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# Portfolio Risk and Diversification: Bitcoin and Currencies Classics

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# Portfolio Risk and Diversification: Bitcoin and Currencies Classics

Imen Ben Achour [α] & Jihed Majdoub [σ]

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## I. Introduction

Since the last couple of years, literature on cryptocurrency has emerged significantly in terms of its relationship with financial market efficiency (Sensoy, 2019; Vidal-Tomas and Ibanez, 2018; Brauneis and Mestel, 2018; Urquhart, 2016), volatility analysis (Rehman and Apergis, 2019), cryptocurrencies speculation (Cheah and Fry, 2015) and their return transaction relationship (Koutmos, 2018). Interestingly, evolution of Bitcoin came across during the most fragile and turbulent financial period. i. e. after global financial crisis of 2008-09, when investors were more vulnerable and seeking an asset class with hedging and safe-haven properties.

In the context of modern portfolio theory, investors should consider uncorrelated assets to construct efficient portfolios that maximise return for a given level of risk. Alternative assets such as gold, oil, hedge funds, art etc. have become a popular choice to diversify a traditional portfolio of equities and bonds. A significant development in this regard is the emergence of a peculiar asset, Bitcoin.

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Value-at-Risk (VaR) is defined as an amount lost on a financial asset, given a probability and a fixed number of days, has become a simple standard tool to quantify market risk by a single number. Value at Risk (VaR), one of the methods developed for investors to visualize all relevant risks of companies as a whole, was developed by JP Morgan's analysts. JP Morgan's VaR algorithm and the data set needed for calculations were made publicly available for free in November 1994. This resulted in the adoption of the method further in the market. VaR also gained attention in the literature and found a way for itself. Not only by professionals from the equity markets but as well by banks, pension funds, other financial institutions and by non-financial companies adopted this method. From the academic point of view, VaR is described as a method which could estimate the highest loss that could arise along a certain period and in certain confidence interval in financial markets

In other words, VaR provides a scale based on a probabilistic estimation of value loss from a portfolio or a single asset within a certain time interval. The method considers statistical calculations and denominates the risk in monetary aspect. The analysis has been utilized in various fields such as risk reporting determination of risk limits, capital adequacy regulations, internal capital allocation, and performance measurement. From this point of view, it is widely employed in risk measurement in foreign exchange operations. This method allows estimation of maximum monetary loss subject to the certain foreign exchange investment of an investor within the certain time interval.

The three most important elements in the VaR method include: the amount of potential loss, a specific time within the risk is estimated and the probability of loss or reliability. The amount of risk may be expressed in absolute or relative number. When it's talking about the period of time within the calculated risk value can be calculated than it can be for 24 hours, week, month, year or other period of time that an analyst wants to evaluate. Time and risk are positively correlated sizes, so longer period is causing higher risk. The likelihood of potential loss or degree of reliability is usually measured at the levels of 90%, 95% and 99% reliability.

Basic methods based on which the VaR can be calculated are: historical method, parametric method and Monte Carlo simulation. Each of these methods is



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marked by certain advantages and disadvantages the historical method is considered one of the easiest methods to use. It is essential to set a time period which will be analyzed, after which the historical market size will be arranged according to the criterion of the size and degree of reliability calculated risk value. Regarding the disadvantages of historical method it is difficult to apply in the more distant future, and it involves the risk of rare events, because of which the result can show greater risk value than the one that actually is.

The parametric method has several names which are used in its defining. The method of variance-covariance, linear or delta normal, VaR are just some of the names used. This is a method that uses historical information to calculate like: arithmetic mean, correlation, standard deviation, all depending on the method used for calculating risk value. The parametric model does not use a long number of historical data as historical method, but it use the historical data to calculate the risk factors in evaluating the potential loss. The two primary variables that parametric method use in its calculation, are namely the mean value of the yield rate, and the standard deviation of the same data. As for the disadvantages, parametric method is less suitable for nonlinear portfolios or distorted distributions.

The last method for calculating VaR is the Monte Carlo method. This methodology is called the stochastic method, and its name Monte Carlo is justified because it requires computer simulation of various influences on the observed portfolio of securities. This method represents the most complex method, it is similar to the historical method, since it calculates future risk or potential loss with a statistical confidence level. The Monte Carlo method is considered the most precise method for calculating VaR which is achieved by statistical simulation of hundreds or thousands of possible scenarios based on which would come up with a solution

The role of bitcoin in terms of portfolio diversification has been researched quite extensively in finance literature. Bitcoin's role as an asset class, its highly volatile behavior, and its low correlation with other assets are factors that could improve the risk-return tradeoff in a well-diversified portfolio (Brière, Oosterlinck, & Szafarz, 2015; Eisl, Gasser & Weinmayer, 2015). In a VaR context, Likitratcharoen et al. (2018) estimated the VaR of Bitcoin and other cryptocurrencies using historical and Gaussian parametric VaR. A further step was made by Osterrieder and Lorenz (2017) and Gkillas and Katsiampa (2018) to consider extreme value theory to estimate VaR. Other approaches take into account the time-varying volatility of cryptocurrencies, such as the performed by Ardia, Bluteau, and Rüede (2019), Stavroyiannis (2018), Troster et al. (2019), Pele and Mazurencu Marinescu-Pele (2019) and Trucíos (2019). Indeed, Guesmi, Saadi, Abid, and Ftiti (2019) showed that a hedging strategy that includes bitcoin in the portfolio reduces risk when compared to a portfolio without bitcoin. Considering the lack of liquidity in the bitcoin market, Kajtazi and Moro (2019) also proposed it as a speculative asset that can generate a better risk-return tradeoff.

The objective of the present study compares currencies classics and Bitcoin (BTC) investor based on the VaR method. To that end, daily market closure price of three major global currencies (Euro, Japanese Yen, and Great Britain Pound) and Bitcoin were used in the present analysis. Obtained results will be assessed in terms of the risk level that they are exposed to when they build their portfolio with the major currencies or the digital money of Bitcoin. In the later section of the study, methods employed in the VaR calculations were presented while findings were assessed and compared with the current literature and the last section.

## II. Portfolio Diversification: Virtual Currencies vs Fiat Currencies

The theoretical framework of [Markowitz, 1959] examined the importance of portfolio diversification. A portfolio is a collection of assets or investments; diversification is the preferred approach for choosing an asset allocation strategy for a portfolio. The diversity of the securities or assets in the portfolio either lowers the risk associated with a given level of return or increases the return associated with a given level of risk. Due to the fact that bitcoin has been demonstrated to be an asset utilized for investing. [˙I¸cellio˘glu and Ozt¨urk, 2018] have studied the ¨ relationship between bitcoin and the dollar, the euro, the yen, the pound and the yuan through the cointegration tests of Engle-Granger and Johansen and the causality test of Granger. The findings indicated that there was no long-term relationship or causality between the variables. [Uyar and Kahraman, 2019] have demonstrated that bitcoin is the riskiest asset, and that adding bitcoin to a portfolio increases global risk by 98%. Using the value at risk (VaR) method, they used data from seven conventional currencies, including bitcoin, from February 2, 2012 to November 7, 2017, including the Swiss franc, euro, pound sterling, Japanese yen, Australian, Canadian, and New Zealand dollars. [Urquhart and Zhang, 2019] studied the relationship between bitcoin and the EUR, JPY, GBP, AUD, and CHF currencies using the CDC model, and discovered that bitcoin may be utilized as a hedge for CHF currencies, EUR and GBP, as well as a diversifier for AUD and JPY. For their part, [Kristjanpoller and Bouri, 2019] used the MF-ADCCA method to examine the performance of five cryptocurrencies: bitcoin, litecoin, ripple, monero, and dash in comparison to conventional currencies (Swiss franc, euro, pound sterling, yen, and the Australian dollar) from 2 June 2014 to 28 February 2018. A significant asymmetry is evident

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in the results. [Abramowicz and Klein, 2020] compared the performance of bitcoin and ripple versus the EUR, GBP, and CNY using the value at risk (VaR) technique between March 1, 2016, and February 8, 2019. Value-at-risk results for the currencies EUR, GBP, and Bitcoin were accepted at all 90%, 95%, and 99% confidence levels; however, VaR measures for the Chinese Yuan were under-estimated at 99% confidence level, in contrast to the ripple cryptocurrency, where VaR measures were accepted at 90% and 99% confidence levels. The findings imply that the bitcoin market cannot function as a medium of exchange. [Palazzi et al., 2021] evaluated how bitcoin compares to six common currencies: the euro, pound sterling, Swiss franc, renminbi, yen, and ruble. Between July 2010 and April 2020, they applied the BEKK-GARCH model and non-parametric causality test. The findings show a connection between the euro and bitcoin. The potential to including the US dollar, the UK pound sterling, the euro, the Japanese yen, and the Chinese yuan, in their research, while also accounting for the period of bitcoin price decrease in 2018. The conditional risk value (CVaR) method was highlighted by [Bedi and Nashier, 2020]. The findings demonstrated that diversified portfolios in US dollars, Chinese yuan, and Japanese yen constitute the best options for bitcoin investments and return improvements. In addition, studies from [Chemkha et al., 2021] have demonstrated that combining three cryptocurrencies bitcoin, ripple, and litecoin with three conventional currencies the euro, the Japanese yen, and the pound sterling during the period from 4 August 2013 to 5 August 2019 can provide investors with the benefits of diversification and more accurate risk estimates with a better return. [Majdoub et al., 2021] studied the relationship between bitcoin and six conventional currencies (CHF- EUR- GBP- AUD- CAD- and JPY) using an ADCC model, they found that bitcoin can be a hedge for CHF, EUR and GBP but acts as a diversifier for AUD, CAD and JPY.

## III. Econometric Methodology

*a) The Data*

Empirical part of this paper refers to calculating VaR for portfolio using Variance-Covariance approach, Historical simulation, and Monte Carlo method. Portfolio consists of major currencies. Dataset consists of daily closure prices of the concerned currencies classics for 1021 days along the period of 29/10/2016 and 23/10/2020. BTC price data and three major global currencies (Euro, Japanese Yen, and Great Britain Pound) in USD index from finance.yahoo.com

In the scope of the study, the digital currency of Bitcoin (BTC) and major currencies were compared based on results of the VaR estimation methods. To this end, logarithmic values of daily closure returns, standard deviation, and correlation matrixes were employed for VaR estimations. Each currency has the same fixed proportion of 25% in portfolio and their total value is 1.000.000$.

*Table 1:* Daily Historical Data

| Date | EUR/USD | GBP/USD | JPY/USD | BIT/USD |
|---|---|---|---|---|
| 29/10/2016 | 1,098467 | 1,221598 | 0,009563 | 714,479004 |
| 30/10/2016 | 1,097333 | 1,223691 | 0,00954 | 701,864014 |
| 31/10/2016 | 1,105705 | 1,223855 | 0,009607 | 700,971985 |
| 1/11/2016 | 1,109755 | 1,230466 | 0,009673 | 729,79303 |
| 2/11/2016 | 1,110248 | 1,246883 | 0,009704 | 740,828979 |
| - | - | - | - | - |
| - | - | - | - | - |
| - | - | - | - | - |
| 19/10/2020 | 1,174398 | 1,301236 | 0,009511 | 12931,53906 |
| 20/10/2020 | 1,170713 | 1,290206 | 0,009491 | 13075,24805 |
| 21/10/2020 | 1,17155 | 1,292775 | 0,009485 | 13654,21875 |
| 22/10/2020 | 1,176886 | 1,294867 | 0,009481 | 13271,28516 |

*b) Calculating VaR using Historical Simulation*

As mentioned previously, the historical simulation model for determining the var is considered simple; it does not need complex calculation and it allows the valuation the present portfolio based on historical data. It is therefore a model of estimating the distribution of price changes from past data. The var model can be summarized as follows, Record the observations (data) on the assets of the portfolio within a certain period of time (series of time) daily and



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monthly. Calculate the relative changes of the mean for each period according to the following formula:

$$Pd_{jt} = (C_{jt} - C_{jt-1})/C_{jt-1} \quad (1)$$

$Pd_{jt}$ The return on the stock j in day t and $C_{j,t}$ the stock price j in day t

Returns can be calculated using the natural logarithm as well.

$$Pd_{jt} = \log\left(\frac{C_{jt}}{C_{jt-1}}\right) \quad (2)$$

After calculating the daily returns of individual currency, portfolio return can be calculated according to formula that follows.

$$PP_t = \sum_{j=1}^{N} w_j Pd_{jt} \quad (3)$$

$PP_t$ The return of the portfolio in the day t, N The total number of shares in the portfolio, $w_j$, The share of cryptocurrency j in portfolio and $Pd_{jt}$ The return on the cryptocurrency j in day t

Using the historical data in Table 1, we apply the Historical Simulation method to calculate the VaR of the linear portfolio Pp composed of EUR/USD exchange rates, GBP/USD, JPY/USD and BIT/USD become the risk factors X1 X2 X3 and X4 respectively. The approaches for estimating the VaR of the Pp portfolio, following the application of this technique, are presented in the following: The value of the linear portfolio Pp is expressed by the following relationship:

$$PP_t = f(X_1, X_2, X_3, X_4) = X_1 + X_2 + X_3 + X_4 \quad (4)$$

The following table shows the observations of risk factors X1, X2, X3 andX4

*Table 2:* Historical Prices

| Date | EUR/USD | GBP/USD | JPY/USD | BIT/USD |
|---|---|---|---|---|
| 29/10/2016 | 1,098467 | 1,221598 | 0,009563 | 714,479004 |
| 30/10/2016 | 1,097333 | 1,223691 | 0,00954 | 701,864014 |
| 31/10/2016 | 1,105705 | 1,223855 | 0,009607 | 700,971985 |
| - | - | - | - | - |
| - | - | - | - | - |
| - | - | - | - | - |
| 20/10/2020 | 1,170713 | 1,290206 | 0,009491 | 13075,24805 |
| 21/10/2020 | 1,17155 | 1,292775 | 0,009485 | 13654,21875 |
| 22/10/2020 | 1,176886 | 1,294867 | 0,009481 | 13271,28516 |
| 23/10/2020 | 1,182984 | 1,295404 | 0,009481 | 13423,30176 |

Then we multiply the value of the rate of return in the amount to be invested. Calculate the total value of the portfolio for each period, and we calculate VaR, which is determined on two basic parameters: the first time range and the second the confidence area. For the first parameter, we chose the daily periods. As for the confidence levels, we chose 90%, 95% and 99%.

It should be noted that another time range can be tested, depending on the investor's needs and needs. Generally, VaR takes the time to calculate returns.

The results obtained are summarized in the following tables:

*Table 3:* Results of Calculating Daily VaR using Historical Simulation

| | |
|---|---|
| VAR 90 % | 14085,46665 |
| VAR 95 % | 21036,25595 |
| VAR 99 % | 36054,87789 |

The amounts 14085,46665; 21036,25595and 36054,87789 represent the VAR at 90%, 95% and 99% confidence intervals respectively, the worst loss to be expected from the portfolio's holding in the next day and under normal market conditions.

*c) Calculating VaR using Parametric Simulation*

Parametric methods of VaR models that are based on standard statistical distributions determine the conditional return distribution and estimate the standard deviation (or covariance matrix) of the returns of asset. The variance-covariance method is one of the simplest approach among various models used to estimate the VaR. Let as assume that returns can be written as:

$$r_t = \mu_t + \varepsilon_t \quad (5)$$

where εt has a distribution function F with zero mean and variance $\sigma_t^2$ . The VaR can be calculated as

$$VaR_t^q = \hat{\mu}_t + F^{-1}(q)\hat{\sigma}_t \quad (6)$$



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Where $F^{-1}(q)$ is the qth quantile value of an unknown distribution function F. We can estimate $\mu_t$ and$\sigma_t^2$by the sample mean and the sample variance by

$$\hat{\mu}_t = \frac{1}{n}\sum_{i=1}^{n} r_t \; \hat{\sigma}_t^2 = \frac{1}{n-1}\sum_{i=1}^{n}(r_t - \hat{\mu}_t)^2$$

In this method, the value at risk is calculated by a relatively simple analytical account in practice and the most common model is the Variance-Covariance method. As portfolio returns and risk factors follow normal distribution as this method assumes that returns are distributed to risk factors.

The results of VAR calculation using the method are shown in the following table

*Table 4:* The Results of Daily VAR using the Parametric Method

| | |
|---|---|
| VaR (90%) | 29076,99 |
| VaR (95%) | 91949,51 |
| VaR (99%) | 205 605,35 |

The amounts 29076,99, 91949,51 and 205 605,35represent the VAR at 90%, 95% and 99% confidence levels respectively, the worst loss to be expected from the portfolio's holding in the next days and under normal market conditions.

*d) Calculating VaR using Monte Carlo Simulation*

Monte Carlo Simulation differs from the other 2 methods since instead of using actual losses/profits to build the distribution, it uses randomly generated prices based on an actual price to build the distribution, which then will be used to determine the VaR.

Monte Carlo simulations provide possible portfolio values on a given date T after the present time t, T > t. The VAR value can be determined from the distribution of simulated portfolio values. The most simplified version of the Monte Carlo approach used to calculate VaR for a specific time horizon and confidence level, involves simulating N draws from the return distribution at time t +1 and ranking them from the lower to the highest. Then it is necessary to locate the price for the α% lowest percentile that corresponds to the initial confidence level for which the VaR is estimated. This means that there is α% probability that the asset value could diminish from this value (Sα% t+1) to even lower levels. Finally, by deducting the above future asset value from the current value (St– S α% t+1), the potential loss that corresponds to the VaR for the specific time interval and confidence level is calculated.

The VaR value in the Monte Carlo approach therefore represents the maximum loss from the random return distribution for a specific and predetermined time interval and confidence level. The results of VAR calculation using the method are shown in the following table

*Table 4:* The Results of Daily VAR using the Monte Carlo Method

| | |
|---|---|
| VaR 90% | 572588305,3 |
| VaR 95% | 309439417,8 |
| VaR 99% | -361260608,4 |

According to the results of Monte Carlo simulation at90%, 95% and 99% confidence levels, an investor who invests one USD would lose maximum $572588305,3, $-309439417,8 and $-361260608,4, respectively.

## IV. Results and Comparison – Historical, Parametric and Monte Carlo

Using the Parametric method as an example, and based of our 4 years of data, 5 percent daily VaR to be $91949, 51 of the portfolio value of $1m, This means that, based on the parametric method, an investor investing $1m in this asset could be 95 percent confident of not losing more than this amount on a given future day, based on history repeating itself. There are some differences in the results yielded by each method in Table 5, which are discussed after the table.

*Table 5:* Comparison of Results from Various VaR Methods

| | 90% | 95% | 99% |
|---|---|---|---|
| Historique | 14085.46665 | 21036.25595 | 36054.87789 |
| Variance-covariance | 91949.51 | 205605.35 | 29076.99 |
| Monte Carlo | 588908630.2 | 216516151.2 | -412061287.8 |

The VaR returns and values calculated from the various methods are shown in the table.

By comparing the results of the historical VAR with the parametric simulation method and the results in a Monte Carlo method, there is a slight difference in the results. The worst expected loss of portfolio investments on the following day calculated on a historical basis is 14085.46665, 21036.25595 and 36054.87789 and calculated on a parametric basis method, it proved to be equivalent to 588908630.2, 216516151.2 and -412061287.8$ and for the Monte Carlo method are 588908630.2, 588908630.2 and -412061287.8$ for confidence zones 90%, 95% and 99% respectively, due to the difference in use of distributions. While the historical method uses empirical distribution, the parametric method uses theoretical distribution.



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## V. VaR Estimation Results with and without Bitcoin

We applied the standard VaR estimation methods to the EUR/USD, GBP/USD, JPY/USD and BIT /USD exchange rates. VaR calculations are performed over a one-day investment horizon and a confidence level of 90%, 95% and 99% during the VaR forecast period from 29/10/2016 to 23/10/2020. Over the VaR forecast period, the average and standard deviation of the estimated losses were calculated at 90%, 95% and 99% confidence levels. The results are presented in Table 6. As part of this study, the VaR value was estimated for two portfolios, one of which includes the BTC/USD parity alongside the major currencies, and the other does not. Two portfolios whose VaR values are presented in Table.

*Table 6:* The VaR Values of the Currency Portfolio with and without Bitcoin

| | Historique Method | | | Variance Covariance Method | | | Monte Carlo Method | | |
|---|---|---|---|---|---|---|---|---|---|
| | VaR 90% | VaR 95% | VaR 99% | VaR 90% | VaR 95% | VaR 99% | VaR 90% | VaR 95% | VaR 99% |
| Portfolio (with BTC) | 14085,46665 | 21036,25595 | 36054,87789 | 91949,51 | 205 605,35 | 29076,99 | 556265412,8 | 186739438,7 | -432861527,3 |
| Portfolio (without BTC) | 3574,407577 | -4370,581926 | -6850,745246 | 21726,27828 | 48581,43514 | 6 870 | -169507,2081 | -177854,7852 | -192462,6462 |

Investments in foreign currencies are also weighted. For the first interval, we are 90% confident that we will incur no more than 556265412.8 losses in the next 1037 days for the first portfolio. While for the second portfolio, we could have a potential loss of 21726.27828 in the worst of 10% of N = 1037 day scenarios. For the second tier of the first portfolio, we are 95% confident that we will not lose more than 186739438.7 over the next 1037 days, while for the second portfolio, we are certain that we could have a potential loss of 48581.43514 for the same period. As for the last one, we are 99% confident that we will not suffer more than 36054.87789 losses. 1037 days for the first investment while for the second we will not lose more than 6870.According to estimated VaR values based on the Historical, the parametric and the Monte Carlo simulation it is observed that the portfolio which does not include BTC/USD parity is found to pose less risk with respect to the ones which do not contain BTC/USD parity. The risk difference between the two portfolios varies between 70% and 150%. It is concluded that inclusion of Bitcoin into the portfolio built has increased the overall risk exposed by investors. On the other, in case of investors to make Bitcoin investment in a distributed portfolio instead of overweighting Bitcoin, this would decrease their potential losses on their investments.

## VI. Conclusion

Risk measurement of an investment tool is viewed as a significant issue in our time. With regard to the risk preferences of investors, their investments are required to be managed. The Value-at-Risk (VaR) method in the risk measurement literature is utilized by researchers commonly but with different techniques such as basically Variance-Covariance, Historical Simulation, and Monte-Carlo Simulation.

The objective of this study is to compare investors with conventional foreign currencies and digital currency of Bitcoin (BTC) by using VaR methods called Historical, Variance Covariance and Monte Carlo Simulation at 90%, 95% and 99% confidence levels.To that end, major currencies suggested is Euro, GBP, JPY, and Bitcoin currency were included in the study. In the analyses, the risk level exposed by investors was oriented and assessed. Daily data of each currency was collected for the period of 29/10/2016 and 23/10/2020.

The results showed that the maximum loss of the portfolio in the same horizons and the specific confidence level slightly differ from the previous results obtained when calculating the VAR. Two portfolios are built; the first one including BTC/USD parity and the second not including. Findings indicate that whereas the later portfolio has lower risk in comparison with the former one. Moreover, it is seen that inclusion of BTC/USD parity into the portfolio elevated overall portfolio risk by 98% on average. However, it is revealed that investors could mitigate their general investment risk by including Bitcoin and major currencies into their portfolio.

The VaR method utilized in the application of this study reveals that Bitcoin is risky investment tool. The main factors increasing risk are mostly indicated as the high volatility of digital currencies and lack of any legislative ground controlling the system. In spite of aforesaid uncertainties and high risk, the investors who want to make an investment in Bitcoin currency are suggested to build portfolios comprised of



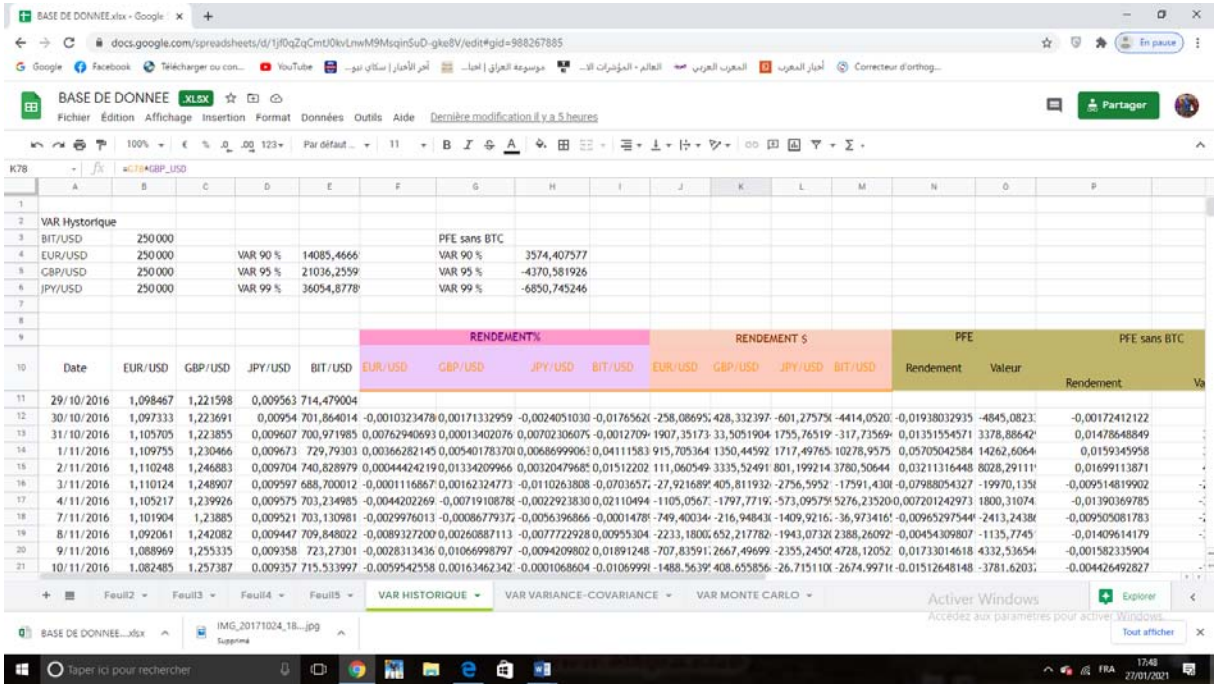
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Bitcoin as well as conventional foreign currencies. Although it is important to measure the risk of the financial portfolio, it has some shortcomings such as unpredictability in the long-term horizon. Dividends and losses are not necessarily subject to normal distribution under extreme financial conditions such as shocks and exceptional market conditions, in which the tail of the distribution is fat. Therefore, a range of other alternative methodologies have been developed for this measure, such as the conditional value, stress tests, sensitivity analysis, scenario analysis and simulation analysis.

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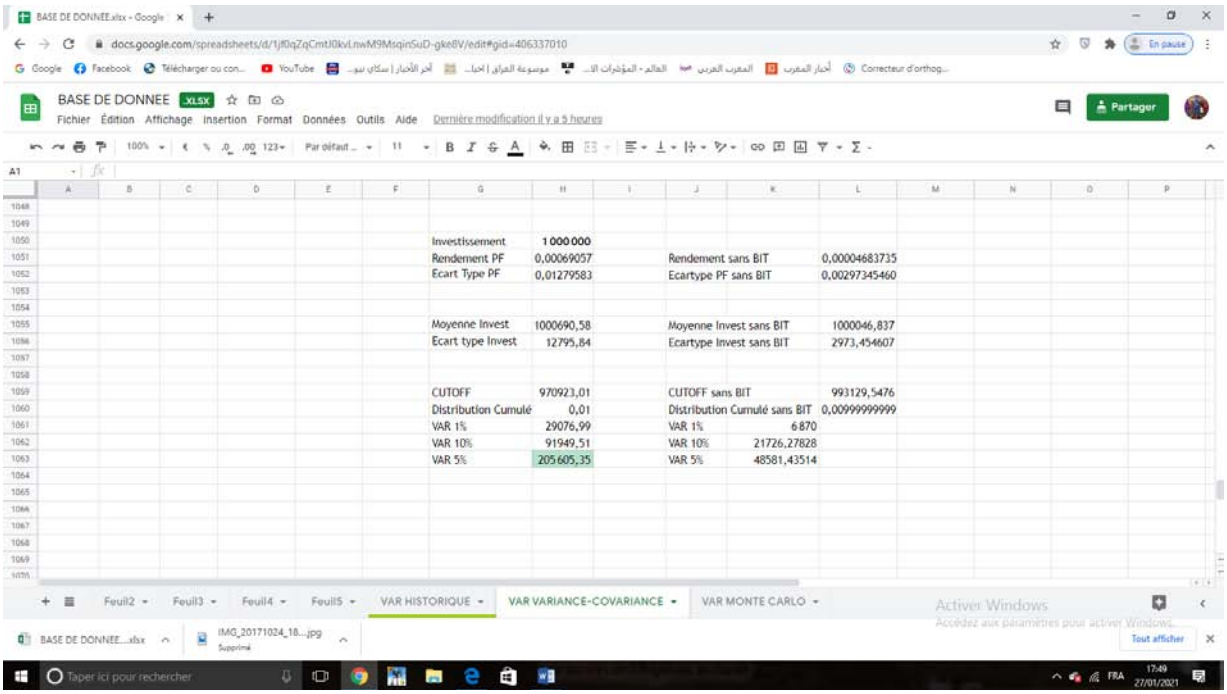

Historical Method



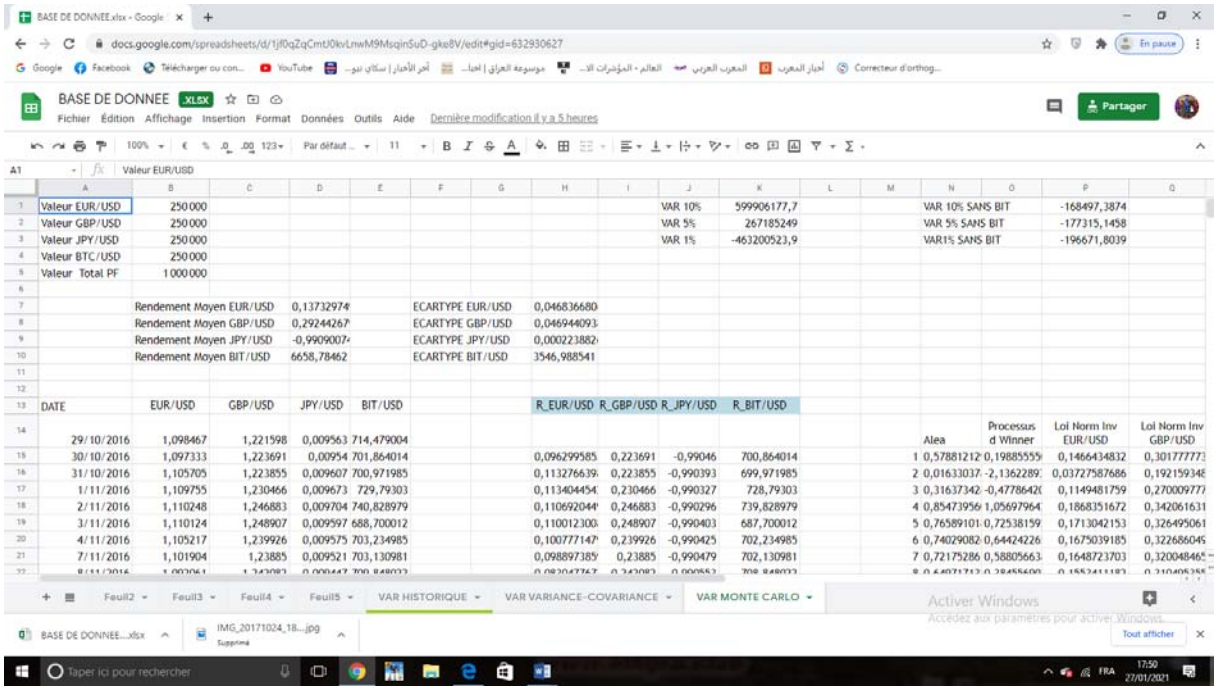



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Variance-Covariance Method




Monte Carlo Method




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