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Basic Aspects of Cryptocurrencies

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Abstract—Cryptocurrency is specific type of virtual currency based on principles of cryptography and electronic communication. In recent years emerged dozens of cryptocurrencies, while the most popular is the first ever introduced - Bitcoin. Cryptocurrencies attracted in recent years lots of attention. Character of cryptocurrencies and their volatility is discussed widely by general public, policymakers and economists. In this paper, basic aspects of cryptocurrencies are briefly introduced. Volatility of two major cryptocurrencies - Bitcoin and Litecoin is investigated. Further it is compared with volatilities of main stock indices, commodities and money pair of euro to US dollar in recent years. Other basic aspects of cryptocurrencies including anonymity, awareness and legislation effects are briefly investigated and discussed. The research results show extremely high volatility of cryptocurrencies in comparison to basic investment instruments. Also multiple legislation barriers for use of cryptocurrencies are detected. Research findings suggest that recent negative awareness of cryptocurrencies might lead to change of the cryptocurrencies' role. Cryptocurrencies might end up as exchange medium in black economy or as a speculation tool for a limited number of speculators daring to trade highly volatile cryptocurrencies for standard fiat currencies.

Keywords-cryptocurrency; virtual currency; volatility; Bitcoin; Litecoin;

I. INTRODUCTION

Cryptocurrencies are a new concept in the global economy. They exist only for approximately five years and they already attracted a lot of attention. Especially, since the year 2013 they experience turbulent changes in their exchange rates. The cryptocurrencies belong to the group of virtual currencies. We can consider cryptocurrency as a digital medium of exchange, based on principles of cryptography allowing performance of secure, decentralized and distributed economic transactions [1].

Theoretical foundations of cryptocurrencies were outlined by Chaum [2] for the first time in 1983 already. The cryptocurrencies integrate electronic virtual money with principles of cryptography [2]. The basic principle of cryptocurrency is that no individual (or organization) may accelerate or significantly abuse the production of a given currency. Typically only a certain predefined amount of cryptocurrency is collectively produced by the entire cryptocurrency system. The rate of production is set by a value defined in prior and is publicly known [3]. The cryptocurrencies allows virtually costless transfers of cryptocurrency units (referred as coins) between client applications via computer peer-to-peer network [2].

The most famous cryptocurrency and the first to be introduced was Bitcoin in 2009. It was designed by a person or a group of persons hiding under pseudonym Satoshi Nakamoto [4]. Two types of Bitcoin users exist: ordinary users and so called Bitcoin miners. Ordinary users of Bitcoin use digital wallet similar to electronic banking applications. The wallet is software for a management of Bitcoin cash, thus for sending and receiving payments in bitcoins. Bitcoins exist only as information in files in a computer or a mobile device. Access to these files is restricted to the holder of private key, which is used to secure the money. If file system in the computer is

damaged or the wallet file is inadvertently deleted, then the wallet file is lost and the bitcoins it contained are lost forever (in case that the wallet file was not backed up). Although the public address of wallet still exists, it can only be accessed by the private key, which was deleted. Unless one breaks the very secure encryption built into the system, then it would not be possible to recover the lost coins and breaking encryption used by Bitcoin network by a force is virtually impossible in timely manner [3].

The mining is process of new Bitcoins creation and it is performed by miners. Miners are second group of Bitcoin users and they are solving artificial mathematical problem by dedicating their computational power to the Bitcoin network. The mining is used to confirm waiting transactions by including them in the block chain. The block chain is created every 10 minutes in the case of Bitcoin. So every payment in Bitcoins is confirmed in time of 10 minutes. It enforces a chronological order in the block chain, protects the neutrality of the network, and allows different computers to agree on the state of the system. For the transactions to be confirmed, they must be packed in a block that fits very strict cryptographic rules that will be verified by the network. These rules prevent previous blocks from being modified because doing so would invalidate all following blocks. Mining also represents some kind of a competitive lottery that prevents any individual from easily adding new blocks consecutively in the block chain. So no individuals can control what is included in the block chain or replace parts of the block chain to roll back their own payments. The creation of block is proof of work system of mining, so the data are costly and time consuming to create in accord with requirements [3]. Bitcoin uses SHA2-256 cryptographic algorithm as a proof of work mechanism during transactions confirmation [3]. Some cryptocurrencies (e.g. Peercoin) employ also a proof of stake mechanism. The proof of stake mechanism means that fractions of cryptocurrency

units are assigned to their holders as a reward for holding the cryptocurrency, what can be considered an analogy of interest.

Since the introduction of Bitcoin tens of other cryptocurrencies emerged. The most are based on the similar specifications as the Bitcoin, which represents first fully implemented cryptocurrency protocol. The second most popular cryptocurrency Litecoin uses scrypt algorithm as a proof-of-work and has faster transaction confirmations (2.5 minutes) [5]. Most cryptocurrencies gradually introduce new units of currency until reaching a preset maximum cap of the total amount of currency that will ever be created. The maximum cap of cryptocurrency aims to assure the scarcity, similar to the case of precious metals. It also should prevent a hyperinflation [6]. On the contrary, some cryptocurrencies might experience hyperdeflation as the amount of the currency in circulation will approach its preset finite cap [7].

All currently existing cryptocurrencies are pseudonymous, so they provide very high degree of anonymity. Therefore cryptocurrencies are less prone to be confiscated by law enforcement institutions [7]. These facts make cryptocurrencies very attractive for black market. The case of the Silk Road is infamous. It was e-marketplace used for drug dealing (and other black market trading) and it was accepting payments in cryptocurrencies [9].

However since introduction of cryptocurrencies, they continually gain attention (positive or negative) from the media and public, especially during the fast price rise of Bitcoin and Litecoin during the year of 2013.

II. LITERATURE REVIEW

The theoretical and empirical research of cryptocurrencies lacks the bigger extent, because the topic of cryptocurrencies is very recent and newly arisen. It lacks longer time data series for analysis, because the organized exchange of cryptocurrencies and fiat money started only in 2010.

Chaum [2] laid the theoretical foundations of cryptocurrencies, when he drafted use of cryptology for allowance of untraceable electronic payments. Above mentioned pseudonymous Nakamoto [4] proposed the creation of Bitcoin at the end of 2008 and further developed it, what led into introduction of a Bitcoin network in early 2009.

Researchers, such as Moore and Christin, mainly investigated security of cryptocurrency accounts. Their results indicated a high risk of breaching security of popular cryptocurrency exchanges. Later crash of Mt.Gox market place confirmed their conclusions [10].

The level of cryptocurrencies' acceptance was investigated by Luther [10]. He concluded that cryptocurrencies like Bitcoin are unlikely to generate widespread acceptance in the conditions of significant monetary stability and absence of a government support.

Tucker points out a high volatility of cryptocurrencies [12]. He indicates that holding cryptocurrencies is very risky due to their very high volatility and high potential for price manipulations. The cryptocurrencies might be manipulated in pump and dump scheme, what is a form of fraud that involves

artificially inflating the price of cryptocurrency through false positive statements, in order to sell the purchased cryptocurrency at a higher price than it was bought. Once the operators of the scheme sell out the cryptocurrency, the price falls and other holders of given cryptocurrency lose their money [12].

Morris indicated that some cryptocurrencies might be manipulated also by pre-mining. In that case a currency is mined or generated by its founders before mining code is released to the general public. This might be a part of a cryptocurrency's original design. Similarly some cryptocurrencies might have hidden launches available to only few individuals and might have extremely high rewards for the first miners [13].

Generally only Bitcoin and Litecoin are directly interchangeable at markets (like BitStamp, Vircorex, BTC-e, BTC China and others) for fiat currencies. Other cryptocurrencies can only be traded for other cryptocurrencies. Banking institutions generally do not accept cryptocurrencies and do not offer services for them. Multiple banks also refuse to offer services to companies dealing with cryptocurrencies [13].

Virtual currencies are based on solving mathematical problems which require enormous computing power. Unfortunately, because of these built-in security mechanisms, the processing power used comes to nothing, rather than be used for something meaningful. Now researchers from Microsoft Research, Cornell Tech and the University of Maryland proposed how these computing resources used for cryptocurrency mining (or rather storing) can be used more useful. They proposed new virtual currency named Permacoin [14].

Permacoins would be generated when users would archive the data from the huge data fund. The researchers suggest, for example, backing up data from the Library of Congress (200 TB of data). Mining of permacoins would therefore be less dependent on computing power and the more storage space. The data would be stored locally. The availability and consistency of stored data would be controlled by a network and the user would obtain corresponding permacoins. Safety features should also check that the data are not stored in the cloud repository and are not vulnerable to attacks on Permacoin network. It is therefore a public archive data that could be useful for mankind. Investments in hardware and storage would actually serve to secure and distribute data in a decentralized system widely available with multiple data backups [14].

Regulators in several countries have warned against use of cryptocurrencies. Some countries have taken specific regulatory arrangements to dissuade potential users of cryptocurrency. Legal ways of acquiring the amount paid in cryptocurrencies back, when some problem arises, do not exist, however administrations try to find solution for consumer's protection while using cryptocurrencies [7]. The most authorities address mainly Bitcoin as prevalent representative of cryptocurrencies. The willingness to accept it varies in different countries. For example Chinese central bank forbid to financial institutions in country to offer services connected to

Bitcoin. Internal Revenue Service (government tax administration authority) in USA issued guidance for treating virtual currencies such as Bitcoin as property rather than currency for federal tax purposes. It may help Bitcoin investors, even though it means Bitcoin users In USA will need to report their transactions [14]. In many other countries Bitcoin and virtual currency in general have also problems with acceptance. Authorities in Norway stated that it does not fulfill requirements of being a currency. In Finland Bitcoin is not considered legal currency, because it is by definition in conflict with local legislation. It states that payment instrument must have the issuer responsible for its actions. On the other hand, buying cryptocurrencies is in Finland considered a purchase of goods [7].

Besides the authorities also economists criticize Bitcoin and other cryptocurrencies. Laureate of Nobel Prize for Economy Paul Krugman in 2013 stated that Bitcoin is very good medium of exchange, but it does not store the value at reasonably stable level [16]. Gold preserves value, because if fiat currencies fail, gold still can be used as currency as it was used in past. Gold's value is limited from above by technology of its mining and its limited supply in mining sites. Federal Reserve System guarantees (in some limits like inflation etc.) the value of US dollar. On the contrary, nobody guarantees minimal value of cryptocurrencies as long as they are decentralized and fully independent. They are mainly limited in preset amount of cryptocurrency units ever be created [16].

The identification and summary of cryptocurrencies' aspects and empirical investigation of cryptocurrency volatility are not present in current research. Therefore we decided to aim our paper in this area.

III. BASIC ASPECTS OF CRYPTOCURRENCIES

Aim of our research was to investigate basic aspects of cryptocurrencies that might influence their prices. Price of cryptocurrency reflects the trust of users in given currency and its future development.

Cryptocurrencies bring to their users freedom of payments. They provide the possibility to send and receive any amount of money quickly anywhere in the world at any time. Users of cryptocurrencies are not limited spatially or in time when realizing their payments, so their users are in full control of their money.

Cryptocurrency payments are processed with no fees or extremely small fees. In the case of Bitcoin, users may include fees with transactions to receive priority processing, which results in faster confirmation of transactions by the network. Additionally, merchant processors exist to assist merchants in processing transactions, converting bitcoins to fiat currency and depositing funds directly into merchants' bank accounts daily. These services are based on Bitcoin, so they can be offered for much lower fees than with PayPal or credit card networks [3].

All information concerning the cryptocurrency money supply is readable and available in the block chain for anybody to verify and use in real-time, so cryptocurrencies are transparent. Furthermore no individual or organization can

control or manipulate cryptocurrencies protocol because they are cryptographically secured [3].

Cryptocurrency payments can be made without personal information linked to the transaction. This offers strong protection against identity theft and almost full anonymity. Cryptocurrency users can also protect their money by encryption and backing up their wallets. In addition, it is impossible for merchants to hide any charges as can happen with other payment methods. The cryptocurrency transactions are secure, irreversible. This protects merchants from losses caused by fraud or fraudulent chargebacks. This allows merchants to have lower fees, enlarge markets and decrease administrative costs [3].

On the other hand total value of cryptocurrencies in circulation and the number of businesses accepting them are very small compared to classic fiat currencies. Therefore, relatively small number of trades or events can significantly affect the price of cryptocurrencies. This volatility might decrease as cryptocurrency markets and technologies will mature [3].

The most of cryptocurrencies and their software are still in development with many incomplete features. New tools, features, and services might still being developed. In addition, many people are still unaware of cryptocurrencies. Both users and businesses accept cryptocurrencies because they want to utilize its advantages, but their numbers remains small and still needs to grow in order to benefit from network effects [3].

While total supply of cryptocurrency is predetermined and gradually increases over time with mining, total demand after it may vary dramatically. However, the supply of cryptocurrency on an e-market is not equal to its total supply. It only reflects the amounts of cryptocurrency that market subjects are willing to sell at given prices at given moment via e-markets.

Prices in official currencies are directly set by demand and supply on e-markets only for two the most popular cryptocurrencies: Bitcoin and Litecoin. Other cryptocurrencies are directly interchangeable on e-markets only for Bitcoin or Litecoin respectively. Therefore their exchange rate is strongly influenced also by changes of Bitcoin or Litecoin exchange rates.

Other major aspects that have influence on exchange rate of cryptocurrency are its acceptance and usability in various applications. Once again Bitcoin is the most widely accepted cryptocurrency in many cases on the web and also brick-and-mortar businesses and merchants.

Many legal official sites accept payments or donations in Bitcoins (or Litecoins). However in addition to that also many sites merchandising unofficial or even illegal goods (drugs, firearms etc.) accept it too. The main reasons are easy transfers and their almost complete anonymity of cryptocurrency transactions. Logically subjects acting on black market want to remain anonymous.

Also availability of cryptocurrency is important issue. The easiness of purchasing or exchanging for classical currency into cryptocurrency and vice versa allows better possibilities to use cryptocurrencies. Consequently it influences their

exchange rates. In case of Bitcoin, there are already ATMs for Bitcoin purchases available in some countries, which use exchange rate from one of major e-markets allowing cryptocurrency exchange with small fee covering the ATMs costs of maintenance and operation. This increases availability of Bitcoin between wide populations. Though the main source of cryptocurrency remain mining and direct trading on electronic markets.

Furthermore legislation changes in many countries influence positively or negatively the possibility of using cryptocurrency in legal money transactions. In some countries legislative arrangements induced by possible illegal cryptocurrency transactions brought restrictions to the use of cryptocurrencies in particular country. However, the influence of this legislation on illegal transactions would be lower, because they already are out of law system of given country from another reason than new legislation restricting cryptocurrency usage.

Awareness about cryptocurrency affects both positively or negatively its exchange rate. Higher awareness of Bitcoin made it very popular in last year what partially contributed to enormous increase of its price in 2013. This also had effect on many other cryptocurrencies, mainly because they are interchangeable with Bitcoin.

All these aspects influence the use of cryptocurrency and its final exchange rate to normal currencies. Together they generate trust in given cryptocurrency. The higher trust brings more stable and higher price of cryptocurrency at market. We can summarize these aspects of cryptocurrencies into following basic aspects:

A. Volatility

Volatility represents measure of intensity of price changes of given investment. High volatility might cause serious problems with given investment.

While considering cryptocurrency, the main problem caused by the volatility is that of a deflationary bias. With more and more people wanting access to a limited number of cryptocurrency, its value will be pushed upwards and things therefore become cheaper for those that have cryptocurrency in possession. Deflation encourages cash hoarding rather than spending and it is incorporated directly into the basic principles of current cryptocurrencies. High increases in cryptocurrency values encourage its users to hold cryptocurrency further and avoid its use for [17]. For example O'Brien at this point suggests that cryptocurrency ceases to be a currency and becomes a virtual commodity [18].

On the other hand, big decreases of cryptocurrency's value encourage its holders to sell out their cryptocurrency and buy more stable traditional currencies or commodities. This leads to even greater decreases of cryptocurrency rates as long as their sell out increases supply of cryptocurrency on the market and sellers tend to sell cryptocurrency at still lower and lower price. In case of traditional currencies central banks exist to avoid these effects and assure currency stability, while cryptocurrencies lack any form of central banking.

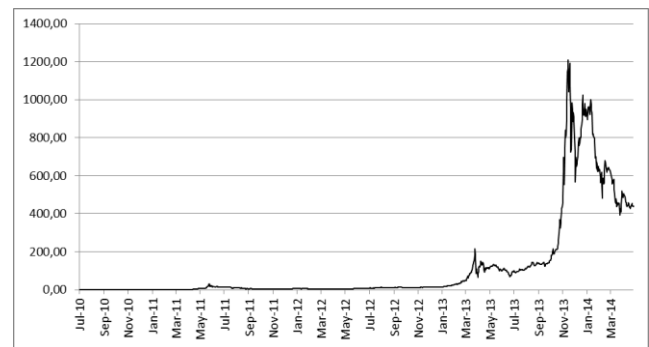


Figure 1. Bitcoin historical price chart

Source: own processing based on [19], [20], [21]

Basic aim of this paper is to investigate volatility of cryptocurrencies and their comparison with volatilities of main currencies, indices and commodities on global markets. Results might suggest if cryptocurrency are suitable investment for anyone. Two the most popular cryptocurrencies Bitcoin and Litecoin were selected, because of their direct interchangeability to fiat currencies at multiple electronic markets.

The figure 1 shows Bitcoin average historical prices on the biggest Bitcoin e-markets. All available daily closing prices data from multiple electronic markets (Bitstamp, BTC-E, Mt. Gox) were used to create figure 1. Data showed here start in the July 2010 when trading with Bitcoin started on Mt. Gox e-market. Data from Mt. Gox were used only in early years before other markets emerged to avoid the period before crash of Mt. Gox (in February 2014) when prices on this market were significantly below prices on other markets. This happened because of generally known problems of Mt. Gox with withdrawals of Bitcoins and users were afraid to use this e-market any further.

The figure 1 clearly shows that the main big price changes of Bitcoin occurred in 2013. Two price peaks were recorded in 2013. First peak was during April 2013, when Bitcoin price peaked at above 200 USD per Bitcoin (USD/BTC) and second in December 2013 at around 1200 USD/BTC. The biggest difference between prices within one year was in 2013 with lowest price at 13.31 and highest at 1209.94. It represents ninetyfold increase of price within period of one year. It illustrates tremendous fluctuations of Bitcoin prices in relatively short periods.

Second chart (see figure 2) shows second Bitcoin rally in 2013. The data illustrated on figure 2 are from October 2013 until May 2014. It is more obvious that highest price was overdeveloped and it decreased to its half during one month. Later decrease in February of 2014 is caused by crash of former biggest Bitcoin e market Mt. Gox, which significantly undermined the trust in cryptocurrencies in general population. Since then has the Bitcoin price decreasing trend.

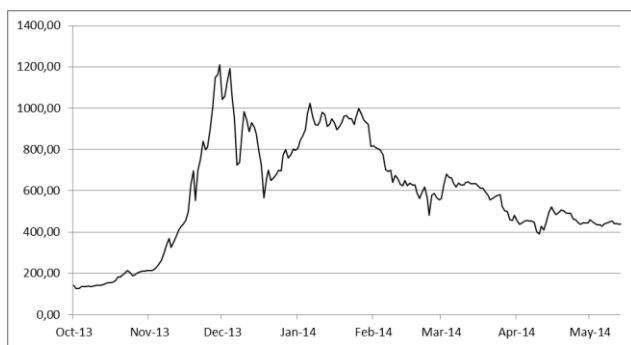


Figure 2. Bitcoin historical price chart – period since October 2013

Source: own processing based on [19], [20], [21]

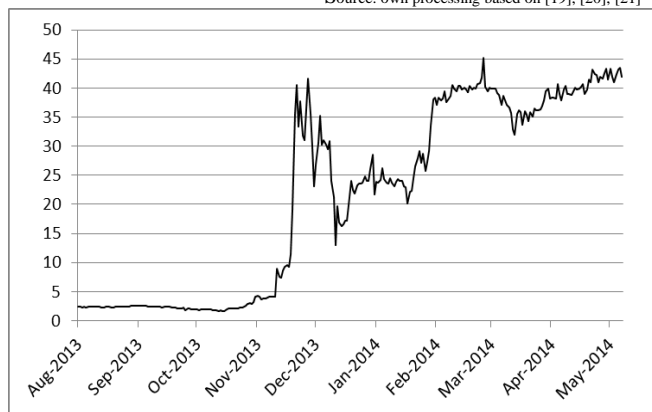


Figure 3. Litecoin historical price chart on BTC-e e-market

Source: own processing based on [22]

The similar case in some areas is the one of the Litecoin. The figure 3 shows historic prices of Litecoin at BTC-e electronic market since August 2013 until May of 2014. Data on Litecoin prices before this period are not available, because of non-existent Litecoin market at time prior to this period. It illustrates shorter period than figure 1, but it is obvious that Litecoin had very volatile period during November and December of 2013, increasing its rate from 4 USD/LTC to above 41 USD /LTC during one month.

On the contrary, in comparison with the Bitcoin's price decrease since February of 2014, Litecoin's price is rising in that period. Litecoin's price rising trend is probably caused by partial switch of cryptocurrency investors and users from Bitcoin to Litecoin since Mt. Gox crash.

The figure 4 even better illustrates Bitcoin and Litecoin prices' changes in the most volatile period since August 2013, with use of adjusted secondary (Litecoin) axis to show both cryptocurrencies on a joint basis. Litecoin prices have similar development as Bitcoin prices with even higher peaks and lower bottoms. This suggests that Litecoin might have higher volatility than Bitcoin.

Litecoin stopped to copy Bitcoin's course of prices in after above mentioned Mt. Gox crash in February of 2014, when Litecoin continued to rise while Bitcoin lost almost half of its original price.

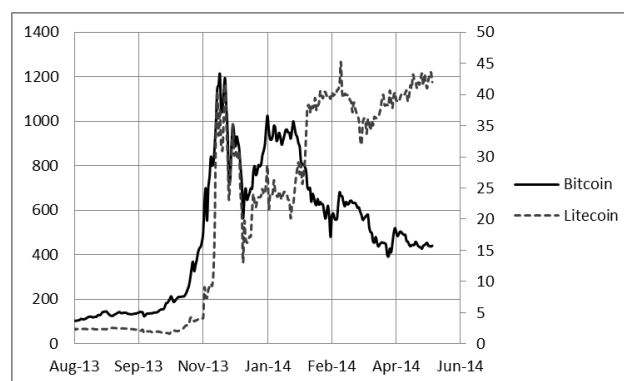


Figure 4. Bitcoin and Litecoin prices comparison since August 2013

Source: own processing based on [19], [20], [21], [22]

From these rate changes of two major cryptocurrencies is already obvious, that cryptocurrencies have high volatility. In order to express their volatilities more accurately, we have gathered available data on Bitcoin and Litecoin prices on electronic markets (graphically presented on above). Further percentage prices change between two following trading days was calculated. As measure of volatility then was used standard deviation of all percentage price changes available. Finally 30-day and annualized volatility were calculated by adjustment with square root rule.

With aim to provide better view of cryptocurrencies' volatilities we further compared them with volatility of stocks, commodities and currencies. Data on major indices (Dow Jones Industrial Average, S&P 500 and NASDAQ) were gathered at given markets and their volatilities were calculated using the same method as in the case of Bitcoin and Litecoin.

For further comparison also volatilities of main commodities were calculated. Gold, silver and crude oil prices from main commodity markets were gathered and processed with the same methods as cryptocurrencies and indices.

For allowance of comparison with common fiat currencies we considered in our analysis also major currency pair EUR/USD on foreign exchange markets with same method of volatility calculation.

All data were gathered from the same period of time (between July 2010 and May 2014), only for Litecoin had to be used shorter period, because e-markets started to allow change of Litecoin for a standard currency later than in the case of Bitcoin.

Following table I shows us comparison of all calculated volatilities of cryptocurrencies, indices, commodities and currency pair.

Besides previous volatility expression based on standard deviation of all percentage change, we decided to further compare volatility expressed by measure of Average True Range (ATR).

The Average True Range is an indicator that measures volatility and was developed by J. Welles Wilder [30]. It was designed considering commodities and daily prices.

TABLE II. VOLATILITY COMPARISON – STANDARD DEVIATION METHOD

Volatility Comparison	Daily Volatility	30-Day Volatility	Annualized Volatility
Bitcoin	7,56%	41,43%	120,09%
Litecoin	9,52%	52,15%	151,13%
DJIA	0,92%	5,28%	14,86%
S&P500	1,05%	5,69%	16,37%
NASDAQ	1,16%	6,31%	18,17%
Gold	0,78%	4,21%	12,19%
Silver	1,57%	8,49%	24,38%
EUR/USD	0,46%	2,51%	7,27%
WTI Crude Oil	1,70%	9,25%	26,72%

a. Own processing based on data from [19],[22],[23],[24][25],[26],[27],[28],[29]

Commodities are often subject to gaps and limit moves, which occur when a commodity opens up or down its maximum allowed move for the session. A volatility formula based only on the high-low range would fail to capture volatility from gap or limit moves. Wilder created Average True Range to capture this “missing” volatility. ATR does not provide an indication of price direction only measures volatility [30].

Average True Range is based on concept called True Range (TR), which is defined as the greatest of the following options:

- 1 current high price less the current low price in given period
- 2 current high price less the previous period close price (absolute value)
- 3 current low price less the previous close price (absolute value)

Absolute values are used to ensure positive numbers to measure the distance between two points, but not the direction, i.e. not increase or decrease of price just size of the price change. If the current period's high is above the prior period's high and the low is below the prior period's low, then the current period's high-low range will be used as the True Range (i.e. first option). Options 2 and 3 are used when there is a gap or an inside day. A gap occurs when the previous close is greater than the current high (signaling a potential gap down or limit move) or the previous close is lower than the current low (signaling a potential gap up or limit move) [30].

As long as True Range uses absolute price changes, also ATR reflects volatility as absolute level. In other words, ATR is not shown as a percentage of the current close. This means low priced stocks will have lower ATR values than high price stocks. Because of this, ATR values are not comparable. Even large price movements for a single security, can make long-term ATR comparisons impractical [30].

To overcome this problem, in our volatility comparison based on ATR we have decided to express ATR percentage. Firstly, True Range of all periods was counted with selecting

the maximum gap of all three possible gap options. Further Average True Range was counted as moving exponential average according following formula:

$$ATR_t = \frac{ATR_{t-1} \times (n-1) + TR_t}{n}$$

where n is period of moving average, TR is true range in given day (t) [30].

In our calculation, we used the most common 14-day period and expressed ATR for the whole period of time (between July 2010 and May 2014). ATR was initialized (at t = 0) with a 14-day trailing average of TR. We have expressed Average True Range percentage as ratio of current ATR to closing price in given day, to allow comparison of volatility between differently priced currencies, indices or commodities. To provide comparison for whole period of our gathered data we expressed a mean of all acquired daily ATRs. The table II shows our results:

TABLE II. VOLATILITY COMPARISON AVERAGE TRUE RANGE METHOD

Volatility Comparison	Highest ATR percentage	Mean ATR percentage
Bitcoin	50,15%	9,41%
Litecoin	38,15%	11,47%
DJIA	6,51%	1,43%
S&P500	4,34%	1,51%
NASDAQ	3,83%	1,40%
Gold	1,38%	0,50%
Silver	3,51%	0,98%
EUR/USD	4,16%	0,33%
WTI Crude Oil	2,57%	1,24%

a. Own processing based on data from [19],[22],[23],[24][25],[26],[27],[28],[29]

Table II contains also single highest ATR percentage recorded during investigated time period. It documents single most extreme movements in prices although smoothed by 14-day moving exponential average. Both cryptocurrencies have extreme highest ATR percentage. Our main indicator of ATR volatility in this method is a mean ATR percentage during investigated time period. There again both Bitcoin and Litecoin recorded multiple-times higher values of volatility than other investigated objects. These results correlate with results of volatility comparison based on standard deviation. Relative stability of gold prices confirms its reputation of safe harbor for investors. Stock indices are slightly more volatile than commodities. However given two cryptocurrencies have dramatically higher volatility confirmed by this method too.

Our results confirm that cryptocurrencies have currently extremely high volatility in comparison to main major currencies, stock indices and commodities. Volatility of Bitcoin was approximately eightfold higher than other instruments investigated. Litecoin had even higher volatility than Bitcoin. Other cryptocurrencies were not investigated as long as they are interchangeable only for Bitcoin or Litecoin

and they copy price course of two main cryptocurrencies. Also their significance and market capitalization is way lower.

However, the high volatility is not for cryptocurrencies users only the bad news. Even short-term speculations might bring high earnings to cryptocurrency speculators. This fact along with high growth of cryptocurrencies exchange rates attracted even more speculators. It led to even bigger price growths and creation of price bubbles. Although users holding cryptocurrencies, who purchased (or mined) it sooner in past before volatile year of 2013 might have recorded above 1000 percent earnings.

Having a volatile currency means that businesses can't plan or budget effectively, and the chaos that this could cause would be too much of a risk for most, even if sometimes they came out ahead. Nobody knows how much stuff a bitcoin will be able to buy in a day, a week, or a month – there are no fundamentals to speak of.

High demand after cryptocurrencies made them very volatile with predominant growth of exchange rate. These effects are transferred from Bitcoin and Litecoin into other cryptocurrencies thanks to their interchangeability only via medium of Bitcoin or Litecoin. Recorded extreme volatility of cryptocurrencies suggests them only for risk-takers considering them as investment possibility.

B. Awareness

The awareness of cryptocurrency affects the count of its users and therefore also the stability of its exchange rate. The higher awareness of given cryptocurrency means its more potential users. Very big role in the field of awareness play the media. High media coverage of Bitcoin's price rally definitely drew attention of numerous additional speculators, who then invested in Bitcoin and participated on its enormous growth of price. Besides the all forms of media also the word of mouth increases the awareness of cryptocurrencies and contributes to increase of cryptocurrency users numbers.

On the other hand, negative information on cryptocurrencies (electronic wallet thefts, banning by legislation, criminal usage etc.) might discourage potential users.

The good example of such negative information might be above mentioned crash of Mt. Gox - former the biggest Bitcoin market. It ceased its operations in February of 2014, because of big losses of Bitcoins and also standard currencies. These losses were caused by faulty processes of market, which were known for longer period, but were not addressed by Mt. Gox management. Price of Bitcoin on this e-market was influenced by this fact in multiple weeks prior to its crash. The Mt. Gox's crash significantly influenced also prices of Bitcoin at other e-markets due to disruption of trust in Bitcoin [31]. Its prices still have decreasing trend since then.

Mt. Gox had faulty processes for years and these faults were not adequately addressed by this e-market management. Fault was in so called transaction malleability. Identification of transaction on Mt. Gox could have been changed during its processing. Then impostor claimed at Mt. Gox that payment with original identification did not ascribe to his wallet. Mt.

Gox customer care did not identify the payment with original identification and sent given amount again, even if such amount already has been sent there but it has only changed identification. This scheme could be repeated multiple times. This wrong procedure led to multiple losses of amount in standard currencies and it could be prevented by early change of procedures on this e-market [32].

C. Availability

Another important aspect of cryptocurrencies is their availability for use. Availability is influenced by easiness of purchasing and their interchangeability for official standard currencies. This is enabled by private electronic markets available to general public.

Number of subjects accepting payments in given cryptocurrency reflects also its availability and usability. Number of merchants accepting some cryptocurrency (Bitcoin mainly) is increasing, but they are facing the problem of high volatility of cryptocurrencies, so at most cases they do not keep cryptocurrency for the longer period of time and change for standard currency. On the other hand, higher availability brings higher and more stable exchange rate of cryptocurrency thanks to increased number of users of given cryptocurrency slowing rate changes and decreasing its volatility in time.

Further the speed of transactions and their confirmations processes makes cryptocurrency more available and practical for payments in electronic environment.

D. Anonymity

All cryptocurrency payments between anonymous sides are hardly traceable. This fact is the main reason of their usage in criminal operations. Very hard transactions traceability and no central guaranty of currency are main reasons of criticism and legislation restrictions of cryptocurrencies.

Governments and security authorities are also afraid of virtually untraceable transactions that might be connected with financing criminal activities or terrorist organizations. Cryptocurrencies with virtually anonymous transactions are potentially very useful for such financial transfers to terrorists from their sponsors. Mainly this lack of transfers' identification led to multiple legislation adjustments and arrangements in recent years for cryptocurrency usage restrictions.

On the other hand, also legal users might prefer anonymous transactions due to concerns of privacy intrusions by any third party not involved in transaction. After recent cases of disclosure of governmental tracking of private communications are privacy concerns even more understandable.

So anonymity of cryptocurrency affects the usage of cryptocurrencies both positively and negatively.

E. Legislation influence

Before year 2009 not a single national legislation contained the term of cryptocurrency. Since then increasing amount of money transferred in form of cryptocurrency forced policymakers in many countries to issue a recommendation or create laws regarding the use of cryptocurrency in national

economy. Broader allowance of cryptocurrency usage definitely supports its usage and generates bigger trust in it. However the most countries did not allowed use of cryptocurrency or they did not concede to them the status of currency. This action restrained their possibility of its usage in legal economy. However in illegal economy it keeps its status of safe and anonymous medium of exchange.

Any illegal transactions by cryptocurrencies as payments for illegal commodities and services are affected by valid cryptocurrency legislation only in minor extent as long as these transactions are already part of activity violating some other laws with greater criminal consequences.

The area of cryptocurrency introduction process rules lacks the legislation treatment. Although cryptocurrencies are to be independent, multiple cases of pre-mining or pump-and-dump schemes during of introduction of some cryptocurrencies affected negatively the trust in all cryptocurrencies.

Basically the most legislative arrangements caused decreases in cryptocurrency exchange rates because it led to restrictions in their usage.

All of mentioned aspects affect trust in cryptocurrencies and their usage and rates. The most of factors are associated to others, have joint effects and together they made cryptocurrencies attractive for speculations.

IV. CONCLUSION

Virtual currencies and specifically cryptocurrencies are very recent topic object in economy. There are multiple aspects of cryptocurrencies and their use in economy. Our research indicated and confirmed enormous volatility of cryptocurrencies exchange rates at levels many-times higher than basic indices, commodities and money pair. Their high volatility causes high risk of trading cryptocurrency and is reflected in the formation of price bubbles. However, the great growths of their exchange rates attracted many speculators, but it is obvious that cryptocurrencies can only hardly retain their value. This fact can lead to change in understanding of cryptocurrencies as payment medium, but rather as specific commodities. In comparison with commodities, cryptocurrencies have advantage of easy portability thanks to its virtual character, but on the other hand, their virtual character makes them useless or non-existent outside of electronic environment unlikely other tangible commodities.

All mentioned aspects generate trust in cryptocurrencies. If potential users will trust in cryptocurrencies, they might be used in increased scale. If trust in cryptocurrencies will not reach sufficient level, the boom of cryptocurrencies might subside. This might be the case of the Bitcoin in last few months, when a few marketplace crashes shook its price significantly. Then cryptocurrencies might become only medium of exchange in black economy or speculation tool of few speculators still daring to trade cryptocurrencies for standard currencies. In this case the value of cryptocurrency will be set by demand and supply of it in unofficial economy, where anonymity of transactions is highly valued characteristic of cryptocurrency usage.

Perhaps, a more promising is idea of Permacoin that offers a glimpse into the future, where digital currency is tied to the real world and users should provide their computing power and storage space to create something useful.

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