An Evaluation Of Volatility Index VIX In The Case Of Cryptocurrency

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I would like to dedicate my dissertation to my parents Goupios Lampros and Mitsopoulou Stavroula and also my sister Goupiou Eftychia for nursing me with affections and love and their dedicated partnership for success in my life. They are always supporting me whatever path I take.
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Summary

In this dissertation we examine the parameters affecting on Bitcoin’s market price, such as number of transactions in blockchain, Volatility Index (VIX) of S&P 500 stock market, the amount of unique addresses and accounts in blockchain or market capitalization. With data of three full years (January 1st, 2014 till December 31st, 2017) and by linear stepwise regressions, results have shown that except market capitalization, which includes the market price, all other parameters does not affect significant on market price of Bitcoin, especially volatility index.

Keywords: Volatility Index, Bitcoin, Blockchain, Cryptocurrency
Περίληψη

Στην παρούσα διπλωματική εργασία εξετάζεται μέσω γραμμικών πολιτικής διπλωματίας, που οι παράγοντες επηρεάζουν την ημερήσια μέση αγορά σε δολάρια ΗΠΑ του πιο ευρέως γνωστού κρυπτονομίσματος, με βασικότερο το δείκτη μεταβλητότητας του Χρηματιστηρίου. Οι άλλοι παράγοντες που επιλεγόταν να χρησιμοποιηθούν ήταν ο αριθμός των ημερήσιων συναλλαγών, η κερδοφορία της αγοράς, ο όγκος των ημερήσιων συναλλαγών και η συνολική αξία τους σε δολάρια ΗΠΑ, ο συνολικός αριθμός των διευθύνσεων χρηματιστηρίων κρυπτονομίσματος και ο συνολικός αριθμός των κρυπτονομισμάτων που έχουν εξορυχθεί. Τα δεδομένα για τα κρυπτονομίσματα συλλέχθηκαν από το περιβάλλον συναλλαγών του κρυπτονομίσματος και ο δείκτης μεταβλητότητας συλλέχθηκε από ένα από τα μεγαλύτερα χρηματιστήρια του κόσμου με έδρα το Σικάγο της πολιτείας του Ιλινόι των ΗΠΑ. Τα αποτελέσματα δεν έδειξαν κατακόρυφα σημαντικά αποτελέσματα στην περίοδο που μελετήθηκε και ειδικά ο δείκτης μεταβλητότητας δεν έχει μόνο το 0.01% του δείγματος.

Λέξεις κλειδιά: Κρυπτονόμισμα, Δείκτης Μεταβλητότητας, Κρυπτογραφία, Γραμμική πολυνόμηση
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Chapter 1

Introduction

1.1 Cryptography and Cryptocurrencies

Cryptography in computer science in the last decades has gained attraction from developers all over the world. In general cryptography is a secure connection between two sides who want to communicate encrypted. Secured features of cryptography, such as hash function for information security and keys - public and private for locking and unlocking encrypted information enticed the idea of cryptocurrency. Hash function is a mathematical function converting any data into string. This function has to be deterministic, quick for any input message and it has to be impracticable both generating the input message from its hash value and finding two different inputs with the same hash value. Additionally, feature of public and private key in cryptography guarantee the locking and unlocking of the information. Public key is known from everyone in the system (locking encrypted message) and in converse private key is known only by one (unlocking encrypted message). Cryptocurrency lean on foundations of cryptography, making trading and transactions secure between users in the same environment.

Of all cryptocurrencies, as the first, Bitcoin has been the most frequent attraction, from 2009 when Satoshi Nakamoto created Bitcoin and opened a new option of "currency", either accepted or not from economics. More and more are trying to identify and clarify whether it is a different way of trading or simply just a new
1.2 Advantages and Disadvantages of Bitcoin

technological finding, researchers are tentatively dealing with its behavior and the way it is affected of different factors. Some economists specialized in behavioral economics also try to examine users behavior on Bitcoin and its change over the last years.

Digital signature and hash functions are supported in Blockchain environment, in which all bitcoin transactions are taking place. By cryptography technology attributes, transactions are warranted. With blockchain technology, each page in a ledger of transactions forms a block. That block, through cryptographic hashing creates a unique secure code, which ties into the next block, making a chain. This chain of blocks is Blockchain.

The high exchange rate has helped to attract interest around Bitcoin. Records of over 300,000 indicates daily value of approximately $300 million, although, it is important to consider about several accounts of only one user. Conversely to established payment networks, Blockchain still remains small-scaled.

1.2 Advantages and Disadvantages of Bitcoin

Bitcoin has several advantages. First of all it is cryptic and fully digital. It has no effect on any underlying value of another currency or commodity and so its market price depends only od supply and demand rules, as they are shaped of all times. As an outcome of cryptography, hush functions and digital signature, as advanced encryption techniques, implement all the security and integrity functions of transactions.

Furthermore, Bitcoin does not belong to anyone and it is not issued by anybody. It is distributed and it has nodes-users communicating to each other and is not controlled by a single node.

Additionally, Bitcoin has a transparent monetary policy. As an open source protocol system, code is available in public and other developers and anyone can control it, change it or copy it.
Lastly, deterministic algorithm is making new currency units within the network of Blockchain, although every specific time a fixed amount of new Bitcoin is mining-issued, which provide computational power to ensure transactions integrity. This mining system issuing new units of Bitcoin it will stop by default when the total amount of 21 million Bitcoins will be mined, which is estimated around 2130.

Disadvantages of Bitcoin and Blockchain transactions also exist. Bitcoin will inevitably encounter the same difficulties that every new currency encounters when it first comes out. Public is not familiar with something as new as digital currency and expertise in usage is needed. Also, although some businesses allow transactions with Bitcoins, it is not well known.

In addition, anonymity of transactions allow and grow illegal trades. Also, electronic wallet can be hacked by anyone. If certain security rules are not met it can be risky. Besides these, trading platforms need authorization of the country they act and Bitcoin is already shutted down once by the government.

As Bitcoin is still in early stages of development, has incomplete operations on which dozen start-ups are currently working on security issues, accessibility, and developing new tools and services.

Last and most important of all Bitcoin has huge price volatility, which is going to change dramatically as more as individuals and businesses use it. This volatility exists because Bitcoin circulates in a limited number and demand increasing daily. Its value now (Sep. 2018) has been increasing very steeply and rapidly above $7,500, in contrast with no value at the time of Bitcoin creation.

1.3 Cryptocurrencies vs Currencies

Bitcoin has all attractive criteria of a typical currency: rarity, divisibility, it also has the ability of storage and transfer and lastly, it can be verified. While USD and Euro is divisible to two decimal places, Bitcoin is divisible to eight. If seen
1.3 Cryptocurrencies vs Currencies

from the point of view of scarcity, it is an important property, although a non
useful divisible. Furthermore, Bitcoin is particular rare, since there is a fix supply
of 21,000,000 Bitcoins, totally different of fiat money where financial institutions
can issue new units. Bitcoin, although it is digital and unable to be destroyed,
such as banknotes, it can be a challenge for users not familiar in digital media;
however it can easily be stored, cheaply and for a long time. The ability to distin-
guish genuine from counterfeit Bitcoins makes it superior throughout verification
ensured by technology of Blockchain used. Last but not least, transfers from a
user to another is easy and unrestricted in Blockchain.

Nevertheless, classical economic theory, although recently founded, is based
on well-established foundations and years of studies on trading and behavior of
currencies. Currency is a generally accepted form of money, including coins and
paper notes, which is issued by a government and circulated within an economy,
the basis of trade. Although, in all developed economic systems, such as the Eu-
ropean Union, the United States, Japan and other developed nations, the trend
has been the same: saving has moved away from traditional. Statistics show that
in recent decades, shares have made up an increasingly large proportion of house-
holds’ financial assets in many countries.

The basic difference between Bitcoin and fiat money is the tangibility of fi-
nancial currency. Thus, Bitcoin is based on decentralized peer-to-peer system as
mentioned above, meaning that no banking control or individual control in trans-
actions is taking place. Moreover, financial institutions can issue more units of
US dollar if needed, but Bitcoin has a total amount to be mined. Besides these,
transactions in Blockchain are fully covered with anonymity, through encryption
of users account. However, all transactions made in blocks are known with the
public key in all users. Additionally, in case of mistaken transactions between
users in financial system, bank can negate the trade immediately, which is not a
possible action in Blockchain.
Table 1. *Bitcoin vs Fiat Money*

<table>
<thead>
<tr>
<th></th>
<th>Bitcoin</th>
<th>Fiat Money</th>
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<tr>
<td>decentralized</td>
<td>decentralized</td>
<td>banking control system</td>
</tr>
<tr>
<td>not inflationary</td>
<td>not inflationary</td>
<td>continuous issuing of units</td>
</tr>
<tr>
<td>anonymity</td>
<td>anonymity</td>
<td>named transactions</td>
</tr>
<tr>
<td>transparent system</td>
<td>transparent system</td>
<td>secretive transactions in public</td>
</tr>
<tr>
<td>irrevocable</td>
<td>irrevocable</td>
<td>reversible mistaken transactions</td>
</tr>
</tbody>
</table>

High volatility in Bitcoin value shown in graph 1 in contrast with US dollar market price in graph 2 is an obvious difference added in previous noted ones.

![Figure 1: Bitcoin market price daily](source: FRED Database)

**Figure 1:** Bitcoin market price daily
Source: FRED Database

![Figure 2: US Dollar market price daily](source: FRED Database)

**Figure 2:** US Dollar market price daily
Source: FRED Database

Thus, Bitcoin reached a high value above $19,000 in February 2018, US dollar
market price has no high jumps.

1.3 Cryptocurrencies vs Currencies

1.3.1 Volatility by calculating VIX and CRIX

Volatility index is usually criticized as a prediction of future volatility. Also, although it is known as a measure of investors, portfolio managers and some investors tend to ignore or dismiss volatility forecasting models. Most important of all though is that VIX index is an established volatility measure over time and the way to calculate VIX index is changing and adjusting to get better as a forecasting formula.

The VIX index estimates expected volatility by aggregating the weighted prices of S&P500 index. More specific, the prices used to calculate volatility index values are midpoints or real time SPX option bid price quotations. Firstly options to be used in the VIX index calculation are selecting and afterwards volatility for both near-term and next-term options are calculating. Then both near-term and next-term 30-day weighted average $\sigma^2$ is calculated and at last VIX is calculated as the square root of that value and both near and next term options volatility, multiplied by 100. VIX index is an amalgam of the information reflected in the prices of all of the selected options.

![Figure 3: Total market index (red), S&P500 (purple) and S&P100 (blue) rescaled all to a starting value of 1000](www.thecrix.de)
1.3 Cryptocurrencies vs Currencies

In crypto market exists another benchmark, named Crypto Index, hereafter CRIX index. CRIX is dedicate to give insight about the current and past movement of crypto market. It is real time computed by volatility of all existing cryptocurrencies, such as Bitcoin, Ethereum, Litecoin and other. In general, CRIX is an index for blockchain based currencies. There are two known calculating formulas of crypto index.

\[
I_t = \sum_{i=1}^{n} w_i \frac{P_i(t)}{P_i(t = 0)}
\]

where:

- \( n \) is total amount of Bitcoin calculated in the equation,
- \( w_i \) is weight of \( i \) cryptocurrency,
- \( t \) is time and
- \( P_i \) is market price of \( i \) cryptocurrency.

Most important difference between two indexes, VIX and CRIX, is that volatility index is a forecasting model, crypto index explain the past and the present of market value of cryptocurrencies, indicating useless of CRIX.

![Figure 4: Performance of CRIX Index](www.thecrix.de)
1.4 Thesis Purpose and Important Findings

Does classical economic theory of trading correlate with cryptocurrencies? In particular which are the factors affecting on Bitcoin’s market price daily? Is Volatility Index of S&P500 stock market one of these factors? Or else, activities in Blockchain, such as the number of transactions, the aggregate number of unique addresses or the total value of the trading volume in Bitcoin exchanges does have a significant impact on daily purchase price of Bitcoin?

Using backward stepwise regression model, results have not shown statistically significant impact on returns of Bitcoin. Especially Volatility Index as the only independent variable of last regression have negative effect on returns with a value at -0.005 and $R^2$ at 0.01%. Results lead to negative interpretation on correlation of volatility index and market price of Bitcoin in years examined. Also, neither variable such as the aggregate number of confirmed transactions, the total number of unique addresses on Blockchain, the number of already mined Bitcoins, the total value of the trading volume in all major Bitcoin exchanges or the volume of transactions in Blockchain have a significant effect on market price of Bitcoin.
Chapter 2

Theory

2.1 Volatility Index

Volatility Index (VIX), or 'fear index', is a financial indicator showing expected market volatility in the next 30 days in S&P 500 index of stock market, calculated from a mathematical type and individual volatility of a specific large number of options. It is else called fear index because it shows the expected increasing or decreasing future jump of S&P 500 index. It also includes information about previous leap contributions to overall volatility (Becker, Clements and McClelland (2009)) and reflects elementary information about future activity.

Chicago Board Options Exchange (CBOE) counts volatility index as a useful market monitoring tool and at the same time a negotiable product. Index increases when investors forecast a short term high volatility. The effects of magnitude, momentum and liquidity can not represent either low average returns with high systemic volatility risk, but neither high idiosyncratic volatility. Calculating VIX is an issue through years, due to errors and investors quandary on index validation.

Historical data of volatility index shows variability over years. For example, in graph 5 we locate a large jump of 41 units of volatility in August 2015, which can be caused by economic changes in financial markets.
2.2 Bitcoin and Blockchain

Cryptocurrency is an electronic payment system based on cryptographic proof instead of trust, a crypto peer-to-peer currency without any financial institution management. Most well-known cryptocurrency is Bitcoin, which was developed by a person or group with the pseudonym Satoshi Nakamoto in 2009. Due to open source software of Bitcoin too many developers have been allowed to experiment with his code and modify it. After Bitcoin, too many more cryptocurrencies are existing, such as ethereum, litecoin and ripple with efforts on improving transactions or anonymity.

Bitcoin divides in subunits named Satoshis, more specifically 1 Bitcoin equal 1,000,000 Satoshis. Financial institutions can issue more units of currency if needed, although that is not feasible in Bitcoin, where fix supply of 21 million Bitcoins exists. Huge price volatility is in addition an important characteristic of Bitcoin.

Figure 6 shows the average USD market price of Bitcoin the last two years and
2.2 Bitcoin and Blockchain

is located the high increase in December 2017 in the amount of $19.290

![Figure 6: Average USD market price across major Bitcoin exchanges. Source: blockchain.com](image)

Blockchain is the environment where all transactions of Bitcoin are made. By allowing digital information to be distributed but not copied, blockchain technology created the backbone of a new type of Internet, originally devised for the digital currency, Bitcoin. Information held on a blockchain exists as a shared — and continually reconciled — database. This is a way of using the network that has obvious benefits. The blockchain database isn’t stored in any single location, meaning the records it keeps are truly public and easily verifiable. No centralized version of this information exists for a hacker to corrupt. Hosted by millions of computers simultaneously, its data is accessible to anyone on the Internet. Blockchain technology is like the internet in that it has a built-in robustness. By storing blocks of information that are identical across its network, the blockchain cannot be controlled by any single entity and has no single point of failure.

Blockchain enables creation and real time movement of digital assets and is embedding trust rules insight transactions and interactions. Additionally, Blockchain permits self-execution of business logic and self-enforcement and also selective transparency and privacy. Identity of ownership and representation is authorized
as well as resistance to single points of failure or censorship.

As a meta technology, shared and distributed ledger concludes reengineering processes, new flows of value and new legal and regulatory frameworks. One more Blockchain’s impact is rethinking roles of intermediaries.

Anyone can create a wallet in blockchain, shown as user in others, but not accessible from other users. At the time someone request a transaction it broadcasts to peer-to-peer network consisting of computers known as nodes. The network of nodes validates the transaction and user’s status using known algorithms. A verified transaction can involve cryptocurrency, contracts, records and other information. Once verified, the transaction is combined with other transactions to create a new block of data for the ledger. This new block is then added to the existing (block)chain, in a way that is permanent and unalterable. After that, transaction is complete.

Cryptocurrency is a medium of exchange, created and stored electronically in the Blockchain, using encryption techniques to control the creation of monetary units and to verify the transfer of funds. Bitcoin remains the best known example. It has no physical form and exists only in the network. In addition, it has no intrinsic value in that it is not redeemable for another commodity, such as gold. Lastly, its supply is not determined by a central bank and the network is completely decentralized.
Chapter 3

Literature Review

3.1 VIX Index

Volatility index as a "barometer of fear" (Whaley (2008)) is a benchmark of expected return volatility over the next 30 days. Also, it is proved (Jiang and Tian(2007)) how crucial VIX is in maintaining market stability and growth and more importantly in investor confidence.

Furthermore, long-term volatility tend over-priced the futures contracts; although errors are reduced when period examined limited in one year (Zhang and Zhu (2006)).

Other empirical research have shown that VIX reflects past jump activity of S&P500 (Becker, Clements and McClelland(2009)), but forecast errors are not correlate to past information of jump activity.

3.2 CRIX Index

In contrast of VIX for stocks and ECU index for euro, CRIX was created (Härdle and Trimborn(2015)) as an index for Blockchain based Cryptocurrency and the approximately common features and formula of ECU. Another approach of CRIX index for the crypto market based on the AIC to record market changes.
Although, different formulas, explain different attributes and characteristics of crypto market, only though in real time and not as a forecasting model.

In order to model volatility using attributes of CRIX index to aid investors and portfolio managers for financial decisions, another version of CRIX was created (Trimborn and Härdle (2016)). It was identified (Elendner et others (2016)) that increasing market value contributes liquidity enlargement. Additionally, as cryptocurrencies expand, crypto market capitalization lead to increase.

3.3 Cryptocurrency

Cryptocurrency may still not be considered a currency so far, but it is being investigated as a commodity and stock. Researched market efficiency of Bitcoin was tested by five (Urquhart, A. (2016)) and by eight different tests (Nadarajah and Chu (2017)). Although Bitcoins returns did not satisfy the efficient market hypothesis first time, it was satisfied by eight different tests approach. Furthermore, using Detrendent Fluctuation Analysis model, Hurst exponent computed on Bitcoin’s case (Fernandez Bariviera, Basgall and Naiouf, M. (2017)) and volatility found on first years of Bitcoin existence, something that tend to stabilize though after 2016. Volatility estimation for Bitcoin examined (Katsiampa (2017)) and best conditional heteroskedasticity model found to be AR-CGARCH with conditional variance the most important parameter.

Although, cryptocurrencies are examined also as assets in a variety of working papers. Tail-Risk is significantly high in cryptocurrencies within cryptomarkets (Borri (2018)) but Bitcoin, Ethereum and Litecoin are not exposed to tail-risk with respect to other traditional global assets like gold. Afterwards, without currency existence, Bitcoin can be used as a hedge against US dollar in short term and also Financial Times Stock Exchange Index (Dyhrberg (2016)).

Consequently, trading values of Bitcoin explained by ARMA model (MacDonell (2014)) and its reaction in volatility index (VIX) shows promptness in non tra-
3.3 Cryptocurrency

ditional investors. Different approach using price clustering (Urquhart (2017)) displays significant correlation between Bitcoin’s price and volume. Furthermore, volume found that can predict returns (Balcilar et others (2017)) but not volatility of returns with non-linearity models and structural breaks in testing.

More specific, correlation between volatility index (VIX) and return of Bitcoin market price was identified at 5% significant level (Estrada (2017)). However, prediction of Bitcoin market price return explained by volatility index, unique addresses in blockchain, realized volatility and traded volume (de Vries and Aalborg (2017)) but not with significant results and $R^2$ explanation in only 1% of the variation in Bitcoin returns.

This dissertation proceed as follows: Description of data and methodology based on appropriate econometric models are presenting in Chapter 4. After that, Chapter 5 discusses the empirical methodology employed to address research question that was set and also, show and discusses results briefly. Thesis concludes with remarks, comments and suggestions for further research, respectively.
Chapter 4

Methodology

4.1 Data Collection

In this empirical study we decided to find a way to examine which factors can impact on Bitcoin market price and the volatility that market price has. Literature review aware a variety of factors that could affect significantly on Bitcoins returns.

A useful sample consists of the following variables: Market price of Bitcoin, volatility index, market capitalization, number of transactions, trade volume, transaction volume, number of unique addresses, output volume and total amount of Bitcoins.

**Bitcoin’s market price:** Average purchase price in US dollars at all major Bitcoin exchanges.

**Volatility Index:** Expected market volatility in the next 30 days in S&P 500 index of stock market calculated by CBOE, daily data.

**Market Capitalization:** The total US dollars value of Bitcoin in currency, daily data.

**Number of Transactions:** The aggregate number of confirmed Bitcoin transactions in the past 24 hours, daily data.
Trade Volume: The total value in US dollars of the trading volume in the major
Bitcoin exchanges calculated daily.

Transaction Volume: The total number of Bitcoin transactions per day.

Unique Addresses: The total number of unique addresses used on the Bitcoin
Blockchain daily.

Output Volume: Volume of transactions in Blockchain daily.

Total Bitcoins: The total number of Bitcoins that have already been mined,
daily data.

4.2 Transactions and Stationarity tests

A stationary time series is one whose statistical properties such as mean, variance,
autocorrelation, etc. are all constant over time. The most important point to be
mentioned is that most of our useful time series theory applies only to stationary
variables and not to non-stationary variables. Most statistical forecasting methods
are based on the assumption that the time series can be rendered approximately
stationary through the use of mathematical transformations.

Another reason for trying to stationarize a time series is to be able to obtain
meaningful sample statistics such as means, variances, and correlations with other
variables. Such statistics are useful as descriptors of future behavior only if the
series is stationary. For example, if the series is consistently increasing over time,
the sample mean and variance will grow with the size of the sample, and they will
always underestimate the mean and variance in future periods. And if the mean
and variance of a series are not well-defined, then neither are its correlations with
other variables. For this reason you should be cautious about trying to extrapolate
regression models fitted to non-stationary data.

Intuitively a time series variable is stationary across some equilibrium path if
after a shock it tends to return to that path. A series is non-stationary if it moves
to a new path after a shock. It is very hard to model the path of a variable that
changes path if it is subject to some shock. Thus we try to find ways to extract
and model the stationary part of a time series.

Most business and economic time series are far from stationary when expressed
in their original units of measurement, and even after deflation or seasonal adjust-
ment they will typically still exhibit trends, cycles, random-walking, and other
non-stationary behavior.

In an effort of being able to use the classical economic-statistical theory, time
series should be stationary, something which does not happen in our time series
as they are according to Dickey-Fuller tests. So the variables will have to be mod-
ified in order to be normalized. In our empirical study we used logarithmic first
differences and z-score normalization methods.

Return of Bitcoin’s price:
\[ return_t = \log(price_t) - \log(price_{t-1}) \]

Return of volatility index:
\[ VixInd_t = \log(VixInd_t) - \log(VixInd_{t-1}) \]

Logarithmic first differences of market capitalization:
\[ marketCap_t = \log(marketCap_t) - \log(marketCap_{t-1}) \]

Logarithmic first differences of number of transactions:
\[ numTrans_t = \log(numTrans_t) - \log(numTrans_{t-1}) \]

z-score Normalization of trade volume:
\[ tradeVol_t = \frac{Vol_t - \bar{Vol}}{\sigma(Vol)} \]
4.3 Model

z-score Normalization of transaction volume:
\[ transVol_t = \frac{Vol_t - \bar{Vol}}{\sigma(Vol)} \]

Logarithmic first differences of unique addresses:
\[ add_t = log(add_t) - log(add_{t-1}) \]

z-score Normalization of output volume:
\[ outVol_t = \frac{Vol_t - \bar{Vol}}{\sigma(Vol)} \]

Logarithmic first differences of total Bitcoin:
\[ totBit_t = log(totBit_t) - log(totBit_{t-1}) \]

4.3 Model

In this empirical analysis we tried to approach the question with linear regressions. Linear regression estimates coefficients to examine the impact and the direction of the effect of independent variables on dependent variable. The mathematical type of linear regression is the following: \( y = a + \beta x + \epsilon_i \) and constant \( \hat{a} \) and estimator \( \hat{\beta} \) are explaining the affection.

Furthermore, stepwise regression is a method of fitting regression models in which the choice of predictive variables is carried out by an automatic procedure. One of the main approaches of stepwise regression is backward elimination, which involves starting with all candidate variables, testing the deletion of each variable using a chosen model fit criterion, deleting the variable (if any) whose loss gives the most statistically insignificant deterioration of the model fit, and repeating this process until no further variables are deleted without a statistically significant loss of fit.

Most business and economic time series are far from stationary when expressed in their original units of measurement, and even after deflation or seasonal adjust-
4.3 Model

ment they will typically still exhibit trends, cycles, random-walking, and other non-stationary behavior.

Augmented Dickey-Fuller (hereafter ADF) tests the null hypothesis that a unit root is present in a time series sample. The augmented Dickey–Fuller (ADF) statistic, used in the test, is a negative number. The more negative the number, the stronger the rejection of the hypothesis that there is a unit root at some level of confidence.
Chapter 5

Economic Analysis

5.1 Data

In order to find which cryptocurrency factors affect on the jump of volatility index, we collected everyday data from January 1st, 2014 till December 31st, 2017, which means that all variables have the same number of observations (1461 obs) as time series. We collected with python code Bitcoin market price and trade volume from coinmarket\(^1\) and stoke’s market Volatility Index (VIX) from CBOE\(^2\) across the same time period 2014-2017. All other variables used where collected from Blockchain.

In detail, our sample consists of the following variables: Market price of Bitcoin, volatility index, market capitalization, number of transactions, trade volume, transaction volume, number of unique addresses, output volume and total amount of Bitcoins.

Some summary statistics of every variable are shown in the following table. These are mean, standard deviation, minimum value, maximum value and number of observations of all variables. We observe a big range from minimum to maximum rate of Bitcoin’s market price during these three years, communicating jumps in exchange of Bitcoin. An increase in the number of unique addresses it

\(^1\)www.coinmarket.com
is also noticed, which shows more created accounts over these years. Next table 2 presents all these informations about the sample and all used variables.

**Table 2. Summary Statistics of Variables**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
<th>Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitcoin market price</td>
<td>1341.176</td>
<td>2537.796</td>
<td>176.5</td>
<td>19498.68</td>
<td>1461</td>
</tr>
<tr>
<td>VIX closing price</td>
<td>14.42205</td>
<td>3.942811</td>
<td>9.14</td>
<td>40.74</td>
<td>1461</td>
</tr>
<tr>
<td>market capitalization</td>
<td>$2.15 \times 10^{10}$</td>
<td>$4.27 \times 10^{10}$</td>
<td>$2.42 \times 10^{9}$</td>
<td>$3.27 \times 10^{11}$</td>
<td>1461</td>
</tr>
<tr>
<td>num of transactions</td>
<td>176324.8</td>
<td>91370.87</td>
<td>41476</td>
<td>490.644</td>
<td>1461</td>
</tr>
<tr>
<td>trade volume</td>
<td>$1.17 \times 10^{8}$</td>
<td>$3.59 \times 10^{8}$</td>
<td>2031246</td>
<td>$5.35 \times 10^{9}$</td>
<td>1461</td>
</tr>
<tr>
<td>unique addresses</td>
<td>345319.4</td>
<td>172881.5</td>
<td>83356</td>
<td>1072861</td>
<td>1461</td>
</tr>
<tr>
<td>output volume</td>
<td>1925597</td>
<td>2225646</td>
<td>245926.7</td>
<td>$4.60 \times 10^{7}$</td>
<td>1461</td>
</tr>
<tr>
<td>total bitcoins</td>
<td>$1.48 \times 10^{7}$</td>
<td>$1360690$</td>
<td>$1.22 \times 10^{7}$</td>
<td>$1.68 \times 10^{7}$</td>
<td>1461</td>
</tr>
<tr>
<td>est. transaction volume</td>
<td>232455.2</td>
<td>107959.1</td>
<td>39199</td>
<td>931548</td>
<td>1461</td>
</tr>
</tbody>
</table>

Note: All statistics are from collected data using Stata.
5.2 Augmented Dickey-Fuller tests

Table 3. Augmented Dickey-Fuller test results

<table>
<thead>
<tr>
<th></th>
<th>test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>return of market price</td>
<td>-28.469</td>
<td>0.000</td>
</tr>
<tr>
<td>VIX Index</td>
<td>-27.231</td>
<td>0.000</td>
</tr>
<tr>
<td>market cap.</td>
<td>-28.440</td>
<td>0.000</td>
</tr>
<tr>
<td>num. transactions</td>
<td>-36.594</td>
<td>0.000</td>
</tr>
<tr>
<td>transactions vol</td>
<td>-13.566</td>
<td>0.000</td>
</tr>
<tr>
<td>trade vol</td>
<td>-7.984</td>
<td>0.000</td>
</tr>
<tr>
<td>addresses</td>
<td>-41.926</td>
<td>0.000</td>
</tr>
<tr>
<td>output volume</td>
<td>-15.032</td>
<td>0.000</td>
</tr>
<tr>
<td>total bitcoins</td>
<td>-10.882</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Note: ADF tests of collected data used Stata

According to previous Table 3, all variables have negative test statistic and the null hypothesis is rejected that there is a unit root. For example, return of Bitcoin’s market price has a test statistic -28.469 and p-value ≤ 0.05 so the null hypothesis \( H_0 \) is rejected so the data does not have a unit root and is stationary. This is valid from table 2 for all normalized data in our sample.

5.3 Model used

In our empirical study was most appropriate to run a stepwise regression model with backward elimination in Stata program\(^3\). Coefficients of all independent variables were estimated according to linear regressions of equations (1) to (8). Firstly, we started with all variables in regression and step by step we eliminated one by

\(^3\)Code used in Stata in Appendix A
5.3 Model used

one the independent variables to end with just one (return of volatility index).

\[ return_t = \alpha + \beta_1 * VixInd_t + \beta_2 * marketCap_t + \]
\[ + \beta_3 * numTrans_t + \beta_4 * transVol_t + \beta_5 * tradeVol_t + \]
\[ + \beta_6 * add_t + \beta_7 * outputVol_t + \beta_8 * totBit_t + \epsilon_t \]

(5.1)

\[ return_t = \alpha + \beta_1 * VixInd_t + \beta_2 * marketCap_t + \]
\[ + \beta_3 * numTrans_t + \beta_4 * transVol_t + \]
\[ + \beta_5 * tradeVol_t + \beta_6 * add_t + \beta_7 * outputVol_t + \epsilon_t \]

(5.2)

\[ return_t = \alpha + \beta_1 * VixInd_t + \beta_2 * marketCap_t + \]
\[ + \beta_3 * numTrans_t + \beta_4 * transVol_t + \]
\[ + \beta_5 * tradeVol_t + \epsilon_t \]

(5.3)

\[ return_t = \alpha + \beta_1 * VixInd_t + \beta_2 * marketCap_t + \]
\[ + \beta_3 * numTrans_t + \beta_4 * transVol_t + \]
\[ + \epsilon_t \]

(5.4)

\[ return_t = \alpha + \beta_1 * VixInd_t + \beta_2 * marketCap_t + \]
\[ + \beta_3 * numTrans_t \]
\[ + \epsilon_t \]

(5.5)

\[ return_t = \alpha + \beta_1 * VixInd_t + \beta_2 * marketCap_t + \epsilon_t \]

(5.6)

\[ return_t = \alpha + \beta_1 * VixInd_t + \epsilon_t \]

(5.7)
5.3 Model used

Graph 7 shows a combination of Bitcoin’s market price and volatility index after normalization. There is a clear suspicion of stationarity, something which must be tested about all variables after transactions.

![Time series graph: Return of Bitcoin’s market price and Return of volatility index over time](image)

**Figure 7**: Time series graph: Return of Bitcoin’s market price and Return of volatility index over time
Source: Stata graph from used data

The following scatterplot can inform us about expecting estimator $\hat{\beta}_1$ of equation (8). The shotgun pattern of scatter 8 indicates no correlation between returns of Bitcoin’s market price and returns of volatility index.
5.3 Model used

Figure 8: Scatterplot: Return of Bitcoin market price and Return of VIX
Source: Stata graph from used data

Furthermore, scatterplot 9 shows a positive correlation between returns of Bitcoin’s market price and market capitalization, which is valid since market capitalization includes market price of Bitcoin.

Figure 9: Scatterplot: Return of Bitcoin market price and Market Capitalization
Source: Stata graph from used data
5.4 Results

Although, to be comprehensive, regressions’ results will validate or not previous suspicions from graphs. Stepwise regression’s model computed step by step all coefficients and can be informative on the correlation of every independent variable positive or negative, statistically significant or not. The following table comprises results of the stepwise regression model.

<table>
<thead>
<tr>
<th></th>
<th>$\alpha$</th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
<th>$\beta_3$</th>
<th>$\beta_4$</th>
<th>$\beta_5$</th>
<th>$\beta_6$</th>
<th>$\beta_7$</th>
<th>$\beta_8$</th>
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<tr>
<td>(1)</td>
<td>0.001</td>
<td>-0.006</td>
<td>0.984***</td>
<td>-0.001</td>
<td>-0.001</td>
<td>0.001</td>
<td>-0.001</td>
<td>0.001</td>
<td>-2.001</td>
<td>96.94%</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.004)</td>
<td>(0.007)</td>
<td>(0.001)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(1.996)</td>
<td></td>
</tr>
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<td>(2)</td>
<td>-0.001</td>
<td>-0.006</td>
<td>0.985***</td>
<td>-0.001</td>
<td>-0.001</td>
<td>0.001</td>
<td>-0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>96.94%</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.004)</td>
<td>(0.006)</td>
<td>(0.001)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.004)</td>
<td>(0.0000)</td>
<td></td>
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<tr>
<td>(3)</td>
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<td>-0.001</td>
<td>-0.001</td>
<td>0.001</td>
<td>-0.001</td>
<td>0.001</td>
<td>-0.001</td>
<td>96.94%</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.004)</td>
<td>(0.006)</td>
<td>(0.001)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
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<tr>
<td>(4)</td>
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<td>-0.001</td>
<td>-0.001</td>
<td>0.001</td>
<td>-0.001</td>
<td>0.001</td>
<td></td>
<td>96.94%</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.004)</td>
<td>(0.006)</td>
<td>(0.001)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
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</tr>
<tr>
<td>(5)</td>
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<td>0.985***</td>
<td>-0.001</td>
<td>-0.001</td>
<td></td>
<td>-0.001</td>
<td></td>
<td></td>
<td>96.94%</td>
</tr>
<tr>
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<td>(0.006)</td>
<td>(0.001)</td>
<td>(0.000)</td>
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<td>(0.000)</td>
<td>(0.000)</td>
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</tr>
<tr>
<td>(6)</td>
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<td>96.94%</td>
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<tr>
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<td>(0.004)</td>
<td>(0.006)</td>
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<td>(0.000)</td>
<td>(0.000)</td>
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<tr>
<td>(7)</td>
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<td></td>
<td></td>
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<td>96.94%</td>
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<tr>
<td></td>
<td>(0.000)</td>
<td>(0.004)</td>
<td>(0.006)</td>
<td>(0.000)</td>
<td>(0.004)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
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</tr>
<tr>
<td>(8)</td>
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<td>-0.005</td>
<td>0.00%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>96.94%</td>
</tr>
</tbody>
</table>

Note: Stata regressions with collected data
5.4 Results

Analytically, results of regressions’ coefficients are not statistical significant except market capitalization variable. Being aware that the total USD value of Bitcoin in currency includes the average purchase price in USD at all major Bitcoin exchanges, this statistical significant positive correlation is expected. Furthermore, regressions $R^2$ shows that affection explains 96.94% of the sample, although in last regression $R^2$ equals 0.01%, which means that previous regressions $R^2$ is not that valid and concerns only market capitalization’s impact.

More closely, equation (1) with estimators of all variables resulted positive effectiveness of market capitalization with 1% statistical significance, of variable of trade volume and of the output volume variable. Nonetheless, there is a negative correlation between returns and volatility index, number of transactions made, transaction volume, number of unique addresses and number of total Bitcoin. By increasing one percentage of returns, returns of VIX seem to decrease about 0.059 percentage units, market capitalization increases by 0.9844, number of transactions made in Blockchain decreases by 0.001 percentage units, transactions volume decreases 0.0001 percentage units, trade volume increases 0.00001, number of unique addresses decreases by 0.0001 percentage units, output volume increases by 0.0001 and total Bitcoins decreases 2.0009 percentage units.

In equation (2), total Bitcoins excluded and brought a change in direction of effectiveness in constant coefficient. All other estimators have approximately the same impact as in equation (1). Nothing changes in estimators direction and effect until equation (6). Also market capitalization has 1% statistical significance across all equations and $R^2$ is in the same percentage at 96.94%.

As independent variables reduces, in equation (7) when returns of Bitcoin market price increases by a percentage unit, constant coefficient decreases by 0.0001 units, returns of volatility index decreases by 0.0062 percentage units and market capitalization increases by 0.9845 percentage units with 1% significance and 96.94% explanation of the sample.

In last equation, results show explanation of 0.01% by $R^2$. Furthermore, a
percentage change in returns of Bitcoin’s market price leads to 0.0046 percentage units decreasing in returns of volatility index and increasing in constant coefficient about 0.0009 units.

Previous estimations lead to negative interpretation on correlation of volatility index and market price of Bitcoin in years examined. Also, neither of other variables such as the aggregate number of confirmed transactions, the total number of unique addresses on Blockchain, the number of already mined Bitcoins, the total value of the trading volume in all major Bitcoin exchanges or the volume of transactions in Blockchain have a significant effect on market price of Bitcoin. Meaning that the purchase price in US dollars of Bitcoin was not affected significantly by any of these factors.
Chapter 6

Conclusions

Cryptocurrency has gained ground fast the last years and interest from economics is growing fast, too. However though, this interest mainly includes theoretical considerations as to whether Bitcoin can adequately perform fiat money operations, as well as studies on money supply and inflation. Additionally, one of forecasting models about stocks in well established financial market, Volatility Index (VIX), it is not verified yet if it applies on crypto market, where a new benchmark (CRIX) created in order to explain crypto market’s reaction.

Following de Vries and Aalborg (2017), in this dissertation we tried to examine if returns of the average purchase price in US dollar is correlate with expected market volatility, calculated as VIX index. Also, with transaction and trade data from Blockchain, we made an effort to include more variables in the equation of linear regression with return as dependent variable. Variables examined where collected in the same period (January 1st, 2014 till December 31st, 2017) so that validation of results does not counterfeit. All variables where transformed with z-score normalization or by calculating returns and in addition, where tested through Augmented Dickey-Fuller test in order to be stationary time series Econometric model used was stepwise linear regression model.

The principal finding of this analysis is the negative correlation of volatility index and Bitcoin’s market price, although without statistic significant impact.
Computing coefficients of a backward stepwise regression model in order to answer the basic question of this empirical study, results have shown that neither of other variables such as the aggregate number of confirmed transactions, the total number of unique addresses on Blockchain, the number of already mined Bitcoins, the total value of the trading volume in all major Bitcoin exchanges or the volume of transactions in Blockchain have a significant effect on market price of Bitcoin.

First step of backward stepwise regression model resulted positive effectiveness of market capitalization, of variable of trade volume and of the output volume variable. Nonetheless, there is a negative correlation between returns and volatility index, number of transactions made, transaction volume, number of unique addresses and number of total Bitcoin. Statistically significant results found only in market capitalization’s variable impact in 1%. No other independent factor have shown statistical significant results.

Although, our model has also disadvantages. This empirical study didn’t run linear regressions separately to examine individual impact of every factor. Furthermore, by examine only a linear model, non linearity is missing. We don’t know if square root or exponent of a variable of the ones used may affect on return of Bitcoin. Moreover, we only use one model and we do not add more variables. At last, CRIX index was not included in regression, due to its uselessness described in first chapter.

Further studies to continue that may could answer the question of which are the factors effecting on returns of Bitcoin’s market price daily would may be examination of different factors or maybe a different model like a non-linear regression model using for example the ratio of \( \frac{\text{returnsofmarketprice}}{\text{returnsofvolatilityindex}} \). Another approach could be a model using square root of volatility index or an exponential form of factors.

Significant results may outcome by linear regressions running with examined factors individually. An alternative approach may be another combination in the order of independent variables. Factors that could be different would be using
another volatility index, for example ECU index for euro currency and check currency and cryptocurrency correlation.

Despite the fact that CRIX is not useful as a forecast measure index, it may affect on returns of Bitcoin market price. Although, this approach involves the risk that CRIX may include weighted Bitcoin return. This lead us to the option of not including Bitcoin when calculating crypto index.
Appendix A

Stata Script

(1) Import data in Stata environment through 'File' → 'Import' and click on the type of your data spreadsheet so you can find the file and use it in Stata program.

(2) Explain to stata program that your data are time series with 'tsset' command in command line and Date variable of your sample.

\textit{tsset Date}

(3) In order to test with Augmented Dickey-Fuller test all the variables, use 'dfuller' command in command line before variable name and use at will trend, number of lags or seasonality.

\textit{dfuller returns, trend regress lags(1)}

\textit{dfuller Vixind, trend regress lags(1)}

\textit{dfuller marketcap, trend regress lags(1)}

\textit{dfuller ntrans, trend regress lags(1)}
dfuller transvol, trend regress lags(1)

dfuller tradevol, trend regress lags(1)

dfuller add, trend regress lags(1)

dfuller outvol, trend regress lags(1)

dfuller totbtc, trend regress lags(1)

(4) Do the stepwise regression model by 'reg' command in command line. Firstly, put all variables after command (with dependent variable leading the row) and step by step start deescalate one by one the independent variables. Use 'robust' after for heteroscedasticity-consistent standard errors.

reg returns Vixind marketcap ntrans transvol tradevol add outvol totalbtc, robust

reg returns Vixind marketcap ntrans transvol tradevol add outvol, robust

reg returns Vixind marketcap ntrans transvol tradevol add, robust

reg returns Vixind marketcap ntrans transvol tradevol, robust

reg returns Vixind marketcap ntrans transvol, robust

reg returns Vixind marketcap ntrans, robust
reg returns Vixind marketcap, robust

reg returns Vixind, robust
References


REFERENCES


REFERENCES

Dame working paper.


