CHAPTER 15

Prediction of Cryptocurrency Market Price Using Deep Learning and Blockchain Information

Bitcoin and Ethereum

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CONTENTS

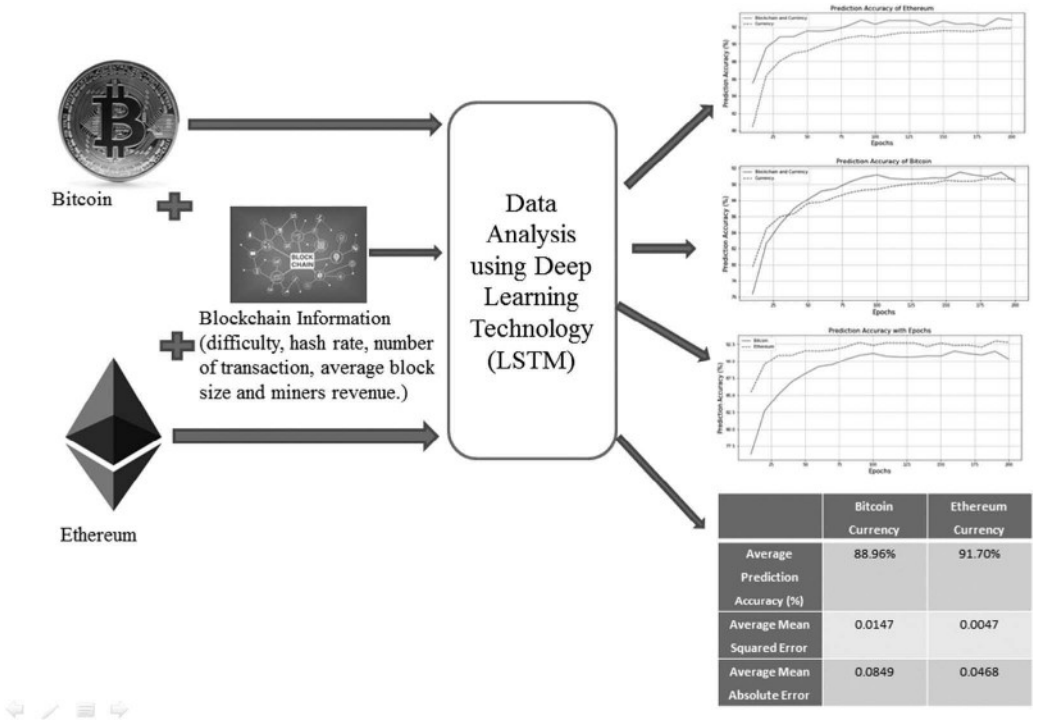
15.1 INTRODUCTION

Bitcoin and Ethereum are different kinds of popular digital currencies introduced into global financial markets based on their unique specifications. In the last few years, the price of both Bitcoin and Ethereum has been increased gradually. However, a price explosion of around AUD 9,613 in the middle of 2018 has been reported for Bitcoin [1], and a price explosion up to AUD 700 has been noted for Ethereum so far in 2018. [2] These currencies are the leading cryptocurrencies around the world with growing adoption over time. They are making a vast majority in the market capitalization. The blockchain technology helps build trust relationship in the market. It offers an easy tracking of digital exchanges and prevents the possible fraudulent actions. The essential features of Bitcoin and Ethereum were derived from blockchain, which have drawn substantial attention from researchers in different areas including economic fields, Deep learning and cryptography.

Numerous studies have been performed on modelling the time series of Bitcoin price in the market and reported the financial asset capabilities of Bitcoin using GARCH models. Recent studies have also focused on statistical and economical properties of Bitcoin price and its characteristics and investigated the statistical properties of the Bitcoin market [3] and exchange rate of Bitcoin verses US dollar. [4] There has also been analyses of the Bitcoin price model under the fundamental market condition, which were supply demand of Bitcoin, total demand of Bitcoin and equilibrium between Bitcoin supply and Bitcoin demand. [5] In addition, some studies have predicted the Bitcoin price using both Deep learning technique [6] and Bayesian Neural Network (BNN) [7], which analyses the time series of Bitcoin price. Moreover, to tackle the low training sample data issue, a few studies have used a small amount of raw data with Deep learning technique. [8]

The vast majority of the past studies have concentrated on either modelling Bitcoin price without considering its relationship to blockchain information or distinguishing just its linear relationship to macroeconomic factors. An essential inadequacy of previous studies is that they analysed only the prediction price of the Bitcoin currency using different techniques; however, they did not focus on comparing the prediction accuracy for different cryptocurrencies. However, the prediction accuracy is increasingly considered to be a vital parameter among investors and consumers to make more profit from their investments and shares. Therefore, the current study attempts to defeat these restrictions by methodically evaluating the prediction accuracy of Bitcoin and Ethereum currencies.

The main purpose of this study is to analyse the prediction accuracy of Bitcoin and Ethereum using a Deep learning approach. This study employs a Deep learning approach with blockchain and cryptocurrency information on Bitcoin and Ethereum, separately. It should be noted that the application of the Deep learning approach with blockchain information and both currency information extends the accuracy of the process as the blockchain technology is the decentralized ledger for



	Bitcoin Currency	Ethereum Currency
Average Prediction Accuracy (%)	88.96%	91.70%
Average Mean Squared Error	0.0147	0.0047
Average Mean Absolute Error	0.0849	0.0468

FIGURE 15.1 Graphical abstract

cryptocurrency. [7] This paper presents the application of the long short-term memory (LSTM) model to calculate the error rate of the currencies using blockchain and crypto data. The blockchain information was gathered by monitoring the variables from online websites. The prediction performance obtained in this study substantiates the effectiveness of machine learning with blockchain data. The rest of the article is organized as follows: Section II describes the material and methods used in this study. Section III shows the collection of results of the prediction of the currency. Section IV concludes the analysis, the limitations on the data and the future works of this area.

15.2 MATERIAL AND METHODS

This section describes the material and methods employed in the present study. The method was divided in to the five steps. These are raw data collection, data preparation, pre-processing, data prediction and data analysis. Figure 15.2 schematically illustrates the materials and the main steps involved in this investigation.

15.2.1 Flowchart

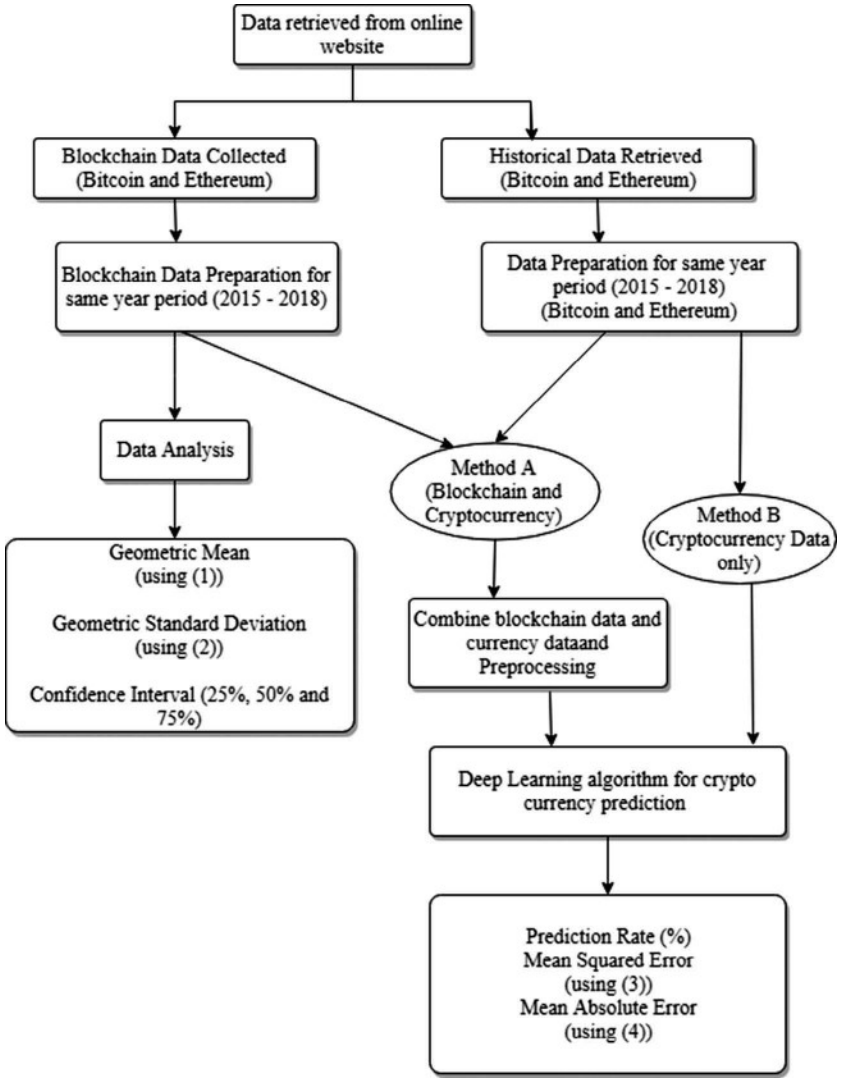


FIGURE 15.2 Proposed analysis for prediction of crypto currency using blockchain and cryptocurrency market price data with the exploitation of Deep Learning algorithm. Method A (blockchain data and cryptocurrency data), Method B (only cryptocurrency data (Bitcoin and Ethereum) were separately studied). Using equations (1) – (4).

15.2.2 Raw Data Collection

The blockchain data were collected from online websites and the retrieved financial information was collected for Bitcoin from 2009 to 2018 and for Ethereum from 2015 to 2018, respectively. These data were based on the reliable source for the data on the Bitcoin and Ethereum blockchain, which was updated every 24 hours. The attributes of

blockchain data include blockchain records such as difficulty, hash rate, number of transactions, average block size and miners revenue.

15.2.3 Blockchain

The foremost advantage of using blockchain is the security. The main application of blockchain data of cryptocurrencies demonstrate the perfect automated micro-transactions made between machines.

Decentralization is the esteem sought after by all cryptocurrencies instead of general at currencies being esteemed by central banks. Decentralization can be indicated by the accompanying objectives: (i) Who will keep up and deal with the exchange record? (ii) Who will have the privilege to approve exchanges? (iii) Who will make new cryptocurrencies? The blockchain is the main accessible innovation that can at the same time accomplish these three objectives. Table 15.1 describes of blockchain variables involved in the prediction of Bitcoin and Ethereum.

The blend of blockchain technologies and the financial showcase is a genuine case of a mix of abnormal state cryptography and market economies.

15.2.4 Data Preparation

In this analysis, blockchain information, Bitcoin information and Ethereum information were first retrieved from online websites. A part of the Bitcoin, Ethereum and blockchain data was utilized in the data analysis (i.e., from 2015 to 2018) because the Ethereum information was retrieved only from 2015 to 2018. The Bitcoin data received from the online resource from 2009 to 2018 have been dealt it out manually with-in that period. As a consequence, 6 years of Bitcoin data were excluded from the analysis. In addition, the individual attributes of blockchain raw data were unable to be obtained in the correct format and, therefore, all the blockchain data were set up into matrix arrange.

15.2.5 Processing the Data

Blockchain and cryptocurrency data joined and began to perform the handling to foresee the exactness of the prediction of the currency. Also, simply the currency data were utilized for forecasting. This investigation opened the way to uncover how the blockchain data affects the prediction. In this processing, LSTM model, which is a specific kind of Deep learning, was employed.

TABLE 15.1 Description of blockchain variables involved in the prediction of Bitcoin and Ethereum.

Blockchain Variables	Description
Market price	USD market price of the Bitcoin change
Difficulty	Measurable value of difficult in the new block
Hash Rate	When Bitcoin network is performing the estimated number (Tera hashes second)
Average Block size	Average block size in (MB)
Confirmed Transactions	Number of confirmed transactions per day
Miners revenue	Total mount of coin base block rewards plus transaction fees paid to miners

15.2.6 Deep Learning

Deep learning technique gives effective results on the prediction. [9] This is totally one of the kind ideas to join Deep learning and cryptos. These models can accomplish cutting edge precision, and now and then surpassing human-level execution. Deep learning achieves acknowledgment accuracy at more elevated amounts than ever before. The two main reasons that the Deep learning becomes useful are Deep learning requires lots of labelled data and substantial computing power. [10]

LSTM (Long Short-Term Memory): This task was also achieved with successful results through the implementation of LSTM to compare the predictive performance with blockchain data and without blockchain data.

A LSTM model is used in this study. It is a specific kind of Deep learning model appropriate to the time series data. This enables the network to learn long-term conditions. LSTM cell contains forget and remember gates which enable the cell to choose what information to piece or pass in the light of its quality and significance. Therefore, weak signs can be blocked, which in turn avoids vanishing slope.

15.2.7 Analysis of the Data

In this analysis, blockchain data were used and analysed to find the Geometric Mean (GM), Geometric Standard Deviation (GSD), maximum, minimum and confidence Interval (25%, 50% and 75%). The statistical analysis to find the equations for mean and standard deviation are as follows.

GM_x is given by,

$$GM = \sqrt[N]{\prod_{i=1}^{N} x_i} \tag{1}$$

where N = the number of elements, x_i the value of each elements and GSD_x is given by,

$$GSD = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(\ln\frac{x_i}{GM_x}\right)^2} \tag{2}$$

where N = the number of elements, x_i = the value of each elements and x' = mean.

The analysis is performed by using Python 3.6 on MacOS Sierra (Version 10.12.6), 1.7 GHz Intel Core i7, 4GB RAM, 1600 MHz DDR3.

15.2.8 Prediction of the Data

LSTM model was employed in Deep learning to predict the crypto currency prices with 80% of training data and 20% of test data. The mean square (MSE) and absolute errors (MAE) were determined using the relationships given in Eqs. (3) and (4) respectively.

$$\text{Mean Squared Error} = \frac{1}{N}\sum_{i=1}^{N}(y_i - y')^2 \tag{3}$$

TABLE 15.2 Ethereum currency: Statistical analysis on blockchain data (mean, standard deviation, minimum, confidence interval (CI), maximum)

	Difficulty	Hash Rate (TH/S)	Miners Revenue	Transaction	Average Block Size
Mean	6.65e+14	4.52e+13	88.91	1.97e+05	6610.61
Standard Deviation	9.74e+14	6.91e+13	56.02	2.85e+05	8376.69
Minimum	1.47e+12	9.52e+10	31.75	1.32e+03	618.29
25% CI	2.44e+13	1.82e+12	50.62	3.25e+04	1375.02
50% CI	8.25e+13	6.37e+12	73.23	4.69e+04	1672.98
75% CI	1.33e+15	7.70e+13	107.95	2.80e+05	10,444.70
Maximum	3.33e+15	2.67e+14	798.60	1.35e+06	33,683.75

TABLE 15.3 Bitcoin currency: Statistical analysis on blockchain data for (mean, standard deviation, minimum, confidence interval (CI), maximum)

	Difficulty	Hash Rate (TH/S)	Miners Revenue	Transaction	Average Block Size
Mean	5.76e+11	4.47e+06	5.99e+06	237,710.44	0.8254
Standard Deviation	6.70e+11	5.36e+06	9.45e+06	63,978.070	0.1755
Minimum	5.22e+10	3.22e+05	7.53e+05	86,583.0	0.3475
25% CI	1.65e+11	1.24e+06	1.32e+06	195,796.0	0.7081
50% CI	2.59e+11	2.05e+06	1.86e+06	235,084.0	0.8570
75% CI	7.12e+11	5.55e+06	5.79e+06	281,116.0	0.9707
maximum	3.01e+12	2.69e+07	5.31e+07	425,008.0	1.1066

$$\text{Mean Absolute Error} = \frac{1}{N}\sum_{i=1}^{N}\frac{y_i - y'_i}{y_i} \tag{4}$$

where N is the number of samples, y_i is the i-th true objective value and y_i is the i-th estimated value.

15.3 RESULTS

In this study, prediction percentage rates with the different epochs were received from the blockchain data and cryptocurrency data. The LSTM model was used to predict the data and generate following tables and figures were generated on the basis of the predicted data. The data set tables (Tables 15.4 and 15.5) illustrate how the Prediction Rate, Mean Squared Error, Mean Absolute Error for Bitcoin and Ethereum cryptocurrencies with Epochs from 2015 to 2018.

15.3.1 Method A:

TABLE 15.4 Method A: Data set with Prediction Accuracy Rate, Mean Squared Error, and Mean Absolute Error for Bitcoin and Ethereum cryptocurrency using blockchain data and currency data for each Epochs value.

Epochs	Bitcoin Prediction Rate (%)	Ethereum Prediction Rate (%)	Bitcoin Mean Squared Error	Ethereum Mean Squared Error	Bitcoin Mean Absolute Error	Ethereum Mean Absolute Error
10	79.7771	85.4563	0.0093	0.0083	0.0726	0.0657
20	83.4849	89.5449	0.0076	0.0060	0.0644	0.0536
30	85.7657	90.8649	0.0066	0.0052	0.0586	0.0489
40	87.3580	90.8878	0.0058	0.0052	0.0542	0.0487
50	87.6308	91.5374	0.0057	0.0048	0.0534	0.0470
60	88.4970	91.5033	0.0053	0.0048	0.0501	0.0470
70	88.8647	91.6494	0.0051	0.0048	0.0482	0.0467
80	89.1559	92.1144	0.0050	0.0045	0.0465	0.0456
90	89.4391	**92.7736**	0.0049	0.0041	0.0448	0.0437
100	89.6268	92.3007	0.0048	0.0044	0.0431	0.0451
110	90.5844	92.7250	0.0048	0.0041	0.0422	0.0435
120	90.6417	92.7146	0.0048	0.0041	0.0417	0.0438
130	90.7258	92.6955	0.0047	0.0042	0.0410	0.0442
140	90.7218	92.1621	0.0047	0.0045	0.0406	0.0458
150	90.6942	92.6751	0.0047	0.0042	0.0405	0.0438
160	90.6997	92.3011	0.0047	0.0044	0.0404	0.0449
170	90.8374	92.3695	0.0047	0.0043	0.0392	0.0447
180	90.5572	92.0811	0.0048	0.0045	0.0411	0.0458
190	**90.9375**	92.9655	**0.0046**	**0.0040**	0.0390	**0.0432**
200	90.8953	**92.7736**	0.0046	0.0041	**0.0389**	0.0438

15.3.2 Method B:

TABLE 15.5 Method B: Data set with Prediction Accuracy Rate, Mean Squared Error, and Mean Absolute Error for Bitcoin and Ethereum cryptocurrency using only currency data for each Epochs value.

Epochs	Bitcoin Prediction Rate (%)	Ethereum Prediction Rate (%)	Bitcoin Mean Squared Error	Ethereum Mean Squared Error	Bitcoin Mean Absolute Error	Ethereum Mean Absolute Error
10	79.7318	80.4207	0.0094	0.0136	0.0712	0.0888
20	84.5086	86.3979	0.0072	0.0094	0.0616	0.0713
30	85.9785	88.0572	0.0065	0.0083	0.0590	0.0650
40	86.3361	88.9239	0.0063	0.0077	0.0573	0.0609
50	87.6247	89.1827	0.0057	0.0075	0.0554	0.0604
60	87.7773	89.8182	0.0056	0.0070	0.0547	0.0590
70	88.4436	90.4216	0.0053	0.0066	0.0530	0.0566
80	88.9776	90.7671	0.0051	0.0064	0.0518	0.0561

(*Continued*)

(Cont.)

Epochs	Bitcoin Prediction Rate (%)	Ethereum Prediction Rate (%)	Bitcoin Mean Squared Error	Ethereum Mean Squared Error	Bitcoin Mean Absolute Error	Ethereum Mean Absolute Error
90	89.3036	90.9971	0.0049	0.0062	0.0512	0.0558
100	89.4059	90.8275	0.0049	0.0063	0.0508	0.0568
110	89.7417	91.1079	0.0047	0.0061	0.0502	0.0555
120	89.9779	91.3392	0.0046	0.0060	0.0497	0.0552
130	90.1729	91.3315	0.0045	0.0060	0.0493	0.0554
140	90.1625	91.4165	0.0045	0.0059	0.0494	0.0552
150	90.496	91.5689	0.0044	0.0058	0.0484	0.0549
160	90.3910	91.5347	0.0044	0.0058	0.0486	0.0551
170	90.3943	91.4797	0.0044	0.0059	0.0486	0.0556
180	**90.7275**	91.6283	**0.0043**	0.0058	**0.0481**	0.0547
190	90.6728	91.8279	**0.0043**	**0.0056**	0.0487	**0.0540**
200	90.6694	**91.8328**	**0.0043**	**0.0056**	0.0483	**0.0540**

The results demonstrate the prediction accuracy of the Bitcoin currency using blockchain data and cryptocurrency data (Figure 15.3). As this figure illustrates, the prediction accuracy is high for Epochs value higher than 30 which obviously demonstrates the high prediction accuracy when the blockchain and cryptocurrency information were employed.

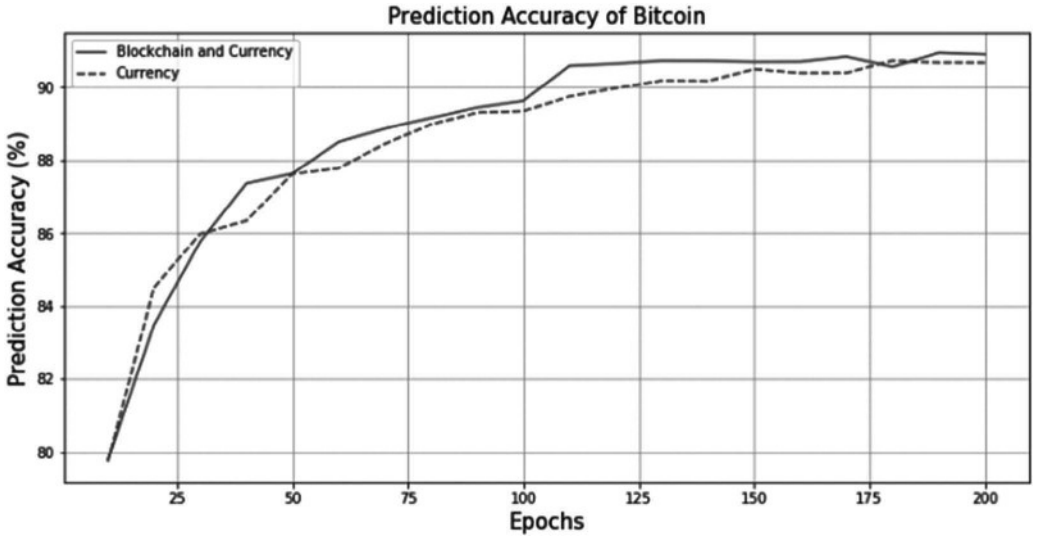


FIGURE 15.3 Bitcoin prediction accuracy of observing influence of blockchain information on prediction accuracy.

The outcome of the analysis demonstrates the prediction accuracy of the Ethereum currency utilizing the blockchain data and cryptocurrency data (see Figure 15.4). As it is evident in this figure, the accuracy is high in all the epochs values. The average increment of the accuracy was 2% contrast with accuracy with the crypto data. The outcomes clearly indicated that the prediction accuracy was high when the blockchain and cryptocurrency information was utilized.

According to the results presented in Figures 15.3 and 15.4, the accuracy of the prediction for the cryptocurrency is more accurate when using the blockchain data and crypto data.

Figures 15.5 and 15.6 show the original and prediction market prices of the Bitcoin currency and Ethereum currency using blockchain data and crypto data respectively when the Epochs value was 100. Both the currencies demonstrate that how the prediction closest to the first esteem. The blockchain data significantly influence the exactness of the prediction.

According to the results, prediction of the market price of the Ethereum currency was very close to the original market price, and the contrary was observed for Bitcoin currency.

The data shown in Figures 15.7 proved that Ethereum currency has highly accurate prediction than Bitcoin. When the epochs value was around 25, the increment of the correctness of Ethereum was 7%. After this epochs value, the increment was down to 2%.

Comparison of Figures 15.8 and 15.9 revealed that the mean squared error and mean absolute error of Bitcoin are higher than Ethereum on the prediction for all the values of epochs.

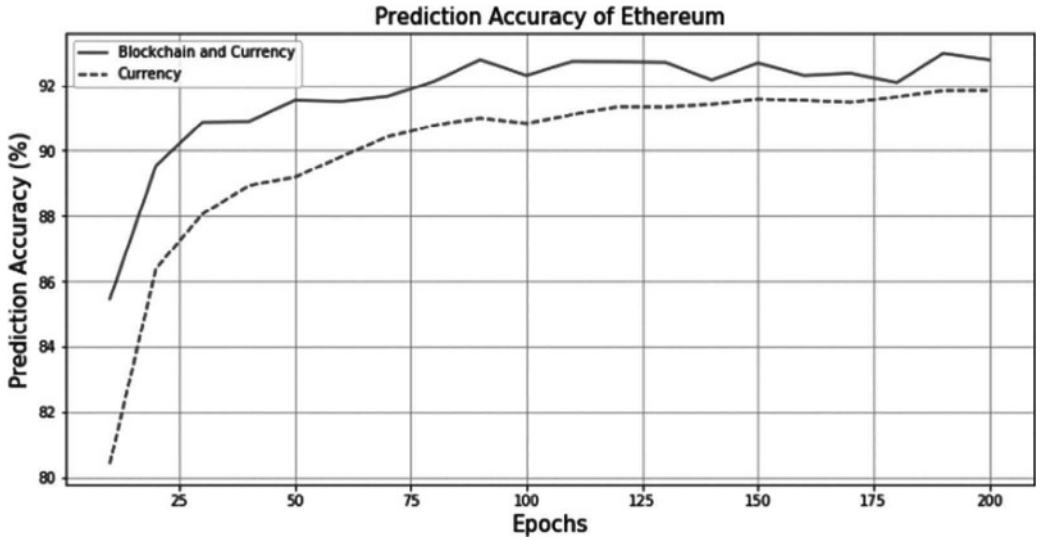


FIGURE 15.4 Ethereum prediction accuracy of observing influence of blockchain information on prediction accuracy.

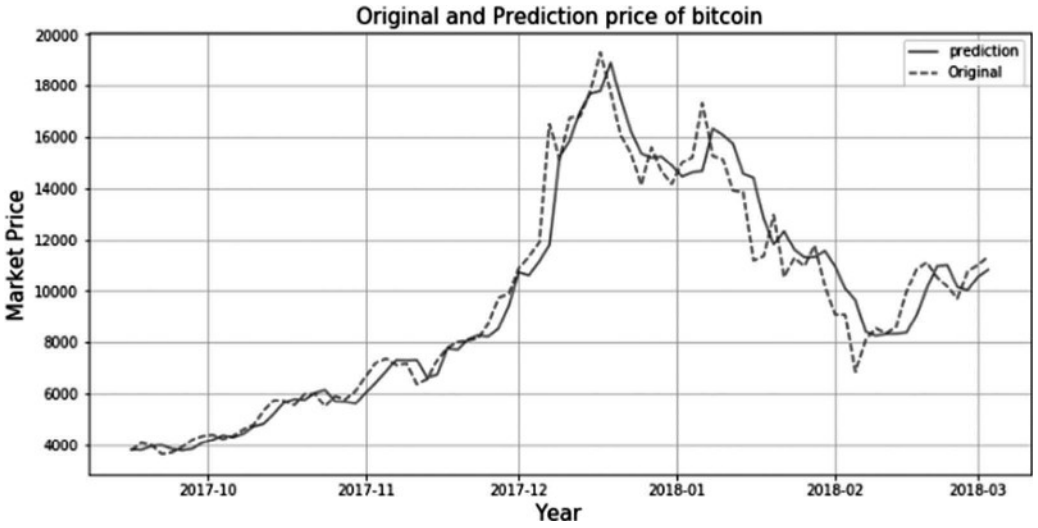


FIGURE 15.5 Original and predicted market price of Bitcoin using blockchain and currency data.

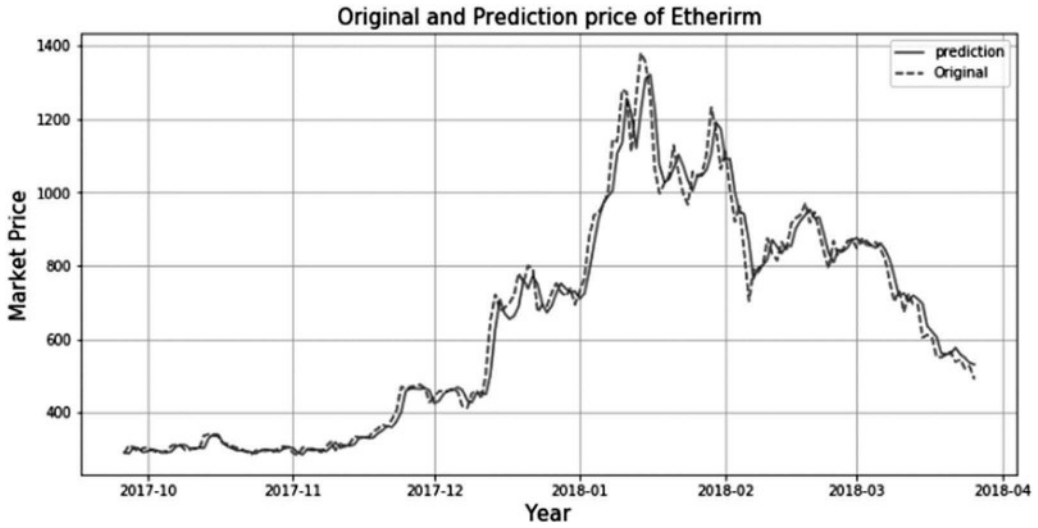


FIGURE 15.6 Original and predicted market price of Ethereum using blockchain and currency data.

15.3.3 Discussion

The main aims of this study are to discern the prediction of the crypto currency prices and to compare the prediction accuracy of two cryptocurrencies (Ethereum, Bitcoin) in the current and future financial market. To the best of the author's knowledge, the present study is the only study till date that reports the prediction

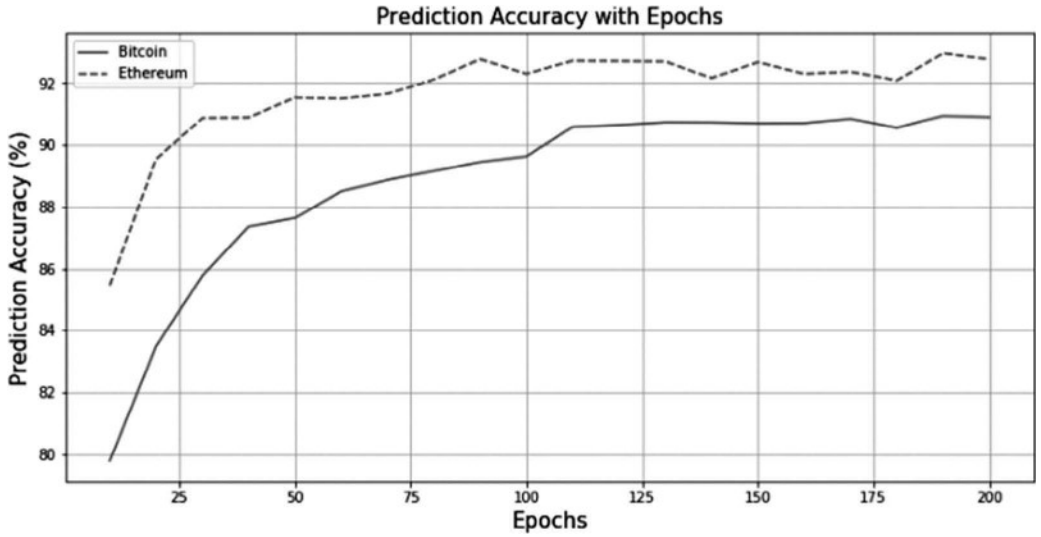


FIGURE 15.7 Prediction accuracy of Bitcoin and Ethereum currencies with different epochs values, when using with blockchain and currency data.

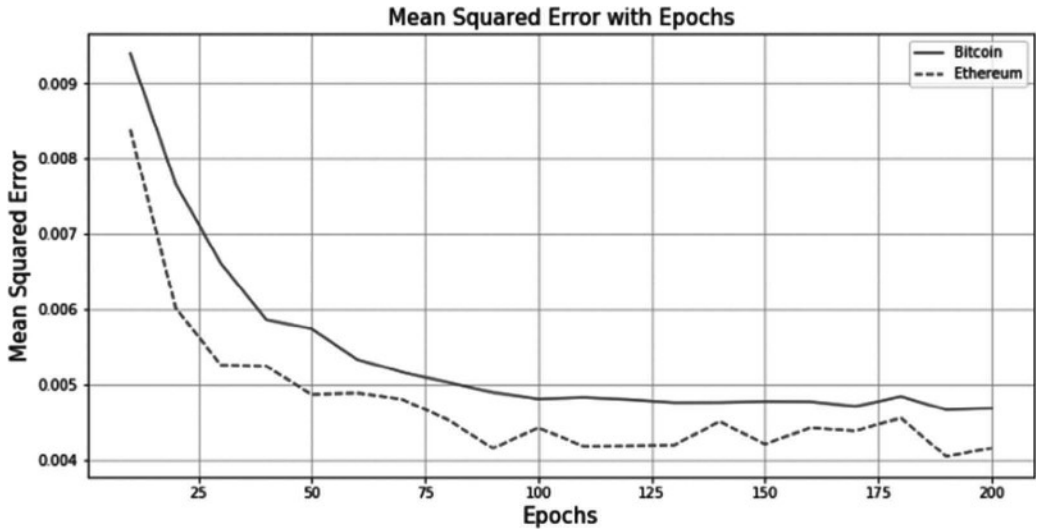


FIGURE 15.8 The Mean Squared Error of Bitcoin and Ethereum currency using blockchain and currency data.

accuracy using Deep learning and blockchain data and compares other currencies to provide the best solution for business, consumers and investors regarding their investments. To accomplish this task, crypto currency data and blockchain data of both currencies were retrieved from online websites and Deep learning model [Long

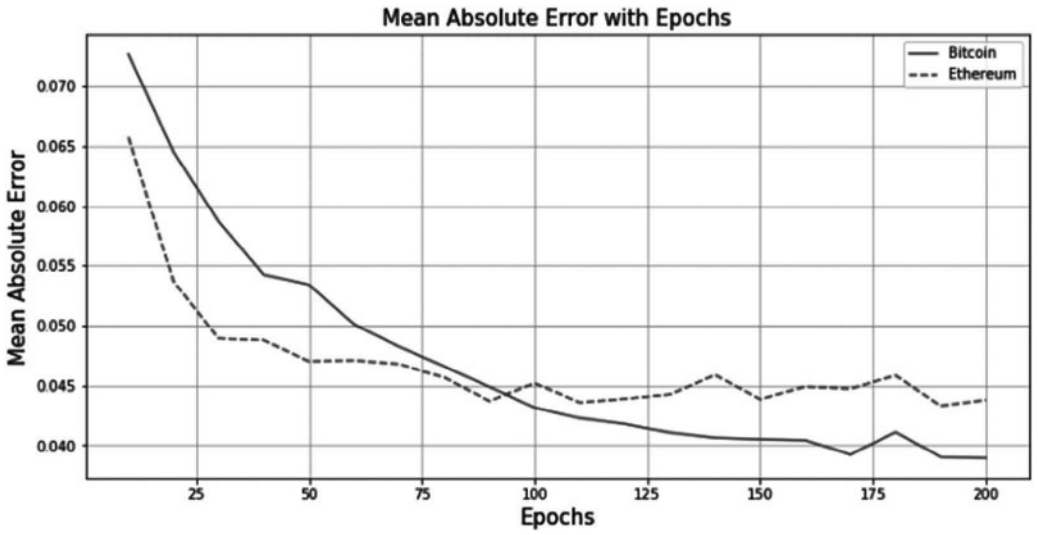


FIGURE 15.9 The Mean Absolute Error of the Bitcoin and Ethereum currency using blockchain and currency data.

TABLE 15.6 Average values for prediction accuracy, MSE and MAE for Bitcoin and Ethereum currencies when using blockchain data and crypto currency data.

	Bitcoin Currency	Ethereum Currency
Average Prediction Accuracy (%)	88.84%	91.70%
Average Mean Squared Error	0.0054	0.0047
Average Mean Absolute Error	0.047	0.0468

Short-Term Memory (LSTM)] was applied to predict the prediction accuracy percentage of the currencies.

Many studies have been conducted on modelling and predicting the cryptocurrency price by employing different technologies, models and statistical analysis. One of the leading outcomes of the present study is that the blockchain data was shown to highly determine the prediction accuracy of the cryptocurrencies. This is owing to the fact the blockchain data keeps the entire history of the cryptocurrency transaction. The blockchain data incorporate significant highlights as primary determinants for pricing Bitcoin. [7] The features of the blockchain information are significant to address the critical issues in the cryptocurrency prediction. [11] The results obtained in this study revealed that Ethereum has higher responsiveness in the current market in long run and short run in contrast to Bitcoin. Analysis of crypto market factors on five different cryptocurrencies, using Autoregressive Distributed Lag (ARDL) showed that Bitcoin and Ethereum are more sensitive. In the cryptocurrency prediction, the use of blockchain data and currency (Bitcoin, Ethereum) data in the Deep learning approach can have

a high impact on the accuracy percentage. The use of blockchain data in prediction overcomes the limitations of the poor prediction of currencies and the prediction can be more accurate when the machine learning models are employed. [7] The study by [12] showed prediction accuracy of Bitcoin using blockchain data was 55% with regular Artificial Neural Network (ANN). However, they suggest that there was limited predictability in blockchain data.

The present study used the Deep learning (LSTM) model to evaluate the prediction accuracy. Usually, Deep learning technique is used in the financial market to predict the price [6,11,13] and LSTM is a clear and compelling method of training data and more competent for perceiving long term dependencies. [6]

The prediction accurateness of the market price was found to be close to the original value for the Ethereum currency, while the opposite was observed for Bitcoin. The study by [13] showed that the predicted values of Bitcoin were closer to the actual values. However, they had an issue with in sufficient data.

On the other hand, the average values of mean squared error (MSE) and mean absolute error (MAE) indicated that the error value of Bitcoin is higher than the error value of Ethereum. Application of LSTM model with only crypto data generated an average MAE of about 0.04 for Bitcoin and 0.05 for Ethereum respectively. [13] The LSTM model was able to achieve MSE of the Bitcoin about 0.03. [6] The main limitation of the current study is the data size. Although the Bitcoin data was retrieved from 2009 to 2018, a part of them (i.e., from 2015 to 2018) were employed in the data analysis due to the fact that the Ethereum information was available only from 2015 to 2018. The prediction of the crypto currency price must be calculated and predicted more accurately. To achieve this task, future research should be aimed at using numerous different sample data and applying cloud computing or artificial intelligence. To amplify the financial reward [14], cryptocurrency prediction has become an important field in the past recent years and the analysis of cryptocurrency has received much attention. The blockchain information influenced the secure accuracy on anticipating and Deep learning approach expanded the accurate for the prediction process. This research helps the business to analyse the price prediction of different currencies.

15.3.4 Conclusion

Ethereum and Bitcoin are increasingly significant standards in the current financial market. A great deal of speculators contributes their cash aggressively and it has been widely contemplated in the field of financial matters and data innovation. In this study, the prediction accuracy and the error rate (Mean Squared Error and Mean Absolute Error) on the prediction of Bitcoin and Ethereum currencies were analysed by applying Deep learning algorithm with historical data (blockchain information and cryptocurrency information). The results showed that the prediction accuracy percentage for the financial cryptocurrency is more accurate when predicting with blockchain data and crypto data. In addition, the error rate on the prediction was low when the blockchain and currency data were used for the analysis. Moreover, the prediction accuracy percentage of Ethereum was higher than that of Bitcoin under the same criteria, whereas

the error rate in the prediction of Ethereum was lower than that of Bitcoin. Based on the results obtained in this study, it can be concluded that the blockchain information gives high security on the digital trades and it demonstrates the high accuracy of the prediction. In addition, the Deep learning prediction approach can be considered as an effective tool for analyzing the blockchain and cryptocurrency data set. This study provides a reference for researchers who examine the cryptocurrency prediction. Future studies should focus on adapting cloud computing and artificial intelligence, and this would be interesting areas to expose to improve the cryptocurrency prediction rate.

AUTHOR CONTRIBUTION

G. S. and M.N.H. conceived the study idea and developed the analysis plan. G. S. analyzed the data and wrote the initial paper. M.N.H. helped preparing the figures and tables, and in finalizing the manuscript. All authors read the manuscript.

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