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Study regarding the volatility of main cryptocurrencies

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Abstract. *Developments in digital technologies are considered to be the most important innovations since the advent of the internet. In several countries, this has led to a significant change in the way payments are made, leading to new forms of payment, such as crypto-currencies. With regard to cryptocurrencies, it remains a complex issue involving especially volatility, but also money laundering and consumer protection issues. While most countries consider cryptocurrencies too volatile to be used as a payment alternative, crypto-currencies gain interest of investors in the last 10 years due to the possibility of obtaining large profits. The aim of the paper is to study the volatility of the first 5 cryptocurrencies (Bitcoin, Ethereum, Binance Coin, Cardano and Ripple) through GARCH models. The process of evaluating highly volatile cryptocurrencies is complex and depends on many parameters. Therefore, our results would be particularly useful in terms of portfolio and risk management and could help them to be more agile in evaluating their investments, in making optimal decisions and making future forecasts. We find that the GARCH (1.1) models provide the best fit, in terms of modelling of the volatility in the most popular and largest cryptocurrencies. The results show that for BTC, ETH and XRP the appropriate model is GARCH (1.1) and in the case of BNC and CARDANO GARCH-M explain better the volatility of the crypto-currencies. Therefore, more in depth analysis of the datasets may be required to confirm or deny possible structural change. The study can be complemented by carrying out an event study on the 5 cryptocurrencies analyzed or extending the analysis by applying other GARCH models, to research the optimal model for several cryptocurrencies.*

Keywords: crypto-currencies, virtual currencies, Bitcoin, Ethereum, GARCH, crypto-currencies volatility

Introduction

Immediately after the outbreak of the financial crisis in 2008, the foundations were laid for a new type of financial asset, based on cryptographic and blockchain infrastructure and which allows the transactions between persons without the intervention of the banks/financial institutions. Crypto-assets/currencies[1] like Bitcoin are digitally encrypted tokens traded in peer-to-peer networks (Malcom, 2018). Cryptocurrencies were born in 2009 with the creation of Bitcoin and although it is 12 years since its appearance, cryptocurrencies are still studied and analyzed at the level of regulators and supervisors.

The market for virtual currencies has grown immensely in terms of the number of new currencies as well as transaction frequency. Cryptocurrencies have become increasingly common among investors due to their attractive characteristics such as being faster and simpler transactions compared to traditional payment methods, the possibility of obtaining large profits, and the reduction in transaction costs. Even though the cryptocurrencies market evolved significantly, Bitcoin has maintained its leading position in the market from the beginning with a market

[1] Please take note that crypto-assets and crypto-currencies will be understand in the same sense in this paper.

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capitalization of 1,161 billion USD on November 4th, 2021, which accounted for more than 65% of total market capitalization for all cryptocurrencies (Crypto Compare, 2021).

Crypto-assets have a number of inherent and unique characteristics such as lack of centralized control (the technology is an innovative one based on decentralized control), anonymity, valuation difficulties, hybrid characteristics of payment and investment instruments. The price formation for Bitcoin is different from those of other financial assets because of its own characteristics (Ciaian et al., 2016). It is shown that Bitcoin exhibits more volatility and higher returns than stocks do, and has insignificant and/or low correlation with the other assets (Yermack, 2015; Baur et al., 2017). In addition, Bitcoin and cryptocurrencies are different from other types of assets and so being difficult for investors to analyze the variables/factors to which cryptocurrencies react.

Given the popularity of cryptocurrencies and the interest of the population in using and investing in crypto-assets, it is quite important to forecast their volatility for companies and for many institutional investors that have included cryptocurrencies in their portfolios. An option to estimate one of the risk metrics related to cryptocurrencies can be the GARCH models, which are according to the academic studies fit when trying to predict the prices and returns for financial assets and the most frequently used in the literature for volatility modeling (Dyhrberg, 2016; Katsiampa, 2017; Chu et al., 2017).

The GARCH models can give an indication on the elements to which cryptocurrencies are sensitive and makes the crypto-market to react; consequently, the focus of this paper is to apply the GARCH model and assessing the volatility of the first 5 cryptocurrencies as they are listed by CryptoCompare, 70% of the transactions with cryptocurrencies being perform through this platform. In conclusion, my paper studies the volatility of the 5 cryptocurrencies: Bitcoin, Ethereum, FileCoin, Cardano and Ripple with the objective to validate the results from previous studies performed only on Bitcoin and with different source of data (different exchanging platforms).

Literature review

At European level, virtual currencies were defined and regulated for the first time in 2018, from the perspective of money laundering and terrorist financing requirements, thus proposing measures and requirements for managing the risk related to the anonymity of parties involved in transactions with such currencies and the ability to use virtual currencies in illicit transactions.

Another topic of interest from the perspective of virtual currencies refers to ways in which investors could control their volatility and profitability, for example, Białkowski (2019) studied methods of managing the risk of volatility of virtual currencies to attract the interest of institutional investors, respectively the application of stop-loss rules that make virtual currencies a feasible investment for institutional investors. At the same time, Anghel (2020) showed that investors in virtual currencies rarely obtain excessively positive returns, in general, trading rules do not seem to offer additional benefits compared to traditional financial markets. Other researchers, for example Bariviera (2020) demonstrated the heterogeneous behavior of virtual currencies according to the size of their volume, analysing 84 virtual currencies.

Zhenghui et al. (2021) continue the series of research related to Bitcoin by studying the increased link between events and the profitability of Bitcoin. They modelled the impact of Bitcoin related events on Bitcoin market activities, using the event study methodology and a GARCH-X model. Empirical results show that the directions of shock between Bitcoin-related events on the price of Bitcoin are strongly correlated with the types of events. In addition, there is a significant

positive influence of domestic events on the volatility response, while foreign events impose their influences on both market reaction expectations and volatility. Another study, Caporale et. al. (2019) paper aims to select the best GARCH model or set of models for modelling volatility of the 4 most popular cryptocurrencies, i.e. Bitcoin, Ethereum, Ripple and Litecoin.

Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models are the most commonly used in the literature for modelling volatility. The original Autoregressive Conditional Heteroskedasticity (ARCH) specification was introduced by Engle (1982) and then extended by Bollerslev (1986), who put forward the GARCH framework.

One of the first studies investigating volatility in cryptocurrencies was conducted by Katsiampa (2017) and it estimates Bitcoin's volatility by comparing various GARCH models, concluding that AR-CGARCH is the model best describing Bitcoin's volatility. Aras (2021) argued that previous studies have only used GARCH (1.1) for volatility analysis, assuming that perform well in financial markets without examining the projected performance of hybrid models. The results show that the use of GARCH hybrid models increases the accuracy of volatility forecasts for Bitcoin (BTC).

K¨ochling et al. (2020) evaluated volatility forecasts for Bitcoin using 172 GARCH models taking into account different volatility proxies. They demonstrated that Gaussian distributions remain in the model's confidence level more than t-conditional distributions, and the results differ depending on the volatility proxies. Dyhrberg (2016) focus on examining the relationship between Bitcoin, gold and US dollar (USD) through GARCH models, showing that the volatility of Bitcoin, being very speculative, differs considerably from that of gold or USD.

Naimy and Hayek (2018) compared GARCH (1.1) and EGARCH (1.1) in the sample and out for modeling and estimating BTC volatility, concluding that EGARCH (1.1) is the appropriate model to explain Bitcoin's volatility and Bitcoin's behavior was not the same as that of other currencies. Caporale and Zekokh (2019) tried to determine a set of the best models using over 1000 GARCH models to predict the volatility of some popular cryptocurrencies, the results supporting that standard GARCH models may be unable to model the volatility of cryptocurrencies.

Kristjanpoller and Minutolo (2015) analyzed the volatility of the price of gold through the ANN-GARCH hybrid model taking into account financial variables as inputs, showing that with the hybrid model, the average absolute percentage error was reduced by 25% compared to the standard GARCH model. Dyhrberg (2016) explored the capabilities of BTC's financial assets using GARCH models. GARCH (1.1) revealed several similarities with gold and USD, indicating hedging capabilities and advantages as a medium of exchange for BTC. Asymmetric GARCH can be useful in risk management and ideal for risk aversive investors in anticipation of negative market shocks.

Soylu et al. (2020) modeled Ripple's volatility, Ethereum and Bitcoin, considering the long-term properties of these cryptocurrencies. The results showed that there is a long memory in the cryptocurrency market reflecting permanency of the shocks and lack of mean reversion in the level series and the right models can capture this and help investors to develop appropriate investment strategies.

Methodology

This study refers to daily, including weekends, closing prices of 5 cryptocurrencies: Bitcoin, Ethereum, Binance Coin, Cardano and Ripple.

The cryptocurrency market was immature until 2015, with difficulties in collecting data sot the period under scrutiny covers February 2018 to September 2021, i.e., the data consists of 1326

observations. During this period, there has been the most rapid fall in the prices of digital currencies. Therefore, it is of great interest to evaluate and analyze the volatility of these currencies returns during this extra bearish period. In the present study, the data is sourced from CryptoCompare.

CryptoCompare provides a set of benchmarks for the digital asset market - the price is offered from a global list of over 50 cryptocurrency exchanges, uses a special pricing mechanism based on the exchange of liquidity for each digital asset, and is a fair representation of prices globally.

For the analysis we calculated the daily logarithmic profitability = log(Pt/Pt-1), more malleable analytically and gives the opportunity to detect various features and patterns in price dynamics.

In the table below is presented a short description of the 5 crypto-currencies included in the study.

Table 1. Short description of the 5 crypto-currencies

BITCOIN	Operate without central authority or banks. The network does transaction management and issuance collectively. It reached a peak of $ 318 billion - the most traded cryptocurrency and one of the main entry points for all other cryptocurrencies The price is as unstable and it can go up or down by 10%-20% in a single day.
ETHEREUM	A decentralized platform that runs smart contracts (applications that run exactly as programmed without any possibility of downtime, censorship, fraud or third party interference). In order to have anything transferred or executed by the network, you have to consume or burn Gas. Ethereum is moving to the proof-of-stake (PoS) consensus mechanism from proof-of-work (PoW).
RIPPLE	Positioned as one of the most liquid currencies, which is fast (settles in 3-5 seconds), scalable (can handle 1,500 transactions per second), decentralized, stable (7-year record) and with negligible energy consumption (due to the consensus protocol vs working evidence). XRPs aren't mined - unlike bitcoin and its peers - but each transaction destroys a small amount of XRP which adds a deflationary measure into the system.
CARDANO	Developed by IOHK in collaboration with the University of Edinburgh, the University of Athens and the University of Connecticut - is a Proof of Stake cryptocurrency.
BINANCE COIN	Binance platform currency based on a go-ethereum-derived network. It supports smart contracts and is based on a new consensus mechanism: the Proof-of-Staked Authority (PoSA) consensus ("Parlia"), which incorporates elements from both the Proof of Stake and the Proof of Authority.

Source: https://www.cryptocompare.com.

Summary statistics for the cryptocurrencies included in the study are presented in Figure 1.

	RENT_BNC	RENT_BTC	RENT_CARDANO	RENT_ETH	RENT_XRP
Mean	0.122331	0.053280	0.060499	0.042277	-0.001258
Median	0.063078	0.066430	0.000000	0.071576	0.000000
Maximum	22.10756	7.737591	12.46006	10.15530	19.50223
Minimum	-25.32594	-21.89428	-23.40364	-25.69459	-23.46245
Std. Dev.	2.533875	1.747542	2.677885	2.304653	2.710041
Skewness	-0.326912	-1.440180	-0.357209	-1.286162	0.109448
Kurtosis	18.19935	23.16703	9.670631	17.12571	16.03755
Jarque-Bera	12719.99	22808.01	2473.549	11329.81	9344.320
Probability	0.000000	0.000000	0.000000	0.000000	0.000000

Figure 1. Descriptive statistics

Source: Authors' own research results/contribution.

The average close to zero indicates a positive asymmetry and an increasing trend, except the case of XRP, which has negative values. The distribution is leptokurtotic, the kurtosis having a value higher than 3, the maximum being in the case of BTC (23.91). The probability value associated with the JB test is zero showing that series are not normally distributed.

Figures 2, 3, 4, 5 and 6 indicate that all the cryptocurrencies included in the study, like other financial assets, are sensitive to certain shocks and present a clear non-stationarity. The graphs therefore suggest a random walk behavior. The most noticeable stylized fact (Enders, 2010) is volatility variability. Every graph shows periods of very high volatility, which is a common feature among crypto-currencies. This indicates that the Bitcoin, Ethereum, Ripple, Cardano and Binance Coin prices are suitable for GARCH modelling.

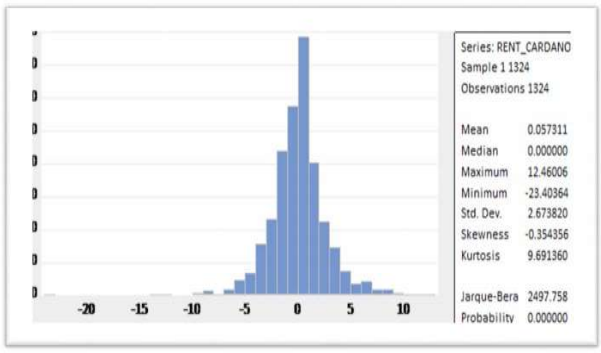

Figure 2. Cardano rentability

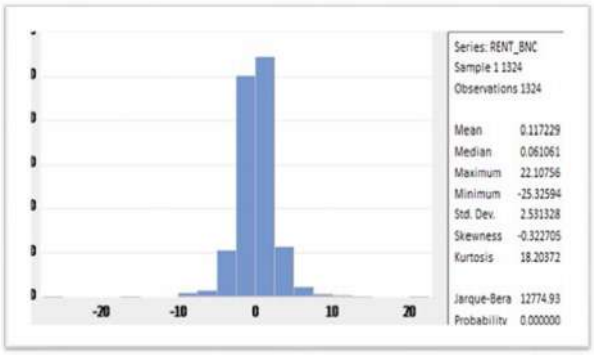

Figure 3. Binance Coin rentability

Source: Authors' own research results/contribution.

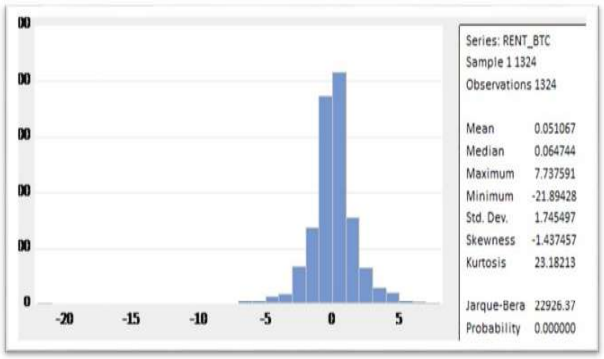

Figure 4. Bitcoin rentability

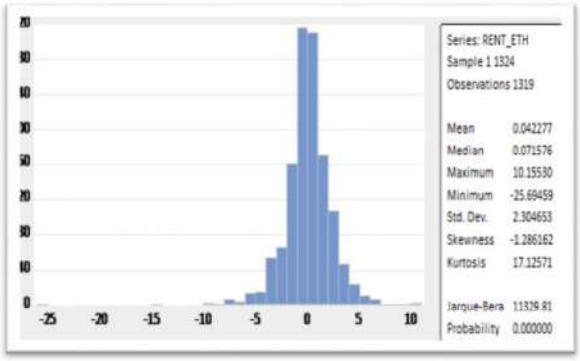

Figure 5. Ethereum rentability

Source: Authors' own research results/contribution.

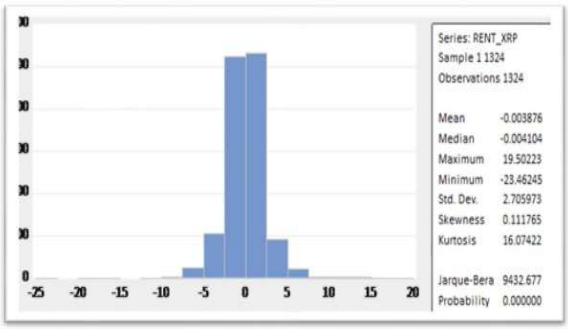

Figure 6. Ripple rentability

Source: Authors' own research results/contribution.

If we note Xt the observed financial data series, in our case, these are the log returns of the prices of the 5 cryptocurrencies, then, GARCH models can be specified as:

$$Xt = \mu t + \sigma t Zt$$

where μt denotes the conditional mean and σt denotes a volatility process.

GARCH processes differ from homoscedastic models in that they require constant volatility and are used in basic OLS analysis. The volatility of asset returns appears to vary over time and depends on past variation, making a suboptimal homoscedastic pattern.

GARCH models are autoregressive; depend on past square observations and past variations to model the current variance. GARCH models are widely used in finance due to their efficiency in asset return modeling. GARCH aims to minimize forecast errors by taking into account errors from the previous forecast and increasing the accuracy of current predictions.

The GARCH-M is often used in financial applications where the expected return on an asset is related to the expected risk of the asset. The estimated expected risk ratio is a measure of the risk-return trade-off.

The study implies the application of GARCH (1,1) and GARCH-M to observe changes in volatility over time and to find which model best suits each crypto-currency.

The most appropriate model was selected by applying several criteria, such as Akaike Information Criterion (1974) and Bayesian Information Criterion (Schwarz, 1978). The smaller the values of these criteria, the better the fit.

In order to assess the robustness of the result we included in the study a stock index, respectively S&P500. Therefore, it was possible to evaluate and compare the results obtained on its volatility and forecast in the case of cryptocurrencies.

Results and discussions

The study is a validation of the results of previous studies conducted only on Bitcoin and with different data sources (different exchange platforms). The process of evaluating highly volatile cryptocurrencies is complex and depends on many parameters. The results obtained allow both portfolio managers and investors to be more agile in evaluating their investments, in making optimal decisions and making future forecasts. This study could provide avenues for further research into the complementarity or substitutability between cryptocurrencies and how this could have an impact on the risk-return trade-off in cryptocurrency portfolios.

In order to investigate the volatility and the relationship between the crypto-currencies, different models of GARCH were evaluated using Eviews 10 for each of the 5 cryptocurrencies. The most appropriate model for each currency was selected using the Akaike Information Criterion and Bayesian Information Criterion. We find that the GARCH (1,1) models provide the best fit, in terms of modelling of the volatility in the most popular and largest cryptocurrencies. The results show that for BTC, ETH and XRP the appropriate model is GARCH (1,1) and in the case of BNC and CARDANO GARCH-M explain better the volatility of the crypto-currencies. Therefore, more in depth analysis of the datasets may be required to confirm or deny possible structural change.

The following Table 2 presents the results of the most appropriate model for each crypto-currency investigated.

Table 2. Results of the econometric model

Variabiles	BTC	ETH	XRP	BNC	CARDANO	S&P500
GARCH(1,1)	0.849094 (0.0000)***	0.8613 (0.0000)***	0.5509 (0.0000)***	0.8301 (0.0000)***	0.8100 (0.0000)***	0.7064 (0.0000)***
Constant	0.0823 (0.0866)*	0.0601 (0.3294)	-0.0917 (0.0566) *	0.0966 (0.0908) *	0.0282 (0.6993)	-0.0413 (0.0001)***
AIC	3.8947	4.4389	4.5742	4.4965	4.7462	1.0318
BIC	3.9104	4.4547	4.5899	4.5122	4.7619	1.0529
GARCH-M	0.849051 (0.0000)***	0.8605 (0.0000)***	0.5447 (0.0000)***	0.8282 (0.0000)***	0.8091 (0.0000)***	0.6708 (0.0000)***
Constant	0.0780 (0.7883)	-0.0523 (0.8892)	-0.0592 (0.7364)	-0.3051 (0.2273)	-0.0592 (0.7364)	-0.1827 (0.0000)***
AIC	3.8963	4.4389	4.5757	4.4951	4.5757	0.9889
BIC	3.9158	4.4600	4.5953	4.5147	4.7615	1.0153

Source: Authors' own research results/contribution
Note: (*), (**) and (***) indicate the probability for 90%, 95% and 99%.

From the table, we conclude that the constants for all cryptocurrencies are statistically insignificant at every level of significance for the GARCH-M model, while for the GARCH (1,1) are statistically significant. Also only in the case of Bitcoin the constant is positive for the GARCH-M model, while for the other cryptocurrencies is negative. All cryptocurrencies are positively related and this

suggests that they are complementary to each other. This means that when Bitcoin have a higher performance, so the other will become more appealing to investors.

Conclusion

The process of evaluating highly volatile cryptocurrencies is complex and depends on many parameters. Due to the increasing demand and interest in cryptocurrencies, we believe that they should be seen as an important element of the financial market. Some cryptocurrencies have seen more growth than others, for example, Bitcoin and Ethereum, dominating the crypto-market. However, there is still much to investigate about this new concept known as cryptocurrencies, especially Bitcoin, in the sense to properly classify them as currencies, assets or investment vehicles. In our paper, we treated them from the perspective of financial assets, where most users are trading them for investment purposes, looking to make a short-term profit. Therefore, our results would be particularly useful in terms of portfolio and risk management and could help investors and portfolio managers and investors to be more agile in evaluating their investments, in making optimal decisions and making future forecasts.

This study could provide avenues for further research into the complementarity or substitutability between cryptocurrencies and how this could have an impact on the risk-return trade-off in cryptocurrency portfolios. Our results show that cryptocurrencies such as Bitcoin, present extreme volatility especially when we look at their inter-daily prices.

GARCH models analysis of the 5 cryptocurrencies studied to assess their price volatility according to the strongest cryptocurrencies on the market, relative to their market capitalization (BTC, ETH and BNC at the moment), which are mainly responsible for the behavior herd in the cryptocurrency markets.

The study can be complemented by carrying out an event study on the 5 cryptocurrencies analyzed or extending the analysis by applying other GARCH models, to research the optimal model for several cryptocurrencies.

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