



DOI 10.2478/sbe-2021-0021

SBE no. 16(2) 2021

---

## DO CRYPTOCURRENCIES OFFER DIVERSIFICATION BENEFITS FOR EQUITY PORTFOLIOS?

---

**ALIU Florin**

*Faculty of Economics, University for Business and Technology, Kosovo*

**NUHIU Artor**

*Faculty of Law, University of Prishtina, Kosovo*

**KNAPKOVA Adriana**

*Faculty of Management and Economics, Tomas Bata University, Czech Republic*

**LUBISHTANI Eral**

*Faculty of Economics, University for Business and Technology, Kosovo*

**TRAN Khang**

*Faculty of Management and Economics, Tomas Bata University, Czech Republic*

### **Abstract:**

*Cryptocurrencies are becoming an exciting topic for legislative bodies, practitioners, media, and scholars with diverse academic backgrounds. The work identifies diversification benefits when cryptocurrencies are combined with the equity instruments from Visegrad Stock Exchanges. Furthermore, the results of the study explore financial and economic benefits for the investors of combining cryptocurrencies with equity stocks on the mixed portfolio. Three different independent experiments were conducted to observe diversification benefits generated from cryptocurrencies. Results from the two experiments show that cryptocurrencies employ higher portfolio risk and generate higher returns when they are involved with equity stocks portfolios. The first experiment indicates that cryptocurrencies reduce the risk level of the equity portfolios while increase average returns. Providing the equity portfolios with additional equity stocks lower the portfolio risk which is in line with the theoretical paradigms. Results indicate that cryptocurrencies must be seriously considered by the portfolio managers as an essential aspect of the portfolio diversification benefits. Future studies might raise the samples of selected portfolios with stocks from different stock indexes, to identify the problem from a broader perspective.*

**Key words:** *Cryptocurrencies, Portfolio risk, Equity stocks, Financial investors, Regulators*

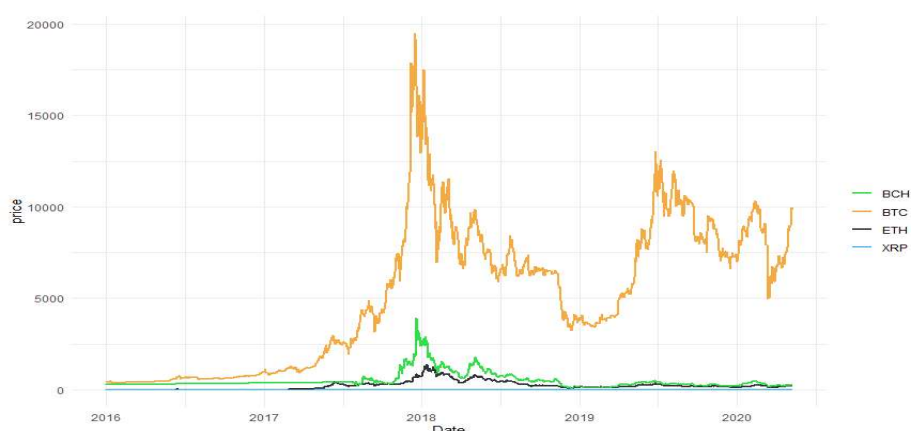
## **1. Introduction**

Cryptocurrencies operate as financial securities and medium of exchange, this dual function provides a novel outlook for the studies on the field of portfolio management. The role and importance of cryptocurrencies have grown rapidly in recent years, gaining attention among scholars, researchers, government institutions, and market participants. Cryptocurrencies experienced an enormous price increase from the period they became popular speculative investments. Damianov and Elsayed (2020) consider that Bitcoin's existence is primarily linked with the investor's perception and its future developments on the blockchain technology. Shiller (2017) highlights that Bitcoin's popularity gained international attention from the narrative economics which spreads like epidemic diseases. Several crypto funds were created that focus entirely on the crypto investments, and offer services for their clients on crypto diversification. Rooney and Levy (2018) on their study show that almost 300 hedge funds hold over \$10 billion of cryptocurrency investments under management. Returns gained from the individual financial securities are one aspect of the investors' interest, combining them with other financial instruments enables having a complete picture of the portfolio's risk. Deregulation and increased complexity of the financial system created space for a growing number of modern synthetic financial instruments that allowed better diversification for investors (Muli and Jagongo, 2019). Financial crises of 2008/09 showed that stock markets around the world are highly integrated where financial problems in one place are easily transmitted to other places. Moreover, this integration of the stock markets in bad times has made investors search for alternative securities different from conventional financial assets (Cumming et al. 2014).

Cryptocurrencies generate diversification benefits since they tend to be unrelated to traditional financial assets. Standard portfolio theories indicate that adding more stocks to the conventional equity portfolios generates lower risk exposure. Markowitz (1952, 1959) established initial concepts on the modern portfolio theory that increasing the number of stocks diminish risk level and enhance portfolio benefits. Diversification risk is mainly influenced by three inputs parameters, such as correlation among assets, volatility generated from the price changes, and concentration level. The correlation among financial assets in the portfolio influences the diversification risk since a higher positive correlation increase diversification risk and vice versa (Aliu et al. 2017; Behr et al. 2013; Drake and Fabozzi 2010; Medo et al. 2009). Still, there is no consensus between scholars and portfolio managers on the appropriate number of stocks that would fully eliminate portfolio risk. Several studies claim that portfolio of 5 to 16 equity stocks reach maximum portfolio benefits (Brand and Gallagher 2005; Tang 2004; Statman 2001; Surz and Price 2000) while the others consider the portfolio of 50 stocks eliminate portfolio risk (Domian et al. 2007; Cleary and Copp 1999). Lack of fundamental value and legal protection constrained cryptocurrencies to operate under diverse market structures from bond and stock exchanges. In contrast to the traditional financial instruments, cryptocurrencies do not have intrinsic value that would diminish their speculative elements. Stock prices are generally influenced by the internal financial and non-financial performance of the firms, economic environment, political context of the country, and so on. The value of the companies listed in the stock exchanges is driven by the human recourses, company

financial position, and the prospect of the company. The intrinsic value that cryptocurrencies depend on the possibility of becoming internationally recognized payment instruments.

Figure 1 represents daily closed prices of the major cryptocurrencies such as Bitcoin, Ethereum, Ripple, and Bitchin Cash, from January 2016 till May 2020. Bitcoin prices experienced a huge increase during 2018 while during 2019 prices started to drop down rapidly. The pandemic crises caused by the coronavirus (COVID-19) pushed the majority of the countries to choose the lockdown approach. The majority of the stock markets crashed since the coronavirus (COVID-19) spread among major European countries during March and April 2020. Even though investors lost their trust in traditional financial instruments, Bitcoin prices were constantly increasing during this period. The Bitcoin market prices jumped from 5238\$ on April 1, 2020, to 9482\$ on May 8, 2020, indicating an increase of 81%.



**Figure 1: The market prices of the four cryptocurrencies with the highest market capitalization**

*Source:* Authors' elaboration based on the Coinmarketcap database.

Bitcoin was constantly a leading and the most significant cryptocurrency, holding almost 50% of the yearly transactions (Al-Yahyaee et al. 2018). Nakamoto (2008) was the first one to introduce Bitcoin technology as a peer-to-peer payment system without the support of financial intermediaries. For this purpose, it is difficult to distinguish the primary function of digital currencies, serving as an electronic cash payment and investment securities. Huge volatility imposed on the cryptocurrencies does not promise them of becoming a worldwide international payment instrument. The currency value in the national context is stored from the Central Banks by keeping inflation under control, while in the international aspect from the exchange rate movements. Digital currencies are not subject to government regulations that generate space for particular users to be involved in the illegal activities of buying and selling goods and services (Baur et al. 2018). Moreover, Foley et al. (2019) indicate that almost one-quarter of the Bitcoin users are involved in the range of 76 billion \$ per year on the banned activities. For this purpose, regulatory agencies were alarmed since the

intensified use of cryptocurrencies might exacerbate the challenge of tracking illegal activities. Security and Exchange Commission (SEC) in March 2017 denied the application from the exchange-traded funds that focus on cryptocurrencies, with the justification of no regulation in place that would protect investors (Foley et al. 2019). Moreover, the Chinese government banned trading with cryptocurrencies and declared Initial Coin Offerings (ICO) as an illegal activity within Chinese territory.

The appearance of different cryptocurrencies has resulted in the rapid increase of their market size. Since the inception of Bitcoin, more than 1500 digital currencies were created with different underlying technology that supports them (Trimborn and Härdle, 2018). In the past few years, a considerable number of researches was focused on the correlation between cryptocurrencies and other financial instruments. Charfeddine et al (2020) show that cryptocurrencies offer substantial financial and economic benefits for the investors when combined with the other traditional financial instruments. Inci and Lagasse (2019) on their work used three main cryptocurrencies with the highest market capitalization (Bitcoin, Ripple, and Litecoin) to investigate risk and return investment opportunities when joined with the selected financial assets. The results of their study show that Ripple contains the highest portfolio benefits, followed by Litecoin and Bitcoin. Despite numerous studies on cryptocurrencies, few of them showed interest in assessing the correlation between cryptocurrencies and equity stocks from the financial perspective (Urquhart 2016). Consequently, several studies investigated the relationship between cryptocurrencies and the equity stocks (Gil-Alana et al. 2020; Kristjanpoller et al. 2019; Corbet et al. 2019; Tiwari et al. 2018; Huynh et al. 2018; Feng et al. 2018) and the correlation between cryptocurrencies with different financial securities (Corbet et al. 2018; Aslanidis et al. 2019; Bariviera 2017). The study by Baur et al. (2018) shows the Bitcoin is not correlated with financial securities such as stocks, bonds, and commodities both in the good times and bad times for the economy.

Lack of financial integration between the stock markets and cryptocurrencies increases opportunities for diversification benefits. Handika et al. (2019) in their study investigated the financial contagion of the cryptocurrencies with the Asian financial markets. The results of their work indicate that cryptocurrencies do not influence movements in the Asian currency exchanges and stock markets. Kristjanpoller et al. (2019) investigated the asymmetric multifractality between five main cryptocurrencies (Bitcoin, Litecoin, Ripple, Monero, and Dash) and six equity ETFs. The results of their work show a significant persistence and evidence of asymmetric multifractality in the cross-correlation between most of the cryptocurrencies and ETFs. Aslanidis et al. (2019) explored the behavior of conditional correlations among main cryptocurrencies, gold, stock, and bond indices, using a generalized DCC class model. Their work concluded that correlations between cryptocurrencies and traditional financial assets are negligible where the cryptocurrency market is detached from the behavior of other financial instruments. Kajtazi and Moro (2018) investigated the effects of bitcoin's role in portfolios of U.S., European, and Chinese assets. The outcomes of their work claim that by adding bitcoin, the portfolio performance improves, due to the increase in returns and reduction in the volatility level. Moreover, the authors conclude that bitcoin may have a role in portfolio diversification even though the study analysis confirms

bitcoin speculative characteristics. Rehman et al (2020) explored the risk dependence between Bitcoin and the main Islamic Stock Exchanges from July 2010 till March 2018. Outcomes of their work claim that Bitcoin indicates time-varying dependence with key Islamic indices such as DJIUK, DJIJP, and DJICA.

Cryptocurrencies tend to operate in an isolated environment, independent from developments in the financial system. They hold no association with other financial instruments and tend to generate diversification opportunities for investors. Previous studies explored short-run and long-run interdependence of the major cryptocurrencies with equity indices. However, our work investigates diversification benefits created from cryptocurrencies when they are involved in the portfolio with Visegrad listed companies that operate in different industries. For this purpose, the work arranges three diverse equity portfolios (experiments) and investigates the risk level when cryptocurrencies are involved within the equity stocks selected from Visegrad stock exchanges. Outcomes of study provide signals for the individual investors, hedge funds, pension funds, etc., on the diversification benefits generated from the mixed portfolios of stocks and cryptocurrencies. Regulators might gain new insight into the prospect of establishing a legal framework that would allow financial institutions to treat digital currencies as an important portfolio instrument. The work investigates if adding cryptocurrencies to equity portfolios generates higher or lower diversification benefits, compared to adding more equity stocks. Standing on the identified problem, the following question has been addressed:

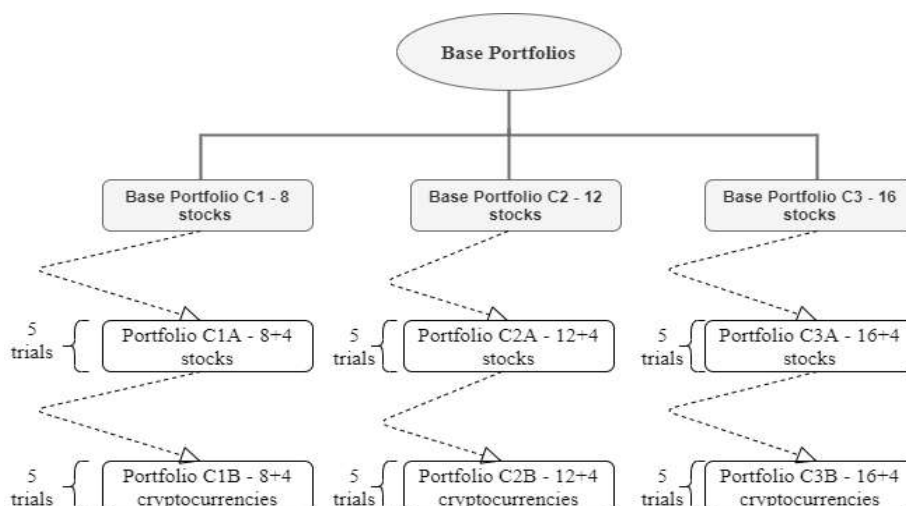
*RQ1:* Does adding cryptocurrencies on the portfolio of equity stocks increase the diversification benefits?

## **2. Methodology**

The study measures diversification benefits generated from the mixed portfolios of stocks and cryptocurrencies. Data concerning stock prices and trade volume were collected every week from the Thomson Reuters Eikon Database (THRED 2020). Weekly cryptocurrency market prices and volume of trade were obtained from Coin Market Cap Database (CMCD 2020). Crypto prices and stock prices were harmonized in the identical dates, from 08.01.2016 till 06.10.2017. Stock prices and their trade volumes of the companies listed in the Visegrad Stock Exchanges (PSE, BUX, WIG20, and SAX) were chosen as the inputs within the portfolio risk model. Eleven companies were carefully chosen from PSE, twenty companies from BUX, twenty from WIG20, and six from SAX. Moreover, twenty cryptocurrencies with the highest market capitalization were chosen as a sample for our work.

Figure 2 shows the schematic diagram of the research process conducted in our study which allows gaining results intended. Three base equity portfolios were created (Portfolio C1, Portfolio C2, and Portfolio C3) with a diverse number of stocks, named as base portfolios. Base Portfolio C1 is compounded with 8 stocks which indicate that from each Visegrad Stock Exchanges (VSE) were randomly selected 2 stocks. Base Portfolio C2 contains 12 stocks that hold three randomly selected stocks from each Visegrad Stock Exchange, different from the Base Portfolio C1. The identical sampling process follows

Base Portfolio C3 were randomly selected stocks are different from the Base Portfolio C1 and C2. To observe diversification benefits, four additional randomly selected stocks were added to the base portfolios (Portfolio C1A, Portfolio C2A, and Portfolio C3A). This experiment was repeated 5 times where each trial of 4 additional stocks is different from each other. The second experiment is constructed with an identical number of trails that involve 4 additional cryptocurrencies to the base portfolios (Portfolio C1B, Portfolio C2B, and Portfolio C3B). Basically, to the base portfolios were added 4 randomly selected cryptocurrencies and this experiment was repeated 5 times where each experiment was independent of each other.



**Figure 2: Methodological process of the research work**

Source: Authors' elaboration.

The Markowitz diversification formula was used to detect the risk level of each portfolio. Moreover, each experiment (portfolio) has been simulated with identical criteria to avoid biased results:

$$\sigma_k^2 = \sum_i^{nk} w_{ik}^2 \sigma_{ik}^2 + 2 \sum_i^{nk} \sum_{j<i}^{nk} w_{ik} w_{jk} \sigma_{jk} \rho_{ijk} \quad (1)$$

where  $\sigma^2$  – variance of returns (stock prices and crypto prices of individual listed companies or cryptocurrencies),  $\sigma$  stands for the standard deviation of returns (stock prices and crypto prices of the individual listed companies or cryptocurrencies) while  $\rho(i,j)$  shows the correlation coefficient within returns (stock prices and crypto prices of the individual listed companies in the stock index or crypto indexes). Cryptocurrencies and equity stocks were considered as financial assets;  $\sigma_k^2$  of the portfolio in year  $k$  is computed on the sample of  $n_k$  companies and cryptocurrencies. The index  $i$  indicates a financial asset (stock and cryptocurrency),  $j$  is an auxiliary index assuring that the covariance is computed on distinct stocks and cryptocurrencies,  $w$  represents the weight of each equity

stock and cryptocurrency within the portfolio based on their trade volume, and  $\omega^2$  represents the squared weight. However, in our study, the weights do not influence the portfolio risk, since financial assets (stocks and cryptocurrencies) hold identical weights in each portfolio. For this purpose, since stocks and cryptocurrencies in the portfolio stand on equal weights, we have used simple arithmetic return not weighted average return.

The formula was implemented from the following programs: Python (version: 3.6.3), Numpy (version: 1.13.3), and Jupiter Notebook (version: 5.2.0). The process starts by separating the columns that contain the stock prices and trading volumes of the listed companies in the Visegrad Stock Exchange (VSE) and selected cryptocurrencies from the Coin Market Cap Database. To identify the validity of the program, the results were simulated also with the Excel program which delivered identical results. The process starts with providing tables with all possible combinations between all possible financial instruments (stocks and cryptocurrencies). Combinations involve such as 1, 2, 3, 4, 5, ...,  $n$  where  $n$  indicates total combination (financial securities) used in the respective experiment. Moreover, combinations might involve "Security A" and "Security B", while the other combination might involve "Security A", "Security B" and "Security C". The process follows merging of the financial securities (stocks and cryptocurrencies) into one place, and for this procedure was used panda library.

The next procedure involves the cleaning of data of all possible combinations. First, were erased rows for the stocks and cryptocurrencies that were not listed from the beginning of the year. In the case of the missing data, the interpolation method was used to generate the best use of the existing data. Interpolation was limited with one forward and one backward track, fulfilling missing cells for the stock prices and volume of trading.

### **3. Results**

The results of the study are divided into three parts, the subsection 3.1 indicates results of the base portfolio with 8 stocks, subsection 3.2 represent outcomes from the base portfolio with 12 stocks while subsection 3.3 explains findings from the base portfolio with 16 stocks.

#### **3.1. Base portfolio with 8 stocks and its combinations**

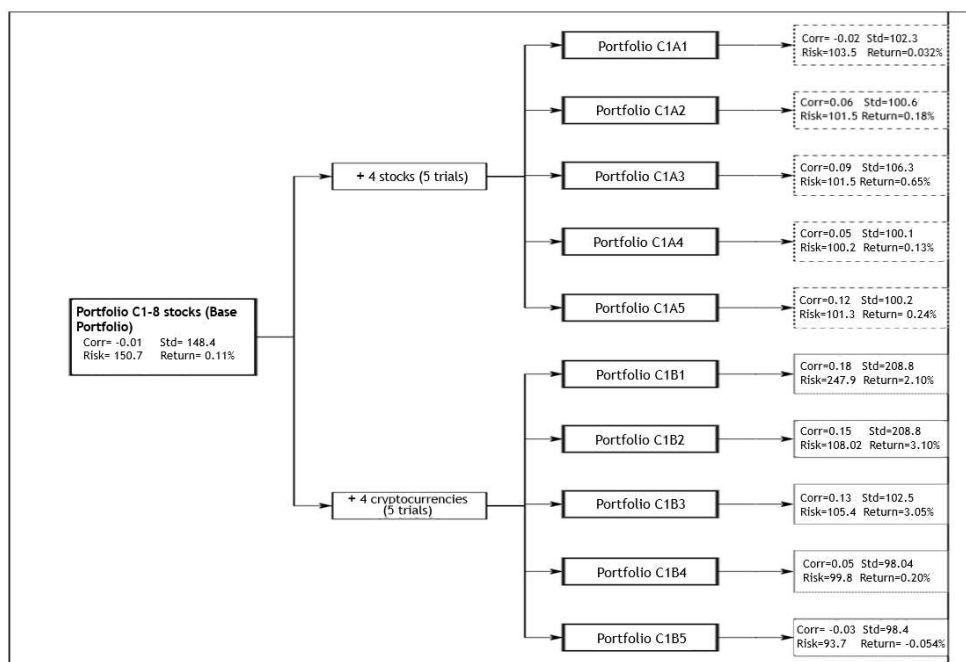
Diversification risk is influenced by the correlation between assets in the portfolio, volatility measured through the standard deviation and weight concentration. Figure 3 shows four different trails combining stocks with cryptocurrencies and compares them with the base portfolio (C1-8). The results indicate that adding cryptocurrencies to the base portfolio of the 8 stocks implies lower risk but offers a higher return. Portfolios from C1A1 to the C1A5 show five trails combined with stocks different from the base portfolio. However, portfolios C1B1 to the C1B5 indicate trails generated from a combination of the base equity portfolio with the cryptocurrencies. According to Table 1 average portfolio risk with five possible trails of cryptocurrencies (Risk=133.4) is 11.4% less risky than the base portfolio with 8 stocks (C1-8). Adding four more cryptocurrencies to the base equity portfolio reduces the average diversification risk of the portfolio. The average volatility

(STD) of the crypto-trials compared to the base portfolio declines for 16.7% while the average positive correlation increases from  $r_{ij}=-0.01$  to the  $r_{ij}=+0.10$ . Average diversification risk declines when cryptocurrencies were added to the base equity portfolio while average returns increased from 0.11% to 1.68%. According to the results of the first experiment, combining cryptocurrencies with the equity stocks generates lower portfolio risk and deliver a higher average return.

**Table 1: Average diversification risk, volatility level, correlation, and returns of the C1 portfolios**

	Avg. Risk	Avg. STD	Average Correlation	Average Return
Base Portfolio C1 - 8 stocks	150.7	147.4	-0.01	0.11%
Portfolio C1A-8 + 4 stocks	102.5	101.3	0.06	0.23%
Portfolio C1B-8 + 4 cryptocurrencies	133.6	123.5	0.10	1.68%

Source: Authors' elaboration based on the Thomson Reuters Eikon and Coin Market Cap Database.



**Figure 3: Diversification risk of the base portfolio with 8 stocks (C1-8) and its combinations**

Source: Authors' elaboration based on the Thomson Reuters Eikon and Coin Market Cap Database.

Table 2 shows the correlation matrix of one trial generated from the combination within the equity base portfolio with eight stocks (C1-8) with four cryptocurrencies. According to the correlation matrix, some of the listed companies in the C1-8 portfolio hold a strong positive correlation with the selected cryptocurrencies while the others showed a strong negative correlation.



Adding four more equity stocks to the base portfolio generates less portfolio risk than adding four more cryptocurrencies. Portfolios C1A1 to the C1A5 on average are 23.2% less risk than portfolios C1B1 to the C1B5. Portfolios C1A1 to C1A5 are 17.9% less volatile than portfolios C1B1 to C1B5 and they hold a 40% less average positive correlation. In contrast, the weekly weighted average return is 6.3 times higher in the crypto trials (C1B1 to C1B5) than in the stock trials (C1A1 to C1A5). For this purpose, adding stocks to the base equity portfolio indicates lower portfolio risk compared with adding cryptocurrencies. Adding cryptocurrencies to the base portfolio indicates a higher weekly weighted average return than adding more stocks.

**Table 2: Correlation matrix of one experiment between base equity portfolio with eight stocks (C1-8) and four additional cryptocurrencies**

	1	2	3	4	5	6	7	8	9	10	11	12
1. Cez	1											
2. Phillip Moris	0.19	1										
3. Richter Gedeon	0.48	0.71	1									
4. Budapesti ELMŰ	-0.14	-0.34	-0.17	1								
5. LPP SA	0.25	0.86	0.70	-0.25	1							
6. Asseco Poland SA	-0.27	-0.76	-0.61	0.59	-0.70	1						
7. Tatry Mountain	0.49	0.82	0.81	-0.25	0.77	-0.75	1					
8. Slov. Energeticka	-0.28	-0.70	-0.86	0.11	-0.72	0.63	-0.83	1				
9. Litecoin (LTC)	0.19	0.92	0.68	-0.46	0.85	-0.80	0.79	-0.65	1			
10. Bitcoin (BTC)	0.29	0.94	0.73	-0.40	0.88	-0.82	0.87	-0.73	0.96	1		
11. Ethereum (ETH)	0.25	0.91	0.72	-0.46	0.83	-0.80	0.77	-0.64	0.95	0.95	1	
12. Ripple (XRP)	0.28	0.81	0.76	-0.46	0.72	-0.71	0.68	-0.59	0.87	0.84	0.91	1

Source: Authors' elaboration based on the Thomson Reuters Eikon and Coin Market Cap Database.

### 3.2. Base portfolio with 12 stocks and its combinations

Section 3.2 identifies possible diversification benefits when cryptocurrencies and equity stocks were added to the base portfolio of 12 stocks (C2-12). Figure 4 shows possible risk outcomes generated from the portfolios C2A1 to C2A5 and from the portfolios C2B1 to C2B5. Table 3 indicates that the average diversification risk of the base portfolio declines for 14.1% when we add four more stocks, from Risk=1.7 to the Risk=1.46. In contrast, average diversification risk increases 11.6 times more in the base portfolio when 4 more cryptocurrencies are involved. Average return (war) increases 23.3% in the base portfolio when four more stocks were added. However, adding four more cryptocurrencies indicates that the average return of the base portfolio C2-12 to increase 383.3%. Including cryptocurrencies to the equity portfolios employ higher diversification risk and higher average portfolio return.

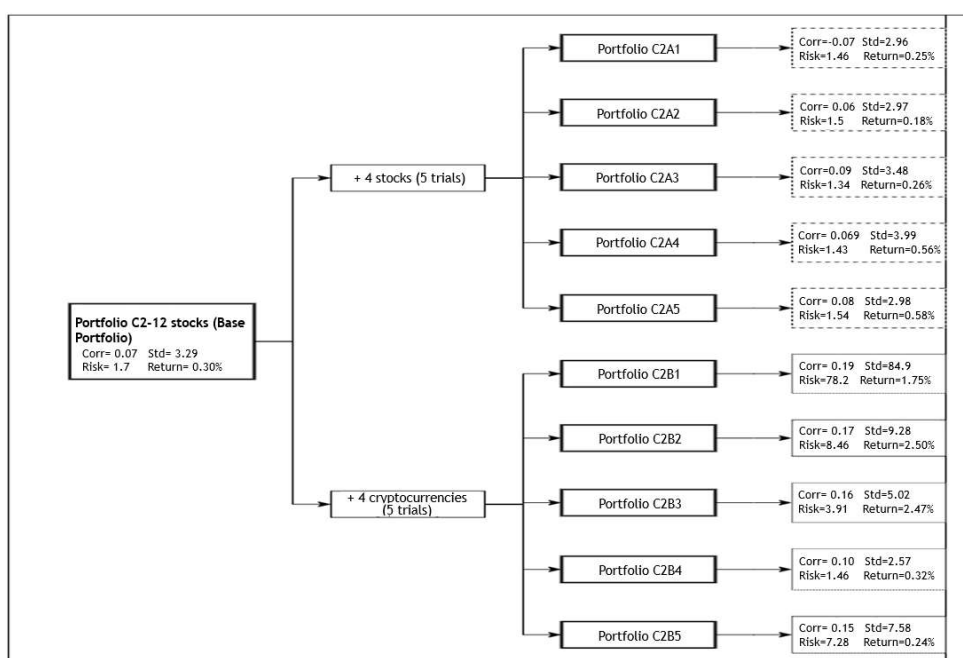
Correlation between financial assets in the portfolio is an extra risk component where a higher positive correlation increases portfolio risk and the other way around. The average positive correlation increases by 14.3% (from  $r_{ij}=0.07$  to the  $r_{ij}=0.08$ ) when 4

additional stocks were combined to the base portfolio. However, when cryptocurrencies were involved in the base portfolio C2-12, the average positive correlation increase for 128% (from  $r_{ij}=0.07$  to the  $r_{ij}=0.16$ ). Higher volatility (STD) of the individual financial assets indicates higher portfolio risk while lower volatility imposes lower risk. The average volatility of the base portfolio (C2-12) declines for 1.82% when four more stocks are involved, from  $STD=3.29$  to the  $STD=3.23$ . In contrast, adding cryptocurrencies to the base portfolio increase average STD five times more (from  $STD=3.29$  to the  $STD=21.88$ ). Five independent experiments show that diversification risk, average positive correlation, and volatility level increase when cryptocurrencies were involved in the base portfolio C2-12.

**Table 3: Average diversification risk, volatility level, correlation, and returns of the C2 portfolios**

	Avg. Risk	Avg. STD	Average Correlation	Average Return
Base Portfolio C2 - 12 stocks	1.7	3.2	0.07	0.30%
Portfolio C2A-12 + 4 stocks	1.4	3.2	0.08	0.37%
Portfolio C2B-12 + 4 cryptocurrencies	19.8	21.8	0.16	1.45%

Source: Authors' elaboration based on the Thomson Reuters Eikon and Coin Market Cap Database.



**Figure 4: Diversification risk of the base portfolio with 12 stocks (C2-12) and its combinations**

Source: Authors' elaboration based on the Thomson Reuters Eikon and Coin Market Cap Database.

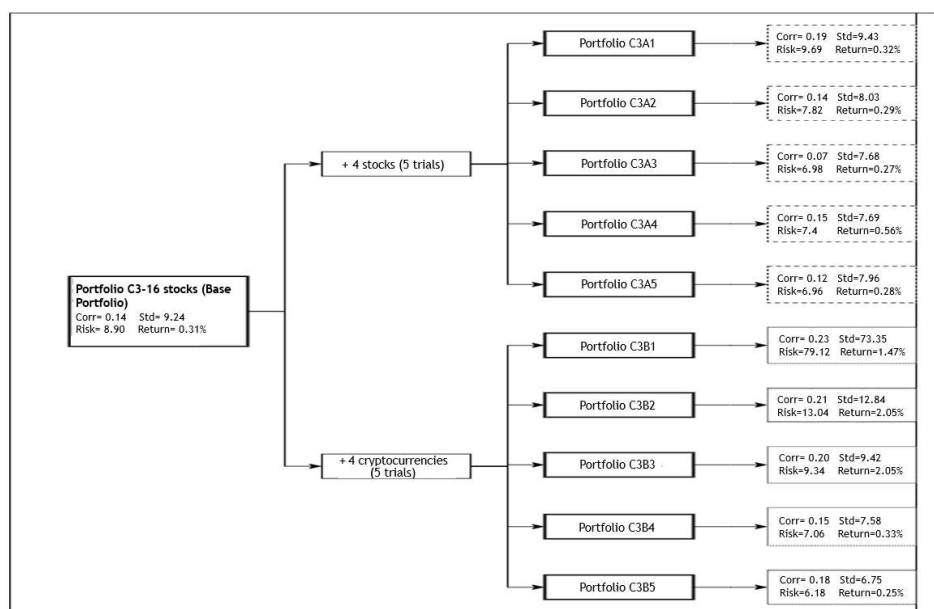
### 3.3. Base portfolio with 16 stocks and its combinations

Section 3.3 represents diversification results generated from the base portfolio with 16 stocks (C2-12) when cryptocurrencies and equity stocks were involved. Figure 5 shows possible risk outcomes generated from the portfolios C3A1 to C3A5 and from the portfolios C3B1 to C3B5. Table 4 shows that adding cryptocurrencies to the base portfolio increases the average portfolio risk of 159% while adding stocks decreases risk level for 13.4%. The volatility of the base portfolio increases for 140% when cryptocurrencies are involved, while declines for 11.9% when common stocks were added. The average correlation decreased by 7.14% when four additional stocks were included in the base portfolio. Moreover, adding cryptocurrencies to the base portfolio increases the positive correlation coefficient of 14.3% (from  $R_{ij}=0.14$  to  $R_{ij}=0.16$ ). Average returns were 9.6% higher when four additional stocks were included on the base portfolio C3-16 while when cryptocurrencies were involved average return increased on average 351%. Adding more cryptocurrencies in the base portfolio C3-16 generates additional portfolio risk but also provide higher average returns.

**Table 4: Average diversification risk, volatility level, correlation, and returns of the C3 portfolios**

	Avg. Risk	Avg. STD	Average Correlation	Average Return
Base Portfolio C3 - 16 stocks	8.9	9.2	0.14	0.31%
Portfolio C3A-16 + 4 stocks	7.7	8.1	0.13	0.34%
Portfolio C3B-16 + 4 cryptocurrencies	23.1	22.1	0.16	1.40%

Source: Authors' elaboration based on the Thomson Reuters Eikon and Coin Market Cap Database.



**Figure 5: Diversification risk of the base portfolio with 16 stocks (C3-16) and its combinations**

Source: Authors' elaboration based on the Thomson Reuters Eikon and Coin Market Cap Database.

#### **4. Conclusion**

Cryptocurrencies are becoming interesting investment phenomena since they tend to operate in an isolated environment, not linked with national and international economic events. In contrast to the traditional financial assets, cryptocurrencies do not have intrinsic value where market prices do not reflect the fundamental characteristics of the digital currencies. The study identifies diversification benefits when cryptocurrencies are combined with the portfolio of equity stocks. Moreover, findings of our work explore diversification outcomes of the individual experiments in terms of risk, return, volatility, and correlation coefficient. Experiments were conducted from three different base portfolios, compounded from stocks and cryptocurrencies. The work shows that average portfolio risk increases when cryptocurrencies are included in the base portfolios with 12 and 16 equity stocks. Two experiments with ten trials show that adding cryptocurrencies to the equity portfolios increase diversification risk. Combining cryptocurrencies with the equity stocks increases the standard deviation of returns and imposes a higher positive correlation. In contrast, to previous studies that show that cryptocurrencies tend to be uncorrelated with the equity stocks, our work indicates that cryptocurrencies increase positive correlation on the portfolio with equity stocks. Moreover, adding cryptocurrencies to the equity portfolios provides more risk, imposes higher volatility while generates higher average returns. The results stand in line with the portfolio theories, where adding more risky assets (cryptocurrencies) in the portfolio create higher risk but also provide higher returns. However, outcomes of the work are mixed, since two independent experiments (those with a base portfolio of 8 and 16 stocks) show that combining cryptocurrencies with stocks increase portfolio risk while the experiment with the base portfolio of 8 stocks indicates the other way around.

Further studies are required to verify if combining cryptocurrencies with equity stocks reduce or increase portfolio risk. Data collection was constrained from the stocks selected exclusively from the Visegrad Stock Exchanges which stands as a limitation of our study. Future research might simulate identical experiments on a larger scale, involving stocks from different stock markets. The study informs hedge funds and individual investors to gain new insights into the risk-reward outcomes employed from cryptocurrencies when combined with equity stocks. Experiments that involve equity stocks to the base portfolios indicate different results from those of adding cryptocurrencies. Placing four additional stocks to the base portfolios of the equity stocks decrease the diversification risk and volatility level of the portfolio. In contrast, involving cryptocurrencies to the base portfolios increase the average positive correlation of the portfolio, standard deviation, and average returns.

The legal framework of cryptocurrencies holds permanent divergences among scholars, practitioners, and regulatory bodies. For this purpose, nation-states are treating differently and independently the phenomena of cryptocurrencies. The results of our study provide clear indications that cryptocurrencies should be seriously considered as valuable instruments in the portfolio of equity stocks. Involving cryptocurrencies in the balance sheets of traditional financial institutions would boost their significance and persuade worldwide regulatory bodies to provide the legal framework for them.

## 5. References

- Aliu, F., Pavelkova, D., Dehning, B. (2017). *Portfolio risk-return analysis: The case of the automotive industry in the Czech Republic*. Journal of International Studies, 10(4), pp. 72–83.
- Al-Yahyaee, K. H., Mensi, W., Yoon, S. M. (2018). *Efficiency, multifractality, and the long-memory property of the Bitcoin market: A comparative analysis with stock, currency, and gold markets*. Finance Research Letters, 27, pp. 228–234.
- Aslanidis, N., Bariviera, A. F., Martínez-Ibañez, O. (2019). *An analysis of cryptocurrencies conditional cross correlations*. Finance Research Letters, 31, pp. 130–137.
- Bariviera, A. F. (2017). *The inefficiency of Bitcoin revisited: A dynamic approach*. Economics Letters, 161, pp. 1–4.
- Baur, D. G., Hong, K., Lee, A. D. (2018). *Bitcoin: Medium of exchange or speculative assets?*, Journal of International Financial Markets, Institutions and Money, 54, pp. 177–189.
- Behr, P., Guettler, A., Miebs, F. (2013). *On portfolio optimization: Imposing the right constraints*, Journal of Banking & Finance, 37(4), pp. 1232–1242.
- Brands, S., Gallagher, D. R. (2005). *Portfolio selection, diversification, and fund-of-funds: a note*, Accounting & Finance, 45(2), pp. 185–197.
- Cleary, S., Copp, D. (1999). *Diversification with Canadian stocks: How much is enough*, Canadian Investment Review, 12(3), pp. 7–16.
- Coin Market Cap Database - CMCD (2017). Market Capitalization of the top 100, available online at <https://coinmarketcap.com/>
- Corbet, S., Lucey, B., Urquhart, A., Yarovaya, L. (2019). *Cryptocurrencies as a financial asset: A systematic analysis*, International Review of Financial Analysis, 62, pp. 182–199.
- Corbet, S., Meegan, A., Larkin, C., Lucey, B., Yarovaya, L. (2018). *Exploring the dynamic relationships between cryptocurrencies and other financial assets*, Economics Letters, 165, pp. 28–34.
- Cumming, D., Helge Haß, L., Schweizer, D. (2014). *Strategic asset allocation and the role of alternative investments*, European Financial Management, 20(3), pp. 521–547.
- Charfeddine, L., Benlagha, N., Maouchi, Y. (2020). *Investigating the dynamic relationship between cryptocurrencies and conventional assets: Implications for financial investors*. Economic Modelling, 85, pp. 198–217.
- Damianov, D. S., Elsayed, A. H. (2020). *Does Bitcoin add value to global industry portfolios?*, Economics Letters, 108935.
- Domian, D. L., Louton, D. A., Racine, M. D. (2007). *Diversification in portfolios of individual stocks: 100 stocks are not enough*, Financial Review, 42(4), pp. 557–570.
- Drake, P. P., Fabozzi, F. J. (2010). *The Basics of Finance: An Introduction to Financial Markets, Business Finance, and Portfolio Management* (Vol. 192). John Wiley & Sons.
- Feng, W., Wang, Y., Zhang, Z. (2018). *Can cryptocurrencies be a safe haven: a tail risk perspective analysis*, Applied Economics, 50(44), pp. 4745–4762.
- Foley, S., Karlsen, J. R., Putniņš, T. J. (2019). *Sex, drugs, and bitcoin: How much illegal activity is financed through cryptocurrencies?*, The Review of Financial Studies, 32(5), pp. 1798–1853.
- Gil-Alana, L.A., Abakah, E.J.A., Rojo, M.F.R. (2020). *Cryptocurrencies and stock market indices. Are they related?*, Research in International Business and Finance Vol. 51.
- Handika, R., Soepriyanto, G., Havidz, S. A. H. (2019). *Are cryptocurrencies contagious to Asian financial markets?*, Research in International Business and Finance, 50, pp. 416–429.

- Huynh, T. L. D., Nguyen, S. P., Duong, D. (2018). Contagion risk measured by return among cryptocurrencies. *International Econometric Conference of Vietnam*. Springer, Cham, pp. 987–998.
- Inci, A. C., Lagasse, R. (2019). *Cryptocurrencies: applications and investment opportunities*, Journal of Capital Markets Studies.
- Kajtazi, A., Moro, A. (2019). *The role of bitcoin in well-diversified portfolios: A comparative global study*, International Review of Financial Analysis, 61, pp. 143–157.
- Kristjanpoller, W., Bouri, E., Takaishi, T. (2019). *Cryptocurrencies and equity funds: Evidence from an asymmetric multifractal analysis*, Physica A: Statistical Mechanics and its Applications, 545, 123711.
- Markowitz, H. (1952). *Portfolio selection*. The Journal of Finance, 7(1), pp. 77–91.
- Markowitz, H. (1959). *Portfolio Selection, Efficient Diversification of Investments*. John Wiley & Sons.
- Medo, M., Yeung, C. H., Zhang, Y. C. (2009). *How to quantify the influence of correlations on investment diversification*. International Review of Financial Analysis, 18(1-2), pp. 34–39.
- Muli, A. M., Jagongo, A. (2019). *Investment strategies, fund size, and financial performance of defined contribution schemes in Kenya: Theoretical review*. International Academic Journal of Economics and Finance, 3(3), pp. 253–265.
- Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system, available online at <http://bitcoin.org/bitcoin.pdf>.
- Rehman, M. U., Asghar, N., Kang, S. H. (2020). *Do Islamic indices provide diversification to bitcoin? A time-varying copulas and value at risk application*. Pacific-Basin Finance Journal, 101326.
- Rooney, K., Levy, A. (2018). *The most influential endowment manager just jumped into crypto with bets on two Silicon Valley funds*, available online at <https://www.cnbc.com/2018/10/05/yale-investment-chief-david-swensen-jumps-into-crypto-with-bets-on-two-silicon-valley-funds.html>
- Statman, M. (2001). *How many stocks make a diversified portfolio?*, Journal of Finance and Quantitative Analysis. Manuscript, Harvard University, Cambridge, MA.
- Surz, R. J., Price, M. (2000). *The truth about diversification by the numbers*. The Journal of Investing, 9(4), pp. 93–95.
- Shiller, R. J. (2017). *Narrative economics*. American Economic Review, 107(4), pp. 967–1004.
- Tang, G. Y. (2004). *How efficient is naive portfolio diversification? An educational note*. Omega, 32(2), pp. 155–160.
- Thomson Reuters Eikon Database - THRED (2020). Excel Reports on the Company Data, available online at <https://www.Thomsonreuters.Com/En/Resources/Third-Party-Restrictions/Tass-Database.html>
- Tiwari, A. K., Cunado, J., Gupta, R., Wohar, M. E. (2018). *Volatility spillovers across global asset classes: Evidence from time and frequency domains*. The Quarterly Review of Economics and Finance, 70, pp. 194–202.
- Trimborn, S., Härdle, W. K. (2018). *CRIX an Index for cryptocurrencies*. Journal of Empirical Finance, 49, pp. 107–122.
- Urquhart, A. (2016). *The inefficiency of Bitcoin*. Economics Letters, 148, pp. 80–82.