated as a possible component of the investor's portfolio. However, they can behave in a various way in different market conditions and their function can depend on the investment horizon

as well. Baur and Lucey (2010) determined conditions to distinguish when an asset can act as a diversifier, hedge, and safe haven. According to their classification, a hedge is defined as an asset that is uncorrelated or negatively correlated with another asset or portfolio on average. A diversifier is defined as an asset that is positively (but not perfectly correlated) with another asset or portfolio on average. A safe haven is defined as an asset that is uncorrelated or negatively correlated with another asset or portfolio in times of market stress or turmoil. Baur and Lucey (2010) emphasize that a safe haven is a place of safety that offers investors shelter in extreme market conditions. The word 'safe' emphasizes the fact that a haven is secure. In our opinion, it should also be an asset with moderate volatility. One can also distinguish a strong hedge asset (significantly negative correlation) from a weak hedge (correlation is equal to zero). As in the case of the hedge definition, we can also distinguish the case when an asset is uncorrelated in time of turmoil (weak safe haven) and when there is a significant negative correlation (strong safe haven).

In this paper, we employed a relatively new method, that is able to examine relationships between mainstream and alternative investments for different investment horizons. We employ a quantile-based approach proposed by Baruník and Kley (2019) to measure dependence structures emerging in the joint distribution in the frequency domain. Quantile coherency has an advantage over traditional correlation, since even uncorrelated variables may possess dependence in different parts of the joint distribution, and at different frequencies (Baruník and Kley, 2019). To the best of our knowledge, quantile coherency measure has never been used before for the analysis between assets considered in this study. Using this method, we are able to determine, whether an asset is a hedge, diversifier and safe haven for different investment horizons, but instead of checking for lack of correlation or negative correlation between assets, we use a quantile coherency measure. In this context our findings add new insights into relation between chosen alternative investments and major European stock markets from the perspective of market participant with short, medium and long-term investment horizons.

2. The Literature Review

There is a lot of previous research focused on the role of gold in a portfolio (Baur and Lucey, 2010; Baur and McDermott, 2010; Coudert and Raymond, 2011; Miyazaki et al., 2012, Anand and Madhogaria, 2012; Miyazaki and Hamori, 2013, Chen and Lin, 2014; Emmrich and McGroarty, 2013; Tuysuz, 2013; Ciner et al., 2013; Hood and Malik, 2013; Gürgün and Ünalmiş, 2014, Bredin et al., 2015; Choudhry et al., 2015; Dicle and Lavendis, 2017; Shahzad, Raza, Roubaud, Arreola-Hernandez, Bekiros, 2019; Shahzad, Bouri, Roubaud, Kristoufek, Lucey 2019; Shahzad, Bouri, Roubaud, Kristoufek, 2019; Naeem et al., 2020; Maghyereh and Hussein, 2020). Most of these studies confirmed that gold is a hedge in normal market conditions and in many cases can be considered as a safe haven asset. However, within these papers only a few analyze an impact of the investment horizon. For example, Baur and McDermott (2010) found that gold is a hedge and safe-haven at daily and weekly and monthly frequency for European countries and in the USA. Bredin et al. (2015) used a wavelet analysis and found that gold acts as a hedge for German, UK and US equity markets for horizons of up to one year.

Moreover, Naeem et al. (2020) analyzed tail and frequency interdependence between BRICS stock markets and gold using quantile on quantile regression and quantile coherency during the Great Financial Crisis and for the pre- and post-GFC period. They found that gold offered protection to Brazilian equity investors in the period after the Great Financial Crisis in the short-term investment horizon. Moreover, in the long-term, gold was a safe haven for Russia and South Africa for all three sub-periods.

On the contrary, in the case of Bitcoin and other cryptocurrencies the results of earlier studies (for example Dyhrberg, 2016; Bouri et al., 2017; Klein et al., 2018; Baumöhl, 2019; Chan et al., 2019; Kliber at al., 2019; Shahzad, Bouri, Roubaud, Kristoufek, Lucey 2019; Shahzad, Bouri, Roubaud, Kristoufek, 2019; Conlon and McGee, 2020) are rather mixed. There can be a several factors affecting the obtained results. One of the important aspects is a currency. Kliber et al. (2019) examined Bitcoin in local currencies and in USD and compared the results. Their conclusions for local currencies depend on the country: for Japan and China, Bitcoin is a diversifier, for Estonia and Sweden it is a weak hedge and only for Venezuela it is a safe haven. On the contrary, when the Bitcoin price is expressed in USD, the role of cryptocurrency changes. In addition to the effect of currency on the role of Bitcoin, earlier authors noted that the conclusions change depending on the frequency of the data. For example, Bouri et al. (2017) analyzed relations between cryptocurrency and major world equities, bonds, oil, gold, the general commodity index, and the US dollar index and found different results for daily and weekly data. Moreover, Chan et al. (2019) focused on the longer investment horizon. They found that Bitcoin is an effective strong hedge for several indices under monthly data frequency, but daily and weekly returns demonstrate weak hedge properties. Baumöhl (2019) analyzed connectedness between major forex currencies and cryptocurrencies using the quantile cross-spectral approach. His results showed, that there are some assymetric intergroup dependencies from both the short- and long-term perspectives.

Previous works in the case of the wine market showed, that investing in fine wines can act as a hedge for equities in the developed markets (Bouri, 2015; Bouri and Roubaud, 2016). It also brings diversification benefits for the global stock market when the MSCI World Index is a proxy (Introvigne et al., 2017), and serves as safe haven when wine is related to the global uncertainty index (Antonakakis et al., 2018). However, there are also contagion effects when different wine indices are considered (Le Fur et al., 2016). According to Le Fur and Outreville (2019), where a comprehensive literature review about various aspects of fine wine returns is reported, results of the analysis of diversification benefits from wine investment depend on the period under study, the methodology used and the type of assets in the portfolio. However, none of the previous studies directly compare results for short, medium and long-term investments in fine wines.

3. Methodology: Quantile Coherency (Baruník and Kley, 2019)

Let $(X_t)_{t\in\mathbb{Z}}$ denotes two-dimensional process $X_t = (X_{t,1}, X_{t,2})'$, F_j is the marginal distribution function of $X_{t,j}$ for $j = 1, 2$ and $q_j(\tau) = F_j^{-1}(\tau) = inf\{q \in \mathbb{R}: \tau \leq F_j(q)\}$, where $\tau \in [0,1]$ denotes the quantile function of $X_{t,j}$.

Baruník and Kley (2019) proposed a matrix $\Gamma_k(\tau_1, \tau_2) = \left(\gamma_k^{j_1, j_2}(\tau_1, \tau_2) \right)_{j_1, j_2 = 1,2}$ of quantile cross-covariance kernels, as a measure for the serial and cross-dependency structure of $(X_t)_{t \in \mathbb{Z}}$, where

$$\gamma_k^{j_1, j_2}(\tau_1, \tau_2) = Cov\left(I\{X_{t+k, j_1} \leq q_{j_1}(\tau_1)\}, I\{X_{t, j_2} \leq q_{j_2}(\tau_2)\} \right), \quad (1)$$

$k \in \mathbb{Z}$, $I\{A\}$ denotes the indicator function of the event A and $\tau_1, \tau_2 \in [0,1]$.

A matrix of quantile cross-spectral density kernel is defined as $\mathfrak{f}(\omega; \tau_1, \tau_2) = \left(\mathfrak{f}^{j_1, j_2}(\omega; \tau_1, \tau_2) \right)_{j_1, j_2 = 1,2}$, where $\omega \in \mathbb{R}$ and

$$\mathfrak{f}^{j_1, j_2}(\omega; \tau_1, \tau_2) = \frac{1}{2\pi} \sum_{k=-\infty}^{\infty} \gamma_k^{j_1, j_2}(\tau_1, \tau_2) e^{-ik\omega}. \quad (2)$$

A quantile coherency kernel which is a measure for the dynamic dependence of the two processes $(X_{t,1})_{t \in \mathbb{Z}}, (X_{t,2})_{t \in \mathbb{Z}}$ is defined as

$$\mathfrak{R}^{j_1, j_2}(\omega; \tau_1, \tau_2) = \frac{f^{j_1, j_2}(\omega; \tau_1, \tau_2)}{\left(f^{j_1, j_1}(\omega; \tau_1, \tau_2) f^{j_2, j_2}(\omega; \tau_1, \tau_2) \right)^{\frac{1}{2}}} \quad (3)$$

for $(\tau_1, \tau_2) \in (0,1)^2$ and is estimated via the smoothed CCR-periodograms. Quantile coherency is a complex-valued function of the variable ω. According to Baruník and Kley (2019), the real parts of the quantile coherency estimates reveal frequency dynamics in quantiles of the joint distribution of the returns.

In this paper we consider three frequencies to measure quantile coherency that corresponds to two-day, weekly and monthly periods and three quantile levels: $\tau = 0.1$, $\tau = 0.5$ and $\tau = 0.9$. For example, using the case when $(\tau_1, \tau_2) = (0.5, 0.5)$, we measure a quantile coherency related to normal market conditions. When $(\tau_1, \tau_2) = (0.1, 0.1)$, we measure a quantile coherency for extreme negative returns. In this case, if the real part of the quantile coherency estimates is significantly positive, it means that there is a coincidence between the events, when $X_{t,1}$ and $X_{t,2}$ are extremely low (i.e. $X_{t,j}$ is equal or lower than a quantile $q_j(0.1)$). On the contrary, when $(\tau_1, \tau_2) = (0.1, 0.9)$, we measure a quantile coherency for extreme negative and positive returns. In this case, if the real part of the quantile coherency estimates is significantly negative, it means that there is a coincidence between the events, when $X_{t,1}$ is extremely low (i.e. $X_{t,1}$ is equal to or less than a quantile $q_1(0.1)$) and $X_{t,2}$ is extremely high (i.e. $X_{t,2}$ is greater than a quantile $q_2(0.9)$).

4. Data and Results

The data consists of daily prices of three major European indices (FTSE, DAX, and CAC) and three types of alternative investments[1]. We use daily Forex

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[1] Historical data for FTSE, DAX and CAC indices, Forex prices of gold in Euro and GBP and GBP/EUR exchange rates were obtained from the database available on the website www.stooq.pl. BTC prices were obtained from the service data.bitcoinity.org. Data for Liv-ex 50 index were obtained from the Liv-ex company. We thank the company for providing us with the index data.

prices of gold in Euro and British Pound (GBP), prices of Bitcoin in Euro from the most liquid – in this case Kraken – trading platform and in GBP from the Coinfloor trading platform. Daily data of the fine wine Liv-ex 50 index originally refers to transactions in GBP, so it's converted into Euro when necessary[2]. We analyze the data in local currencies, and it implies that the study focuses on the characteristics of investment in gold, Bitcoin and fine wine from the perspective of investors/hedgers operating in the British, German and French stock markets. The data cover January 2, 2015 until February 20, 2019. In all calculations we use daily percentage logarithmic returns defined as $r_t = 100 \cdot \ln \frac{P_t}{P_{t-1}}$, where P_t denotes price of an asset at time t. The analysis is performed in R, specifically the *quantspec* package (v.1.2-2; Kley, 2020) is used to estimate quantile coherency.

4.1 Preliminary Results

Table 1 gives calculated basic descriptive statistics of daily percentage logarithmic returns. Mean value in most cases is close to zero. High mean Bitcoin returns in both currencies is an exception. Volatility measured by standard deviation is moderate for FTSE, CAC and DAX indexes and for gold. The lowest standard deviation is in case of LIV-EX, the largest for Bitcoin. So, we have three types of alternative investments with completely different characteristics. It is worth noting that volatility of GOLD and LIV-EX returns is relatively low and, in these cases, we can accept that this type of investment is a rather safe alternative to traditional stock markets. Minimum values of FTSE, CAC, DAX and LIV-EX (in Euro) returns and maximum values of GOLD in both currencies occurred exactly at the same day, i.e. June 24, 2016, after the Brexit referendum in the United Kingdom. This event also affected values of excess kurtosis.

Table 1 Descriptive Statistics

	Min	Mean	Max	Standard deviation	Skewness	Excess kurtosis
FTSE	-7.46	0.02	3.66	0.87	-1.15	11.63
CAC	-8.38	0.02	4.06	1.14	-0.50	4.40
DAX	-7.07	0.02	4.87	1.18	-0.32	2.62
GOLD/EUR	-3.45	0.02	7.44	0.79	0.87	9.80
GOLD/GBP	-3.55	0.03	13.32	0.95	2.84	39.46
BTC/EUR	-18.73	0.26	20.16	4.05	0.09	4.19
BTC/GBP	-19.82	0.27	20.41	4.12	0.14	4.06
LIV-EX (in EUR)	-5.43	0.02	2.41	0.57	-0.81	9.07
LIV-EX (in GBP)	-0.54	0.03	1.03	0.18	0.65	2.32

4.2 Quantile Coherency Estimates

We start our analysis of the coherency related to the normal stock and gold markets conditions. We are taking into account quantile coherency estimates when

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[2] Since GBP/Euro dynamics affect in these cases our results, we decided to analyze also all effects for pairs DAX, Liv-ex 50 and CAC, Liv-ex 50 without currency conversion. These results are included in the Appendix.

$(\tau_1, \tau_2) = (0.5, 0.5)$. According to the results presented in Table 2, in almost all cases we get insignificant estimates. In normal market conditions, there is no coherency between returns for FTSE, CAC, DAX and gold. In these cases, gold acts as a weak hedge for two-day, weekly and monthly investment horizons. Moreover, gold is a strong hedge for a two-day frequency in the case of CAC, since estimated coherency is significantly negative. In the case of Bitcoin and all considered markets we received similar results, that Bitcoin is a weak hedge.

Table 2 Quantile Coherency for Medians: Point Estimate of the Real Part and 95% Confidence Interval

	frequency	FTSE	CAC	DAX
GOLD	two-day	-0.12 (-0.35, 0.10)	**-0.28** **(-0.49, -0.07)**	-0.13 (-0.36, 0.10)
	weekly	-0.12 (-0.29, 0.04)	-0.12 (-0.28, 0.05)	-0.02 (-0.19, 0.14)
	monthly	-0.01 (-0.17, 0.15)	-0.03 (-0.19, 0.13)	-0.03 (-0.19, 0.13)
BTC	two-day	0.0005 (-0.23, 0.23)	-0.02 (-0.25, 0.20)	-0.14 (-0.37, 0.09)
	weekly	0.07 (-0.09, 0.24)	0.01 (-0.15, 0.18)	-0.06 (-0.22, 0.10)
	monthly	-0.04 (-0.20, 0.12)	-0.02 (-0.18, 0.14)	0.05 (-0.11, 0.21)
LIV-EX	two-day	0.005 (-0.23, 0.24)	0.18 (-0.04, 0.39)	0.06 (-0.17, 0.29)
	weekly	0.03 (-0.14, 0.19)	0.12 (-0.05, 0.28)	0.08 (-0.09, 0.24)
	monthly	0.09 (-0.08, 0.26)	**0.29** **(0.15, 0.43)**	**0.26** **(0.11, 0.40)**

Notes: Entries are in bold when the 95% confidence interval does not include zero.

A more divergent situation is for the fine wine index. There is no coherency between returns for FTSE, and LIV-EX in normal market conditions. It means that from the perspective of the British market participant, investing in wine acts as a weak hedge for two-day, weekly and monthly investment horizons. In the case of monthly frequency for the LIV-EX index and DAX and CAC index, the quantile coherency is significantly positive. Generally, investment in wines acts as a weak hedge for investors, but it's only a diversifier for participants with longer investment horizons in the French and German markets. This result may arise from GBP/EUR dynamics which affects our analysis. Indeed, a closer look into the results in Table A1 in the Appendix reveals, that investing in fine wines would act as a weak hedge for monthly frequency, if we take values of the Liv-ex index without currency conversion. This result is important for investors, who apply appropriate strategies to hedge against currency risk.

The next step of our analysis is to check, whether considered alternative investments act as a strong safe haven for the investments in times of market stress. To this end, we estimate quantile coherency for $(\tau_1, \tau_2) = (0.1, 0.9)$, i.e. taking quantile level 0.1 for stock market (extremely low returns) and 0.9 for alternative investment (extremely high returns). Estimation results are reported in Table 3. Similarly, we estimate quantile coherency for $(\tau_1, \tau_2) = (0.1, 0.5)$, and $(\tau_1, \tau_2) = (0.1, 0.1)$. Using these estimates, we can see in these cases two things: firstly,

whether the results are consistent, and secondly, whether there is a contagion effect. Estimation results are reported in Tables 4 and 5.

In the case of gold, for all considered frequencies, estimated values in Table 3 are negative. Negative quantile coherencies are significant for the French market with a two-day frequency and for monthly frequency for all markets. It means that in these cases gold acts as a strong safe haven. Stock markets and gold markets are negatively and more strongly related in longer periods of market downturns. When monthly stock market returns are extremely negative, gold returns are extremely high. Moreover, according to the results in Table 4, we observe a significant negative coherency between extreme negative returns in the British stock market and gold market, also in the case of weekly frequency and between extreme negative returns in the French and German stock markets and gold market in the case of a two-day frequency. We can say, that in these cases gold also acts as a strong safe haven, although the effect is weaker – when stock market returns are extremely negative, gold returns are greater than median. We observe that gold acts as a weak safe haven for other frequencies since there is no positive coherency in times of market stress.

Table 3 Quantile Coherency for Left and Right Tail: Point Estimate of the Real Part and 95% Confidence Interval

	frequency	FTSE	CAC	DAX
GOLD	two-day	-0.18 (-0.40, 0.03)	**-0.27** **(-0.47, -0.06)**	-0.08 (-0.31, 0.14)
	weekly	-0.13 (-0.29, 0.03)	-0.08 (-0.24, 0.08)	-0.09 (-0.25, 0.07)
	monthly	**-0.16** **(-0.32, -0.004)**	**-0.18** **(-0.34, -0.03)**	**-0.33** **(-0.48, -0.18)**
BTC	two-day	-0.05 (-0.27, 0.18)	0.11 (-0.12, 0.34)	0.05 (-0.18, 0.28)
	weekly	**-0.18** **(-0.34, -0.03)**	**-0.17** **(-0.33, -0.01)**	-0.09 (-0.26, 0.07)
	monthly	0.06 (-0.10, 0.22)	0.03 (-0.13, 0.19)	0.05 (-0.12, 0.21)
LIV-EX	two-day	-0.10 (-0.33, 0.12)	0.20 (-0.03, 0.42)	**0.23** **(0.001, 0.46)**
	weekly	-0.05 (-0.21, 0.11)	-0.08 (-0.24, 0.08)	0.04 (-0.12, 0.20)
	monthly	-0.01 (-0.17, 0.15)	0.15 (-0.01, 0.30)	0.11 (-0.04, 0.27)

Notes: Entries are in bold when the 95% confidence interval does not include zero.

In the case of Bitcoin, estimation results in Table 3 revealed, that it acts as a strong safe haven for British and French stock markets in the case of weekly frequency. For longer periods, we didn't get significant estimates of quantile coherency between extremely low stock market returns and extremely high Bitcoin returns. It implies, that when there were relatively short periods of stock market downturns in Great Britain and France, investing in Bitcoin could offer high profits, but this effect vanished in longer periods of stock market declines. Moreover, we should comment on this result also taking into account the high volatility of Bitcoin. In our opinion, the use of such an instrument as a safe haven may raise legitimate concerns. Furthermore, estimates in Table 5 clearly show, that in the case of monthly frequency, Bitcoin downturns coincide with stock market declines in all considered cases. It means that there are contagion effects between considered stock markets and

the Bitcoin market in the long period of stock market downturns. A contagion effect also occurs in the case of DAX for a two-day frequency.

Table 4 Quantile Coherency for Left Tail and Median: Point Estimate of the Real Part and 95% Confidence Interval

	frequency	FTSE	CAC	DAX
GOLD	two-day	-0.19 (-0.40, 0.03)	**-0.29** **(-0.51, -0.07)**	**-0.37** **(-0.58, -0.16)**
	weekly	**-0.23** **(-0.39, -0.08)**	-0.09 (-0.25, 0.07)	-0.15 (-0.32, 0.01)
	monthly	-0.07 (-0.23, 0.09)	-0.08 (-0.24, 0.08)	-0.16 (-0.31, 0.0002)
BTC	two-day	0.04 (-0.19, 0.26)	0.08 (-0.14, 0.31)	0.004 (-0.23, 0.24)
	weekly	-0.13 (-0.29, 0.02)	**-0.18** **(-0.34, -0.03)**	-0.14 (-0.30, 0.02)
	monthly	**0.18** **(0.03, 0.34)**	0.13 (-0.03, 0.29)	0.05 (-0.11, 0.22)
LIV-EX	two-day	-0.11 (-0.34, 0.11)	**0.22** **(0.002, 0.44)**	0.10 (-0.13, 0.33)
	weekly	**-0.19** **(-0.35, -0.03)**	0.02 (-0.15, 0.17)	0.02 (-0.14, 0.18)
	monthly	**0.18** **(0.01, 0.25)**	**0.21** **(0.06, 0.36)**	0.08 (-0.08, 0.23)

Notes: Entries are in bold when the 95% confidence interval does not include zero.

Table 5 Quantile Coherency for Left Tails: Point Estimate of the Real Part and 95% Confidence Interval

	frequency	FTSE	CAC	DAX
GOLD	two-day	**-0.28** **(-0.48, -0.07)**	-0.01 (-0.24, 0.22)	0.002 (-0.23, 0.23)
	weekly	0.08 (-0.08, 0.25)	0.01 (-0.15, 0.17)	0.01 (-0.15, 0.17)
	monthly	-0.06 (-0.22, 0.10)	0.01 (-0.15, 0.17)	0.08 (-0.08, 0.24)
BTC	two-day	-0.04 (-0.28, 0.19)	0.04 (-0.19, 0.28)	**0.23** **(0.001, 0.46)**
	weekly	0.03 (-0.13, 0.19)	0.08 (-0.08, 0.24)	0.02 (-0.14, 0.19)
	monthly	**0.24** **(0.09, 0.39)**	**0.24** **(0.09, 0.39)**	**0.30** **(0.15, 0.44)**
LIV-EX	two-day	0.02 (-0.21, 0.25)	0.01 (-0.22, 0.24)	-0.14 (-0.37, 0.09)
	weekly	-0.04 (-0.21, 0.12)	0.10 (-0.06, 0.26)	**0.19** **(0.03, 0.35)**
	monthly	0.07 (-0.10, 0.23)	**0.22** **(0.07, 0.38)**	**0.30** **(0.15, 0.45)**

Notes: Entries are in bold when the 95% confidence interval does not include zero.

Investigation of the tail dependence between stock markets and fine wine markets provides an interesting conclusion. Firstly, according to the results in Table 4 for weekly investment horizon, investing in wines acts as a strong safe haven for FTSE index but for longer periods we observe an opposite effect. In the case of DAX, estimation results in Table 5 suggest a contagion effect, since there is positive coherency between the left tails of the distribution. This effect is significant for the LIV-EX index expressed in EUR. Importantly, ignoring currency risk would lead to an opposite conclusion. Results from Table A2 in the Appendix, when there is no

currency conversion, suggest that investing in fine wines would act as a strong safe haven for the DAX index. There is also a contagion effect for monthly CAC and LIV-EX returns. One of the important factors of economic growth in France is the country's export sector driven by increased demand for French wine. In the long period there is a coincidence between the wine and French stock market downturns.

4.3 Robustness Check

The previous section contains the results for three fixed frequencies and three quantile levels: one corresponding to the center of the distribution, and one for left and right tail. As a robustness check, we examine whether detected patterns change for other quantile levels and for other frequencies related to the short, medium and long-term investment horizons. To this end we additionally check two possible quantile levels $\tau \in \{0.45, 0.55\}$ being close to the center of the distribution and $\tau \in \{0.2, 0.8\}$ corresponding to the left and right tail. Moreover, we measure a quantile coherency for a wide range of frequencies (from a two-day to two-monthly investment horizons). Figures A1-A9 in the Appendix show estimates of a quantile coherency for all pairs used in the study.

In all cases a coherency estimate for the quantile levels in the center of the distribution are very similar (see upper left panels from Figures A1-A9). According to the results in the previous section, we classified most of the considered alternative investments as a hedge for selected types of investment horizon or a diversifier in two cases. We can see, that this pattern remains unaffected. For example, if we take into account estimates for frequencies from the two-weekly to the two-monthly investment horizon for pairs CAC – LIV-EX and DAX – LIV-EX, we observe significantly positive (but still relatively low) quantile coherency estimates, that confirm that investing in fine wines acts as a diversifier in these cases.

There are a relatively low differences between estimates of a coherency in the tails, if we compare the results when the quantile level 0.1 is replaced by 0.2 and when 0.9 is replaced by 0.8. We can see that 95% confidence intervals largely overlap each other. But the main conclusions remain stable – in almost all frequencies there is a negative coherency between left tail of stock indices and right tail of GOLD. Also note, that contagion effects between all indices and Bitcoin in the long-term are clearly visible in the bottom right panels in the Figures A2, A5 and A8. Similarly, there is a contagion effect in long-term between CAC or DAX and LIV-EX index observed in the Figures A6 and A9 respectively.

5. Conclusions

We analyzed dependencies between assets in the traditional stock market and three types of alternative investments for different investment horizons. We checked whether gold, Bitcoin and fine wine can act as a hedge, diversifier or safe haven and verified possible contagion effects for investors, that have in their portfolio, assets from British, German and French stock markets. Using a quantile coherency approach, we measured the dependence between traditional and alternative markets in normal market conditions. We also examined whether the occurrence of the extreme negative returns in the stock-exchange, coincides with the occurrence of high positive or negative returns in the Bitcoin, gold and fine wine markets.

Table 6 provides a summary of our findings. The results of our research show that in normal market conditions it is beneficial for the investors to include in their portfolio all considered alternative investments. However, in the event of strong declines in the stock market, only investment in gold is a safe haven for short and long-term investments. Our results are in line with the previous works, since most authors, considering the role of gold for investors from various markets, came to the conclusion that gold is a hedge in normal market conditions and can be considered as a safe haven asset. We also found that role of the Bitcoin in times of market stress depends on the investment horizon, which is in line with the results of Bouri et al. (2017). We did not find the effects reported by Chan et al. (2019), who suggested that longer-term Bitcoin returns have stronger hedging abilities than the short-term returns, but their results occurred in the case of Euro Stoxx index and in different time periods. Moreover, according to our results, investing in fine wines acts as a hedge in short and medium-term, which is line with the earlier reports for the developed markets (Bouri, 2015; Bouri and Roubaud, 2016). But a currency risk leads to a weakening of the role of investment in fine wines in the long-term from the perspective of German and French markets, and it can be treated as a diversifier. Furthermore, similar to Le Fur et al. (2016), we also found that there is a contagion effect for monthly frequency in all cases.

Table 6 Summary of Results

	situation in the stock market	frequency	United Kingdom	France	Germany
GOLD	normal	two-day	weak hedge	strong hedge	weak hedge
		weekly	weak hedge	weak hedge	weak hedge
		monthly	weak hedge	weak hedge	weak hedge
	extreme declines	two-day	weak safe haven	strong safe haven	strong safe haven
		weekly	strong safe haven	weak safe haven	weak safe haven
		monthly	strong safe haven	strong safe haven	strong safe haven
BTC	normal	two-day	weak hedge	weak hedge	weak hedge
		weekly	weak hedge	weak hedge	weak hedge
		monthly	weak hedge	weak hedge	weak hedge
	extreme declines	two-day	weak safe haven	weak safe haven	contagion effect
		weekly	strong safe haven	strong safe haven	weak safe haven
		monthly	contagion effect	contagion effect	contagion effect
LIV-EX	normal	two-day	weak hedge	weak hedge	weak hedge
		weekly	weak hedge	weak hedge	weak hedge
		monthly	weak hedge	diversifier	diversifier
	extreme declines	two-day	weak safe haven	contagion effect	weak safe haven
		weekly	strong safe haven	weak safe haven	contagion effect
		monthly	contagion effect	contagion effect	contagion effect

Our results contribute to the existing literature in two ways. They can be useful to market participants, portfolio management staff and risk analysts as an indication of whether the alternative investments used in the study help reduce portfolio risk. Moreover, we found evidence that investment horizon is an important factor when we examine the dependence structure between financial instruments. For example, it turned out that investment in cryptocurrency like Bitcoin, that may look

attractive in the short-term, may also be too risky in the long-term, and this is a finding that market participants shouldn't ignore.

Certainly, the current crisis caused by the COVID-19 epidemic is quite a challenge for financial market participants. The subject of future research could be to assess, whether in a period of such a high uncertainty, all considered alternative investments were trusted by investors.

APPENDIX

1. Results for DAX, CAC and LIV-EX without Currency Conversion

Table A1 Quantile Coherency for Medians: Point Estimate of the Real Part and 95% Confidence Interval

	frequency	CAC	DAX
LIV-EX	two-day	-0.13 (-0.35, 0.09)	-0.03 (-0.26, 0.20)
	weekly	0.04 (-0.13, 0.20)	-0.07 (-0.24, 0.09)
	monthly	-0.05 (-0.22, 0.13)	-0.08 (-0.25, 0.09)

Notes: Entries are in bold when the 95% confidence interval does not include zero.

Table A2 Quantile Coherency for Left and Right Tail: Point Estimate of the Real Part and 95% Confidence Interval

	frequency	CAC	DAX
LIV-EX	two-day	-0.08 (-0.31, 0.15)	-0.15 (-0.39, 0.08)
	weekly	-0.14 (-0.30, 0.02)	**-0.17** **(-0.32, -0.01)**
	monthly	-0.11 (-0.27, 0.04)	**-0.26** **(-0.41, -0.11)**

Notes: Entries are in bold when the 95% confidence interval does not include zero.

Table A3 Quantile Coherency for Left Tail and Median: Point Estimate of the Real Part and 95% Confidence Interval

	frequency	CAC	DAX
LIV-EX	two-day	**-0.26** **(-0.48, -0.05)**	-0.03 (-0.27, 0.20)
	weekly	-0.12 (-0.28, 0.04)	-0.02 (-0.19, 0.14)
	monthly	0.15 (-0.01, 0.32)	-0.11 (-0.28, 0.06)

Notes: Entries are in bold when the 95% confidence interval does not include zero.

Table A4 Quantile Coherency for Left Tails: Point Estimate of the Real Part and 95% Confidence Interval

	frequency	CAC	DAX
LIV-EX	two-day	0.07 (-0.16, 0.30)	-0.16 (-0.39, 0.08)
	weekly	0.09 (-0.07, 0.25)	0.07 (-0.09, 0.23)
	monthly	0.11 (-0.05, 0.27)	-0.04 (-0.20, 0.12)

Notes: Entries are in bold when the 95% confidence interval does not include zero.

2. Results for FTSE, DAX, CAC and GOLD, BTC, LIV-EX from Two-Day to Two-Monthly Frequency

Figure A1 FTSE – GOLD
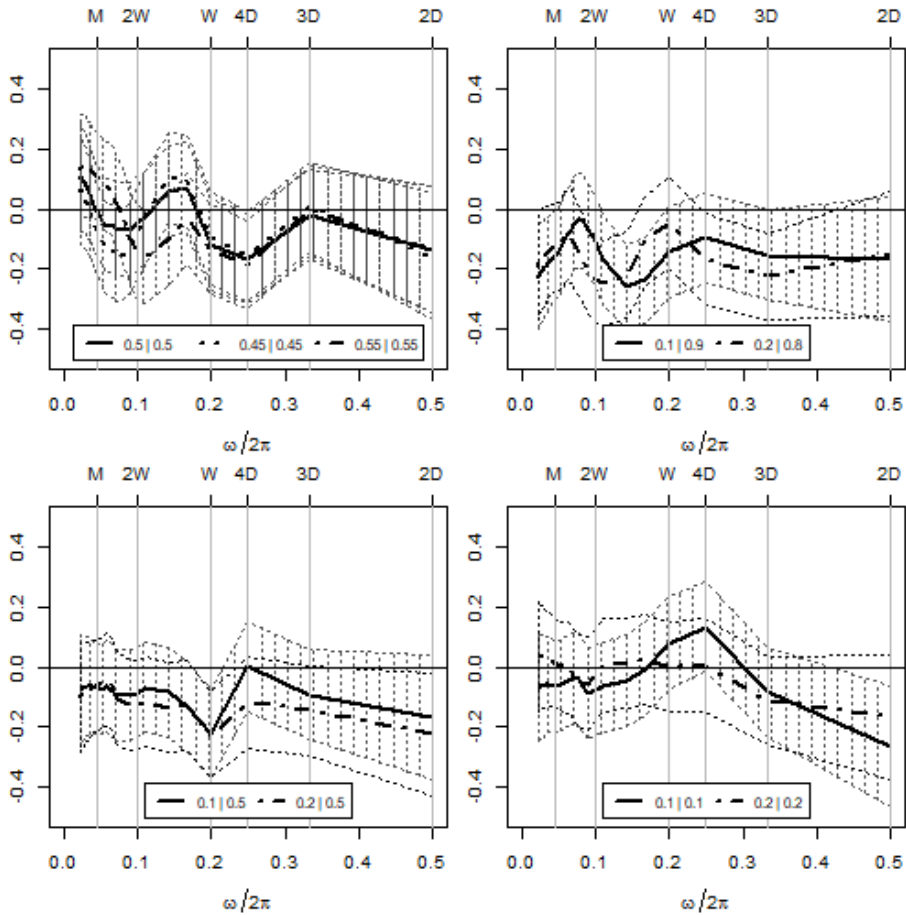
Notes: This figure presents a quantile coherency estimates in the center of the distribution (upper left panel), between left and right tail (upper right panel), between left tail and median (bottom left panel), and between left tails of the distribution (bottom right panel)
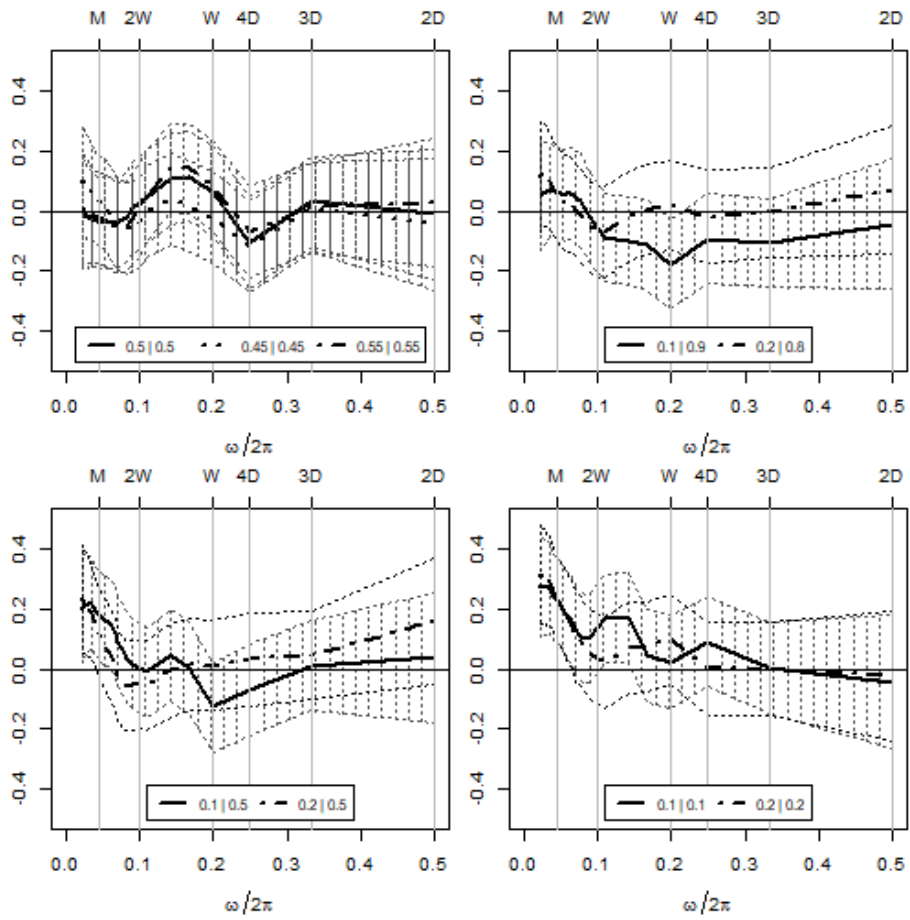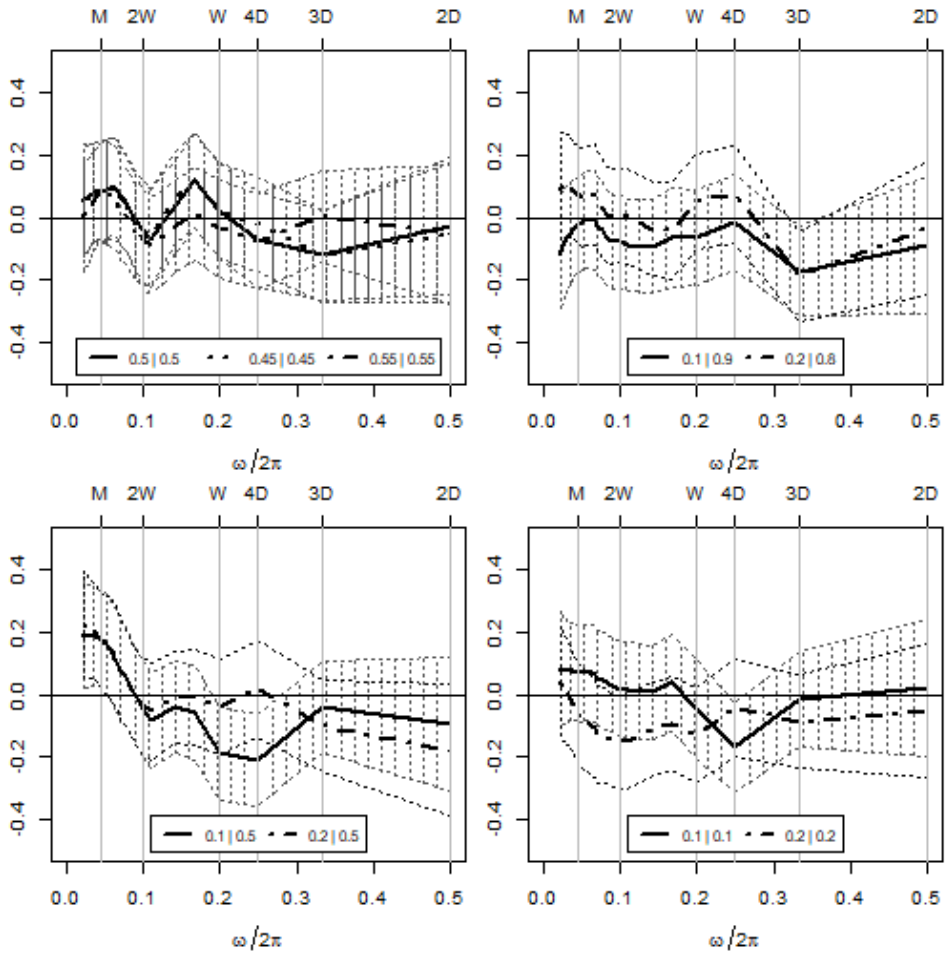
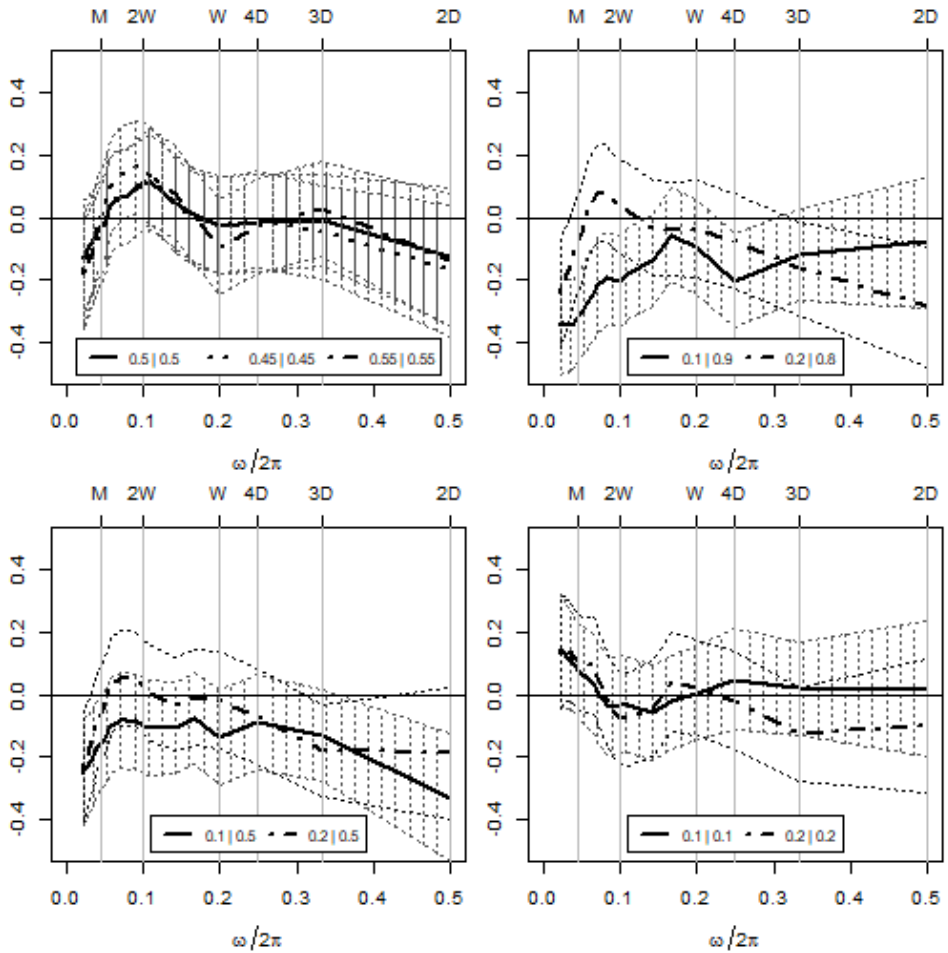**Figure A2 FTSE – BTC**

Figure A3 FTSE – LIV-EX

Figure A4 DAX – GOLD

Figure A5 DAX – BTC
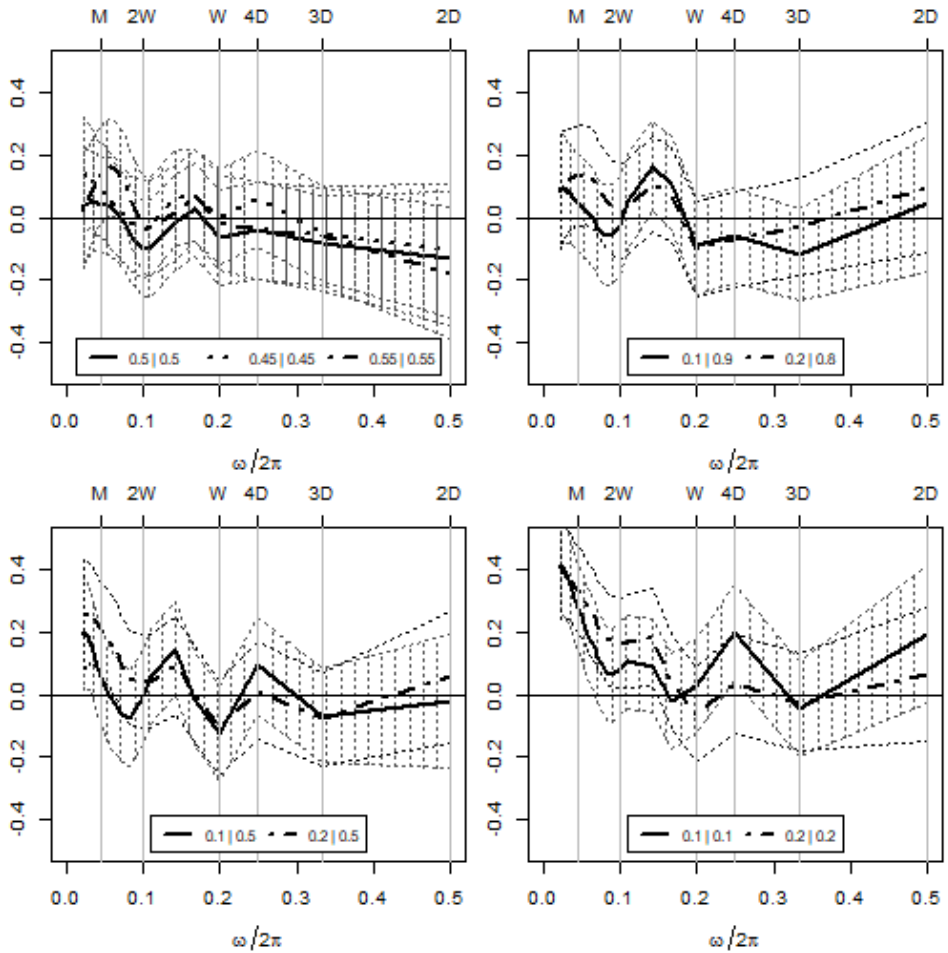
Figure A6 DAX – LIV-EX
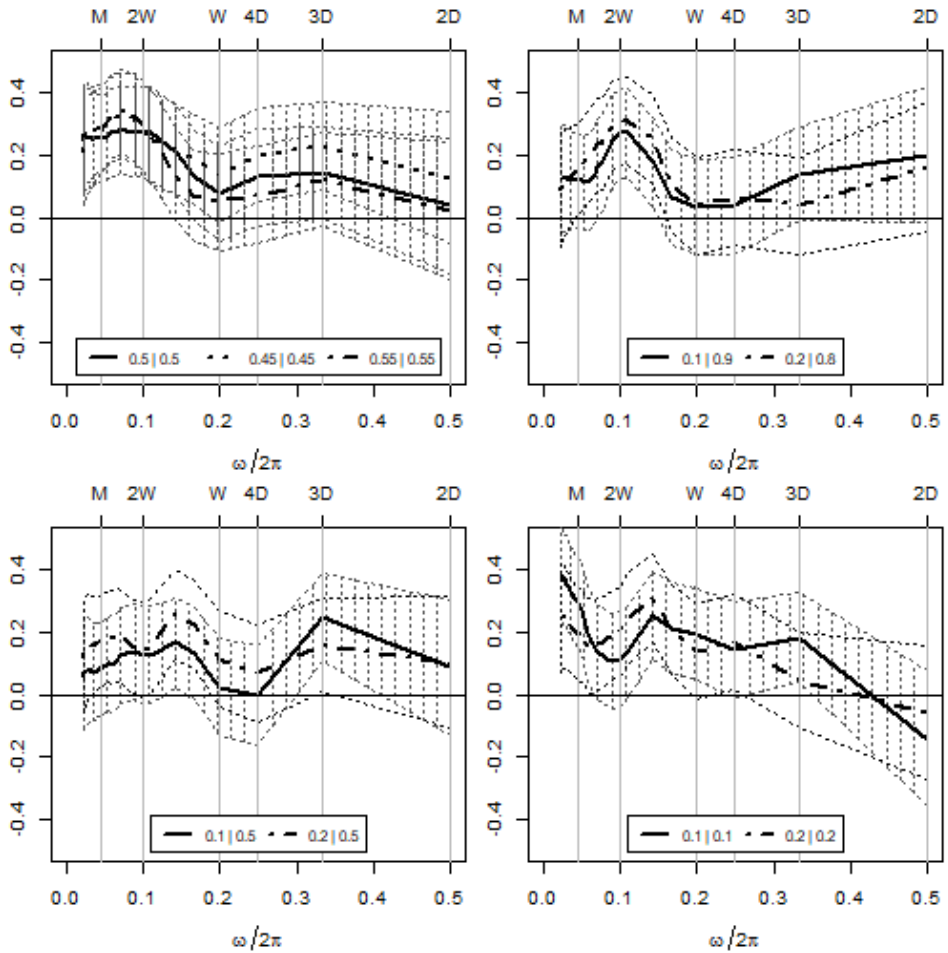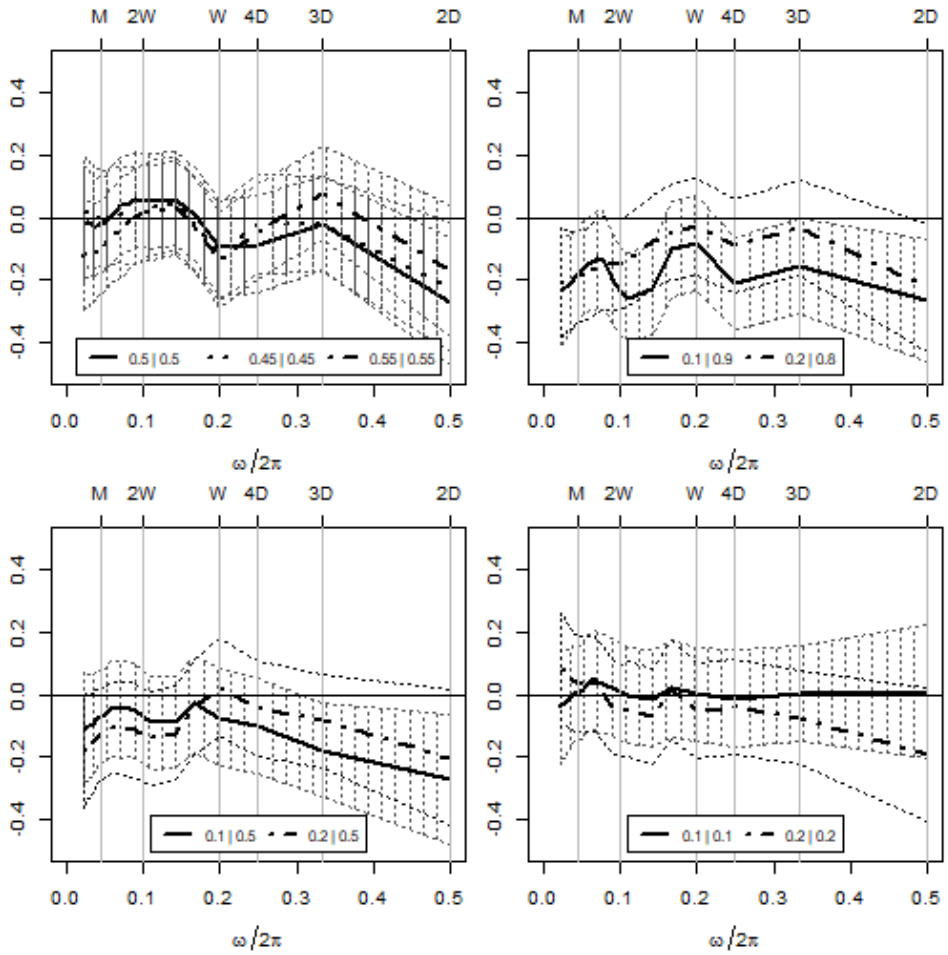
Figure A7 CAC – GOLD
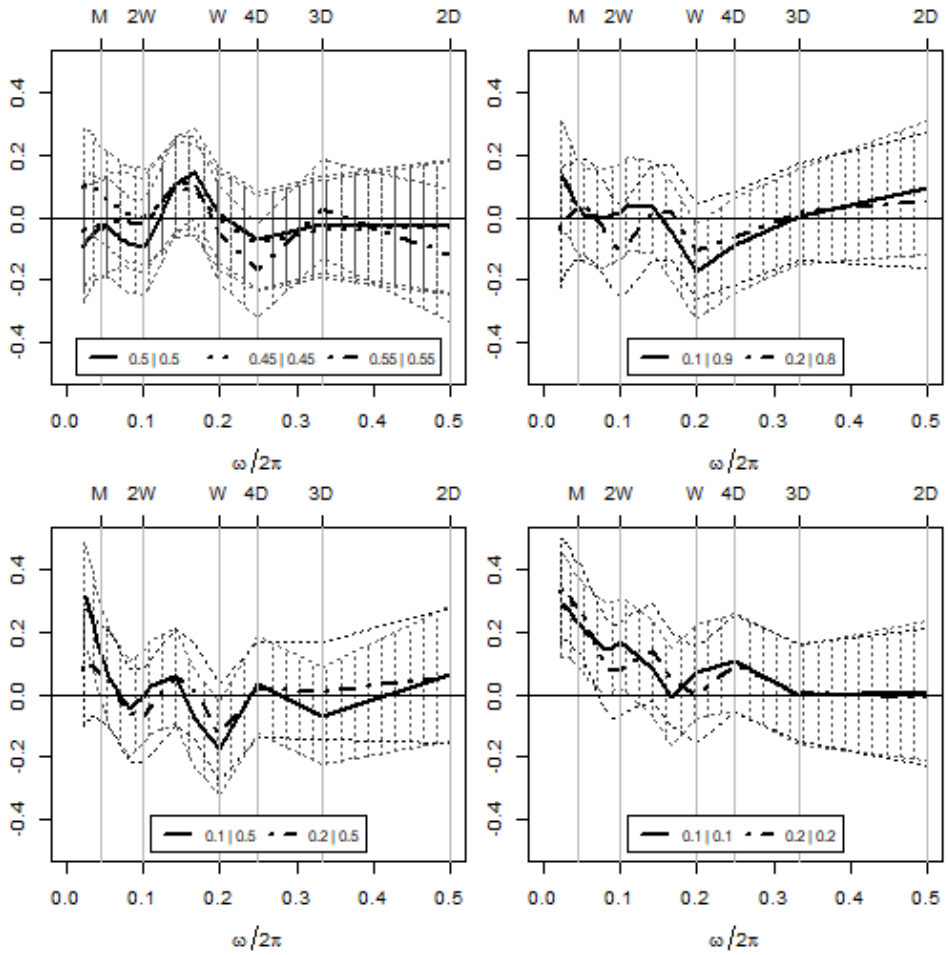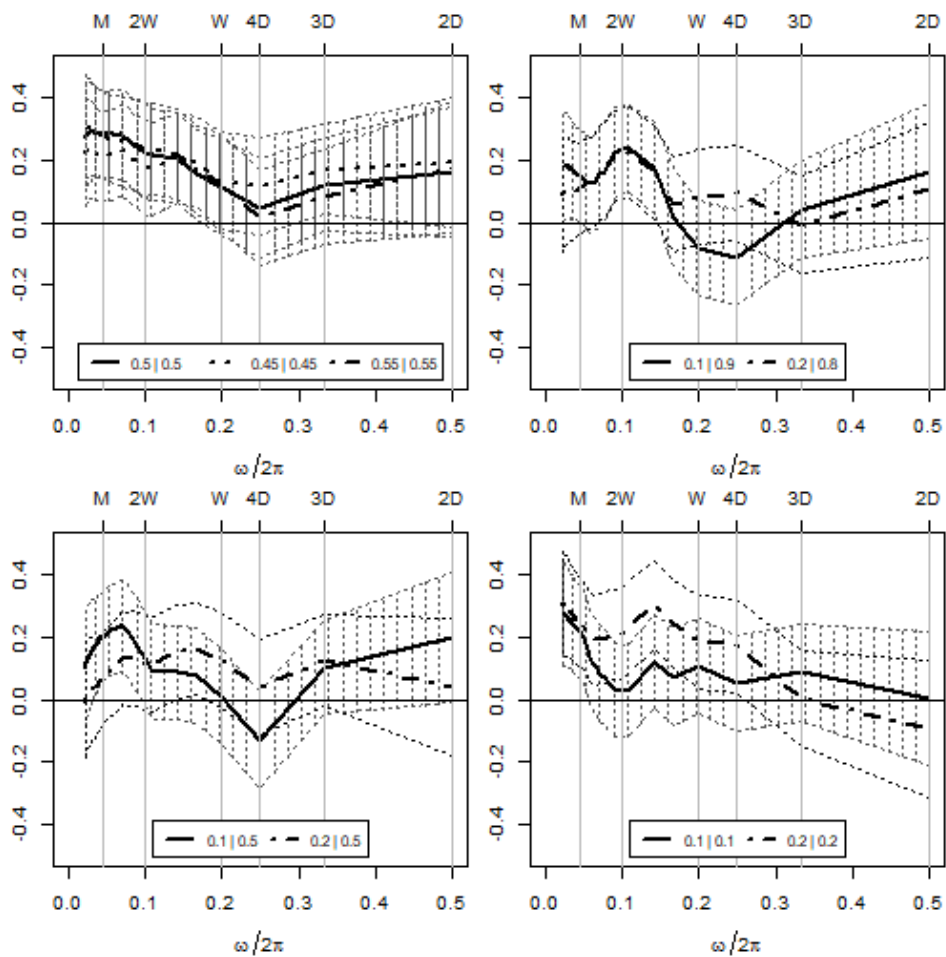
Figure A8 CAC – BTC

Figure A9 CAC – LIV-EX

REFERENCES

Antonakakis N, Balcilar M, Bouri E, Gupta R (2018): Is Wine a Safe-Haven? Evidence from a Nonparametric Causality-in-Quantiles Test. *Advances in Decision Sciences*, 22:1-19.

Anand R, Madhogaria S (2012): Is gold a Safe-Haven? An Econometric Analysis. *Procedia Economics and Finance*, 1:24-33.

Baruník J, Kley T (2019): Quantile Coherency: a General Measure for Dependence Between Cyclical Economic Variables. *Econometrics Journal*, 22:131-152.

Baumöhl E (2019): Are Cryptocurrencies Connected to Forex? A Quantile Cross-Spectral Approach, *Finance Research Letters,* 29: 363-372.

Baur DG, Hong K, Lee AD (2017): Bitcoin: Medium of Exchange or Speculative Assets? *Journal International Financial Market,* 54:177-189.

Baur DG, Lucey BM (2010): Is Gold a Hedge or a Safe Haven? An Analysis of Stocks, Bonds and Gold. *The Financial Review,* 45:217–229.

Baur DG, McDermott TK (2010): Is Gold a Safe Haven? International Evidence. *Journal of Banking and Finance*, 34:1886–1898.

Bouri EI (2015): Fine Wine as an Alternative Investment during Equity Market Downturns. *Journal of Alternative Investment,* 17:46-57.

Bouri EI, Roubaud D (2016): Fine Wines and Stocks from the Perspective of UK Investors: Hedge or Safe Haven? *Journal of Wine Economics*, 11: 233–248.

Bouri EI, Molnár P, Azzi G, Roubaud D, Hagfors LI (2017): On the Hedge and Safe Haven Properties of Bitcoin: Is It Really More Than a Diversifier? *Finance Research Letters,* 20:192-198.

Bredin D, Conlon T, Potì V (2015): Does Gold Glitter in the Long-Run? Gold as a Hedge and Safe Haven Across Time and Investment Horizon. *International Review of Financial Analysis*, 41:320-328.

Ciner C, Gurdgiev C, Lucey BM (2013): Hedges and Safe Havens: An Examination of Stocks, Bonds, Gold, Oil and Exchange Rates. *International Review of Financial Analysis*, 29: 202-211.

Chambers DR, Anson MJP, Black KH, Hossein K (2015): *Alternative Investments: CAIA Level I*, London: John Wiley & Sons.

Chan WH, Le M, Wu YW (2019): Holding Bitcoin Longer: the Dynamic Hedging Abilities of Bitcoin, *The Quarterly Review of Economics and Finance*, 71, 107-113.

Chen AS, Lin JW (2014): The Relation between Gold and Stocks: An Analysis of Severe Bear Markets. *Applied Economics Letters*, 21:158-170.

Choudhry T, Hassan SS, Shabi S (2015): Relationship between Gold and Stock Markets During the Global Financial Crisis: Evidence from Nonlinear Causality Tests. *International Review of Financial Analysis,* 41:247–256.

Conlon T, McGee R (2020): Safe Haven or Risky Hazard? Bitcoin During the Covid-19 Bear Market. *Finance Research Letters*, 2020, 101607 (In press).

Coudert V, Raymond H (2011): Gold and Financial Assets: Are There Any Safe Havens in Bear Markets? *Economics Bulletin*, 31:1613–1622.

Dicle MF, Levendis JD (2017): Hedging Market Volatility with Gold. *Quantitative Finance Economics*, 1:253-271.

Dyhrberg AH (2016): Bitcoin, Gold and the Dollar – A GARCH Volatility Analysis. *Finance Research Letters,*16: 85–92.

Emmrich O, McGroarty FJ (2013): Should Gold be Included in Institutional Investment Portfolios? *Applied Financial Economics*, 23:1553–1565.

Gürgün G, Ünalmış İ (2014): Is Gold a Safe Haven Against Equity Market Investment in Emerging and Developing Countries? *Finance Research Letters*, 11:341-348.

Hood M, Malik F (2013): Is Gold the Best Hedge and a Safe Haven under Changing Stock Market Volatility? *Review of Financial Economics*, 22:47-52.

Introvigne S, Bacchiocchi E, Vandone D (2017): A Cointegration Analysis of Wine Stock Indexes. *Risk Governance and Control: Financial Markets and Institutions*, 7:178–188.

Klein T, Thu HP, Walther T (2018): Bitcoin is Not the New Gold – A Comparison of Volatility, Correlation, and Portfolio Performance. *International Review of Financial Analysis*, 59:105-116.

Kley T. (2020): Quantspec: Quantile-Based Spectral Analysis of Time Series. R package version 1.2-2. http://github.com/tobiaskley/quantspec

Kliber A, Marszałek P, Musiałkowska I, Świerczyńska K (2019): Bitcoin: Safe Haven, Hedge or Diversifier? Perception of Bitcoin in the Context of a Country's Economic Situation – A Stochastic Volatility Approach. *Physica A: Statistical Mechanics and its Applications,* 524:246-257.

Le Fur E, Ameur HB, Braune E (2016): Financial Market Contagion and Fine Wines: the Evidence of the ADCC GARCH Model. *International Journal of Entrepreneurship and Small Business,* 29:583-60.

Le Fur E, Outreville JF (2019): Fine Wine Returns: a Review of the Literature, *Journal of Asset Management,* 20,196-214.

Maghyereh A, Hussein A (2020): Tail Dependence Between Gold and Islamic Securities, *Finance Research Letters*, 2020, 101503 (In press).

Miyazaki T, Hamori S (2013): Testing for Causality Between the Gold Return and Stock Market Performance: Evidence for 'Gold Investment in Case of Emergency'. *Applied Financial Economics*, 23:27–40.

Miyazaki T, Toyoshima Y, Hamori S (2012): Exploring the Dynamic Interdependence Between Gold and Other Financial Markets. *Economics Bulletin*, 32:37–50.

Müller UA, Dacorogna MM, Davé RD, Olsen RB, Pictet OV, von Weizsäcker JE (1997): Volatilities of Different Time Resolutions – Analyzing the Dynamics of Market Components. *Journal of Empirical Finance*, 4:213-239.

Müller UA, Dacorogna MM, Davé RD, Pictet OV, Olsen RB, Ward JR (1993), Fractals and Intrinsic Time – a Challenge to Econometricians. Olsen and Associates, Working Papers, No. 1993-08-16.

Naeem MA, Hasan M, Arif M, Balli F, Shahzad SJH (2020): Time and Frequency Domain Quantile Coherence of Emerging Stock Markets with Gold and Oil Prices. *Physica A: Statistical Mechanics and its Applications*, 2020, 124235 (In press).

Shahzad SJH, Raza N, Roubaud D, Arreola-Hernandez J, Bekiros S (2019): Gold as Safe Haven for G-7 Stocks and Bonds: A Revisit. *Journal of Quantitative Economics*, 17:885-912.

Shahzad SJH, Bouri E, Roubaud D, Kristoufek L, Lucey B (2019): Is Bitcoin a Better Safe-Haven Investment than Gold and Commodities? *International Review of Financial Analysis*, 63:322–330.

Shahzad SJH, Bouri E, Roubaud D, Kristoufek L (2019): Safe Haven, Hedge and Diversification for G7 Stock Markets: Gold Versus Bitcoin. *Economic Modelling*, 87:212-224.

Tuysuz S (2013): Conditional Correlations between Stock Index, Investment Grade Yield, High Yield and Commodities (Gold and Oil) During Stable and Crisis Periods. *International Journal of Economics and Finance*, 5:28-44.

Wang J (2012): *Investment in Gold: An Empirical Study of the Gold Return from 90s to 21st*. Copenhagen Business School, Denmark.

World Economic Forum (2015): *Alternative Investments 2020: An Introduction to Alternative Investments.* Available from: https://www.weforum.org/reports/alternative-investments-2020-future-alternative-investments.

Yermack D (2015): Is Bitcoin a Real Currency? An Economic Appraisal, In: Chuen DLK (ed.) *Handbook of Digital Currency: Bitcoin, Innovation, Financial Instruments and Big Data*, Academic Press, 31-43.