Predictive Price Model for Buy-Sell Bitcoin

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Abstract

This study aims to find a suitable forecasting model for buying and selling bitcoin by using external factors of finance and commodities which can be divided into five major groups: foreign exchange rates, safe assets, crude oil price, the volume of buying and selling bitcoin, and stock market price index. This study used bitcoin price data collected from January 1, 2016 to March 31, 2018. However, we will consider only the latter data collected after the highest value of bitcoin, from December 27, 2017 to October 31, 2018 and we use analysis in the form of multiple linear regression, factor analysis and the Box-Cox transformation theory. When analyzing the data, it was found that $\hat{Y}^{-09} = 0.001 - 1.333\times10^{-8} F_1 - 2.360\times10^{-14} F_2 - 1.180\times10^{-8} F_3 - 1.241\times10^{-8} F_3$ is a better forecasting equation than other forecasting equations when forecasting for a short period of time only. The first factor is Chinese and South Korean stock market price index, safe assets and the foreign exchange rate. The second factor is oil prices and the volume of buying and selling of bitcoin. The third factor is Japan and Germany stock market price index and the fourth factor is the stock market price index for the U.S., Canada and Australia.

Keywords: Bitcoin, Exchange Rates, Gold Price, Stock Market, Oil Prices

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ตัวแบบการพยากรณ์ราคาการซื้อ-ขายบิทคอยน์

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บทคัดย่อ

งานวิจัยนี้มีจุดประสงค์ของการศึกษาเพื่อหาตัวแบบพยากรณ์ราคาการซื้อ-ขายบิทคอยน์ที่เหมาะสม โดยอาศัยปัจจัยภายนอกที่อยู่ในขอบเขตของด้านการเงิน และสินค้าโภคภัณฑ์ 5 กลุ่มใหญ่ ๆ ได้แก่ อัตราแลกเปลี่ยนเงินตราต่างประเทศ สินทรัพย์ปลอดภัย ราคาน้ำมันดิบ ปริมาณการซื้อ-ขายบิทคอยน์ ดัชนีราคาตลาดหลักทรัพย์ และอื่น ๆ ซึ่งข้อมูลราคาบิทคอยน์ที่ใช้เป็นข้อมูลรายวันย้อนหลังตั้งแต่วันที่ 1 มกราคม พ.ศ. 2559 ถึงวันที่ 31 มีนาคม พ.ศ. 2561 โดยทำการวิเคราะห์ข้อมูลถัดจากช่วงที่บิทคอยน์มีราคาสูงสุด คือ ตั้งแต่วันที่ 27 ธันวาคม พ.ศ. 2560 ไปจนถึงวันที่ 31 ตุลาคม พ.ศ. 2561 และใช้การวิเคราะห์ในรูปแบบสมการถดถอยเชิงเส้นพหุ (Multiple linear regression) การวิเคราะห์ปัจจัย (Factor analysis) และทฤษฎี Box-Cox transformation ผลจากการศึกษา พบว่า $\hat{Y}^{-09} = 0.001 - 1.333\times10^{-8} F_1 - 2.360\times10^{-14} F_2 - 1.180\times10^{-8} F_3 - 1.241\times10^{-8} F_3$ เป็นสมการพยากรณ์ที่ดีกว่าสมการพยากรณ์อื่น เมื่อพยากรณ์ในช่วงระยะเวลาสั้น ๆ เท่านั้น โดยที่ F_1 คือ ดัชนีราคาตลาดหลักทรัพย์จีน และเกาหลีใต้ สินทรัพย์ปลอดภัย และอัตราแลกเปลี่ยนเงินตราต่างประเทศ F_2 คือ ราคาน้ำมันและปริมาณการซื้อ-ขายบิทคอยน์ F_3 คือ ดัชนีราคาตลาดหลักทรัพย์ญี่ปุ่นและเยอรมนี และ F_3 คือ ดัชนีราคาตลาดหลักทรัพย์อเมริกา แคนาดา และออสเตรเลีย

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1. Introduction

Bitcoin was the first created cryptocurrency and is the most well-known. Bitcoin was created with a computer language and thus it has no owners, no shape and it is immaterial which is different from banknotes or coins (Siamblockchain, 2014) In bitcoin systems, the number of coins has a maximum limit of 21 million bitcoins (Goalbitcoin, 2017b) and it is also the most popular digital currency that the market has almost completely accepted for most buy-sell exchanges compared to other digital currencies. The advantages of bitcoin is that it has a low cost of transaction, and those who confirm a transaction will be rewarded with a bitcoin that has already been created. In addition, bitcoin is difficult to detect so it is popular in many countries that have restrictions on money transfers and political problems (Lueangnarumitchai, 2015).

Nowadays, many countries have begun to accept bitcoin such as the U.S., Canada and Japan. Bitcoin can be used instead of cash and these countries also passed legislation to control the use of Bitcoin in 2015 (Kapook, 2014). Japan and South Korea passed legislation to control digital money to be used correctly and control tax status and safety of use, and also prevent money laundering and illegal use (Mgronline, 2017; Todaylineme, 2017). In Japan, the government introduced bitcoin as a way to stimulate the economy and counter deflation that has persisted for more than 30 years. Moreover, 10 major companies in the U.S. accept payments with bitcoin: PayPal, Dell, WordPress, Dish, Wikipedia, Subway, EBay, Microsoft, Apple Store and Amazon (Goalbitcoin, 2017a). Bitcoin can be used to buy and sell products instead of cash whether making purchases of products on Amazon, booking hotels, booking air tickets, making payment of tuition fees, ordering a pizza, using a VPN service, buying a diamond, buying and selling Dell computers, buying Windows operating systems and purchasing via gift card. There are currently more than 100,000 shops and services that accept bitcoins around the world (Jiraboon, 2017a).

Many countries have begun to accept bitcoin and people are using it to buy and sell more. Therefore, Bitcoin has become an increasingly attractive investment alternative. Also, as bitcoin can be used legally in many countries, it may affect many organizations or businesses in terms of finance and other aspects. In addition, the creator of Bitcoin Satoshi Nakamoto said, “We have proposed a system for electronic transactions without relying on trust” (Nakamoto, 2008). The excerpt implies that bitcoin is a social economic product

as trust was explicitly mentioned. Therefore, bitcoin might be a significant economic indicator in the future (Kapook, 2014; Secretariat of the House of Representatives Academic group, 2017). However, bitcoin currency is still considered a new currency to the society. Although it was created nearly 10 years ago, people have become seriously interested in bitcoin in only the last 2-3 years in Thailand. Furthermore, few researchers have studied bitcoin. However, Greaves and Au (2015) used a Regression Model consisting of Linear Regression and SVM Regression, and classification model that consisted of Logistic Regression SVM and Neural Network in an analysis of bitcoin price. It was found that the price forecast of bitcoin in dollars 1 hour in advance was accurate. The movement of bitcoin price was approximately 55%. McNally (2016) used Machine Learning in their analysis and found that the operations of Bayesian optimized recurrent neural network (RNN) and Long Short Term Memory (LSTM) networks are the most accurate. Moreover, Jang and Lee (2017) used Bayesian Neural Networks to analyze bitcoin and found Bayesian neural networks (BNNs) predict the price of bitcoins and explains the high volatility of the latest bitcoin prices best. All these studies discussed above used external factors in their analyses.

Figure 1 shows the fluctuation in the bitcoin price which was significantly higher by the end of 2017 due to the separation Bitcoin to Cash (BCH) on July 1, 2017, and the update of bitcoin to Segwit2X (B2X) on August 1, 2017. Later, there is a new version of the protocol that separates the back line bitcoin from the block number 491,407 on the blockchain of Bitcoin to Bitcoin Gold (BTG) on November 1, 2017 and it is allowed to download on November 12, 2017 (Jiraboon, 2017b). In addition, the largest financial institution which provides buy-sell option market in the U.S., the Chicago Board Options Exchange (CBOE), launched Bitcoin Futures on December 10, 2017 (DAVITT, 2017). After that, Chicago Mercantile Exchange & Chicago Board of Trade, also known as CME Group Inc. (CME), launched the same product on December 18, 2017 (Jiraboon, 2017d, 2017e) Then, on 28 December 2017, it has returned to use B2X again after announcing the cancellation of the hard fork on November, 2017. After that, began the buying and selling of Bitcoin Diamond (BCD) which resulted from the separation from bitcoin on January 16, 2018. The amount of bitcoin, which is limited to 21 million BTC, was increased to 210 million BCD (Blognone, 2017b) and there was another digital currency which separated from Bitcoin to BitcoinZ (BTCZ) on February 22, 2018 (Blognone, 2017a).

However, there are still a large number of groups that want to separate from bitcoin lines, including Bitcoin Silver, Bitcion Platinum, Bitcoin Uranium, Bitcoin Cash Plus, Super Bitcoin and Lightning Bitcoin (Arstechnica, 2017). This may affect the bitcoin price in the short term.

Since the researcher who had studied forecasting the bitcoin price as mentioned above used internal factors to analyze in a very short period of time, the differences on the overall bitcoin price may not be seen. Therefore, the researcher is interested in applying external factors in forecasting in order to develop a suitable model for forecasting bitcoin prices.

Figure 1: Bitcoin Amount by Currency

2. Related Documents and Research

Based on documents and research related to bitcoin, the researcher found that the same independent variables that are external factors other researchers have used in their studies are the gold price, foreign exchange rate, bitcoin exchange rates for foreign currencies and the S&P 500 index.

However, Bitcoin is similar to shares (Prachachat Business, 2017). The researcher studied the independent variables obtained from documents and research related to stock prices. It was found that independent variables that are external factors other researchers have used in their studies are the Dow Jones Industrial Index, foreign exchange rates, gold prices and crude oil price index. Therefore, the variables that the researcher is interested in studying are the Dow Jones Industrial Index and crude oil price index.

According to documents and research related to bitcoin price and stock price, and also the study of variables related to the stock market index, and the information on Siam blockchain, which is a collection of news and information about the major digital currency of Thailand, here is a summary of the information pertaining to bitcoin.

1. Japan was the first country that accepted bitcoin as a currency.
2. The U.S. collects bitcoin tax.
3. China accepts bitcoin and has been considered to have the highest level of bitcoin mining.
4. Finanzen.net, the largest financial website in Germany, has listed bitcoin as the main currency.

Moreover, Marketingoops reveals that Canada had the world's first bitcoin ATM, and the latest data of CoinATMradar suggests that the country with the largest number of bitcoin ATMs installed is the U.S., Canada and Austria respectively. In addition, the UPbit.com, one of the top five bitcoin trading international websites, had the highest level of the buying and selling of bitcoin in 2018, and it is supported only for Korean traders.

All the above-mentioned information shows that bitcoin is accepted and there are a large number of investors who are interested in investing in bitcoin in these countries. Therefore, the researcher is interested in studying the stock market index variables in the stock exchange of Japan, the U.S., China, Germany, Canada, Australia and South Korea.

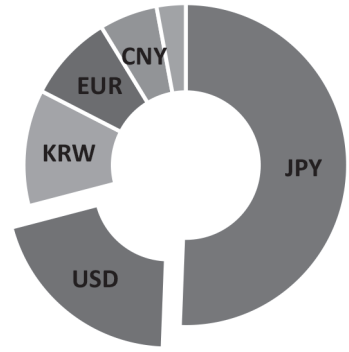


Figure 2: Bitcoin Amount by Currency
Source: https://bitcoin-addict.com/2017/10/05/why-bitcoin-depend-on-japan-and-south-korea

Figure 2 shows the amount of buying and selling of bitcoin. It has been bought and sold most in Japanese yen (JPY), U.S. dollar (USD), South Korean won (KRW), euro (EUR) and Chinese yuan (CNY), respectively. Therefore, the variable of the foreign exchange rate that the researcher is interested in studying is the currency exchange rate of the Japanese Yen, U.S. Dollar, South Korean Won, the Euro and Chinese Yuan.

According to the demand and supply principles, the buy-sell price is related to the volume of buying and selling. Therefore, the amount of buying and selling bitcoin is another study variable. The independent variables used in this study can be summarized as follows: the foreign exchange rate of the Japanese yen, U.S. dollar, South Korean won, Euro and Chinese yuan; gold prices including gold spot price (USD), platinum spot price (USD), gold futures contract (USD) and platinum futures contract (USD); crude oil price, which is the oil price from major markets in the world including WTI crude oil spot prices (USD), WTI crude oil futures contracts (USD), Brent oil futures contracts (USD) and US gasoline futures contracts (USD) as the U.S. is the country that imports most oil in the world; the volume of bitcoin buying and selling (USD) and the Japanese stock market price index (the major indexes are Nikkei 225 (N225) and TOPIX (TOPX)), U.S. stock exchange price index (the major indexes are Dow Jones Industrial Average (DJI), Nasdaq 100 (NDX) and NASDAQ Composite (IXIC)), Chinese stock market price index (the major indexes are Shanghai Composite (SSEC) and SZSE Component (SZSC1)), Germany stock market price index (the major indexes are DAX (GDAXI) and Euro Stoxx 50 (STOXX50E)), the Canadian stock market price index (the major index is S&P / TSX Composite (GSPTSE)),

Australian stock market price index (the major index is S&P / ASX 200 (AXJO)) and South Korean stock market price index (the major indexes are KOSPI (KS11) and KRX 100 (KRX100)).

3. Methodology

3.1 Data Collection

The data used in this study is secondary data that can be found from various sources such as bitcoin price data, retrieved from https://finance.yahoo.com, and other relevant variable information retrieved from https://th.invest-ing.com etc.

This study used bitcoin price data searched for on June 17, 2018, which consists of daily data of 402 days (excluding weekend and public holidays) collected from January 1, 2016 to March 31, 2018. Therefore, the information of other related variables have to be managed in accordance with both the date of the data collection and the total number of days.

External factors that will be analyzed are the term of finance and commodities, which can be divided into five major groups: foreign exchange rates, safe assets, crude oil price, the volume of buying and selling bitcoin, and stock market price index.

3.2 Variables and Tools

This study uses analysis in the form of multiple linear regression and factor analysis, which are analyzed using program SPSS 24 and Minitab 16 as an analytical supporter. The variables are shown in Table 1.

Table 1: Dependent and Independent Variables Used in Multiple Linear Regression Analysis

Symbol	Definition	Unit
Y	Daily close price of Bitcoin	USD
X_1	US dollar exchange rate to Japanese yen	USD/JPY
X_2	US dollar exchange rate to South Korean won	USD/KRW
X_3	US dollar exchange rate to euro	USD/EUR
X_4	US dollar exchange rate to Chinese yuan	USD/CNY
X_5	Gold spot price	USD
X_6	Platinum spot price	USD
X_7	Gold futures contract	USD
X_8	Platinum futures contract	USD
X_9	WTI crude oil spot prices	USD
X_{10}	WTI crude oil futures contracts	USD
X_{11}	Brent oil futures contract	USD
X_{12}	US gasoline futures contracts	USD
X_{13}	The amount of buying and selling bitcoin	USD
X_{14}	Dow Jones Industrial Average Stock Index (DJI)	None
X_{15}	Nasdaq 100 Stock Index (NDX)	None
X_{16}	NASDAQ Composite Stock Index (IXIC)	None
X_{17}	Nikkei 225 Stock Index (N225)	None
X_{18}	Topix stock index (TOPX)	None
X_{19}	DAX Stock Index (GDAXI)	None
X_{20}	Euro Stoxx 50 Stock Index (STOXX50E)	None
X_{21}	Shanghai Composite Stock Index (SSEC)	None
X_{22}	SZSE Component Stock Index (SZSC1)	None
X_{23}	S & P / TSX Composite Stock Index (GSPTSE)	None
X_{24}	S & P / ASX 200 Stock Index (AXJO)	None
X_{25}	KOSPI Stock Index (KS11)	None
X_{26}	KRX 100 Stock Index (KRX100)	None

3.3 Research Methods

Daily bitcoin price is depend on various factors, and such factors may or may not have a direct effect on the price of bitcoin on the specific day or it may directly affect the bitcoin price tomorrow or the day after tomorrow. This represents that the price of bitcoin in the specific day may be affected from the result of the bitcoin price of the previous days. Thus, the historical price may affect the current price of bitcoin. The researcher therefore chose to use the multiple linear regression analysis method in this study by performing linear regression of external factors as appropriate.

In this study, the multiple linear regression analysis model will be calculated as follows:

$$Y_1 = \beta_0 + \beta_1 X_{1,t-1} + \beta_2 X_{2,t-1} + \ldots + \beta_{26} X_{26,t-1} + \varepsilon_t \quad (1)$$

t is the duration, ε_t is a random error, and the dependent variables (Y) and the predictive variable $X_1, X_2, \ldots, X_{26}$ are shown in Table 1.

Bitcoin price forecasting in this study uses linear regression analysis based on the model (1) above, regression modeling for bitcoin price forecasting will begin by examining various assumptions and correcting the hypothesis which is not true. Checking examination and implementation will be stated in the following steps.

The first step, we are going to use the data from January 1, 2016 until March 31, 2018, as the first data which fluctuates because it is during the launch of bitcoin. The prediction uses past events to predict the future as the future may be similar to the past. Since the first data is likely to be different from the future, so we will consider only the latter data which is the data collected after the highest value of bitcoin, and it is the price of bitcoin from December 27, 2017 to October 31, 2018. The analysis is divided into two cases: first, raw data will be analyzed; second, data converted into default value will be analyzed.

In the second step, since the data were collected from variables with very different units, the data will be converted to the default value and analyzed as follows.

1. To examine the hypothesis and resolve the lack of important features.

1.1 Hypothesis examination for regression analysis, examination methods and criteria as follows.

1) Examination of Multicollinearity will consider VIF, if VIF > 10, means the variable has Multicollinearity. If Multicollinearity is found in the variable, problems have to be fixed until the Multicollinearity has no longer exist in the variable.

2) To examine the hypothesis of random errors (ε).

2.1) To fit the linear model by using Ordinary least squares (OLS).

2.2) To enumerate check by considering the Significant values of Kolmogorov-Smirnov statistics and Normal Probability Plot.

2.3) To examine the Homogeneity of variance of random errors by using the Residual plot.

2.4) To examine the Autocorrelation of random errors by using the test of Durbin- Watson.

The third step, To correct the hypothesis which is not true, refer to the following steps.

1) To solve multicollinearity problems by using Factor analysis as detailed below.

1.1) To Measure the appropriateness of the data by using statistics of Kaiser-Meyer-Olkin (KMO).

1.2) To do preliminary test by using Measure of Sampling Adequacy (MSA), MSA values of variables can be seen from the Anti-image correlation matrix by reading the diagonal values of the matrix, which is the Communality: h^2.

1.3) To do factor extraction (Component factor analysis) by using Principal component Method (PC).

1.4) To do rotation by using orthogonal rotation with the Varimax method, and to specify the number of factors by using the Latent root criterion method, that will be considered from Eigenvalue (Eigenvalue should be greater than or equal to 1.) If the maximum weight factor is found in any factor, such variable will be set in that factor.

2) To solve the problem of the hypothesis of random error which is not true by using the Box-Cox transformation theory that the data conversion format,

is $Y' = Y^{\lambda}$ when λ is the parameter value obtained from the data, where $1 \leq \lambda \leq -1$.

2. To develop models from the result of problem solution and bring the information into the developed model.

3. To calculate significant indicators for every forecasting evaluation in order to see the error of the model in forecast.

4. To compare forecasting equations.

4. Results

Bitcoin price data from December 27, 2017 to October 31, 2018 will be analyzed, which can be divided into two cases as follows.

Case 1: Use the bitcoin price data as raw data in the analysis

When analyzing, we can divide the data into four factors as follows: Factor 1 is "Chinese and South Korean stock market price index, safe assets and the foreign exchange rate." The second factor is "oil prices and the volume of buying and selling bitcoin." The third factor is "Japan and Germany stock market price index" and the fourth factor is "The stock market price index for the U.S., Canada and Australia." There are two types of models as follows.

Model 1: $$Y_t = \beta_0 + \beta_1 F_{1,t-1} + \beta_2 F_{2,t-1} + \beta_3 F_{3,t-1} + + \beta_4 F_{4,t-1} + \varepsilon_t$$

Model 2: $$Y_t^{0,9} = \beta_0 + \beta_1 F_{1,t-1} + \beta_2 F_{2,t-1} + \beta_3 F_{3,t-1} + + \beta_4 F_{4,t-1} + \varepsilon_t$$

While β_0, β_1, β_2, β_3 and β_4 of each model with the values as Table 2 and $F_1 = \sum_{i=1}^{n} X_i$ when $i = 1,2,...,n$ and X_i is a variable that is a member of factor t.

Case 2: Use the bitcoin price data that has been converted to default values in the analysis

In this analysis, we will analyze in the same way as in Case 1, which has similar results. We will obtain the model 3 and 4 as follows.

Model 3: $$Y_t' = \beta_0 + \beta_1 F_{1,t-1} + \beta_2 F_{2,t-1} + \beta_3 F_{3,t-1} + + \beta_4 F_{4,t-1} + \varepsilon_t$$

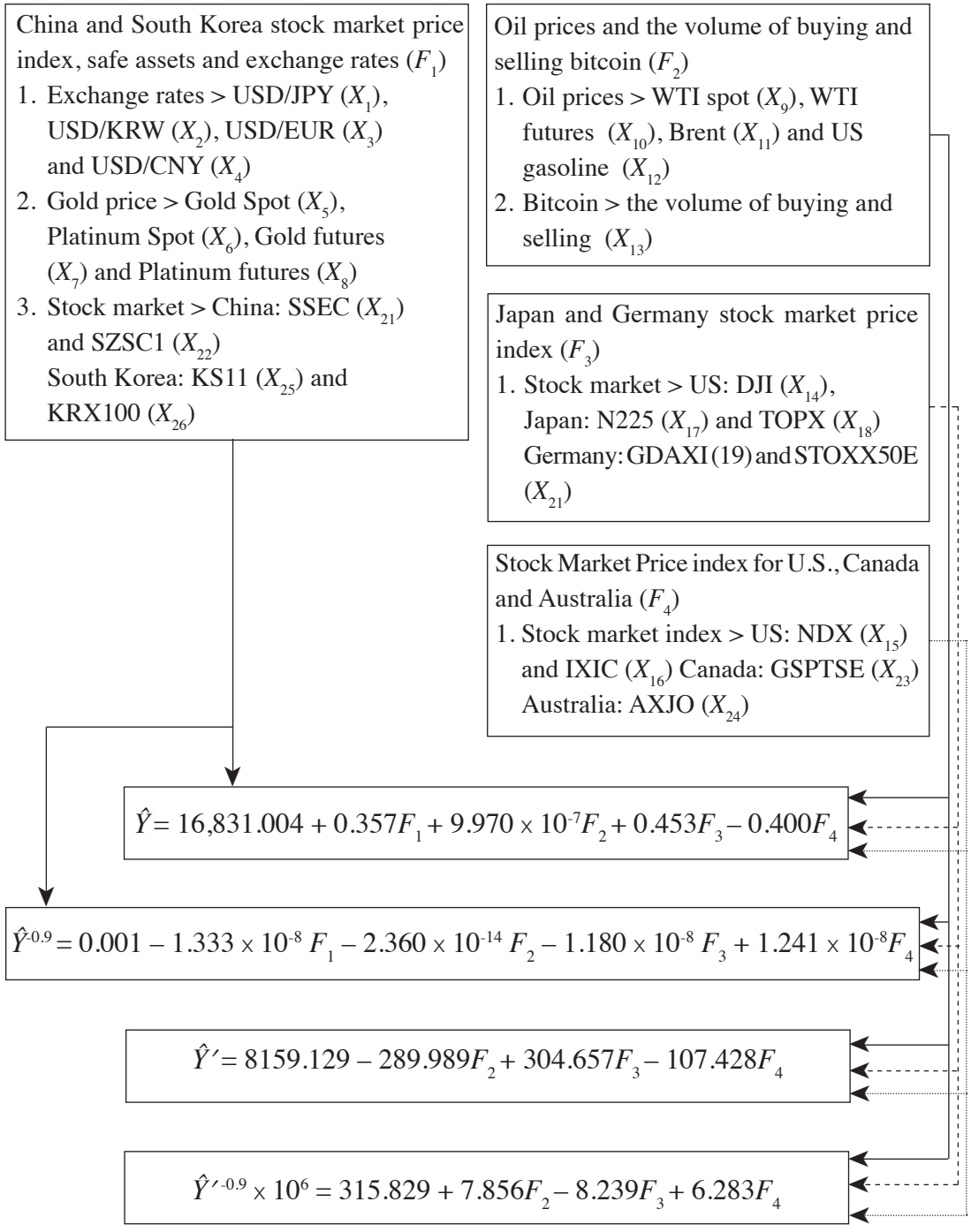
Model 4: $$Y_t'^{0-,9} = \beta_0 + \beta_1 F_{1,t-1} + \beta_2 F_{2,t-1} + \beta_3 F_{3,t-1} + + \beta_4 F_{4,t-1} + \varepsilon_t$$

While $\beta_0, \beta_1, \beta_2, \beta_3$ and β_4 of each model with the values as Table 2 and $F_1 = l_{t,i} Z_{t,i} + l_{t,i+1} Z_{t,i+1} \ldots + l_{t,i+n} Z_{t,i+n}$ when $i = 1,2,...,n$ and l_t is the weight of factors derived from factor analysis.

Table 2: Various Models from the Analysis

Regression Coefficients of the Variables					
Model	β_0	β_1	β_2	β_3	β_4
1	–16,831.004	0.357	9.970×10^{-7}	0.453	–0.400
2	0.001	-1.333×10^{-8}	-1.333×10^{-8}	-1.180×10^{-8}	1.24110-6
3	8159.129	-	–289.989	304.657	-170.428
4	315.829×10^{-6}	-	7.856×10^{-6}	-8.239×10^{-6}	6.283×10^{-6}

4.1 Variables in Each Factor of Case 1 and Case 2



4.2 Forecast from the Model that can be Obtained

From all the above analysis, will obtain the forecast equation as follows:

$$\hat{Y} = 16{,}831.004 + 0.357F_1 + 9.970 \times 10^{-7}F_2 + 0.453F_3 - 0.400F_4 \quad (2)$$

$$\hat{Y}^{-0.9} = 0.001 - 1.333 \times 10^{-8}\,F_1 - 2.360 \times 10^{-14}\,F_2 - 1.180 \times 10^{-8}\,F_3 + 1.241 \times 10^{-8}F_4 \quad (3)$$

$$\hat{Y}' = 8159.129 - 289.989F_2 + 304.657F_3 - 107.428F_4 \quad (4)$$

$$\hat{Y}'^{-0.9} \times 10^6 = 315.829 + 7.856F_2 - 8.239F_3 + 6.283F_4 \quad (5)$$

When applying the four predictive equations, the short-term forecasting model is a period of one week from 1 November 2018 until 9 November 2018 (not counting weekends or holidays) and long-term forecast is one month from 1 November 2018 until 30 November 2018 (not counting weekend or holidays). Results as shown in Table 3, Figure 3 and Figure 4.

Table 3: Statistics of Various Models

Model	Statistics			
	R Square	Adjusted R Square	RMSE (1-week)	RMSE (1-month)
Model 1	0.613	0.599	362.12	1,679.60
Model 2	0.657	0.645	134.40	1,680.63
Model 3	0.670	0.661	1,674.10	4,574.12
Model 4	0.697	0.688	1,385.10	4,367.60

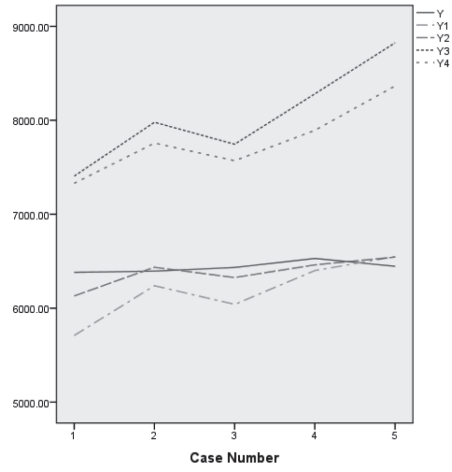


Figure 3: Forecast in 1-week Period

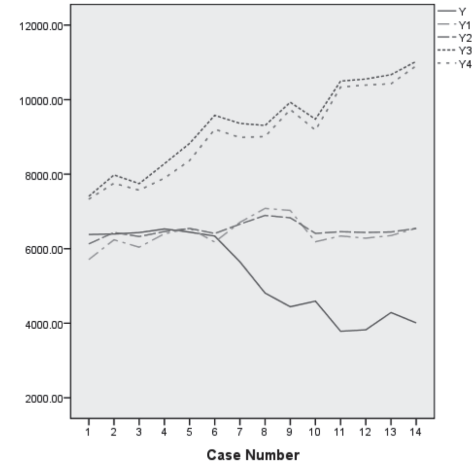


Figure 4: Forecast in 1-month Period

The forecast for a period of one week it can be seen that the prediction using the model in Case 1 will be able to predict better than the model in Case 2, and the second model forecasts better than the Model 1. Regarding the prediction within the duration of one month it can be seen that Model 1 and Model 2 can predict well in the first period only. Later, both models perform poor predictions. In Model 3 and Model 4, a false forecast can be seen since the beginning, with the bitcoin price likely to change differently from the actual value. From this, it can be seen that, the longer the period of forecasting, the less predictability of every model. Thus, long-term forecasting may not be appropriate as we can see that the forecasting in the two different periods of time, and the models used in the analyses fit in different ways. In the case of long-term forecasting, other variables may also be required to be considered because bitcoin prices are still fluctuating, therefore choosing the right model for the nature of the data should be more useful than choosing one specific model.

5. Summary

Based on the study of factors affecting the price of bitcoin by converting raw data into default values and using factor analysis to solve the problem of multicollinearity, cases 1 and 2, when analyzing later graph data by analyzing data from December 27, 2017 to October 31, 2018, the result is the Chinese and South Korean stock market price index, safe assets and foreign exchange rates, oil prices and the amount of buying and selling bitcoin, Japan and Germany stock market price index and the stock market price index for USA, Canada and Australia have affecting the price of bitcoin. And from the study to find a suitable forecasting model for buying and selling bitcoin by using external factors, it was found that, case 1, when analyzing the factors consisting of China and South Korea stock market price index, safe assets and foreign exchange rates, oil prices and the amount of buying and selling bitcoin, Japan and Germany stock market price index and the stock market price index for USA, Canada and Australia to solve the problem of multicollinearity and variable conversion, and to do Box-Cox transformation to solve the problem of the hypothesis of random error which is not true. 2 forecasting equations were obtained as shown in the equation (2) and (3). In case 2, raw data is converted to default values and then analyzed in the same way as in case 1, 2 forecasting equations were obtained as shown in the equation (4) and (5).

6. Discussion

6.1 Technical Discussion

When analyzing the data, it was found that the data had multicollinearity problems. We therefore use factor analysis to solve the problem. The result is the data has no multicollinearity problems. In addition, the dependent variable has an abnormal distribution of random errors. We therefore solved the problem by using the Box-Cox transformation theory, and the result is a distribution of random errors that is normal. When converting raw data to default values, it was found that the forecasting equations were in a more compact form and can easily change the result. For the analysis results of the factor analysis, the results are the same as the previous analysis.

To convert raw data to the default values helps each factor to have equal units, and in each forecasting equation, the coefficient of any factor is very important, which means it has a large influence on the price of bitcoin.

6.2 Informational Discussion

When applying the analytical factors to the multiple linear regression analysis, it was found that the factors that came into the forecasting equations of all four models were Factors 2, Factor 3 and Factor 4 of both cases. The second factor was oil price and the amount of buying and selling bitcoin; the third factor is the Japanese and German stock market price index; and the fourth factor is the stock market price index of the U.S., Canada and Australia. Each factor obtained from the analysis will be changed constantly because the price of bitcoin is still unstable. However, if there is a large amount of data to be analyzed, results should improve.

The objective of studying the factors that affect the bitcoin price and studying the suitable model for the price forecast of bitcoin is based on external factors. The result of the study shows that when categorizing all external factors, it was found that in Case 1, all external factors affected the price of bitcoin which is in line with Georgoula et al. (2015) who stated the exchange rate between U.S. dollars and euro affects the bitcoin price. Moreover, Poyser (2017) stated that foreign exchange rate affects the market price of bitcoin. In fact, in each of these factors, there may be some factors that do not in fact affect the bitcoin price but the combination of factors that are related to

each other is the avoidance of multicollinearity problems. It can be seen that the prediction from the model is close to the actual price of bitcoin during the first period. Also, there will be discrepancies during the period in which the bitcoin price is very volatile, and this may be affected by events that occurred during the specific period, whether it is the separation of the new currency from bitcoin or other situations that occurred during that period. According to the model adopted to predict the data derived from the data used in this study, it was found that the result is not very close to the actual price of bitcoin, which means that long-period forecast may not be appropriate. In addition, in Case 1, the analysis result obtained from raw data is closer to the actual data than the analysis result obtained from data that has already been converted to default values.

6.3 Forecasting Discussion

When comparing all the forecasting equations from the analysis to see the direction of changes that will affect the price of bitcoin, the result is that the prices of foreign exchange rates and the safe assets had changed in the same direction as the bitcoin price. Most stock market price indexes will change in the same direction as the bitcoin price, especially the Dow Jones Industrial Average (DJI), stock market index of Japan and stock market index of Germany. In terms of the buying and selling bitcoin, it has multicollinearity with variables within other factors which cannot determine the exact direction. Therefore, it should be considered together with other variables. Moreover, the crude oil price also cannot determine the exact direction.

However, there are still researchers who predict bitcoin prices in various ways such as Ji, Kim, and Im (2019) who used daily data from November 29, 2011 to December 31, 2018 and internal factors analyzed with Deep Learning. It was found that their performance was not particularly accurate for Bitcoin price prediction. Overall, there was no clear best model and the performance of all deep learning models were comparable to each other. They also determined the effect of the sequence size on regression and effect of the sequence size on classification. Moreover, Mangla, Bhat, Avabratha, and Bhat (2019) studied approximately one-hour intervals between October 10, 2015 and March 01, 2019 using internal factors ad analyzed with Machine Learning. They found that ARIMA performs well for next day's predictions but performs poor for longer terms such as given

last few days' price to predict the next five to seven days' prices. RNN performs consistently up to six days. From both of these studies, it can be seen that long-term bitcoin price forecasting is not appropriate and it is still premature to solely use such models for algorithmic bitcoin trading, which is consistent with the results of this researcher. Both of these studies used internal factors to analyze which is different from this research which used external factors. In addition, this research and the other two studies are different in the extent of the data used and the range of data used. Therefore they cannot be compared.

7. Recommendations

7.1 Recommendations for Models and Analytical Techniques

1. This study uses the factor analysis techniques to solve multicollinearity problems. The value that is calculated is the sum of each variable in that factor which may result in forecast as the value obtained may not be as close to the actual value as it should be.

2. To use the Box-Cox transformation theory to resolve the problem that the rest of the variable has an unusual distribution. If the data are abnormal in the same way as the data that is analyzed, we may consider from the normal probability plot graph that is obtained.

3. To convert raw data to default values, we may convert the value in order to make each factor have equal units and change the result easier.

4. The model obtained from the analysis may be insufficient for the possibility that may affect a bitcoin price.

7.2 Recommendations for Applying the Result

1. Since bitcoin has the highest market value and buying and selling volume among digital currencies we can apply the results to other digital currencies to consider the price trend and reduce the risk of investment.

2. Those interested in studying or investing in bitcoin can apply the research result to study and make a decision to invest in bitcoin in the future in order to reduce investment risks. Moreover, external factors that affect the price of bitcoin in this study

can be used to make a decision, which may emphasize variables related to oil prices, stocks and foreign exchange rates primarily as well as being able to apply the model from the study to analyze the trend of the bitcoin price during a short period of time in order to support the investment, so one can see if the investment in the specific period is very risky or suitable to invest in or not. However, the model obtained from the study could be used to predict the bitcoin price over a short period of time. It is not suitable for forecasting over a long period of time because the price of bitcoin is still highly volatile.

3. Regarding organizations, the result of this study may not be very beneficial. However, the organizations that are interested in investing in bitcoin can use the result from this study to obtain better results in future studies.

7.3 Recommendations for Further Studies

1. Forecasting

In this study, the data were analyzed from December 27, 2017 to October 31, 2018, which is a period of significant fluctuation. If a researcher wishes to predict further, they may cut some historical data and analyze only the data at the point that is considered appropriate by selecting the forecast data in the period with the least change.

2. The duration and data used in forecasting

This study analyzes daily data to forecast for a period of one week and one month, which may be regarded as too long, making the forecast not appropriate because bitcoin prices are still fluctuating significantly. In future studies, researchers may determine a shorter forecast time. If the data used is still daily data, they may determine the short-term forecasting period of three days, medium period of one week and long period of 10 days.

In this study, the events that occurred and affected bitcoin were not taken in account in the analysis. In future studies, such events may be analyzed as well. In addition, researchers may take into account recruit a spectrum of trust dimensions as input variables to advance the research.

3. Investment

In this study, the predictive model may not be very suitable. If researchers apply the result as an investment guide, they may have to take into account other aspects to make decisions as well to reduce the risk.

References

Arstechnica. (2017). Get ready for a wave of Bitcoin forks. Retrieved from https://arstechnica.com/techpolicy/2017/11/get-ready-for-a-wave-of-bitcoin-forks/

Blognone. (2017a). Bitcoin Gold (BTG) separates lines from Bitcoin (BTC) .Use Equihash to reduce the use of specialized chips. Retrieved from https://www.blognone.com/node/96550 (In Thai)

Blognone. (2017b). Groups have split the Bitcoin line after Bitcoin Cash / Bitcoin Gold succeeds. Retrieved from https://www.blognone.com/node/97883 (In Thai)

Davitt, K. (2017). Cboe Bitcoin Futures Announcement.

Georgoula, I., Pournarakis, D., Bilanakos, C., Sotiropoulos, D., & Giaglis, G. M. (2015). Using time-series and sentiment analysis to detect the determinants of bitcoin prices. *Available at SSRN 2607167*.

Goalbitcoin. (2017a). 10 big companies in America Payment accepted by Bitcoin. Retrieved from https://goalbitcoin.com/10-บริษัทยักษ์ใหญ่ในอเมร/?fbclid=IwAR2ShECfjBnEVsYivNcWNfn7oFnmrfxPZlZ11a0Yi12_SH0Li9Tvw8eJ0W0 (In Thai)

Goalbitcoin. (2017b). 20 bitcoin Bitcoin questions for newbies Let's solve the questions!. Retrieved from https://goalbitcoin.com/20-คำถาม-บิทคอยน์-bitcoin-สำหรับม/?fbclid=IwAR2y1LAwUGoGNTse3OaQh4 xz9dWgYCARyUVlbSpVaHm1hcX5ilic9n5nuK8 (In Thai)

Greaves, A., & Au, B. (2015). Using the Bitcoin Transaction Graph to Predict the Price of Bitcoin.

Jang, H., & Lee, J. (2017). An Empirical Study on Modeling and Prediction of Bitcoin Prices With Bayesian Neural Networks Based on Blockchain Information. Seoul National University.

Ji, S., Kim, J., & Im, H. (2019). A comparative study of bitcoin price prediction using deep learning. *Mathematics*, *7*(10), 898.

Jiraboon, N. (2017a). 9 things you might not know if you can use bitcoin to buy. Retrieved from https://siamblockchain.com/2017/04/07/9-things-didnt-know-buy-bitcoin/ (In Thai)

Jiraboon, N. (2017d). Looks like Bitcoin Futures of the giant CME company will be available for trading on December 11. Retrieved from https://siamblockchain.com/2017/11/21/cmes-bitcoin-futures-likely- (In Thai)

Jiraboon, N. (2017e). Bitcoin's price remained at $11,000 after price adjustment. Retrieved from https://siamblockchain.com/2017/12/03/bitcoin-price-stabilizes-11000-region-recovers-correction/ (In Thai)

Kapook. (2014, 2017). What is Bitcoin? Digital money in the online world ... opportunity or risk ?!. Retrieved from https://money.kapook.com/view84147.html (In Thai)

Lueangnarumitchai, P. (2015). Is it true that Bitcoin is yet another serious investment tool, not just stocks and gold?. Optimise Magazine. (In Thai)

Mangla, N., Bhat, A., Avabratha, G., & Bhat, N. (2019). Bitcoin Price Prediction Using Machine Learning. *International Journal Of Information And Computing Science*, *6*(5).

McNally, S. (2016). Predicting the price of Bitcoin using Machine Learning. School of Computing National College of Ireland.

Mgronline. (2017). Not just Bitcoin! Cryptocurrency, the world's major currency. Retrieved from https://mgronline.com/cyberbiz/detail/9610000005110 (In Thai)

Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System.

Prachachat Business. (2017). Share bitcoin investment chain outbreak, "National Bank" warns of risk of losing money. Retrieved from https://www.prachachat.net/finance/news-74049 (In Thai)

Secretariat of the House of Representatives Academic Group. (2017). Bitcoin, the future virtual currency of the future. Electronic academic documents. (In Thai)

Siamblockchain. (2014). What is Bitcoin. Retrieved from https://siamblockchain.com/bitcoin-%E0%B8%84% E0%B8%B7%E0%B8%AD-%E0%B8%AD%E0%B8%B0%E0%B9%84% E0%B8%A3/ (In Thai)

Todaylineme. (2017). South Korea set to enact a law prohibiting trading + "Bitcoin". (In Thai)

Truc´ıos, C. (2018). Forecasting Bitcoin risk measures: A robust approach. Sao Paulo School of Economics.