BITCOIN: Systematic Force of Cryptocurrency Portfolio

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Abstract

Cryptocurrencies represent a new type of digital asset that cannot be linked to the framework of fundamental and systematic factors of existing financial instruments of the traditional capital market. Due to the lack of strictly defined fundamental indicators, supported by the results of research by the academic community, considering cryptocurrencies as investment opportunities can put investors in a subordinate position, a situation of complete uncertainty. Cryptocurrencies and their entire technical infrastructure are still a kind of unknown to the general public. Due to this, but also the lack of a regulatory framework, investors have to rely on sometimes uncertain information gathered through various media platforms. However, regardless of the type of assets and the mentioned shortcomings, when constructing a portfolio, investors should consider the dynamics of returns of potential components of the portfolio in order to identify and quantify the assumed investment risk and define the expected return. Cryptocurrencies are based on the idea of decentralization initially introduced by bitcoin blockchain technology and as such have their own historical sequence of origin. Since bitcoin is the first digital currency based on asymmetric cryptography, the change in its value can serve as a leading indicator of the movement of the cryptocurrency market as a whole. Accordingly, this paper will formally identify and describe the performance of the cryptocurrency portfolio with different optimization goals taking into account the assumption of a significant systematic impact of bitcoin cryptocurrency on the dynamics of the value of the aggregate secondary cryptocurrency market. For this purpose, six optimization targets will be formed: MinVar, MinCVaR, MaxSR, MaxSTARR, MaxUT and MaxMean. The results of the formed portfolios will be compared with the results of portfolios with the same allocation objectives, but which include a limitation on the impact of BTC as a systematic factor. The results suggest that by controlling the exposure by factor, better overall portfolio performance can be achieved through higher returns and Sharpe Ratio in four of the six implemented optimization strategies, while in terms of absolute risk measure five out of six portfolios achieved lower overall risk. Also, the obtained results confirm that the bitcoin transaction system plays a major role in defining the future movement of the value of the secondary cryptocurrency market.

Keywords: cryptocurrencies, portfolio choice, factor investing, risk management, portfolio return

JEL classification: E49, G11, P45

Introduction

With the increasingly significant development of information technologies and the Internet in the last two decades, the already existing idea of digital money has been revitalized. The result was the publication on October 31, 2008 of a document entitled "Bitcoin: A Peer-to-Peer Electronic Cash System" which describes a new decentralized transaction system that excludes the central body as an intermediary between potential participants in the transaction. Bitcoin is a computer program that was released on January 9, 2009, which created the transaction infrastructure for the first cryptocurrency - bitcoin. Bitcoin transactions are recorded on a public ledger, secured by cryptography and managed by the consensus of the participants in the community that accepts it. All transactions created on the Bitcoin protocol are grouped into transaction blocks, which means that the general ledger is actually a chain of transaction blocks (blockchain).

Cryptocurrencies can also be viewed as a new type of digital asset that does not fall into any of the existing definitions and classification categories of financial instruments. The open source feature has also contributed to the spread of new technology companies that base their business idea on the practical application of distributed ledger technology. Such companies financed their initial development by issuing new cryptocurrencies adapted to their business philosophy. The practical implementation of blockchain technology on the one hand and the positive reaction of the public to the idea of transparency and decentralization on the other hand, contributed to the creation of supply and demand conditions and thus created a new primary cryptocurrency market. The development of the primary market has led to an increase in the number of exchanges that enable active trading in cryptocurrencies, thus creating a completely new self-sustainable ecosystem of the primary and secondary market of new digital assets - cryptocurrencies.

The cryptocurrency market is a highly risky market burdened by the absence of a regulatory framework. In addition, a mathematical expression has not yet been derived to calculate at least an approximate intrinsic or fundamental value that would serve as a stabilizer of the price momentum of a particular cryptocurrency. If, from one point of view, there are assets that have been traded on some form of market for more than ten years, and from the other point of view there is no stronghold of fundamental value that would justify that price, one cryptocurrency can be expected to double in one day, but also loses most of its value. Accordingly, in order to assess risk, it is primarily necessary to define variables that could in theory affect the market value of cryptocurrencies, and only then examine and study their causal relationship. After that, taking into account these new insights, one can approach the construction of the portfolio in order to try to stabilize its risk by modeling.

The dynamics of change in the value of the cryptocurrency market can be justified through several theoretical assumptions. The first is that it is influenced by some other fundamental, technical systematic factors that have not yet been defined and examined and therefore remain unknown. There are only a few recent papers described below that link the price of cryptocurrencies and certain technical properties presented as systematic factors. The second is that the cryptocurrency market depends solely on the state of mind of investors who base their positions solely on technical analysis. And the third is that the value of the cryptocurrency market is defined with the current condition of investors in the traditional capital market, which could be seen at the end of the first quarter of 2020. However, whatever the reason, the fact is that the cryptocurrency market and its entire infrastructure is continuously growing. Due to its availability, more and more investors invest and trade in cryptocurrencies, which is why there is an even greater need for research conducted in this paper in order to define investment opportunities, but also the associated systematic risks. Given that cryptocurrencies are new digital assets that cannot be linked to the framework of fundamental indicators of existing financial instruments, this paper will formally identify and describe portfolio performance with different optimization objectives taking into account the bitcoin cryptocurrency as the only systematic factor that could define the price dynamics of the cryptocurrency market presented as a portfolio. Such a theoretical assumption arises from the significant influence of the value of bitcoin cryptocurrency on the aggregate value of the cryptocurrency market.

Literature review

Among the first studies to define the relationship between the market value of cryptocurrencies and selected indicators is conducted by Hayes (2014). In his paper an author implements a multiple regression model using cross-sectional data on 66 of the most widely used cryptocurrencies. The dependent variable was represented by the market value of the cryptocurrency, while for the independent variables the data of five variables representing the properties of the blockchain system were used. The results of the regression model confirmed three of the five theoretical hypotheses set out in the paper: mining power, dynamics of mining new coins and hashing algorithm as an independent variables describe as many as 84% of the variations of the dependent variable.

Bouoiyour & Selmi (2014) also used a regression model to examine the relationship between bitcoin cryptocurrency returns and 18 selected independent variables. The results indicate that most variables do not describe well changes in the value of bitcoin and that there is no significant relationship between explanatory variables and bitcoin. Also, the results suggest that only lagged google search were significant at the 1% level. Cianan, Rajcaniova & Kancs (2016) showed a negative relationship between the number of transactions and bitcoin price returns, which is contrary to the theoretical assumption that more transactions mean higher demand, or higher price. To examine how well selected factors can explain the value movement of 11 leading cryptocurrencies, Renkens (2018) creates long / short single and multiple-factor portfolio strategies. By far the best performance was achieved by google trends single-factor strategy, so it can be concluded that google trends can be used as a factor in describing movements of the crypto market.

The linear relationship between the five leading cryptocurrencies and three categories of factors: market micro structure, traditional financial markets and internet attention is carried out by Khamisa (2019). The results suggest that the exchange volume is one of the major factor of the crypto market. The linear relationship between the price of 39 cryptocurrencies and the blockchain fundamental indicators computing power and network size, derived from the five leading cryptocurrencies, is proven by Bhambhwani, Delikouras & Korniotis (2020). In addition to the influence of the index of fundamental indicators, the authors also point out the significant influence of bitcoin cryptocurrency as an isolated factor on the movement of other cryptocurrencies.

All of the above papers examine the impact of an individually selected factor, or a linear combination of them, on the dynamics of cryptocurrency market movements to potentially define a fundamental relationship. However, given the results obtained, it is still not possible to unambiguously conclude which factors are the drivers of the fundamental value of cryptocurrencies. The reason for the conflicting results arises from both the methodological approach and the time frame of the observation. In addition, the cryptocurrency market is only in its infantile phase with the characteristics of each emerging market, and as such is subject to extremely large reactions to information. Some of these reactions are probably fundamentally grounded, and some are just market noise. In all researches, dependent variables are presented through the movement of the value of an individual cryptocurrency with the aim of defining factors as a possible information input during the construction of the portfolio. Accordingly, the research results suggest the importance and impact of bitcoin transaction infrastructure on the aggregate cryptocurrency market. This paper complements previous researches and observes and defines how much changes in the value of bitcoin cryptocurrency, as the only factor, affect the movement of the cryptocurrency market presented through created portfolios with different optimization goals.

As bitcoin is the first cryptocurrency that can be traded in some form of secondary market (Mt. Gox started in 2010), during 2013 and 2014 bitcoin achieved great price growth and attracted the attention of the scientific community. Due to that, it has been included and considered as an individual alternative asset in the construction of the portfolio. Its inclusion in a well-diversified portfolio of traditional assets is carried out by Briere, Oosterlinck & Szafarz (2015) and Eisl, Gasser & Weinmayer (2015). The research results of both papers suggest that bitcoin should be included in the portfolio because the higher risk is compensated with higher portfolio expected return. The contribution of portfolio dynamics created from traditional assets to continental affiliation is examined by Kajtazi & Moro (2018). The results also suggested the inclusion of bitcoin cryptocurrencies in a well-diversified portfolio of traditional assets contributes to improving reward-risk ratio. Research which potentially denies previous results was conducted by Klein, Hien & Walther (2018). Comparing the performance of bitcoin cryptocurrencies and gold, the authors conclude that bitcoin does not have investment characteristics like gold. A portfolio that includes bitcoin, e.g., S&P 500 / bitcoin, contains a small proportion of bitcoin, as opposed to the S&P 500 / gold portfolio where there is a larger share of gold in the portfolio.

Trimborn, Li & Härdle (2019) conduct research where they introduce a number of cryptocurrencies into the existing portfolio composed of traditional financial instruments. All portfolios created that include cryptocurrencies in their composition performed better than portfolios created only from traditional assets. The contribution to the performance of the portfolio created from traditional assets is confirmed by Petukhina, Trimborn & Härdle (2018) and Chuen, Guo & Wang (2018). The results of all optimization goals indicate the usefulness of considering cryptocurrencies as a component in a portfolio made up of traditional assets.

The secondary cryptocurrency market can be viewed as a separate entity and for this reason it is desirable to examine the possibility of constructing an efficient portfolio composed exclusively of cryptocurrencies with different allocation objectives. Such possibilities are examined by Liu (2018), Brauneis & Mestel (2018) and Platanakis, Sutcliffeb & Urquhartc (2019). The authors form multiple portfolios with different optimization goals of risk minimization, returns maximization, and return to risk ratio maximization. The results which were obtained were contrary to expectations. All authors state that no optimization strategy can outperform portfolio performance if weights are equally represented, and conclude that a portfolio with equal shares is the best choice when creating and modeling a portfolio in the cryptocurrency market.

Depending on the goal which needs to be achieved, exposure to market factors can be both positive and negative. Thus, for example, if a factor trading strategy is applied to individual assets, it is desirable to have as much exposure to the market factor as possible, in order to minimize the risk or deviation from short and long positions. On the other hand, if portfolios are created, and the market is extremely burdened by individual systematic factors, the success of risk diversification, as well as other optimization goals, is questionable. In accordance with the above, the paper will examine the possibility of portfolio construction with different optimization goals, if the exposure to BTC cryptocurrency, as the only systematic factor is controlled and reduced to a minimum. The described methodological approach has not been considered so far and represents a significant contribution in the field of research of investment opportunities in the cryptocurrency market.

Data and Methodology

The study used publicly available data on daily value movements for 122 cryptocurrencies (in USD), collected from the Coinmarketcap - CMC platform. The observation period used is from 26/08/2019. to 04/05/2020. which represents a sample of a total of 253 daily observations, or 252 daily discrete returns for 122 time series. To examine the impact and control of bitcoin cryptocurrency as a systematic factor on the created portfolios, the research was conducted through three steps. In the first step, portfolios are created from an existing data set that does not include bitcoin as a potential component, various optimization goals are performed, and the obtained portfolio performance is measured and interpreted. In the second step, applying a simple linear regression model, the influence and dependence between a single cryptocurrency as a dependent variable and bitcoin cryptocurrency as an independent variable is examined in order to define the beta coefficient as a systematic risk factor. The same model also defines the relationship between the obtained time series of portfolio returns as dependent variables and bitcoin cryptocurrency. In accordance with the obtained results of the regression model, in the third step a linear lower bound constraint is created $\beta_{p,bitcoin}^{L} = 0{,}05$ and upper bound is created $\beta_{p,bitcoin}^{U} = 0{,}10$ according to the exposure of the bitcoin cryptocurrency portfolio to control the risk of the systematic factor, and restart the portfolio optimization with the same optimization goals and parameters, the results are interpreted and conclusions are drawn.

Formed optimization goals of asset allocation and portfolio notation in which factor exposure is not controlled are the following: minimum variance (MinVar), minimum CVaR (MinCVaR), maximize sharpe ratio (MaxSR), maximize stable tail-adjusted return ratio (MaxSTARR), maximize utility function (MaxUT) and maximize mean return (MaxMean). Given the results of research by Briere et al. (2015) and Chuen et al. (2018) and the absence of normal return distribution, in addition to the standard deviation, for the risk measure will be used conditional value at risk - CVaR, or the methodology that accompanies the work of Rockafellar and Uryasev

(2000), with a confidence level of 95%. The notation of portfolio optimization goals in which bitcoin cryptocurrency exposure is controlled as a systematic factor is as follows: minimum variance (MinVar-B), minimum CVaR (MinCVaR-B), maximize sharpe ratio (MaxSR-B), maximize stable tail-adjusted return ratio (MaxSTARR-B), maximize utility function (MaxUT-B) and maximize mean return (MaxMean-B). Optimization was performed as out of sample backtesting with equal parameters for each optimization goal. The assessment of initial parameters and portfolio weights was performed on a time period of K = 10 days, and considering the dynamics of the cryptocurrency market, a more frequent monthly rebalance k = 30 days was chosen with the so-called extending window approach K + k. For each period K + 1, portfolio returns were extracted with respect to the results of weights optimization in the previous k and K + k moment, respectively.

Regression model and risk decomposition

The linear regression model used to estimate the beta coefficient, as well as to estimate the dependence of portfolio returns on bitcoin is given by expression (1).

$$r_{it} = \alpha_i + \beta_i r_{\mathrm{B}t} + \varepsilon_{it} \tag{1}$$

Where r_{it} represents the cryptocurrency return (portfolio) i for period t, α_i stands for cryptocurrency return component (portfolio) i which is not explained by bitcoin, β_i is the covariance relationship between cryptocurrency returns (portfolio) i and bitcoin returns, $r_{\mathrm{B}t}$ represents the returns of bitcoin cryptocurrency for period t and ε_{it} is the residual deviations from the slope (portfolio return not explained by the bitcoin return).

According to Škrinjarić (2013), the total portfolio variance can be divided into two components: a non-systematic component that represents a specific investment risk and manifests itself as a deviation from the functional relationship in regression, and a systematic component that represents variations explained by an independent factor. In order to determine the influence of the systematic factor, the assumption of the same relationship can be applied in the cryptocurrency market where the dependent variable is represented by portfolio returns, and the independent bitcoin. Therefore, the total portfolio risk can be written as expression (2).

$$risk_{Pt} = \beta_i^2 risk(r_{\mathrm{B}t}) + risk(\varepsilon_{it}) \tag{2}$$

The factor contribution to the total risk of the portfolio can be distinguished according to other risk measures. In addition to the decomposition of variance of the portfolio from expression (2), it will be conducted and presented the percentage decomposition of Conditional Value at Risk (CVaR) (6) the risk measure following the work Zivot (2016) by using Euler theorem.

Global Minimum Variance Portfolio Formation

Portfolio modeling was approached by applying the Modern Portfolio Theory concept, which represents the theoretical basis for the problem of asset allocation and defining the optimal portfolio investment (Markowitz 1952). The original form of the model minimizes the variance for a given level of expected return within certain theoretical assumptions, which is why it is known as the mean-variance (M-V) model. If the limitation of the required rate of return is omitted from the basic model, the optimization of the portfolio creates the Global Minimum Variance Portfolio - GMV. The formulation for GVM in this paper is given by expression (3) which includes a linear limit for exposure to the bitcoin beta coefficient as a systematic factor. For a portfolio that does not include factor control, the linear constraint is omitted.

$$\begin{gathered}\min_{w} \quad \sigma_p^2\,(w) = w^{\mathrm{T}}\hat{\Sigma}w \\ s.t.\;\; \mathbf{1}_N^{\mathrm{T}}w = 1 \\ 0{,}05 \leq \beta_{P,\mathbf{B}} \leq 0{,}10 \\ w_i \geq 0,\;\; i = 1, \dots, N\end{gathered} \tag{3}$$

where σ_p^2 represents the portfolio standard deviation, $w = (w_1, w_2, \dots, w_N)^T$ is the weight on individual assets in the portfolio and $\hat{\Sigma}$ stands for the estimated covariance matrix of the respective assets *N*. The above relation includes three additional constraints: $\mathbf{1}_N$ represents the $(N \times 1)$ vector where all elements of the vector represent portfolio weights and their sum must be 1 (full investment constraint), $\beta_{P,\mathrm{B}}$ represents the total exposure of the portfolio according to the systematic factor given that $\beta_{P,\mathrm{B}} = \sum_{i=1}^{N} w_i \beta_{i,\mathrm{B}}$, and the last constraint defines the prohibition of short sale of assets, which means that all weights in the portfolio must be of a positive value.

Global Minimum CVaR Portfolio Formation

Research done by Briere et al. (2015) and Chuen et al. (2018) shows the evidence of the presence of a heavy-tailed distribution of cryptocurrency returns. The relation used in this pape ris based on Petukhina et al. (2018) and Eisl et al. (2015), which is based on the methodology of Rockafellar and Uryasev (2000). In this case, a more reliable measure of CVaR is taken as the risk measure so that the Mean-Variance model transitions to Mean-Conditional Value at Risk (M-CVaR).

We define the cumulative distribution function of a loss function $z = f(w, y)$ as

$$\Psi(w, \zeta) = P\{y | f(w, y) \leq \zeta\} \tag{4}$$

Where w is fixed decision vector (i.e. portfolio weights), ζ loss associated with that vector and y uncertainties (e.g. market variables) that impact the loss. Then, for a given confidence level α, the Value at Risk (VaR_α) associated with portfolio is given as

$$VaR_\alpha(w) = min\{y | \Psi(w, \zeta) \geq \alpha\} \tag{5}$$

If $f(w, y)$ exceeds the VaR, then the expected value of the loss is defined as

$$\mathrm{CVaR}_\alpha(w) = \frac{1}{1-\alpha} \int_{y(w) \leq VaR_\alpha(w)} y f(y|w)\, dy \tag{6}$$

This relation is adjusted to the optimization goal of risk minimization, with a confidence level of 95%. For portfolios that do not include bitcoin factor control, the linear constraint is omitted.

$$\begin{gathered} \min_w \quad \mathrm{CVaR}_\alpha\,(w) \\ s.t. \quad \mathbf{1}_N^{\mathrm{T}} w = 1 \\ 0{,}05 \leq \beta_{P,\mathbf{B}} \leq 0{,}10 \\ w_i \geq 0, \quad i = 1, \dots, N \end{gathered} \tag{7}$$

Maximize Sharpe and STARR Ratio Portfolio Formation

The ratio of the expected return of the portfolio, adjusted for the risk-free interest rate in the same observation period and the standard deviation of the portfolio, results in a Sharpe ratio, a ratio that defines how much additional return is obtained per taken unit of risk. By changing the investor's risk tolerance, the optimization goal of maximizing the return for a given level of risk is performed. Portfolios that have the highest expected return for a given level of risk create an efficient frontier of possible portfolios, and the portfolio that has the highest Sharpe ratio represents the optimal tangent portfolio (8). As before, for portfolios without bitcoin factor control, the restriction is omitted.

$$\begin{gathered} \max_w \quad \left\{ \frac{w^{\mathrm{T}} \mu}{\sqrt{w^{\mathrm{T}} \hat{\Sigma} w}} \right\} \\ s.t. \quad \mathbf{1}_N^{\mathrm{T}} w = 1 \\ 0{,}05 \leq \beta_{P,\mathbf{B}} \leq 0{,}10 \\ w_i \geq 0, \quad i = 1, \dots, N \end{gathered} \tag{8}$$

Where $w^{\mathrm{T}}\mu$ is the expected portfolio return. For the purposes of the research, the risk-free interest rate was omitted, which is evident from equations (8) and (9). If CVaR is used as a risk measure in the denominator of expression (8) instead of the standard deviation, the Sharpe ratio changes to Stable Tail-Adjusted Return Ratio (STARR) and is given by expression (9). The optimization goal is to maximize the STARR ratio with a 95% confidence level and a linear limit for the bitcoin systematic factor.

$$\begin{gathered} \max_w \quad \left\{ \frac{w^{\mathrm{T}} \mu}{\mathrm{CVaR}_\alpha(w)} \right\} \\ s.t. \quad \mathbf{1}_N^{\mathrm{T}} w = 1 \end{gathered} \tag{9}$$

$$0{,}05 \leq \beta_{P,\mathbf{B}} \leq 0{,}10$$
$$w_i \geq 0, \;\; i = 1, \dots, N$$

Maximize Quadratic Utility Function Portfolio Formation

By changing the investor's risk tolerance, it is possible to create an indifference or utility curve as a function of the investor's risk preference for lower but safer, as opposed to higher but riskier expected returns, where different combinations of risk and return providing equal satisfaction to the investor. In order to derive the curve, it is necessary to introduce the degree of investor aversion to risk γ. The value of the parameter used in this paper is 1. A lower value of the parameter also means a lower penalty of the portfolio risk contribution, which leads to a higher risk portfolio and a higher expected return. In the case of more risk aversion, higher risk portfolios will also be more penalized, leading to a portfolio with lower risk and lower expected return. The restriction is omitted for portfolios without control impact of bitcoin factor.

$$\max_{w} \;\; \mu\,(w) - \frac{\gamma}{2} w \hat{\Sigma} w \tag{10}$$
$$s.t. \;\; \mathbf{1}_N^{\mathrm{T}} w = 1$$
$$0{,}05 \leq \beta_{P,\mathbf{B}} \leq 0{,}10$$
$$w_i \geq 0, \;\; i = 1, \dots, N$$

Maximize Return Portfolio Formation

In this paper an optimization is performs that maximizes the expected return on the portfolio where the average return on individual assets of the previous period is used to estimate the highest expected return on the portfolio in the next period. The formulation used to maximize the expected return is given by expression (11) which includes a linear constraint for the influence of bitcoin factors.

$$\max_{w} \;\; \mu_p\,(w) = w^{\mathrm{T}} \tag{11}$$
$$s.t. \;\; \mathbf{1}_N^{\mathrm{T}} w = 1$$
$$0{,}05 \leq \beta_{P,\mathbf{B}} \leq 0{,}10$$
$$w_i \geq 0, \;\; i = 1, \dots, N$$

Where μ_p is the expected portfolio return.

Performance Metrics

In order to define the performance of the portfolio, this paper presents the results of several absolute measures of return and risk: geometric return, cumulative return with initial wealth of $ 1, standard deviation, VaR, CVaR, worst drawdown and decomposition of CVaR. In order to consider investment opportunities, the results of relative measures derived from the results of the linear regression model (1) between the series of portfolio returns and BTC returns as market benchmark are presented. Except regression beta and R-squared, all values are expressed on an annual basis and refer to the total time series of portfolio returns.

For realized portfolio return annual geometric average return is used $R_{Gi} = prod(1 + R_{d,i})^{\frac{scale}{n}} - 1$, where $R_{d,i}$ is the daily realized return of portfolio i for period t, n the total number of existing observations and $scale$ number of observations in one year 252. Standard deviation, VaR and CVaR is expressed annually in terms $risk_{a,i} = risk_{d,i} \times \sqrt{252}$, where $risk_{d,i}$ is the risk mesure of daily returns. If the risk-free interest rate is omitted from the calculation as an indicator of opportunity profitability, the Sharpe ratio $SR_{d,i}$ used in this paper is given by the expression (12).

$$SR_{d,i} = \frac{R_{Gi}}{\sigma_{ai}} \tag{12}$$

Results and discussion

As follows, results are presented and interpreted for out-of-sample backtesting of each of the implemented optimization goals. First of all, the results are compared and interpreted at the level of asset allocation models. In order to define the impact of factor isolation on portfolio performance, the results are compared below between portfolios that differ in their composition due to a factor constraint.

Table 1 shows the results of portfolio optimization without limiting the impact of bitcoin cryptocurrency. The first three rows of the table show the parameters of the fitted regression line between the portfolio return as a dependent variable and the bitcoin cryptocurrency as an independent variable. Only the MaxMean portfolio did not achieve a statistically significant relationship with bitcoin cryptocurrency, all other variables are significant at a significance level of 5% and achieve a positive beta. The MaxUT strategy has the highest response of the portfolio to changes in the value of BTC, where the beta coefficient is 0.54. However, from the aspect of considering systemic risk, it can be said that strategies are still less volatile than bitcoin. The decomposition of variance presented by the R-squared measure suggests that most variations are described from the MaxUT and least from the MaxMean portfolio. Equally, all portfolios on average achieve higher returns than BTC returns indicating regression alpha. However, although the MaxMean portfolio achieved significantly higher average returns, it was the only one to achieve a negative geometric or cumulative return, as well as a lower return than BTC. On the other hand, the best performance was achieved by the MaxSR portfolio with a cumulative return of 1.32 and 32%, respectively, and a standard deviation of 36%. Risk measures are consistent with optimization goals. The MinVar and MinCVaR portfolios have the lowest level of risk compared to other portfolios, while MaxMean is by far the most risky strategy.

Table 1: Asset allocation models without factor exposure constraint

		Asset Allocation Models						
Performance Metrics		MinVar	MinCVaR	MaxSR	MaxSTARR	MaxUT	MaxMean	BTC
Beta (p - value)	$\beta_{i,\mathrm{B}}$	0,28 (0,00)	0,34 (0,00)	0,33 (0,00)	0,48 (0,00)	0,39 (0,00)	0,40 (0,16)	1
R-squared	R^2	0,36	0,49	0,40	0,44	0,54	0,01	1
Annualized Alpha	$\alpha_{a,i}$	0,10	0,08	0,32	0,04	0,26	7,54	0,00
Annualized Return	$R_{G,i}$	0,15	0,15	0,38	0,07	0,35	-0,10	0,09
Cumulative Return $1	CY_i	1,13	1,13	1,32	1,06	1,29	0,91	1,07
Sharpe Ratio	$SR_{a,i}$	0,49	0,44	1,08	0,13	0,96	-0,03	0,13
Annualized Std Dev	$\sigma_{a,i}$	0,32	0,33	0,36	0,50	0,36	2,87	0,69
Annualized VaR	$VaR_{a,i}$	0,51	0,53	0,56	0,81	0,57	4,57	1,11
Annualized CVaR	$CVaR_{a,i}$	0,64	0,67	0,71	1,03	0,72	5,77	1,39
Worst Drawdown	WD_i	0,22	0,29	0,22	0,42	0,25	0,93	0,52
CVaR Decomp.	$CVaR_{\%}$	36,76	48,95	40,96	44,60	54,41	1,06	100

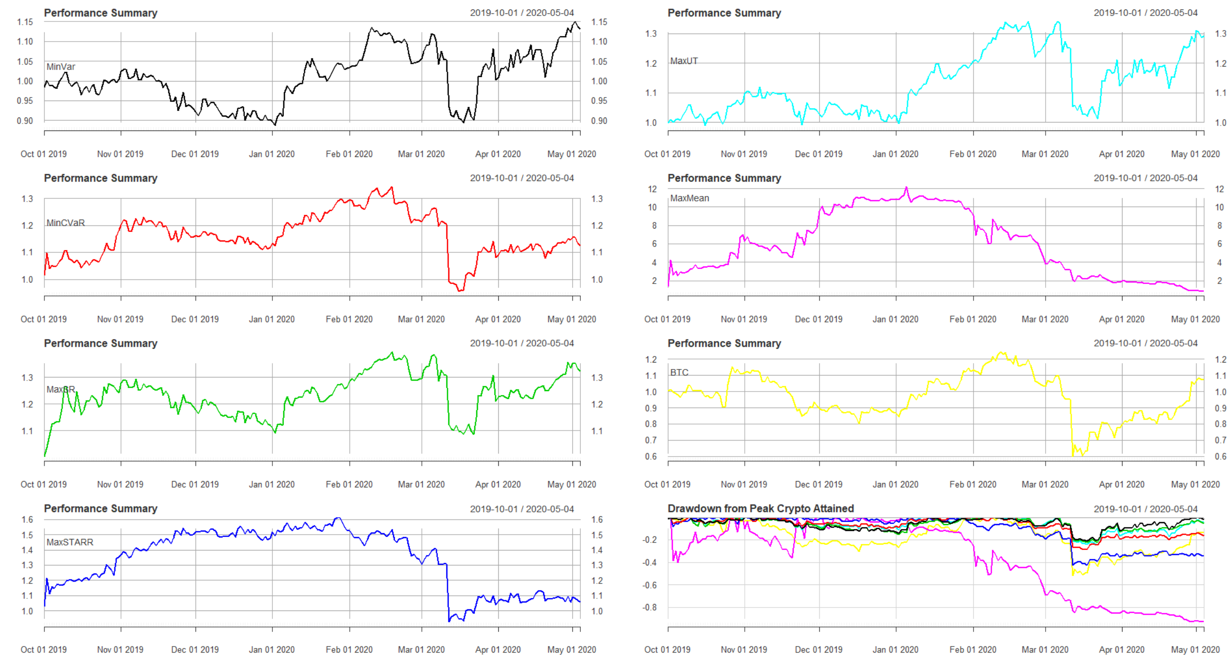
Source: author's calculation

Figure 1 shows the dynamics of daily cumulative returns of individual strategies and the underwater chart for drawdown which additionally illustrates the performance of portfolio optimization goals.

Table 2 shows the results of portfolio optimization with a limitation on the exposure to bitcoin cryptocurrency as a systematic factor. As before, only the MaxMean portfolio does not have a significant relationship between BTC returns and portfolio returns, which confirms the extremely large impact of BTC on the overall cryptocurrency market. Regardless of the implemented optimization strategy, changes in the value of the portfolio can still be defined by changes in the value of bitcoin cryptocurrency. On the other hand, the regression coefficients still suggest a slightly lower impact of BTC on portfolio dynamics. Only the MinVar-B portfolio achieved a higher beta than the MinVar portfolio, and MaxSR-B achieved a slightly higher R-squared. Of all the observed portfolios with constraint, the highest average alpha, geometric as well as total cumulative return was achieved by the portfolio with the aim of maximizing it, and the usefulness of introducing a limit on BTC exposure can already be confirmed here. In the context of risk, the lowest standard deviation was achieved by the MinCVaR-B strategy, while the MinVar-B strategy achieved a slightly higher risk compared to MaxSR-B and MaxUT-B.

Compared to BTC, except MaxUT-B where the geometric return is 1% lower, all constrained strategies achieved higher geometric and cumulative returns, and lower risk

Figure 1: *Performance summary various strategies without factor exposure constraint*



Source: author's illustration

Control of BTC exposure as a systematic factor had a significant impact on the overall performance of the portfolio. Namely, in comparison with Table 1, only MaxSR-B and MaxUT-B achieved a lower annual geometric and cumulative return and Sharpe Ratio compared to MaxSR and MaxUT. The impact of factor control is particularly emphasized in the MaxMean-B portfolio, where the portfolio achieved a significantly positive geometric and cumulative return compared to the MaxMean portfolio, but also to other portfolios with a limit on factor exposure. The positive consequence of the introduction of constraints is also visible through the values of risk measures. Only the MinVar-B portfolio achieved a slightly higher standard deviation compared to the equivalent unconstrained strategy, all other strategies achieved significantly lower risk. On the other hand, CVaR decomposition results suggest that the impact of BTC on portfolio risk is still present. In the case of the MaxSR-B and MaxMean-B strategies, BTC achieved a higher share of risk than on equivalent unconstrained strategies.

Table 2: Asset allocation models with factor exposure constraint

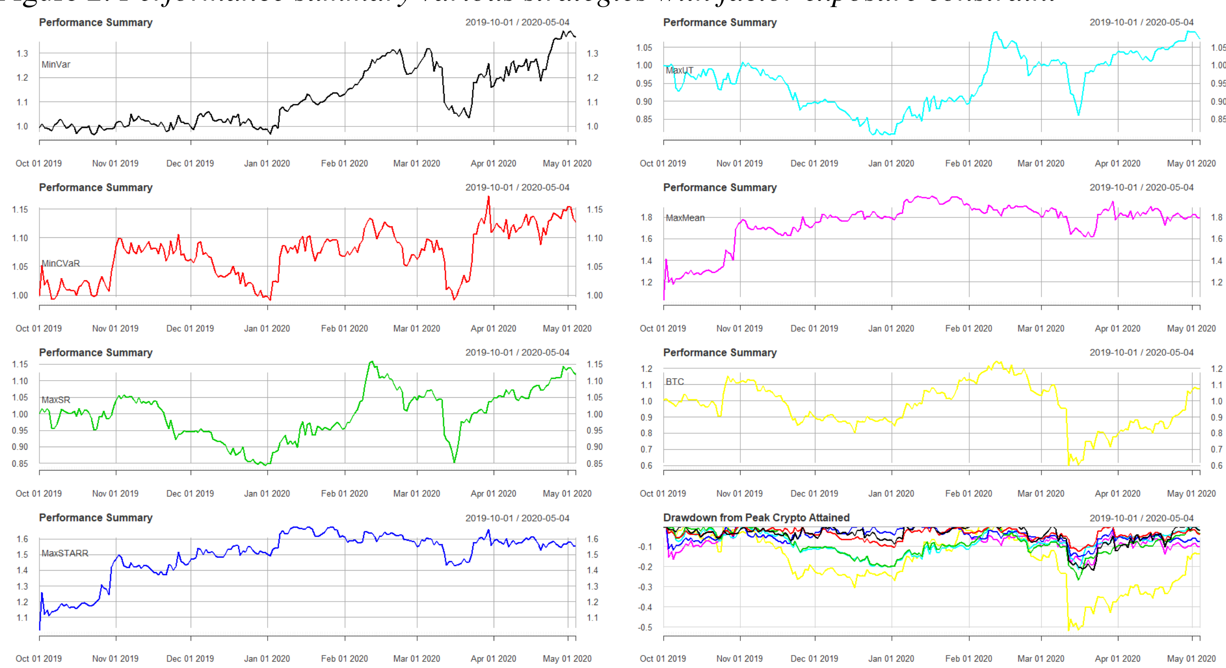
		Asset Allocation Models						
Performance Metrics		MinVar-B	MinCVaR-B	MaxSR-B	MaxSTARR-B	MaxUT-B	MaxMean-B	BTC
Beta (p - value)	$\beta_{i,B}$	0,30 (0,00)	0,10 (0,00)	0,30 (0,00)	0,09 (0,03)	0,20 (0,00)	0,11 (0,07)	1
R-squared	R^2	0,35	0,09	0,48	0,02	0,25	0,01	1
Annualized Alpha	$a_{a,i}$	0,38	0,14	0,07	0,76	0,05	1,23	0,00
Annualized	$R_{G,i}$	0,43	0,15	0,14	0,66	0,08	0,97	0,09

Return								
Cumulative Return $1	CY_i	1,36	1,13	1,12	1,55	1,07	1,79	1,07
Sharpe Ratio	$SR_{a,i}$	1,27	0,64	0,46	1,56	0,31	1,63	0,13
Annualized Std Dev	$\sigma_{a,i}$	0,34	0,23	0,30	0,43	0,27	0,60	0,69
Annualized VaR	$VaR_{a,i}$	0,54	0,37	0,48	0,66	0,44	0,92	1,11
Annualized CVaR	$CVaR_{a,i}$	0,68	0,46	0,60	0,84	0,55	1,17	1,39
Worst Drawdown	WD_i	0,22	0,12	0,26	0,15	0,21	0,19	0,52
CVaR Decomp.	$CVaR_{\%}$	35,66	9,68	48,44	2,38	25,88	1,67	100

Source: author's calculation

Given the presented results, it is necessary to emphasize the dynamics of the MaxMean portfolio for both methodological approaches. Although no statistically significant association with bitcoin cryptocurrency was found, the strategy still performed much better with a constraint than a unconstrained strategy.

Figure 2: *Performance summary various strategies with factor exposure constraint*



Source: author's illustration

The obtained results significantly contribute to the current research of investment opportunities in the field of cryptocurrency markets because they suggest the usefulness of considering BTC factors when defining the parameters of optimization strategies. Namely, by controlling the influence of factors on portfolio performance, the optimization algorithm is forced to include cryptocurrencies that it would not initially include as potential components of the portfolio. This approach reveals "undervalued" lower-ranking cryptocurrencies by market capitalization whose bitcoin value is not so much influenced, or which is influenced by some other, for now, unknown factors or trends, but which generate additional returns and lower risk.

Figure 2 shows the dynamics of daily cumulative returns of individual strategies and the underwater chart for drawdown which further illustrates the performance of portfolio optimization goals with a constraint on the influence of factors. Comparing Figure 1 and Figure 2, we can see the volatility and the impact of changes in the value of BTC on the dynamics of the portfolio, which is especially evident by comparing *Drawdown from Peak Crypto Attained*.

Due to its importance in cryptocurrency ecosystem, bitcoin is known to be the leading variable in the cryptocurrency market. Therefore, the decline in the value of BTC, caused by the uncertainty associated with the global pandemic virus COVID-19, has affected the decline in the value of all other cryptocurrencies, and thus indirectly in the overall results of optimization strategies. However, by isolating the influence of the BTC factor, portfolio returns are no longer so much exposed to sudden changes in bitcoin cryptocurrency but, by choosing other components, portfolios are constructed over which BTC does not have as much influence. In this case that resulted in portfolios with lower risk and better overall performance.

Conclusion

Consideration of the possibility of constructing a cryptocurrency portfolio with different optimization goals taking into account the systematic factor presented by the dynamics of change in the value of bitcoin cryptocurrency is the primary topic of this paper. The implemented methodological approach has not been considered so far, which additionally contributes to the current research of investment opportunities in the field of cryptocurrency markets. The methodology of research on the usefulness of systematic factor isolation during portfolio construction was implemented and presented in two steps. The first step creates and presents portfolio results that did not include a factor exposure constraint, and the second step sets a limit and restarts portfolio optimizations with the same allocation targets. The inclusion of the BTC factor constraint is justified by the theoretical assumption of a significant impact of the change in the value of the bitcoin cryptocurrency on the aggregate movement of the secondary cryptocurrency market. Taking into account such an assumption, it is possible to examine the possibility of constructing portfolios with a controlled influence of a systematic factor in order to avoid taking on additional systematic risk and to achieve better overall performance.

The obtained results suggest that portfolios with limited exposure to changes in the value of BTC presented as a systematic factor achieve higher returns and Sharpe Ratio in four of the six implemented optimization strategies, while in terms of absolute risk five of the six portfolios achieved overall lower risk. Accordingly, it can be concluded that by controlling the portfolio exposure according to the systematic factor represented by bitcoin cryptocurrency, it is possible to achieve better overall portfolio performance, higher cumulative return and lower risk.

From the other point of view, in the context of considering the strategy to be applied, significant exposure to changes in factor values may be a good or bad property. For portfolio managers, it would be ideal to make the most of the dependence on the factor during its positive momentum, and to hedge its position at the time of negative returns. Otherwise, the performance of the portfolio will depend in part on the value of that factor, that is, on its performance. Equally, exposure to BTC as a factor does not necessarily means bad performance. As a proposal for further research, it is suggested to examine the response of the portfolio to different frequency of the rebalance, different time period of model optimization, but also other acceptable ranges of exposure to BTC as a factor or a combination of several. Such approach during practical implementation can certainly achieve results that are more in line with the aversion and tolerance of the portfolio manager towards risk, which contributes to the overall performance of the portfolio in the cryptocurrency market.

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