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Bitcoin vs Gold : who's best at diversifying risk ?

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Abstract

When constructing a financial portfolio, whether as an independent or institutional actor, one must contend with a degree of risk. There are several methodologies that can be utilized to address this issue. The present study shall be centered on the examination of both Value at Risk and Expected Shortfall through the utilization of both parametric and non-parametric methodologies. The primary objective of this inquiry is to undertake an investigation into the risk measures of four portfolios that are representations of national economies, namely those of Belgium, Switzerland, Argentina, and Turkey. In this study, I will incorporate either bitcoin or gold into each of the portfolios in equivalent proportions to determine which asset yields a superior mitigating effect on risk. The temporal scope of the investigation pertains to the period spanning 01/01/2018 to 31/12/2022, during which data was gathered on a daily basis. All estimators will be subjected to evaluation at four distinct probability thresholds, namely 90%, 95%, 97. 5%, and 99%. Subsequently, the accuracy of the estimates shall be ascertained through the process of backtesting. The findings indicate that there is no observable evidence of Bitcoin affording a noteworthy advantage over gold with regard to mitigating risk across the examined cases. Contrarily, gold may lead to a more significant diminution of the VaR than bitcoin in certain scenarios in Belgium and Turkey. When examining the impact on the ES, empirical evidence suggests that gold exhibits a greater capacity for reducing risks in certain instances within Switzerland and Turkey compared to bitcoin.

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1.Introduction

1.1 Motivations

The endeavor initiated by Satoshi Nakamoto, the enigmatic individual behind the inception of Bitcoin, to bestow complete proprietorship of the assets to the user has piqued my interest without delay. According to Warkme (2021), Bitcoin serves as a potential remedy for an unjust system in which public funds are allocated to private banks. In order to expand my knowledge and understanding of the subject matter, I made a conscientious decision to allocate a portion of my time at Bocconi University to attending informative lectures on Bitcoin, facilitated by esteemed professors Fransesco Bruschi and Leonardo de Rossi. After undergoing these courses, my inclination to explore the intricacies of Bitcoin was emboldened owing to its novelty and lack of comprehensive research in the field.

1.2 The rationale for conducting this study.

Consequent to these instructional sessions and my concomitant perusal of scientific journals, I ascertained the intriguing potential of Bitcoin's attributes for a portfolio. Several research studies have examined the notable variability exhibited by Bitcoin in relation to conventional assets, while others have explored the characteristics of including Bitcoin as part of investment portfolios. Kliber et al. (2019) posit that a safe haven property may have limited impact in a particular instance of hyperinflation, as detailed in the subsequent literature review. The study conducted by Stensås et al. (2019) suggests that Bitcoin may serve as a secure refuge during particular instances of susceptibility.

The present inquiry pertains to the possibility of other instances and the potential capacity of Bitcoin to excel markedly and surpass the preeminent safeguard asset, namely gold, with regard to risk. Is it plausible for Bitcoin to substantially diminish the Value at Risk and Expected Shortfall of certain portfolios to a greater extent than Gold?

To date, there appears to be no academic literature identifying the comparative evolution of Value at Risk/ Expected Shortfall in relation to the inclusion of Bitcoin or gold within both developed and emerging country asset portfolios. I have elected to undertake this comparison

by examining nations exhibiting "managed" inflation alongside those experiencing hyperinflationary conditions. The aforementioned decision appeared to possess a reasonable basis, considering the implications gleaned from Kliber et al. (2019) investigation into the safe haven phenomenon, as well as Baur and Lucey (2010) findings on the comparatively weakened safe haven attribute of gold within emerging economies, the details of which will be elaborated upon in subsequent sections. The present article endeavors to address the lacuna in the extant literature by propounding the preliminary hypothesis that in particular instances of hyperinflation and inadequately diversified portfolios, the act of holding Bitcoin may be more alluring vis-à-vis gold as a means of risk reduction.

2. Literature review

2.1 Bitcoin particularly interesting for emerging countries ?

Bitcoin is a highly disputed area of research, and due to its novelty, scholarly literature provides an opportune arena for investigation and analysis. Research findings regarding the subject matter exhibit occasional contradictory interpretations, albeit significantly engaging. MicroStrategy is acknowledged as the inaugural major corporation to allocate resources towards Bitcoin investment during the year 2020. A year subsequent to the aforementioned event, the American conglomerates JP Morgan, Goldman Sachs, and Morgan Stanley, each put forth propositions for investment solutions incorporating the cryptocurrency Bitcoin, within the period of March through April in the year 2021.

In the following discourse, an initial inquiry revolves around the positioning of Bitcoin vis-a-vis conventional currencies and precious metal assets. Additionally, an inquiry delves into its placement within a wallet and its corresponding behavioral characteristics. Based on the consensus among the majority of scholarly authors, Bitcoin's noncompliance with the three fundamental facets of money designated approximately a century ago disqualifies it from being acknowledged as a conventional currency. “Money has three principal functions. It is a medium of exchange, a common measure of value, and a store of value. In performing these functions, money is a convenient form for the exchange of goods and services, a means for comparing the values of dissimilar goods and services, and a method for saving and accumulating wealth.” Keynes (1930). According to recent studies by Corbet et al. (2018) and Yermack (2015), Bitcoin's capability to function as a unit of account is limited by its considerable volatility as an asset. Corbet et al. (2018) point out that there has been an increase in the spot price subsequent to the introduction of Bitcoin futures contracts. Furthermore, their analysis indicates that Bitcoin exhibits predominantly speculative characteristics rather than fulfilling the conventional functions of a currency as evidenced by portfolio tests. According to Corbet et al. (2018), in order for prices to function as a unit of account, there must be a stabilization of prices resulting from the reduction of variance subsequent to the implementation of futures contracts. When looking at the literature, studies by Lee et al. (2014) have indeed shown a stabilization of property prices following the introduction of futures contracts.

Yermarck (2015), Smales (2019), and Williamson (2018) emphasize the challenge posed by the retention of value. According to Smales (2019) and Williamson (2018), the actualization of a transfer of digital assets over blockchain technology necessitates several minutes for completion. Moreover, the transaction process must also be completely secure to ensure data integrity and prevent unauthorized access. However, the validity of this statement is subject to ongoing debate. Poon and Dryja (2015) have introduced the Lightning Network, a system that facilitates off-chain transactions while offering cost-efficient and swift security measures.

The debatability of the function of store of value notwithstanding, it is difficult to dispute that Bitcoin falls short of fulfilling the unit of account characteristic, primarily owing to its surging fluctuations in value, thereby failing to align with Keynes' conception of a currency. Numerous scholarly investigations underscore the volatility of the aforementioned fluctuation and often draw comparisons to that of the gold. Undoubtedly, a pronounced variation exists in the overall capitalization of bitcoin when compared to gold, with the former exhibiting significantly lower figures. Numerous research endeavors emphasize such volatility and occasionally make a parallel to that of gold. Undoubtedly, a noteworthy disparity between bitcoin and gold lies in the discrepancy of their overall capitalization, with the former exhibiting considerably lower figures. The findings presented by Bouteska et al. (2022) elucidate the efficacy of market sentiment as a reliable surrogate for forecasting Bitcoin prices, as evidenced by their utilization of a text analyzer on social networks. Further, the study indicates that such a strategy is particularly effective during economic downturns marked by crises such as the COVID-19 pandemic. Chen et al. (2020) arrived at a comparable conclusion utilizing a comparable approach. In their recent research, Sarkodie et al. (2022) examined the volatility of cryptocurrencies such as Bitcoin, Litecoin, Ethereum, and Bitcoin cash during a period of economic stress caused by the COVID-19 pandemic. Utilizing the Romano-Wolf multiple hypotheses technique, the authors were able to identify substantial fluctuations in these digital assets.

A multitude of measures found in scholarly sources have endeavored to capture market sentiment towards Bitcoin. Karalevicius et al. (2018) and Abraham et al. (2018) demonstrated a correlation between the prices of Bitcoin and the search volume of the term on various search engines. In the study by Karalevicius et al (2018), the authors find, a parallel correlation can also be observed in the frequency with which Bitcoin is referred to on various social media platforms. This phenomenon has been corroborated by Choi (2021), whose research indicates

that the quantity of occurrences of the term "Bitcoin" in tweeted messages is indicative of prevailing market sentiment and corresponding fluctuations in its value. In point of fact, Tetlock (2007) had already demonstrated the association between media and market downturns 15 years earlier in his research studies. Nevertheless, this phenomenon holds significant importance, especially in the context of Bitcoin. One plausible explanation for this phenomenon is the relatively reduced presence of institutional investors in this asset class, in addition to its relatively higher proportion of youthful investors. Bouri et al. (2019) elucidate that the demographic of investors participating in the cryptocurrency market tends to be of younger age, on average, and as a result, is particularly susceptible to the influences of media. Consequently, this segment exhibits a heightened degree of market volatility.

While adhering to Keynes' definition, it would not be accurate to label Bitcoin simply as a currency. The matter at hand is more intricate than this surface-level classification may suggest. Several nations have endorsed Bitcoin as a legitimate mode of payment, as exemplified by Japan. Several entities have designated it as their official currency, such as the nation of El Salvador. Prior to the mining prohibition in 2017, this particular commodity had attained widespread popularity within the Chinese market. Is it worth contemplating the addition of Bitcoin to one's portfolio, given certain circumstances?

The literature unequivocally supports the notion that the answer to this matter is in the affirmative. The research conducted by Kliber et al. (2019) provides an extensive analysis of the topic at hand, drawing from a diverse sample of five countries with varying daily returns, including Estonia, Sweden, Venezuela, China, and Japan. The findings of the study indicate the presence of hedge properties in Estonia and Sweden, diversification effects in China and Japan, and potentially even a Safe Haven in Venezuela. Nonetheless, as highlighted by Kliber et al. (2019), the outcomes may substantially diverge based on the portfolio composition and the frequency of data gathering. Chan et al. (2019) elucidated upon a specific topic in their scholarly work. They distinct outcomes and robust hedging properties of Bitcoin in relation to prominent indices - namely the Euro-Index, ShanghaiA-Share, S&P 500, Nikkei, and the TSX Index - were discerned. The observed variability is attributed to distinct modes of data collection, which were conducted on a monthly basis, as documented in the Chan et al. (2019) study. Or the study conducted by Kliber et al. (2019) comparatively was in daily occurrences. The scholarly endeavor of Gusmi et al. (2019) investigated the properties of a portfolio comprising petrol, gold, emerging market equities, and bitcoin.

The findings indicated that bitcoin functioned as a hedge in the daily return of the portfolio. This is confirmed by Stensås et al. (2019) concerning the hedging properties of bitcoin for emerging markets.

Apart from the instance of Venezuela, Stensås et al. (2019) have documented other occurrences of Safe Haven. One example highlighted by scholars pertains to the US presidential election, where Bitcoin served as a notable refuge in the days preceding the event. Conversely, in the context of Brexit, it was observed that Bitcoin served as a robust refuge owing to the pervasive ambiguity surrounding the resultant implications for pertinent nations such as the United States, United Kingdom, Japan, Germany, France, China, and South Korea. It is imperative to exercise caution in drawing any premature inferences, particularly concerning the Venezuelan scenario outlined by Klibert et al. (2019) findings. The literature posits that Bitcoin may function as a secure and reliable refuge in situations characterized by distress and ambiguity. According to Smales (2019) scholarly publication, Bitcoin is presently not considered a reliable and secure investment option, but this notion may be subject to exceptions under particular circumstances and with the further development of the market. One compelling explanation for the distinct characteristics of bitcoin is its potential as a mechanism for hedging against fluctuations in the US dollar. Dyhrberg (2016) research has demonstrated that bitcoin has the potential to serve as a hedging instrument against the US dollar over a brief time horizon, contingent upon the attainment of specific thresholds of volatility.

The last paragraph of the discourse necessitates a nuanced approach. Despite the notion of Bitcoin functioning as a hedge or even as a safe haven during times of unpredictability, previous research has exhibited contradictory results. The research conducted by Colon and McGee (2020) indicates that Bitcoin is not a viable option as a safe haven during the Covid-19 market crisis, particularly in relation to the S&P500. The proposition that Bitcoin serves as a safe haven during all the times of heightened distress is evidently invalid.

2.3 Gold versus Bitcoin as a safe-haven

For centuries, gold has been relied upon as a secure means of investment, commonly regarded as a safe haven asset with direct link to an exchange rate against any currency Baur and McDermott (2010). For centuries, India has maintained a distinguished reputation with regard

to its association with gold, resulting in the largest populace in possession of this precious metal owing to its intrinsic value and symbolic significance Baur and McDermott (2010).

The existence of safe-haven properties has been a topic of much discussion in academic discourse. Baur and Lucey (2010) contribute to this literature through their analysis of the negative quantiles of 1%, 2. 5%, and 5% of the distribution over a period of 15 days during a stock market shock. According to Baur and Lucey (2010), subsequent to this particular time interval, gold ceases to function as a safe-haven. The authors explicate that such a strategy proves to be highly advantageous in relation to equities; however, its efficacy is subdued when applied to fixed income securities. In their research study, Bilgin et al. (2018) have demonstrated that gold possess characteristics of a safe haven against oil. According to Baur and McDermott (2010), the attributes of safe havens are primarily applicable to developed nations, whereas this phenomenon is not widespread in flourishing economies.

Ciner et al. (2013) demonstrate the capacity of gold to function as a secure and stable investment during a market downturn, particularly in response to a decline in exchange rates. Various studies have illustrated the capacity of gold to function as a safe haven in particular scenarios, wherein the marketplace responds to specific information. According to Dyhrberg (2016), bitcoin exhibits similar hedging capabilities as gold and the dollar, thus rendering it a potential alternative to gold, particularly when evaluated using the GARCH model. They respond comparably to positive or negative news. Bitcoin exhibits a unique characteristic that distinguishes it from gold, namely its notably smaller market capitalization Dyhrberg (2016). Additionally, the scholarly discourse posits that the significance of the safe haven phenomenon is comparatively diminished in economies that are less advanced, thereby reinforcing the relevance of the present study.

2.4 Risk and Bitcoin studies

According to Kwon (2021), Bitcoin exhibits the characteristic of possessing extensive distribution tails, which are primarily influenced by fluctuations in monetary policy risk and trading volume of Bitcoin. The recent study conducted by Desagre et al. (2022) show a significant increase in order volumes and traded currencies, both on the buy and sell side when placed is in these parts of the distribution.

Kwnon (2021) posits that the utilization of Value at Risk analysis holds relevance for Bitcoin owing to the significant magnitude of its price volatility. The author contends that the market for Bitcoin is of a nascent nature, evinced by its erratic fluctuations, pronounced volatility and recurrent occurrence of speculative bubbles. The analysis of Value at Risk holds significant importance Kwnon (2021). Begušić et al. (2018) confirm the tails of Bitcoin were more significant in comparison to stocks, resulting in much more substantial fluctuations, despite similar sample sizes.

To date, there have been almost no studies on VaR and Bitcoin. Kwnon (2021), mentioned above, studies Value at Risk at 1% and 5%, taking into account 30 economic factors such as Bitcoin trading volume, monetary policy rate, etc., and observes how these indicators affect VaR. Nonetheless, the present investigation diverges significantly namely incorporating Bitcoin into nationally portfolios with substantial market capitalization. A study conducted by Valstad & Vagstad (2014) demonstrates that Bitcoin exhibits a VaR that is 10 times higher than both gold and the US dollar. Nevertheless, it must be acknowledged that the aforementioned statements necessitate a stepback due to the passage of 9 years since the implementation of said studies. Undeniably, annually, the market capitalization of Bitcoin increase on average meaning that a marginal increase of 1% necessitates a correspondingly greater level of financial capital. It is evident to see from the Bitcoin price chart that as the bull markets recurs, the fluctuations are smaller and smaller in percentage terms.

Currently, there is a paucity of research on the Value at Risk of Bitcoin, thus posing a challenge to determine the optimal VaR estimator for data analysis. In the subsequent section, a thorough examination of the models will be conducted by comparing the models with each other

3. Methodology

3.1 Data collection

The present work has been executed with a focus on daily returns as the preferred unit of time for Bitcoin, owing to the fact that a majority of the salient characteristics discovered were ascertained in this time frame cf. Baur & Lucey (2010), Kliber et al. (2019), Gusmi et al. (2019), Stensås & al. (2019) … In regard to the field of cryptocurrency, the decision was made to focus on Bitcoin, primarily based on the extent of available data outlined by Shiller (2014) in his paper. Moreover, this investigation was motivated by several other prominent factors, inclusive of: Bitcoin's position as the most significant market capitalization entity within the scope of cryptocurrencies, with market share fluctuations ranging between 37% and 72% throughout the studied period (cf. to Appendix 1); the exceptionally strong correlation shared by various cryptocurrencies irrespective of their type; and the fact that Bitcoin is the lone cryptocurrency endorsed as an authorized form of payment within selected nations (cf. Kliber et al. 2019).

For the purpose of conducting data collection, the website https://www.investing.com/ was utilized to obtain data corresponding to each of the assets included in the study. I elected to conduct my analysis pertaining to the previous 5 years, specifically. The time period spanning from January 1st, 2018 to December 31st, 2022. In consideration of sustained market variability and alternating market cycles, I elected to allocate a relatively extensive timeframe for analysis. Nevertheless, antecedent data prior to 2018 was omitted to prevent delving too far back into the past as a result of the heightened volatility of Bitcoin during that temporal epoch. As previously stated, it is evident that Bitcoin's capitalisation has exhibited an annual increase on average. The inclusion of bull runs in 2013 and 2017, which demonstrated multiples of approximately 8000% and 1800%, respectively, would be considered impractical for analysis. The probability of observing comparable fluctuations within a condensed timeframe is notably implausible, primarily attributed to the progression of the overall market capitalization.

The selection of countries was motivated by a desire to explore the development of Value at Risk in both emerging and developed nations. This decision was informed by extant scholarly literature positing that gold may not exhibit safe haven characteristics to the same extent in

emerging nations and that bitcoin may represent an opportunity in this context (cf. Section 2). In the context of emerging economies, it is imperative to consider the reliability and availability of data. On the other hand, my research endeavors have involved assessing nations that face significant challenges characterizing inflation control mechanisms to explore the potential of bitcoin as an alternative asset that could offer superior performance compared to gold. Therefore I started a roster of nations by opting for ten countries with the most elevated extant yearly inflation rate. The countries categorized in a descending order of inflation rate are Venezuela, Sudan, Lebanon, Syria, Suriname, Zimbabwe, Argentina, Turkey, Iran and Ethiopia, which are tabulated in Appendix 2. According to Kellner et al. (2016) the two nations possessing the highest Gross Domestic Product have been selected from the aforementioned list. The countries of Turkey and Argentina emerged as the primary focus and elemental foundation of my research (cf. Appendix 3). In relation to the context of developed nations, an investigation has been conducted on Switzerland and Belgium owing to their stable inflation rates and comparable sizes to Turkey and Argentina. The aforementioned reasoning was employed to justify the selection of these countries, as opposed to larger economies like Japan, whose inflation rate is relatively low, yet whose GDP exceeds that of Argentina by a factor of 14.

3.2 Data construction

When constructing the portfolios, the initial phase entailed importing information pertaining twenty of the largest capitalized corporations from each of the selected countries included in this inquiry, namely...

Belgium (ABI, ACKB, AED, AGS, APAM, ARGX, COFB, COLR, DIE, ELI, GLPG, GBLB, KBC, PROX, SOF, SOLB, UCB, UMI, VGP, WDP)

Switzerland (NESN, NOVN, ROG, ZURN, UBSG, ABBN, CFR, LONN, GIVN, SIKA, SREN, CSGN, HOLN, GEBN, SGSN, SCMN, SLHN, UHR, ADEN, SIKA2)

Argentina (ALUA, BMA, BBAR, BYMA, CVH, CEPU, COME, CRES, EDN, GGAL, SUPV, JMIN, LOMA, MIRG, PAMP, TECO2, TXAR, TGNO4, TRAN, YPFD)

Turkey (AKBNK, AKSA, ALARK, ARCLK, ASELS, BIMAS, EKGYO, ENKAI, EREGL, FROTO, GARAN, GUBRF, HEKTS, KRDMD, KCHOL, KOZAL, KOZAA, ODAS, PGSUS, PETKM).

In obtaining price data for Bitcoin and Gold, the BTC/USD currency pair was utilized alongside the Amundi Physical Gold ETC, an instrument that accurately replicates commodity prices for Gold.

In order to preserve the precision and impartiality of the ensuing analysis, I proceeded to convert all price values to United States dollars, utilizing the exchange rates corresponding to each day of the specified time frame. Subsequently, the daily return for every asset was assessed separately through the designated formula:

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}}$$

Where :

$R_t = \text{daily return}$

$P_{t-1} = \text{ price of the stock in } t-1$

$P_t = \text{ price of the stock in } t$

Subsequently, an equally-weighted portfolio was established for each respective country in which both Bitcoin and gold could be seamlessly integrated, utilizing the subsequent mathematical expression:

$$R_{(x,w)} = (1-w) * \frac{\sum_1^{20} R_t}{20} + w * R_x$$

Where :

$R_{(x,w)} = \text{daily return of the portofilo}$

$R_t = \text{daily return of each of the 20 national stocks that constitute the portfolio}$

$R_x = \text{daily return of the diversifying asset (gold or bitcoin), same formula as } R_t$

$w = \text{ weight invests in the diversifying asset (gold or bitcoin)}$

In this phase, a portfolio has been procured for every country examined, wherein 20 most prominent national capitalisations hold an equal weighting and a diversifying asset with adjustable weight.

There were two primary justifications for my selection of an equally distributed portfolio. One potential benefit of selecting such a portfolio is that it affords an inherent diversification, thereby mitigating the extent to which one is exposed to fluctuations in any single asset or investment. Undoubtedly, given the high level of volatility intrinsic to certain assets analyzed, particularly those in emerging markets, it was deemed more impartial to opt for an equally weighted portfolio. Secondarily, my aim was to mitigate potential sources of bias in the study and abstain from assigning disparate significance to assets based on their respective geographic locations. As an illustration, the occurrence of substantial fluctuations in the primary asset of one of the portfolios studied during the analyzed period could impart a bias to my analysis.

3.3 Value at risk

3.3.1 Definition

According the definition of Jadhav et al. (2009). "Value-at-risk is defined as the maximum potential loss in the value of a portfolio of financial instruments with a given probability over a certain horizon." Value at risk estimates the maximum loss that a portfolio can incur with a confidence level of 100(1 - α)% over the next T days Jadhav et al. (2009). In other words, VaR gives the amount one can lose over a period of time. For illustration, within the case of my study, in the case of a VaR at 1% with a certainty level of 95%, given that the work was conducted in day by day units, this implies that the most extreme day by day misfortune will not surpass 1% of the esteem of my portfolio 95% of the time.

Before discussing the different estimators used in the analysis, the end of this section will show the set of equations defined by Jadhav et al (2009) in his paper.

Let X denote the return random variable on a probability space (Ω, F, P) with distribution function $F_X(x)$. Then for each $\alpha \in (0, 1)$, the VaR with $100(1 - \alpha)\%$ confidence level is defined as:

$$VaR_{\alpha}(X) = -q^{\alpha}(X)$$

where $q^{\alpha}(X)$ is the largest $\alpha -$ quantile:

$$q^{\alpha}(X) = inf\{x : P(X \leq x) > \alpha\}$$

$$= sup\{x : P(X < x) \leq \alpha\}$$

This definition can also be expressed in terms of $q_{(1-\alpha)}(-X)$, the smallest (1 − α) quantile. Consider:

$$q_{(1-\alpha)}(-X) = inf\{x : P(-X \leq x) \geq 1 - \alpha\}$$

$$= -sup\{y : P(X < y) \leq \alpha\}$$

$$= -q^{\alpha}(X)$$

3.3.2 Comparison of VaR models

In this study, a variety of VaR estimators were utilized, encompassing both parametric and non-parametric methods. As a timely reminder, it should be noted that the parametric approach is predicated on the assumption that the returns of the portfolio conform to a Gaussian probability distribution. Historical statistics such as the mean and standard deviation are computed and utilized for the purpose of establishing the distribution at a particular level of confidence. In contrast, the non-parametric method does not presuppose a normal distribution. The approach involves deriving an empirical distribution through the utilization of return. Given the lack of precision in the available literature regarding the selection of appropriate estimators, the choice was made to employ various estimators and subsequently evaluate their performance through a backtesting procedure (referred to in section 3.5), with the aim of identifying the estimators that exhibited the greatest level of statistical significance. Jadhav et al. (2009) posit that despite the existence of variances in estimators, these differences do not significantly affect the resultant outcomes, thereby indicating minimal disparities among the various estimators.

The Variance-Covariance approach is the most commonly used for parametric methods as it is also the simplest. As mentioned above, it requires only the mean and standard deviation assuming that the returns are normally distributed. The coefficient Z from the normal distribution table is employed to multiply the standard deviation of the portfolio.

The formula to find the covariance matrix can be written as follows:

$$S = COV(X) = \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \cdots & \sigma_{1N} \\ \sigma_{21} & \sigma_2^2 & \cdots & \sigma_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{N1} & \sigma_{N2} & \cdots & \sigma_N^2 \end{bmatrix}$$

Where :

$\sigma_{i,j} =$ the covariance of asset i and j

$N =$ number of single assets in portfolio

Then, the computation of the portfolio variance can be expressed through the following formula:

$$\sigma_p^2 = [w_1 \quad w_2 \quad \dots \quad w_N] \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \cdots & \sigma_{1N} \\ \sigma_{21} & \sigma_2^2 & \cdots & \sigma_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{N1} & \sigma_{N2} & \cdots & \sigma_N^2 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_N \end{bmatrix} = w^T S\, w$$

$$\sigma_p = \sqrt{\sigma_p^2}$$

Finally, the VaR according to the Variance-Covariance approach, may be expressed algebraically as follows:

$$VaR = Z_{(1-\propto)} \sigma_p P$$

Where :

$Z_{(1-\propto)} =$ the standard normal distribution quantile with confidence level $(1-\propto)$

$\sigma_p =$ the standard deviation of portfolio

$P =$ portfolio value in t_0

The approach of historical returns utilizes a non-parametric methodology and refrains from making assumptions regarding the normal distribution of returns. It is computed using a more straightforward methodology. Initially, the investigation will entail the identification of the most severe losses pertaining to the selected quantile. Specifically, this study shall utilize

quantiles of 1%, 2.5%, 5%, and 10%, which serve as indicative measures of our historical value at risk.

3.4 Expected shortfall / Conditionnal value at risk

3.4.1 Definition

The Expected Shortfall, in contrast to the Value-at-Risk metric, provides an estimate of the average losses incurred in the event of critical market conditions at specific quantiles, namely 1%, 2.5%, 5%, and 10%, as examined in the analysis. The term is mathematically expressed through the use of a formula:

$$CVaR(\propto) = \frac{1}{\propto}\int_0^{\propto} VaR(x)dx$$

In the present investigation, due consideration was given to the expected shortfall in light of the recent amendment of the Basel regulation. Furthermore, in contrast to the Value at Risk, certain scholars, including Embrechts et al. (2014), contend that the Expected Shortfall serves as a more cautious metric for assessing risk within a distribution that features extended tails. The empirical shortfall exhibits a higher degree of superiority over the value-at-risk at a 99% confidence level in the handling of volatile assets Embrechts et al. (2014). Given the inclusion of Bitcoin and gold in the analysis, it appeared prudent to employ both risk measures. Furthermore, extant scholarly literature does not exhibit a clear preference for any particular risk measure. Notably, Kellner et al. (2016) contend that, during times of financial duress, employing the 99% Value at Risk metric is a more equitable approach. In consideration of comprehensiveness, incorporation of both measures was made.

3.4.2 Comparison of models

In the present study, the formula outlined in Section 3.4.1 will be utilized to calculate the value at risk for both parametric and non-parametric approaches. This will facilitate a comparative analysis of the results obtained from these two different methods. Moreover, a choice of computing the Conditional Value-at-Risk (CVaR) utilizing the technique of inverse Mills ratio

was made. The rationale behind selecting this particular technique is its consideration of the substantial distribution tails. As per my portfolios, it was intriguing to employ a parametric approach that does not presuppose a Gaussian distribution of returns.

Using the parameters in section 3.3.2, the CVaR according to the inverse Mills ratio is calculated using the following formula :

$$CVaR(\propto) = P\ (\mu - \ \sigma_p \frac{\varphi\left(\frac{VaR(\propto) - \ \mu}{\sigma_p}\right)}{\phi\left(\frac{VaR(\propto) - \ \mu}{\sigma_p}\right)})$$

Where :

$P =$ portfolio value in t_0

$\mu =$ portfolio mean

$\sigma_p =$ portfolio standard deviation

3.5 Backtesting

The process of backtesting is a crucial undertaking in the evaluation of various models or strategies. On the one hand, the outcomes of my endeavors are upheld and validated. On the other hand, this measure facilitates the identification of the most effective estimator based on the given dataset. The choice to opt to confirm the accuracy of the findings through Kupiec's validation method was made. In light of existing literature, it is suggested that utilization of the Kupiec test may prove to be a more comprehensive approach compared to employing a conventional coverage test.

Stavroyiannis and Zarangas (2013) conducted an analysis on the practice of backtesting and arrived at the conclusion in favor of Kupiec as the preferred method over other alternatives. Stavroyiannis et al. (2012) have also incorporated the Kupiec methodology in their research on Value-at-Risk analysis, the lone critique of the Kupiec test pertains to its singular focus on the quantity of occurrences surpassing a given threshold. However, the distribution of these exceedances has not been subject to empirical testing. Kupiec's work lacks any mention regarding the clustering procedure Stavroyiannis and Zarangas (2013). The Christoffersen test

offers a solution to the aforementioned issue, but does not furnish a comprehensive evaluation of the precision of the VaR model. This limitation presents a predicament within the purview of the present study.

The Kupiec test is designed to evaluate whether the number of instances surpassing the anticipated level as projected by the VaR estimator. In pursuit of this objective, a ratio is utilized, and the initial step involves examining the quantity of violations with the aid of the Valstad & Vagstad (2014) equation.

$$H_t = \begin{cases} 1 \text{ if } Y_t < Q_t \\ 0 \text{ if } Y_t \geq Q_t \end{cases}$$

Where :

$H_t =$ the indicator sequence

$Y_t =$ the observed return

$\mathrm{Q_t} =$ the predicted VaR quantile, $\mathrm{Q_t}$ at t time

Subsequently, we shall gauge the conformity of the count of transgressions with the designated level of confidence interval, by assuming two hypotheses, namely the null hypothesis, where the model is deemed to be valid, and the alternative hypothesis, where it is assumed not to be so. The Kupiec (1995) test may be mathematically represented by the following equation:

$$LR_{POF} = -2ln\left(\frac{p^x(1-p)^{T-x}}{\left(\frac{x}{t}\right)^x\left[1-\left(\frac{x}{t}\right)\right]^{T-x}}\right) \sim x^2$$

Where :

$T =$ the number of observations

$x =$ the number of violation based on the first equation

$p =$ specific level of confidence

The probability distribution conforms to an x^2 distribution having a single degree of freedom. In the event that the LR_{POF} surpasses the critical x^2 value, it is appropriate to reject the null

hypothesis which supports the accuracy of the model. In this instance, it can be inferred that our VaR estimator has either overestimated or underestimated the occurrence of breaches.

4. Empirical part

4.1 Portfolio metrics

4.1.1 Description of daily standard deviations

In compliance with the methodology outlined in section 3, four national portfolios have been successfully established - namely Belgium, Switzerland, Argentina, and Turkey - each consisting of twenty large caps wherein the stocks are evenly weighted within the respective portfolio. In the following section, the present study aims to incorporate Bitcoin and Gold to observe the progression of the risk metrics, as elucidated in the antecedent section.

Table 1 presents the standard deviations of the initial portfolios.

	Standard deviation
Belgium	1,08%
Switzerland	1,26%
Argentina	2,59%
Turkey	2,14%

Upon examining the aforementioned initial portfolios, it becomes apparent that hyperinflationist countries carry significantly higher standard deviations, as their averages are observed to be twice that of non-hyperinflationist countries. The predictable nature of this outcome can be attributed to a number of hypotheses, as discerned by common intuition. One notable aspect is that, as a consequence of hyperinflation, the costs associated with goods and services may escalate in a precipitous and erratic manner, which may, in turn, manifest in a state of fluctuation within the equity market. An additional conjecture posits that the inherent instability of the market may be attributed to the dynamic and unpredictable nature of currency regulations and policies in these nations. The existence of these risks compels investors to make more frequent adjustments, or even to exit the market altogether. This leads to a decrease in total liquidity and an increase in volatility due to the consequent reduction in overall capitalization. The aforementioned hypotheses are contended to be non-exhaustive.

4.1.2 correlation between portfolios and diversifying assets

Prior to conducting an initial analysis on the selected risk measures, the foremost stage involved examining the correlation existing between the 20 national assets constituting each portfolio with reference to both gold and bitcoin as depicted in Appendices 4 through 11.

Table 2 shows the average correlation of national assets with bitcoin and gold.

Correlation	Bitcoin	Gold
Belgium	0,007	0,012
Swiss	0,028	-0,029
Argentina	-0,008	0,019
Turkey	0,032	0,001

Regardless of the particular scenario considered, there is a notable lack of strong correlations with either Bitcoin or Gold. This indicate that both assets appear to present prospects for diversification, and can similarly aid in the alleviation of the risk metrics under scrutiny.

4.2 VaR analysis

4.2.1 VaR without diversifying assets

In Section 4.2 will delineate the outcomes pertaining to the primary assessments of Value at Risk antecedent to the integration of the diversifier asset. Within each nation, there exists a tabulated representation of the Value at Risk estimations pertaining to four discrete probability thresholds, specifically those denoted as 1%, 2. 5%, 5%, and 10%. For each of the aforementioned thresholds, the Value at Risk has been computed via two distinct methods as outlined in the methodology (cf. section 3.3.2): VCV VaR has been employed for the parametric approach, while HS has been utilized for the non-parametric approach based on historical returns. The expression of these values initially pertains to a percentage before being presented in monetary terms in relation to a portfolio valued at one million units (selected without any specific criteria).

Table 3 shows the value at risk in the absence of a diversifying asset

Belgium	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28	1,36%	1,12%	13.598,68 $	11.183,87 $
	95%	-1,64	1,75%	1,72%	17.505,29 $	17.205,24 $
	97,50%	-1,96	2,09%	2,25%	20.893,69 $	22.454,10 $
	99%	-2,33	2,48%	3,06%	24.833,43 $	30.565,55 $

Switzerland	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28	1,60%	1,37%	15.979,81 $	13.720,52 $
	95%	-1,64	2,06%	2,03%	20.561,00 $	20.277,77 $
	97,50%	-1,96	2,45%	2,65%	24.534,50 $	26.461,46 $
	99%	-2,33	2,92%	3,36%	29.154,55 $	33.571,55 $

Argentina	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28	3,29%	2,28%	32.860,08 $	22.750,53 $
	95%	-1,64	4,23%	3,40%	42.254,38 $	33.968,19 $
	97,50%	-1,96	5,04%	4,54%	50.402,53 $	45.433,62 $
	99%	-2,33	5,99%	5,68%	59.876,51 $	56.845,37 $

Turkey	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28	2,65%	2,16%	26.479,07 $	21.622,95 $
	95%	-1,64	3,43%	3,26%	34.255,56 $	32.603,90 $
	97,50%	-1,96	4,10%	4,55%	41.000,51 $	45.493,96 $
	99%	-2,33	4,88%	6,42%	48.842,97 $	64.163,78 $

This table presents various observations that can be made. Initially, it is important to note that the utilization of the parametric Variance-Covariance methodology yields larger Value at Risk outcomes for both the 90% and 95% thresholds in all scenarios when contrasted with the Historical simulation process. However, with the exclusion of Argentina, it can be observed that in the remaining three instances (Belgium, Switzerland, Turkey) the values obtained through the HS VaR methodology are comparatively higher at both the 97. 5% and 99% thresholds. It should be noted that the parametric VaR methodology is predicated upon the assumption of a normal distribution of returns. As a consequence of this assumption, its ability to capture the extreme values within the distribution is somewhat limited, resulting in a tendency towards an underestimation of VaR at the 97. 5% and 99% confidence levels. On the other hand, the HS VaR computed on historical returns is relatively more precise when considering the extremity of the distribution.

The juxtaposition between nations experiencing profound inflationary trends and those that are not is rather unequivocal. It is observable that Argentina and Turkey exhibit relatively elevated

levels of VaR metrics, specifically a VaR VCV 2 times superior, and an HS VaR 2.5 times superior in comparison to that of Belgium and Switzerland. Multiple factors may contribute to the observed differences. As elucidated in the antecedent section, the political landscape in Argentina and Turkey is characterized by greater instability, thereby culminating in a relatively less stable monetary policy milieu, with concomitant increases in both uncertainty and volatility. On the contrary, it can be hypothesized that market participants exhibit a tendency to avoid the domestic currency in response to exchange rate fluctuations and inflationary pressures. Such behavior culminates in a decline in the aggregate market capital and a concomitant amplification in market volatility. Nonetheless, it is imperative to present certain limitations and conditions to the aforementioned theory. Upon review of the literature pertaining to the analysis of exchange rate volatility in relation to market volatility, certain scholars have arrived at divergent conclusions. In their research on Nigeria, Nkoro and Uko (2016) established a negative correlation between fluctuations in the exchange rate and variations in equity market volatility. It should be noted that the scenarios exhibit notable distinctions; primarily due to the extent of data scrutinized by Nkoro & Uko (2016), as it comprises a comprehensive 26-year timespan. In addition, it must be noted that there exist certain time periods which cannot be reasonably compared. It was imperative to provide a qualifier for my remark, in order to indicate that these findings were not inherently self-evident, despite appearing to align with common sense.

4.2.2 VaR evolution when adding 1 and 5% of Bitcoin or Gold

In the forthcoming section, prior to applying measures aimed to minimise my values, a comprehensive analysis of the VaR trends for individual nations will be conducted with respect to the inclusion of 1% and 5% of Bitcoin or Gold. In this section, values that closely approximate reality have been employed alongside two distinct strategies selected by a prospective fund manager. These strategies correspond to those delineated in Kwon's study (2021). It is improbable that portfolios, for the most part, would comprise values exceeding 5% for Bitcoin. Furthermore, any influence exerted by such proportions would be deemed insignificant when the value falls short of 1%. At all thresholds and for every VaR estimator utilized, a backtesting analysis was conducted on the obtained outcomes. When a table box is greyed out, it indicates that the validation of the Value at Risk estimator by Kupiec could not be achieved. When employing comparisons of means, I apply the following procedure:

calculation of the mean is carried out on the series of legitimate estimations. For instance, in the event wherein both Value-at-Risk measures, namely Variance-Covariance VaR at 95% confidence level and Historical Simulation VaR at 95% significance level, demonstrate validation by Kupiec's test, the adoption of an averaged outcome is deemed appropriate. Subsequently, computation of the arithmetic mean is performed on the data retrieved for every Value at Risk threshold.

Table 4 shows the data for the Belgian portfolio to which we have added: 1% BTC, 1% Gold, 5% BTC, 5% Gold.

1% BTC	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	1,35%	1,12%	13.472,94 $	11.168,82 $
	95%	-1,64485	1,73%	1,66%	17.346,67 $	16.631,31 $
	97,50%	-1,95996	2,07%	2,21%	20.706,56 $	22.116,08 $
	99%	-2,32635	2,46%	3,00%	24.613,15 $	29.956,04 $

1% Gold	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	1,35%	1,11%	13.462,70 $	11.063,25 $
	95%	-1,64485	1,73%	1,71%	17.331,04 $	17.054,54 $
	97,50%	-1,95996	2,07%	2,22%	20.686,24 $	22.184,11 $
	99%	-2,32635	2,46%	3,02%	24.587,39 $	30.179,76 $

5% BTC	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR €
	90%	-1,28155	1,32%	1,11%	13.228,52 $	11.062,36 $
	95%	-1,64485	1,70%	1,65%	17.044,05 $	16.506,62 $
	97,50%	-1,95996	2,04%	2,19%	20.353,45 $	21.917,56 $
	99%	-2,32635	2,42%	3,01%	24.201,34 $	30.060,76 $

5% Gold	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	1,29%	1,07%	12.928,95 $	10.686,39 $
	95%	-1,64485	1,66%	1,59%	16.647,06 $	15.859,36 $
	97,50%	-1,95996	1,99%	2,12%	19.871,97 $	21.154,18 $
	99%	-2,32635	2,36%	2,86%	23.621,61 $	28.636,62 $

The initial observation that can be made is that, regardless of the situation, the inclusion of either 1% or 5% of bitcoin or gold results in a decrease in VaR across all probability thresholds. Upon analysis of the comparative results between gold and bitcoin, it has been observed that the risk reduction provided by bitcoin is superior to that of gold by adding 1% across a range of thresholds such as 95%, 97. 5% and 99%, contingent on the employed HS VaR method. In all the other scenarios at 1% and 5%, gold reduces risk better. When analysing these results on

average, with a weight of 1%, bitcoin reduces VaR by 1.46% compared with 1.07% for gold. With a weight of 5%, bitcoin reduces VaR by 2.4% compared with 5.69% for gold.

Table 5 shows the data for the Swiss portfolio to which we have added: 1% BTC, 1% Gold, 5% BTC, 5% Gold.

1% BTC	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	1,59%	1,35%	15.938,54 $	13.502,56 $
	95%	-1,64485	2,05%	2,07%	20.510,80 $	20.730,46 $
	97,50%	-1,95996	2,45%	2,60%	24.476,56 $	25.951,79 $
	99%	-2,32635	2,91%	3,32%	29.087,61 $	33.215,15 $

1% Gold	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	1,59%	1,37%	15.908,22 $	13.689,86 $
	95%	-1,64485	2,05%	2,00%	20.469,30 $	20.022,11 $
	97,50%	-1,95996	2,44%	2,63%	24.425,35 $	26.255,53 $
	99%	-2,32635	2,90%	3,31%	29.025,12 $	33.070,01 $

5% BTC	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	1,56%	1,34%	15.611,79 $	13.371,37 $
	95%	-1,64485	2,01%	1,95%	20.102,53 $	19.490,70 $
	97,50%	-1,95996	2,40%	2,60%	23.997,57 $	26.001,01 $
	99%	-2,32635	2,85%	3,34%	28.526,40 $	33.370,59 $

5% Gold	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	1,52%	1,31%	15.246,67 $	13.111,56 $
	95%	-1,64485	1,96%	1,98%	19.620,93 $	19.793,88 $
	97,50%	-1,95996	2,34%	2,55%	23.414,96 $	25.498,15 $
	99%	-2,32635	2,78%	3,22%	27.826,33 $	32.164,73 $

The findings for Switzerland are unequivocally indicative of a more substantial decrease in risk associated with gold, irrespective of the specific circumstances. On average, with a weighting of 1%, bitcoin reduces VaR by 0.41%, compared with 0.69% for gold. With a weighting of 5%, we see a VaR reduction of 2.21% for Bitcoin compared with 4.12% for gold.

Table 6 shows the data for the Argentine portfolio to which we have added: 1% BTC, 1% Gold, 5% BTC, 5% Gold

1% BTC	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	3,25%	2,23%	32.514,63 $	22.264,90 $
	95%	-1,64485	4,18%	3,37%	41.813,96 $	33.670,05 $
	97,50%	-1,95996	4,99%	4,50%	49.879,73 $	44.974,17 $
	99%	-2,32635	5,93%	5,63%	59.257,94 $	56.251,33 $

1% Gold	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	3,25%	2,26%	32.535,23 $	22.584,52 $
	95%	-1,64485	4,18%	3,39%	41.837,26 $	33.919,11 $
	97,50%	-1,95996	4,99%	4,49%	49.905,39 $	44.934,97 $
	99%	-2,32635	5,93%	5,62%	59.286,33 $	56.239,89 $

5% BTC	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	3,12%	2,22%	31.245,44 $	22.221,24 $
	95%	-1,64485	4,02%	3,31%	40.196,81 $	33.142,65 $
	97,50%	-1,95996	4,80%	4,35%	47.960,79 $	43.497,07 $
	99%	-2,32635	5,70%	5,41%	56.988,10 $	54.095,03 $

5% Gold	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	3,12%	2,19%	31.239,91 $	21.858,97 $
	95%	-1,64485	4,02%	3,32%	40.174,07 $	33.178,77 $
	97,50%	-1,95996	4,79%	4,29%	47.923,12 $	42.940,34 $
	99%	-2,32635	5,69%	5,45%	56.933,07 $	54.478,96 $

The initial observation highlights that irrespective of the situation, a decline in Value at Risk can be observed as well in both gold and bitcoin as compared to the initial portfolio. One notable observation is that the VCV estimator only satisfies Kupiec's backtesting requirement at a threshold of 99%. Beyond this level, the estimator fails to meet the validation criteria. The findings pertaining to Argentina exhibit a greater degree of complexity compared to those observed in Switzerland and Belgium. On average, with a 1% diversifier weighting, bitcoin reduces VaR by 1.22% compared with 0.8% for gold. With a 5% diversifier weighting, bitcoin reduces VaR by an average of 3.74%, compared with 4.16% for gold.

Table 7 shows the data for the Argentine portfolio to which we have added: 1% BTC, 1% Gold, 5% BTC, 5% Gold.

1% BTC	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	2,76%	2,14%	27.590,28 $	21.437,60 $
	95%	-1,64485	3,57%	3,20%	35.681,82 $	32.031,22 $
	97,50%	-1,95996	4,27%	4,55%	42.700,03 $	45.483,02 $
	99%	-2,32635	5,09%	6,39%	50.860,21 $	63.927,24 $

1% Gold	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	2,76%	2,13%	27.566,10 $	21.325,57 $
	95%	-1,64485	3,56%	3,22%	35.648,67 $	32.249,21 $
	97,50%	-1,95996	4,27%	4,51%	42.659,09 $	45.099,24 $
	99%	-2,32635	5,08%	6,36%	50.810,23 $	63.572,79 $

5% BTC	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	2,67%	2,09%	26.692,61 $	20.948,26 $
	95%	-1,64485	3,45%	3,11%	34.529,82 $	31.061,23 $
	97,50%	-1,95996	4,13%	4,32%	41.327,43 $	43.239,91 $
	99%	-2,32635	4,92%	6,29%	49.231,13 $	62.869,67 $

5% Gold	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	2,65%	2,04%	26.450,28 $	20.360,89 $
	95%	-1,64485	3,42%	3,08%	34.208,17 $	30.830,45 $
	97,50%	-1,95996	4,09%	4,34%	40.936,99 $	43.416,73 $
	99%	-2,32635	4,88%	6,12%	48.760,69 $	61.204,44 $

The initial perceptible inference is that the VCV model is inadequate for the Turkish portfolio, as its effectiveness remains unattainable at all probability thresholds. It can be posited that in the instance at hand, the assumption of normality is not upheld, thereby precluding the employment of the Variance-Covariance estimator. Employing the Historical Simulation VaR estimator, with a diversifying asset weight of 1%, bitcoin reduces VaR by 0.75% compared with 1.06% for gold. With a weight of 5%, bitcoin reduces VaR by 3.71% compared with 5.11% for gold.

4.2.3 Theoretical case for maximum VaR reduction

The present section shall examine the theoretical potential of bitcoin to minimise VaR when compared to gold through the optimal allocation of weights in portfolios. In the ensuing discourse, the HS VaR model will be employed as it has undergone more extensive backtesting in comparison to the VCV method across all nations. An attempt shall also be made to mitigate the 99% Value at Risk, given its prevalence within the banking sector as a tool for risk

assessment. The decision has been taken to avoid excessive complexity in the context of the theoretical aspects of the segment.

For Belgium, the minimum VaR can be obtained by allocating a weighting of 7.97% to bitcoin, which gives a VaR of 2.9%. Using the same approach for gold, It provides a minimum VaR of 1.73% by allocating 52.7% to gold.

For Switzerland, using the same reasoning, a minimum VaR of 3.32% can be obtained by allocating 2.15% to bitcoin. For gold, the minimum VaR is 1.89% by allocating 74.36% to gold.

For Argentina, a minimum VaR of 5.19% is obtained by allocating 9.83% of bitcoin. For gold, the minimum VaR is 2.47% by allocating 87.34% of gold.

For Turkey, the minimum VaR is 6.28% by allocating 5.45% bitcoin. For gold, the minimum VaR is 2.24% by allocating 90.39% gold.

4.2.4 What happens when dealing in local currency ?

Subsequent to considering the aforementioned sections, it is evident that irrespective of the scenario at hand, bitcoin bears limited potentiality in mitigating risks in comparison to gold. As explicated in the initial section, certain authors have served as the impetus for my research through their remarkable findings concerning bitcoin. Kliber et al (2019) demonstrated through their empirical research that Bitcoin possesses the potential to function as a safe-haven in Venezuela. Particularly, this was observed when the asset was traded utilizing the native currency and a study that utilized daily data. This study incited my curiosity, leading me to replicate the identical tests performed in the earlier section, albeit utilizing the currency that is indigenous to the country. The numerical data is progressively accruing; however, a thorough discussion of these findings will be undertaken in section 5 to enhance comprehensibility. In order to ascertain the initial values of each VaR that has been treated in the local currency, reference may be made to Appendix 12.

Table 8 shows the results for the Belgian portfolio treated in euros

1% BTC	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) €	HS VaR €
	90%	-1,28155	1,35%	1,12%	13.450,39 €	11.170,93 €
	95%	-1,64485	1,73%	1,66%	17.318,05 €	16.604,05 €
	97,50%	-1,95996	2,07%	2,21%	20.672,66 €	22.059,90 €
	99%	-2,32635	2,46%	2,99%	24.573,13 €	29.892,33 €

1% Gold	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) €	HS VaR €
	90%	-1,28155	1,34%	1,10%	13.440,12 €	11.024,92 €
	95%	-1,64485	1,73%	1,71%	17.302,34 €	17.060,27 €
	97,50%	-1,95996	2,07%	2,22%	20.652,24 €	22.169,25 €
	99%	-2,32635	2,45%	3,01%	24.547,23 €	30.117,23 €

5% BTC	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) €	HS VaR €
	90%	-1,28155	1,31%	1,09%	13.123,07 €	10.912,63 €
	95%	-1,64485	1,69%	1,64%	16.910,29 €	16.436,56 €
	97,50%	-1,95996	2,02%	2,17%	20.195,14 €	21.690,60 €
	99%	-2,32635	2,40%	2,94%	24.014,49 €	29.381,17 €

5% Gold	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) €	HS VaR €
	90%	-1,28155	1,28%	1,06%	12.818,61 €	10.570,12 €
	95%	-1,64485	1,65%	1,59%	16.506,91 €	15.881,55 €
	97,50%	-1,95996	1,97%	2,11%	19.705,97 €	21.082,04 €
	99%	-2,32635	2,34%	2,83%	23.425,56 €	28.323,95 €

Similar outcomes are observable as when traded in US dollars. On average, VaR is reduced by 1.62% when 1% bitcoin is included, compared with a reduction of 1.22% for gold. With a 5% diversifying asset point, VaR by adding bitcoin is reduced by 3.49% compared with 6.34% with gold. Obviously, these decreases are founded on a primary Value at Risk initially denominated in Euros.

Table 9 shows the results for the Swiss portfolio treated in Swiss pounds

BTC 1%	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) CHF	HS VaR CHF
	90%	-1,28155	1,47%	1,21%	14.736,69 CHF	12.123,52 CHF
	95%	-1,64485	1,90%	1,81%	18.952,96 CHF	18.113,83 CHF
	97,50%	-1,95996	2,26%	2,40%	22.609,94 CHF	23.979,53 CHF
	99%	-2,32635	2,69%	3,41%	26.861,98 CHF	34.095,67 CHF

Gold 1%	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) CHF	HS VaR CHF
	90%	-1,28155	1,47%	1,20%	14.708,91 CHF	12.032,22 CHF
	95%	-1,64485	1,89%	1,83%	18.914,73 CHF	18.304,57 CHF
	97,50%	-1,95996	2,26%	2,41%	22.562,65 CHF	24.088,59 CHF
	99%	-2,32635	2,68%	3,42%	26.804,15 CHF	34.222,34 CHF

BTC 5%	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) CHF	HS VaR CHF
	90%	-1,28155	1,45%	1,22%	14.457,03 CHF	12.196,65 CHF
	95%	-1,64485	1,86%	1,71%	18.605,29 CHF	17.073,20 CHF
	97,50%	-1,95996	2,22%	2,29%	22.203,29 CHF	22.868,85 CHF
	99%	-2,32635	2,64%	3,26%	26.386,75 CHF	32.637,91 CHF

Gold 5%	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) €	HS VaR €
	90%	-1,28155	1,41%	1,16%	14.087,81 €	11.625,07 €
	95%	-1,64485	1,81%	1,75%	18.118,53 €	17.498,35 €
	97,50%	-1,95996	2,16%	2,31%	21.614,58 €	23.104,92 €
	99%	-2,32635	2,57%	3,30%	25.679,49 €	33.014,99 €

The findings pertaining to Switzerland are noteworthy. It has been observed that, in certain instances, the value at risk associated with Bitcoin is greater than that of gold. With a weight of 1% bitcoin we manage to reduce VaR by 0.67% compared with 0.55% for 1% gold. On the other hand, with a 5% weighting, bitcoin takes VaR down by 3.77% compared with 4.5% for gold. Although the data suggest that the 5% growth in gold remains highly intriguing, the outcomes are notably superior in comparison to when the entirety of the market is evaluated solely in terms of US dollars.

Table 10 shows the results for the Argentine portfolio when processed in Argentine pesos

Bticoin 1%	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR €
	90%	-1,28155	2,60%	1,87%	25.999,60 $	18.680,71 $
	95%	-1,64485	3,39%	2,81%	33.948,86 $	28.092,38 $
	97,50%	-1,95996	4,08%	3,51%	40.843,66 $	35.118,17 $
	99%	-2,32635	4,89%	4,85%	48.860,35 $	48.475,94 $

Gold 1%	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	2,60%	1,86%	26.009,43 $	18.611,98 $
	95%	-1,64485	3,40%	2,72%	33.958,26 $	27.155,72 $
	97,50%	-1,95996	4,09%	3,50%	40.852,68 $	34.951,81 $
	99%	-2,32635	4,89%	4,81%	48.868,94 $	48.146,40 $

Bitcoin 5%	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	2,50%	1,78%	24.957,12 $	17.751,23 $
	95%	-1,64485	3,26%	2,71%	32.625,44 $	27.109,83 $
	97,50%	-1,95996	3,93%	3,42%	39.276,56 $	34.160,05 $
	99%	-2,32635	4,70%	4,76%	47.009,93 $	47.643,48 $

Gold 5%	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var) $	HS VaR $
	90%	-1,28155	2,49%	1,76%	24.874,44 $	17.628,09 $
	95%	-1,64485	3,25%	2,60%	32.503,23 $	25.984,52 $
	97,50%	-1,95996	3,91%	3,37%	39.120,08 $	33.738,13 $
	99%	-2,32635	4,68%	4,66%	46.813,59 $	46.556,21 $

For Argentina, the properties of gold and Bitcoin are not as close as those seen when traded in dollars. With a diversifier weight of 1%, bitcoin can reduce VaR by 0.96%, compared with 1.91% for gold. With a weighting of 5%, the VaR reduction is 4.35% for bitcoin compared with 5.95% for gold.

Table 11 shows the results for the Turkish portfolio when traded in Turkish lira

1% BTC	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var)	HS VaR
	90%	-1,28155	1,88%	1,64%	₺18.792,36	₺16.356,20
	95%	-1,64485	2,47%	2,39%	₺24.721,39	₺23.918,50
	97,50%	-1,95996	2,99%	3,52%	₺29.863,94	₺35.207,75
	99%	-2,32635	3,58%	5,23%	₺35.843,27	₺52.310,23

1% Gold	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var)	HS VaR
	90%	-1,28155	1,88%	1,62%	₺18.796,25	₺16.213,01
	95%	-1,64485	2,47%	2,39%	₺24.723,66	₺23.852,39
	97,50%	-1,95996	2,99%	3,47%	₺29.864,80	₺34.749,85
	99%	-2,32635	3,58%	5,21%	₺35.842,49	₺52.115,32

5% BTC	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var)	HS VaR
	90%	-1,28155	1,81%	1,56%	₺18.115,07	₺15.627,21
	95%	-1,64485	2,39%	2,33%	₺23.857,39	₺23.296,30
	97,50%	-1,95996	2,88%	3,46%	₺28.838,00	₺34.638,98
	99%	-2,32635	3,46%	5,09%	₺34.629,03	₺50.902,76

5% Gold	confidence interval	Z-stat	VCV Var (%)	HS Var (%)	VCV (Var)	HS VaR
	90%	-1,28155	1,80%	1,54%	₺17.966,50	₺15.413,92
	95%	-1,64485	2,37%	2,28%	₺23.653,05	₺22.791,70
	97,50%	-1,95996	2,86%	3,38%	₺28.585,28	₺33.830,62
	99%	-2,32635	3,43%	4,99%	₺34.320,07	₺49.928,20

Gold continues to demonstrate a greater capacity for risk reduction in comparison to bitcoin, despite their narrow variance in values. On average, with a weight of 1%, bitcoin reduces VaR by 0.72% compared with 1.28% for gold. With a weight of 5%, VaR is reduced by 3.66% with bitcoin and 5.33% with gold.

4.3 Expected Shortfall

4.3.1 HS ES in different countries

In the preceding section, it was demonstrated that gold holds the potential for a comparatively more noteworthy reduction in Value at Risk as opposed to bitcoin. The inclusion of the anticipated shortfall metric in this study is a judicious decision, as although the occurrence of extraordinary circumstances with gold is relatively infrequent, it is crucial to consider the potential consequences in such instances. Specifically, it is paramount to ascertain the average loss incurred upon reaching a critical threshold to fully comprehend the effects of extreme situations. Furthermore, in view of the insignificant results obtained in local currency analyses favoring bitcoin, the analysis shall focus solely on ES denominated in U. S dollars, with the

objective to not make the work any heavier. To refrain from introducing additional numerical data, it has been determined that the comparison shall be predicated upon the HS ES. Nonetheless, all assessments conducted on the three estimators were executed according to the stipulations in the methodology. The Appendices containing the relevant information can be located within the range of 13 through 16.

confidence interval	Belgium base value	1% BTC	1% Gold	5% BTC	5% Gold
90%	1,97%	1,95%	1,95%	1,92%	1,87%
95%	2,61%	2,58%	2,58%	2,51%	2,47%
97,50%	3,29%	3,25%	3,25%	3,14%	3,12%
99%	4,47%	4,42%	4,43%	4,26%	4,26%

confidence interval	Switzerland base value	1% BTC	1% Gold	5% BTC	5% Gold
90%	2,34%	2,32%	2,31%	2,28%	2,22%
95%	3,06%	3,04%	3,03%	2,97%	2,91%
97,50%	3,83%	3,80%	3,79%	3,72%	3,63%
99%	4,96%	4,93%	4,90%	4,88%	4,70%

confidence interval	Argentina base value	1% BTC	1% Gold	5% BTC	5% Gold
90%	4,23%	4,19%	4,19%	4,05%	4,02%
95%	5,66%	5,60%	5,61%	5,38%	5,38%
97,50%	7,44%	7,35%	7,37%	7,04%	7,07%
99%	11,12%	11,00%	11,01%	10,51%	10,57%

confidence interval	Turkey base value	1% BTC	1% Gold	5% BTC	5% Gold
90%	3,97%	3,94%	3,93%	3,83%	3,77%
95%	5,39%	5,35%	5,34%	5,18%	5,12%
97,50%	7,01%	6,95%	6,94%	6,73%	6,66%
99%	9,77%	9,68%	9,68%	9,32%	9,30%

It is noteworthy to mention that under equivalent assumptions as for Value at Risk, the Expected Shortfall of nations experiencing heightened levels of economic challenges is observed to be approximately two-fold. Put differently, during times of substantial market decline, the typical financier experiences a loss that is twice the amount. Analysed by country, for Belgium, the addition of bitcoin or gold allows an average reduction in the expected shortfall of 1.02% and 0.98% with 1% of asset and 4.09% and 4.88% with 5% of asset. For Switzerland, with an asset weight of 1%, bitcoin reduces ES by an average of 0.68%, compared with 1.05% for gold. At 5%, bitcoin can reduce ES by 2.28%, compared with 5.13% for gold. In the case of inflationary countries, at an asset weight of 1%, Argentina saw a reduction of 1.09% for bitcoin, compared with 0.99% for gold. At 5%, the ES was reduced by 5.18% for bitcoin versus 4.92% for gold.

Finally, for Turkey, we see a reduction with 1% asset of 0.86% for bitcoin versus 0.98% for gold. At 5%, an ES reduction of 4.16% for Bitcoin versus 4.92% for gold.

5. Discussion

Upon reviewing the outcomes presented in Section 4, it is pertinent to ascertain the conclusive inferences that can be derived from them. In order to accomplish this task, a summation of the data has been compiled into three distinct tables: namely, the reduction of VaR in dollar, the reduction of VaR in local currency, the reduction of ES. The objective is to examine and compare the impact of gold and bitcoin, with the aim of determining which asset has exhibited a superior effect.

The initial observation indicates that regardless of the utilized risk metric, including the probability threshold or the weight assigned to bitcoin or gold, the incorporation of this diversifying asset consistently demonstrated a reduction in the aforementioned measures. The partial explanation for this phenomenon can be attributed to the lack of a semblance of correlation between portfolios and the diversifying assets of gold and bitcoin, as can be seen in Appendices 4 to 11. In order to determine the comparative appeal between the inclusion of bitcoin or gold, statistical analysis was conducted via student t-tests. In order to achieve this, a comparative analysis was conducted whereby the VaR estimates, derived from a specific country with a defined weightage (w), were juxtaposed across all probability thresholds. In practical terms, it allows to determine for each country whether the difference in VaR/ES reduction reduction between bitcoin and gold is significant or not.

The null hypothesis H0 posits that the disparity observed in VaR/ES between gold and bitcoin is attributable to random variation, as evidenced by their test results. Opposing the alternative hypothesis H1, which posits that the difference in results between the addition of gold and Bitcoin is statistically significant. The alpha threshold for the present tests was selected to be 5%. As such, the null hypothesis could be rejected on the condition that the observed t-value falls below the 5% threshold. The tests can be found within Appendix 17.

Table 12 the reduction of VaR in dollar

Reduction of the VaR (w =1%)	Bitcoin	Gold
Belgium	1,46%	1,07%
Switzerland	0,47%	0,77%
Argentina	1,22%	0,80%
Trurkey	0,75%	1,06%

Reduction of the VaR (w =5%)	Bitcoin	Gold
Belgium	2,40%	5,69%
Switzerland	2,20%	3,97%
Argentina	3,74%	4,16%
Trurkey	3,71%	5,11%

Significantly, we can conclude that for Belgium and with a weight w = 5% that gold contributes better than bitcoin to a reduction in VaR. In the seven alternative scenarios, a definitive determination regarding which asset, gold or bitcoin, is superior for reducing Value-at-Risk cannot be made.

Table 13 the reduction of VaR in local currency

Reduction of the VaR (w =1%)	Bitcoin	Gold
Belgium	1,62%	1,22%
Switzerland	0,67%	0,55%
Argentina	0,96%	1,91%
Trurkey	0,72%	1,28%

Reduction of the VaR (w =5%)	Bitcoin	Gold
Belgium	3,49%	6,34%
Switzerland	2,20%	3,97%
Argentina	4,35%	5,95%
Trurkey	3,66%	5,33%

We can significantly conclude that gold contributes to a better VaR reduction than bitcoin with a weight w = 5% for Belgium and Turkey. In the 6 other scenarios, it cannot be said that gold is statistically better than bitcoin in terms of VaR reduction. The results are not exactly the same, as demonstrated by Kliber et al (2019), depending on whether we treat our portfolios in dollars or in local currency. This phenomenon can be elucidated through the daily fluctuations in the currency exchange rate. In the event that one currency devalues in relation to the other, this undoubtedly has repercussions on the Value at Risk. One another plausible elucidation is

the instability of currency exchange rates. If the volatility of exchange rates between two currencies is lower than the volatility of share prices in a foreign currency, this may result in a lower percentage VaR in foreign currency than in dollars.

Table 14 the reduction of ES

Reduction of the ES (w =1%)	Bitcoin	Gold
Belgium	1,02%	0,98%
Switzerland	0,68%	1,05%
Argentina	1,09%	0,99%
Trurkey	0,86%	0,98%

Reduction of the ES (w =5%)	Bitcoin	Gold
Belgium	4,09%	4,88%
Switzerland	2,28%	5,13%
Argentina	5,18%	4,92%
Trurkey	4,16%	4,92%

The present tests finds compelling evidence to suggest that, for both Switzerland and Turkey, both with a weight w = 1% and w = 5% gold contributes to a greater reduction of the ES than bitcoin.

One additional aspect that warrants discussion in this particular section pertains to the estimators. Irrespective of the method employed, Historical Simulation, proved to be the predominant technique in case of these study during the back-testing process.

6. Limits of the study and possible continuity

Subsequent to the analysis of outcomes, a pressing matter is to scrutinize the sundry constraints inherent in the study and prospective paths for further investigation.

Undoubtedly, the primary constraint arises from the construction of portfolios. In the present study, it is noteworthy that each of the portfolios comprises 20 assets that correspond to the most sizeable capitalizations on a per-country basis. It is improbable that an investor would exclusively rely on the capitalization of the assets to inform their investment decisions, without any attempt to diversify their portfolio across various sectors. It would be overly presumptuous to assert that these portfolios accurately depict the totality of the nation's economic landscape. Moreover, the decision to opt for a set of 20 assets devoid of a specific criterion is subjective, and it is highly likely that the findings would differ in the event of a revision of this parameter. Another salient aspect to consider is the improbability of an investor exclusively possessing domestic assets. Then, the portfolios are established with equal weighting, thus eliminating the need for a subjective evaluation of all underlying assets. The utilization of equally weighted portfolios is a frequently employed technique; nevertheless, it should be noted that portfolios are highly variable on a day-to-day basis. Additionally, maintaining an equally-weighted portfolio poses significant challenges when there exists a dearth of substantial liquidity. Regrettably, due to practical concerns, the analysis of portfolio distributions was omitted from the study despite its potential to enhance the investigation. Undoubtedly, the inclusion of four distinct portfolios, wherein each portfolio comprises of either gold or bitcoin in diverse proportions, would have given rise to a vast array of distributions. Such a complex scenario would likely have resulted in increased complexity and cumbersomeness of reading.

A further constraint of the research pertains to its divergent approach towards risk assessment. From one perspective, my analysis entails the examination of VaR and ES to the extent of the 99th percentile threshold. The restricted dataset length, which was deliberately selected to span a period of 5 years (refer to Section 2), results in a relatively scant number of observations, amounting to solely 12 instances for this threshold. Consequently, it follows that in the event of a portfolio experiencing a dire trading day, the ramifications on the 99% value at risk/expected shortfall would be substantial. In addition to the foregoing, the present study employs four thresholds (i. e, 90%, 95%, 97. 5%, and 99%) that are deemed crucial. Observing

the developmental trajectory of VaR in a perpetual manner, as opposed to solely at distinct thresholds, would have provided a compelling avenue of exploration. Moreover, the objective of this research endeavor is to exclusively assess and contrast the risk levels associated with gold and bitcoin, rather than examining both the risk and return aspects together. This approach may present an initial focal point for future investigation.

Regarding the outcomes, Kupiec backtesting was conducted on all the results and from a statistical standpoint, there is insufficient evidence to assert that gold more effectively mitigates Value at Risk and Expected Shortfall relative to bitcoin on average. Nonetheless, it is challenging to assert that Bitcoin mitigates risk to the same degree as gold in the majority of instances, owing to the various factors outlined previously.

An additional variable to consider is that the duration examined in this investigation was uninterrupted and did not explicitly incorporate periods of turmoil. Continuing this research and conducting it during periods of crisis, such as the Covid-19 pandemic, would yield paramount interest. It is possible that during certain distinct time periods, Bitcoin may function as a safe-haven asset whereas gold may not.

Finally, it must be noted that although the conclusions of this study do not provide conclusive evidence in favor of bitcoin as a superior investment option to gold in terms of risk mitigation in inflationary countries, it is important to consider that the focus of this research is limited to the specific cases of Turkey and Argentina. Further exploration and analysis are required to draw more comprehensive conclusions on a broader scale. An alternative methodology entails encompassing all countries facing economic difficulties, whereby it is plausible that in certain contextual scenarios, Bitcoin is more effective than gold in mitigating risk indicators.

7. Conclusion

In the opening section of this study, a central inquiry was raised concerning the possibility of Bitcoin exhibiting unanticipated behavior and surpassing gold as a commonly recognized safe-haven. The authors Kliber et al. (2019) present a case study in their scholarly publication of a country experiencing hyperinflation, namely Venezuela. It was demonstrated that bitcoin exhibited characteristics consistent with serving as a safe haven. The present study investigates the potential utility of Bitcoin in mitigating the Value at Risk and Expected Shortfall of select portfolios relative to gold, under specific configurations.

Primarily, irrespective of the selected asset, whether it is Bitcoin or gold, the inclusion of said assets in national portfolios has resulted in a noteworthy decrease in the Value at Risk and Expected Shortfall across all probability thresholds investigated.

The study indicated an absence of statistically significant evidence that Bitcoin yielded a reduction in Value at Risk or Expected Shortfall more than gold in both established and developing markets. Based on the analysis of the cases studied, it can be inferred that bitcoin demonstrated a comparable level of effectiveness as gold in mitigating risks during the investigated period. Nonetheless, the inverse is not applicable. For Belgium, the significantly conclusion that gold contributed to a better reduction of VaR in both US dollars and euros than bitcoin when a 5% diversifier asset is added can be made. Same conclusion for Turkey when VaR is processed in Turkish lira. For ES, both incorporating 1% and 5% of gold or bitcoin led to a significant reduction in the expected shortfall in the case of Switzerland and Turkey.

In conclusion, it can be inferred based on the findings of this research and within the context of these particular instances, that there exists a considerable similarity in terms of the risk mitigation potential between bitcoin and gold, which aligns with the findings posited by Dyhrberg (2016).

Declaration of Authorship

I hereby declare that, with the exception of the aids described in the acknowledgements section, all the work has been 100% carried out by myself.

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