Efficiency of Using Cryptocurrencies as an Investment Asset

Mykola I. Bondar[1,*], Anna S. Stovpova[1], Natalia A. Ostapiuk[2], Olena H. Biriuk[3] and Olena V. Tsiatkovska[4]

[1]*Faculty of Accounting and Tax Management, Kyiv National Economic University named after Vadym Hetman, Kyiv, Ukraine*

[2]*Department of Accounting, Sopot University of Applied Sciences, Sopot, Poland*

[3]*Department of Accounting and Taxation, Kyiv National Economic University named after Vadym Hetman, Kyiv, Ukraine*

[4]*Department of Accounting in Credit and Budgetary Institutions and Economic Analysis, Kyiv National Economic University named after Vadym Hetman, Kyiv, Ukraine*

Abstract: The study of the effectiveness of using cryptocurrencies as an investment resource was conducted on the basis of testing the hypothesis that the introduction of leading cryptocurrencies that are components of the CRIX index into the investment portfolio improves its quality (efficiency). Cryptocurrency investment opportunities are explored on the basis of statistics for July 2016-June 2019. An average annual return on investment (ROI), which is adjusted for passive income on an investment asset (PI), is used to evaluate investment performance. In this study, cryptocurrencies are compared with the following alternative investment areas: Forex market, equities (companies with the highest weights in Nasdaq 100, Euro STOXX 50), commodities, government bonds, real estate. The criteria were determined by the increase in the Sharpe ratio of the investment portfolio and its average annual return. Optimization of investment portfolios without cryptocurrencies and with them was performed on the basis of the Markowitz model. The result shows the confirmation of the hypothesis: the introduction of 3 cryptocurrencies – Bitcoin, Ripple, Litecoin – in the proportions of 2.31%, 1%, 1%, respectively, increased the Sharpe ratio of the investment portfolio by 3.29 points, and the coefficient of return by 9.42 percentage points while increasing the risk by only 0.51 percentage points. This result indicates that the quality (increase in efficiency) of the investment portfolio due to the introduction of cryptocurrencies and the ability to control the investment risk of the portfolio despite the high volatility of cryptocurrencies. This proves the investment (speculative) function of crypto-assets, which can be the basis for developing a model of accounting for crypto-assets.

Keywords: Investment portfolio, Bitcoin, Markowitz Model, Sharpe ratio, risk.

INTRODUCTION

Cryptocurrencies belong to decentralized virtual currencies. Central banks do not regulate such currencies. Today there are 2907 cryptocurrencies (Crypto Index… 2020). The problem with using cryptocurrencies as an investment resource is the risks associated with significant fluctuations in its price (volatility). For example, Bitcoin in January 2018 had the equivalent of $ 17319, December 2018 – $ 3225, May 2019 – $ 8780, June 2019 – $ 12686, July 2019 – $ 9540, August 2019 – $ 11804, September 2019 – $ 8087, November 2019 – $ 9218 (Market Price… 2020). This applies not only to Bitcoin, but also to Ripple, Litecoin and other cryptocurrencies.The unpredictability of cryptocurrency prices makes it difficult for investors to choose the right position in trading and investing to maximize profits (Timkina *et al.* 2019; Tashpulatov *et al.* 2018a; Tashpulatov *et al.* 2018b; Savchyn 2020). There are significant risks to investing in cryptocurrency, including currency risk, operational risk and security of transactions. Therefore, more in-depth research should answer the question: are cryptocurrencies capable of performing an investment (speculative) function and improving the quality of the investment portfolio (Bakashbayev *et al.* 2020; Kobets *et al.* 2020; Kovaliuk and Kobets 2019a; Makushkin 2019a; Makushkin 2019b).

There have been various studies on the possibilities of incorporating cryptocurrencies in investment portfolios in the world of science. For example, Austrian researchers A. Eisl and K. Weinmayer (Eisl *et al.* 2015), using the CVaR approach, analysed the impact of the inclusion of Bitcoin into an investment portfolio, which included securities, sources of fixed income, money, real estate, and commodities. This influence was recognized by the authors of the study as positive (Bitcoin share was 7.69%). They revealed an increase in the profitability and risk ratios, but the increase in profitability outweighed the additional risks of the investor (Eisl *et al.* 2015, Yessentayeva *et al.* 2018; Barabanshchikov *et al.* 2016; Kovaliuk and Kobets 2019b; Privalko *et al.* 2005; Tashpulatov *et al.* 2020; Perederii 2020).

*Address correspondence to this author at the Kyiv National Economic University named after Vadym Hetman, Kyiv, Ukraine; Tel: +380 (44) 456-31-62; E-mail: myk-bondar5750@uohk.com.cn

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An international team of researchers, S. Trimborn, M. Lee, and W. Hardle (Trimborn *et al.* 2017), using the LIBRO approach, an extended version of Markowitz's methodology, found that inclusion in the portfolio of 39 cryptocurrencies improves risk/return ratio for different data sample variants. Indonesian researchers Y. Andrianto and Y. Diputra (2018), using modern portfolio theory (Markowitz model), also investigated the impact of the inclusion of cryptocurrencies (Bitcoin, Ripple, Litecoin) in already formed investment portfolios of foreign currencies, commodities, stocks, stock ETs. Their research has shown that cryptocurrencies do increase the efficiency of the investment portfolio in two ways: by minimizing the standard deviation and increasing the options for the investor. The optimal share of cryptocurrencies has been determined by researchers from 5% to 20% depending on the investor's tolerance for risk (Andrianto and Diputra 2018, Nurmaganbetova *et al.* 2020; Barashkin and Samarin 2005; Adygezalova *et al.* 2018; Mansurova *et al.* 2018; Trusova *et al.* 2017; Petryshyn and Tatsiy 2020). The disadvantages of these studies are:

– data obsolescence (the studies were used in 2010-2016);

– the possibility of some investments not simultaneously taking into account investment income from price changes and passive (permanent) income is not taken into account.

Passive income can have:

– traditional currencies – income from changes in the exchange rate and interest on bank deposits);

– real estate – rising real estate value and at the same time passive income from letting it;

– stocks – rising in value and receiving dividends.

However, passive income is a significant factor in deciding a potential investor, such as investing in real estate and bank deposits. Therefore, there is a need to investigate the investment opportunities of cryptocurrencies, using more up-to-date statistics and an average annual return on investment (ROI) that is adjusted for passive income of an investment asset (PI) (Bashynska *et al.* 2019; Bashynska *et al.* 2018; Bogaevskaya *et al.* 2020; Kasyanov *et al.* 2019; Moldagozhieva *et al.* 2017; Trusova *et al.* 2018).

The purpose of the article is to investigate the effectiveness of using cryptocurrencies as an investment resource, to demonstrate their ability to perform an investment (speculative) function and to help determine the most appropriate strategy for the formation of an investment portfolio, which includes cryptocurrencies.

MATERIALS AND METHODS

The following indicators were used to study the effectiveness of cryptocurrencies as investment resources: annual return on investment (ROI), which is increased by the percentage of passive income (PI) that this investment brings; standard deviation of the daily return on investment (σ), which is transformed into the annualized standard deviation – this is a measure of the risk of an investment; Sharpe ratio – is a measure of the effectiveness of an investment that takes into account surplus income and existing risk (Hobbs 2018; Alieva *et al.* 2020; Krayushkina *et al.* 2019; Moumen *et al.* 2019; Muradl and Ahmadov 2019; Pukhkal *et al.* 2016; Trusova 2016; Politanskyi 2020).

For analysis, we used the following formula for the rate of return on investment of each investment asset (ROI_i):

$$ROI_i = \frac{P_{n+1} - P_n}{P_n} \times 100\% \times \sqrt{WD} + PI, \quad (1)$$

where P_n, P_{n+1} (price) – this is the value of the investment price on a certain date (day) and the previous date (based on information on stock trading and other statistical sources mentioned in the study materials); WD (Work Days) – average number of working days per year. This is the number of days on which the stock exchange was traded. In calculations, this figure is 251-365 days. Exchanges do not trade every calendar day, so to convert the daily return (daily ROI) into an annual (Annualized ROI) used the number of working days, not calendar days per year (365). This ensures the comparability of annual yield data on different investment assets; PI (Passive Income) – passive income of the investment asset (%). For example, interest when placing money on a deposit account in a bank, rent when renting real estate, etc. (Bashynska 2016; Dinzhos *et al.* 2015; Kaimbayeva *et al.* 2020; Kapitonov *et al.* 2016; Lapidus and Bumarskova 2017; Salimyanova *et al.* 2019).

The logical sequence of actions during the study was as follows:

Step 1. Assess the profitability and effectiveness of the main areas of possible investment (Forex

currencies, cryptocurrencies, stocks, real estate, commodities, and government bonds). This step includes:

- Withdrawal of daily data from stock trading and their conversion to Excel from *.csv files, sorting and preparation of the required data format;
- Calculation of average daily yield, average monthly yield, average annual yield, statistical deviation, Sharpe's ratio;
- Ranking of assets by profitability and efficiency (Sharpe ratio).

Step 2. Selection of the most effective 12 assets according to the Sharpe ratio and the formation of the investment portfolio 1.

Step 3. Optimization of investment portfolio 1 according to the Markowitz model. This step includes calculating the return on the portfolio, calculating the statistical deviation of the portfolio using the covariance matrix, calculating the efficiency of the investment portfolio (Sharpe ratio), and search for the optimal share of portfolio assets based on maximizing the Sharpe ratio.

Step 4. Create an investment portfolio 2 by adding cryptocurrencies to the investment portfolio 1. Optimization of the investment portfolio according to Markowitz (repeat step 3). The Solver add-in is used to find the optimum. Comparison of profitability and Sharpe ratio of both investment portfolios. Conclusion on the effectiveness of using cryptocurrencies as an investment resource.

As a risk-free rate of return, the calculated average geometric interest rate on deposits in dollars and euros in banks of Ukraine, Europe and the USA (≈ 2.36%) was used in the calculation of the Sharpe ratio. Time interval of statistical data processed in the study: 01/07/2016 – 06/30/2019 (1095 calendar days). The Markowitz Portfolio Optimization Model was used to compare the two portfolios, which is to maximize the Sharpe ratio (Markowitz 1952). However, an additional restriction is used: all pre-selected investment assets with a share of at least 1% must be in the portfolio. When conducting the study, the Markowitz model was built in Microsoft Excel 2013, and the search for the best solution was performed using the Solver add-on (Alpysbayev *et al.* 2020; Ashikbayeva *et al.* 2018; Bayanov *et al.* 2019; Bieliatynskyi *et al.* 2018; Dubrovin *et al.* 2014; Ryapukhin *et al.* 2019).

The study selected those cryptocurrencies that are among the top 5 most important assets that form the well-known CRIX cryptocurrency index, which uses the largest shares in the market. These are Bitcoin (BTC), Ethereum (ETC), Ripple (XRP), Bitcoin Cash (BCH) and Litecoin (LTC) (Sarma *et al.* 2019; Seisenbayeva *et al.* 2020; Shtal *et al.* 2019; Šimonová *et al.* 2019; Ushakov and Ermilova 2020; Bohutskyi 2020).

Cryptocurrencies can be used as:

1) Medium of exchange. For example, Bitcoin is already used in calculations by some well-known companies such as Microsoft, Dell, Tesla, Amazon, PayPal, Subway (Cryptocurrency List… 2020, Bloomberg… 2017).
2) Investment resource. It is a commodity used for speculative earnings to increase its price over time (Aziza 2019, Baur *et al*. 2018, Ciaian *et al*. 2015; Mussapirov *et al.* 2019; Padilla *et al.* 2019). Traditional (fiat) currencies of the Central Banks can also be used for the same purpose, for example, in Forex trading (Starikov *et al.* 2011; Stepanchuk *et al.* 2017; Zykova *et al.* 2021).

RESULTS AND DISCUSSION

Table **1** shows the result of the selection of investment resources by major areas of investment, their abbreviated designations and investment indexes used to evaluate the effectiveness of investing. Information sources for financial investors Investing.com (2020), Dividend.com (2020), Yahoo Finance (2020) were used as the source of the majority of data, except for the information about the real estate of Ukraine, where the specialized platform of the real estate market in Kyiv was used (Real estate in Kyiv… 2020).

The selection criteria for investment assets were:

1) Cryptocurrencies. Index CRIX (Crypto Index CRIX Methodology… 2020) are selected.
2) Forex market currency. It is advisable to compare cryptocurrencies with other types of money. The euro, dollar, Swiss franc, and pound sterling were selected as the most stable currencies in the world and the hryvnia as the currency of the base country of study (Ukraine). Chinese Yuan, Japanese Yen, Russian Ruble are selected as they are attractive to invest because of their appreciation against the dollar.

Table 1: Investment Assets Analysed in the Study

Area of investment	Investment assets	Abbreviated notation, index
Cryptocurrencies	Bitcoin	BTC
	Ethereum	ETC
	Ripple	XRP
	Bitcoin Cash	BCH
	Litecoin	LTC
	Cryptocurrency index	Index CRIX
Currencies (Forex)	Euro	EUR
	British Pounds Sterling	GBP
	Chinese Yuan	CHY
	Russian Ruble	RUB
	Japanese yen	JPY
	Swiss franc	CHF
	Ukrainian hryvnia	UAH
Commodities	Gold	XAU
	Silver	XAG
	Oil	Brent Oil Futures
State Bonds	US Treasury bonds, 5 years	US 5Y Bonds
	Eurobond futures (Germany)	Euro Bund
	Government bonds of Ukraine (3-year)	Ukr 3Y Bonds
Stocks	US Stock Market Index (500 companies)	S&P 500
	US Stock Market Index (100 companies)	Nasdaq 100
	US Stock Market Index (30 companies)	Dow Jones
	EU Stock Market Index (50 Eurozone companies)	Euro STOXX 50
Real Estate	EU Real Estate Market Index (Germany, France, Switzerland, United Kingdom)	MSCI RE Europe
	US Real Estate Market Index, Based on the Value of US Real Estate Companies (Investment Funds))	Dow Jones US Real Estate
	Cost of 1 square meters of living space in Kiev, Ukraine	Ukr RE

3) Commodities. Bitcoin is often compared to gold as “digital gold”, so the most popular precious metals (gold and silver) and oil (“black gold”) are included in the portfolio.

4) Government bonds. They are considered risk-free investments. Selected US and German bonds as stable economies and Ukraine as the base country of study, whose economy shows a tendency to strengthen.

5) Stocks of enterprises. Selected stocks of companies from stable economies of the world – USA and EU.

6) Real estate. Two popular indexes from MSCI and Dow Jones have been selected for Europe and the USA. For Ukraine, such indexes are not calculated, so statistical data on the cost of a one-room apartment in Kyiv are used, as there is no average information throughout Ukraine (Zvorykin *et al.* 2016; Yuilin *et al.* 2019; Zatsepin *et al.* 2018).

The return analysis of the above 26 investment assets in a generalized form is presented in Table **2**.

The analysis of the data in Table **2** shows the high return of cryptocurrencies, but also the high (standard deviation) risk indicators for them. Return growth is usually accompanied by increased risk. Figure **1** shows the tendency for the selected set of investment assets.

The study concluded that not all cryptocurrencies are highly profitable: the top two outsiders were CRIX, namely Bitcoin Cash (BCH), Ethereum (ETH). In addition, despite all expectations, gold (XAU) during the 3-year period (2016-2019) is not a high-return investment asset. Table **2** summarizes the return-to-risk ratio and has a ranking of investment assets by the

Table 2: Return on Investment Assets (ROI)

Ranked place	Investment asset	Average Annual Return (ROI)*, %	Risk (standard deviation σ), %	Area of investment
1	XRP	301.06	188.57	Cryptocurrencies
2	LTC	216.79	131.57	Cryptocurrencies
3	Index CRIX	180.85	79.99	Cryptocurrencies
4	BTC	160.62	80.16	Cryptocurrencies
5	US 5Y Bonds	23.65	31.67	Government bonds
6	Nasdaq 100	23.12	16.66	Stocks (stock market)
7	Dow Jones	16.26	12.67	Stocks (stock market)
8	Dow Jones US RE	16.26	16.26	Real estate
9	S&P 500	13.69	12.31	Stocks (stock market)
10	Brent Oil Futures	9.74	29.13	Commodities
11	MSCI Europe	9.53	12.59	Real estate
12	Euro STOXX 50	9.53	12.59	Stocks (stock market)
13	Euro Bund	7.14	5.14	Government bonds
14	Ukr RE	5.86	3.07	Real estate
15	JPY	4.38	8.12	Currencies (Forex)
16	UAH	4.17	7.18	Currencies (Forex)
17	CHY	3.56	3.87	Currencies (Forex)
18	XAU	2.43	15.75	Currencies (Forex)
19	RUB	2.21	11.66	Currencies (Forex)
20	EUR	1.80	7.00	Government bonds
21	Ukr 3Y Bonds	1.17	1.17	Commodities
22	CHF	0.25	6.67	Currencies (Forex)
23	GBP	-0.20	8.93	Currencies (Forex)
24	XAG	-7.97	25.88	Commodities
25	BCH	-61.55	131.57	Cryptocurrencies
26	ETC	-76.90	230.31	Cryptocurrencies

Note: * adjusted for passive income.

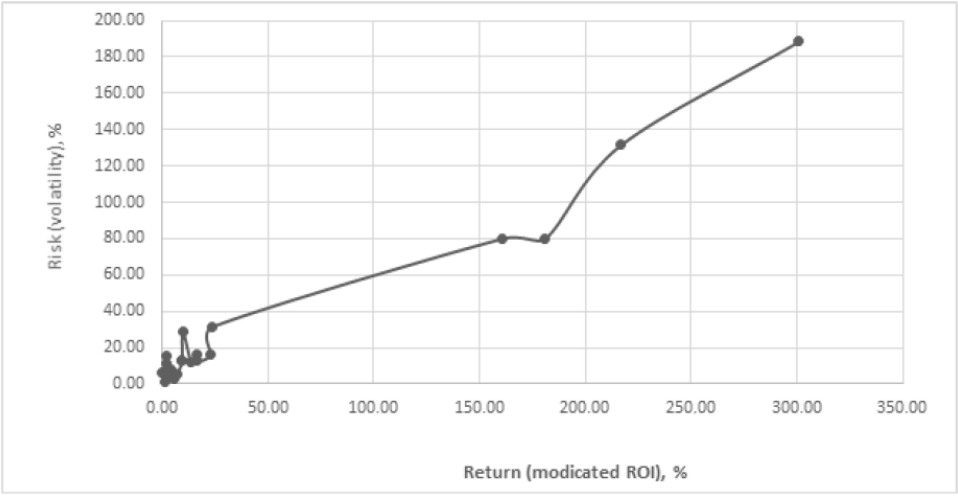

Figure 1: The relationship between risk and return on investment assets.

Table 3: Rating of Investment Assets by Performance

Ranked place	Investment asset	Sharpe ratio	Area of investment
1	Index CRIX	2.23	Cryptocurrencies
2	BTC	1.97	Cryptocurrencies
3	LTC	1.63	Cryptocurrencies
4	XRP	1.58	Cryptocurrencies
5	Nasdaq 100	1.25	Stocks (stock market)
6	Ukr RE	1.14	Real estate
7	Euro Bund	0.93	Government bonds
8	S&P 500	0.92	Stocks (stock market)
9	Dow Jones	0.92	Stocks (stock market)
10	MSCI Europe	0.86	Real estate
11	US 5Y Bonds	0.67	Government bonds
12	Euro STOXX 50	0.57	Stocks (stock market)
13	Dow Jones US Real Estate	0.52	Real estate
14	CHY	0.31	Currencies (Forex)
15	Brent Oil Futures	0.25	Commodities
16	UAH	0.25	Currencies (Forex)
17	JPY	0.25	Currencies (Forex)
18	XAU	0.0046	Commodities
19	RUB	-0.01	Currencies (Forex)
20	EUR	-0.08	Currencies (Forex)
21	Ukr 3Y Bonds	-0.04	Government bonds
22	GBP	-0.29	Currencies (Forex)
23	CHF	-0.32	Currencies (Forex)
24	ETC	-0.34	Cryptocurrencies
25	XAG	-0.36	Commodities
26	BCH	-0.48	Cryptocurrencies

Sharpe ratio. An increase in profitability affects the increase in the Sharpe ratio, but an increase in risk, on the contrary, decreases this indicator. Considering the formula for calculating this indicator, an investment with a higher risk but the same return will have a lower Sharpe ratio. The negative value of the Sharpe ratio indicates that the return on investment did not exceed the risk-free rate, such as the situation in silver (XAG), Russian ruble (EUR), and Ethereum cryptocurrency (ETC) (Efimov *et al.* 2014; Fedyunin *et al.* 2018a; Fedyunin *et al.* 2018b; Lapidus *et al.* 2017; Pichkur *et al.* 2015; Shakbutova *et al.* 2020; Monaienko *et al.* 2020).

It turns out that from the point of view of the theory of investing – investing in cryptocurrencies is a fairly logical and justified step, since the values of the Sharpe coefficient do not deny, but on the contrary, emphasize their effectiveness (Shevgunov 2019; Shevyakova *et al.* 2019). However, in practice, investments are made not in a separate asset, but in a group of assets that form an investment portfolio. This reduces the risks. Investment portfolio No. 1 (excluding cryptocurrencies) selected 12 investment assets that showed the highest Sharpe ratio in Table **3**. Extended investment portfolio 2 (with cryptocurrencies) added three cryptocurrencies that showed high Sharpe ratio values: Litcoin, Ripple, Bitcoin, Ripple 15 investment assets included. The result of the selection of investment portfolios No. 1 and No. 2 with defined areas of investment are shown in Table **4**.

The Yahoo Finance (2020) resource was used to construct the Markowitz model as a source of share

Table 4: Assets Set of Investment Portfolios for Analysis by Markowitz Model

No.	Investment assets	Abbreviations, indexes	Area of investment
Investment Portfolio No. 1 (without cryptocurrencies):			
1	Chinese Yuan	CNY	Forex market
2	Japanese yen	JPY	
3	Microsoft Company (USA)	MCFT	Stocks (companies with the highest Nasdaq 100 weights)
4	Amazon Company (USA)	AMZN	
5	Apple Company (USA)	AAPL	
6	Siemens Company (Germany)	SIEGY	Stocks (companies with the highest weights in Euro STOXX 50)
7	Total S.A. Company (France)	TOT	
8	Oil (Brent futures)	Brent Oil Futures	Stocks
9	US Treasury bonds, 5 years	US 5Y Bonds	Government bonds
10	Eurobond futures (Germany)	Euro Bund	
11	EU Real Estate Market Index (Germany, France, Switzerland, United Kingdom)	MSCI RE Europe	Real estate
12	Real estate in Kyiv, Ukraine	Ukr RE	
Investment Portfolio No. 2 (= cryptocurrency investment portfolio 1 + 3):			
13	Bitcoin	BTC	Real estate
14	Ripple	XRP	
15	Litecoin	LTC	

Table 5: Optimization of Investment Portfolio by Markowitz Model

Asset	Optimized portfolios, asset share, %		Non-optimized portfolios, share of assets, %	
	1	2	1	2
BTC	0.00	2.31	0.00	6.67
XRP	0.00	1.00	0.00	6.67
LTC	0.00	1.00	0.00	6.67
CNY	10.20	2.87	8.33	6.67
JPY	1.00	1.00	8.33	6.67
MCFT	5.75	7.70	8.33	6.67
AMZN	1.00	1.00	8.33	6.67
AAPL	1.00	1.00	8.33	6.67
SIEGY	1.00	1.00	8.33	6.67
TOT	1.00	1.00	8.33	6.67
Brent Oil Futures	1.00	1.00	8.33	6.67
US 5Y Bonds	3.97	4.74	8.33	6.67
Euro Bund	34.27	36.45	8.33	6.67
Real Estate (Ukr)	37.82	36.92	8.33	6.67
MSCI Europe	1.99	1.00	8.33	6.67
Total	100.00	100.00	100.00	100.00
Indexes:				
Expected portfolio return ($E(R_p)$), %	8.97	18.39	14.59	56.90
Standard Deviation Portfolio (σ_p), %	0.66	1.17	2.15	5.10
Sharpe ratio (Sp)	10.04	13.69	5.68	10.70

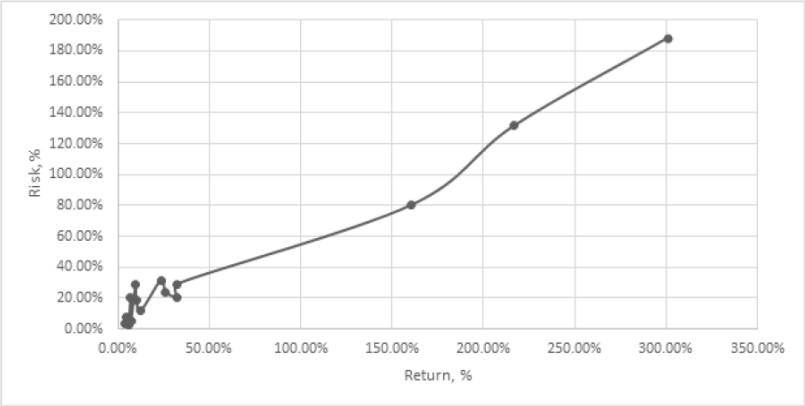

Figure 2: Comparison of risk and return on individual investment portfolio assets in the study.

price data. Table **5** shows the obtained result of optimization of investment portfolios by Markowitz. Comparison of optimized and non-optimized investment portfolios shows much better values of profitability indicators and Sharpe ratio in the first. In addition, a study based on the Markowitz model shows the following: firstly, the addition of cryptocurrencies has improved the quality of the portfolio, as expected returns have increased by almost 2 times and the value of the Sharpe ratio has also increased despite increasing risk; second, to increase the quality of the investment portfolio, the share of cryptocurrencies should be small, namely 2.31% for Bitcoin and 1% for Litecoin and Ripple (Fialko *et al.* 1994; Jaksybekova *et al.* 2018; Shtal *et al.* 2018a; Shtal *et al.* 2018b; Prentkovskis *et al.* 2010; Shumylo 2020).

With such a small presence of cryptocurrencies in the portfolio, even investors with low risk tolerance can be quite satisfied, as the risk (standard deviation) of the investment portfolio remains close to 1%. If we consider each of the investment assets separately, then the risk (standard deviation) may be at a rather high level (Figure **2**).

CONCLUSION

The study made it possible to conclude on the effectiveness of using cryptocurrencies as an investment asset, their ability to perform an investment (speculative) function. Introduction of 3 cryptocurrencies that are in the top 5 of the CRIX index – Bitcoin, Ripple, Litecoin – in the proportions 2.31%, 1%, 1% respectively increased the Sharpe ratio of the investment portfolio by 3.29 points and the profitability ratio by 9.42 percentage points while increasing investment risk by only 0.51 percentage points. This result shows that cryptocurrencies have improved the quality of the investment portfolio, that is, increased its efficiency. An investor can control the risk of an investment portfolio despite the high volatility of cryptocurrencies that it contains.

The proven cryptocurrency investment (speculative) function should be taken into account in further studies of possible cryptocurrency accounting models, providing a theoretical framework for solving the problems of recognition, classification and valuation of cryptocurrencies for accounting purposes.

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