Towards an Understanding of Cryptocurrency: A Comparative Analysis of Cryptocurrency, Foreign Exchange, and Stock

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***Abstract*—Cryptocurrency is a cutting-edge Fintech innovation and currently a worldwide hotspot. However, the high-speed evolution of it has already caused a series of public security related events all around the world. Cryptocurrency was built initially as a possible implementation of digital currency, then various derivatives were created in a variety of fields such as financial transactions, capital management, and even non-monetary applications. This paper aims to offer analytical insights to help understand cryptocurrency by treating it as a financial asset. We position cryptocurrency by comparing its dynamic characteristics with two traditional and massively adopted financial assets: foreign exchange and stock. Based on the daily close prices about four years, we first construct the correlation matrices and asset trees of all three markets, then conduct comparisons on five properties: volatility, centrality, clustering structure, robustness, and risk. Our investigation suggests that the dynamics of cryptocurrency are more similar to stock. As to the robustness and clustering structure, our analysis shows cryptocurrency market is more fragile than stock market, thus it is currently a high-risk financial market. Our work is the first to study cryptocurrency with the help of well-understood financial assets and may shed some light on investment decisions, regulation, and legislation.**

***Index Terms*—cryptocurrency, blockchain, financial market, correlation matrix, asset tree, systemic risk**

I. Introduction

Since Bitcoin, the first cryptocurrency, emerged in 2009, the cryptocurrency market has become an important component of the international financial market after ten years' development. Nonetheless, the prices of cryptocurrencies change drastically, affecting the behavior of traders. Besides market risks, there also exist shallow market problems, adversary risks, transaction risks, operational risks, privacy-related risks, and legal and regulatory risks [1]. These pose a significant challenge to build a comprehensive understanding of the cryptocurrency market. Lots of works have focused on Bitcoin, analyzing its price bubbles [2] and determinants [3], as well as a comparative analysis of Bitcoin with other financial assets [4].

Thus we still lack basic concepts to fully describe cryptocurrency. In contrast, we do have relatively more experience and knowledge in traditional financial assets (e.g., foreign exchange and stock) [5], [6] and these can help us understand the nature of cryptocurrency. Among which, we select widely adopted methods, asset tree and correlation matrix, based on price data from January 2015 to November 2018, to investigate the characteristics of the cryptocurrency market and position it through comparisons with other traditional financial markets.

As an extension of work [7], the main contributions and findings of this paper can be summarized as follows. First, we study the cryptocurrency market at the financial market level and compare it with traditional financial markets. Second, our investigation yields interesting findings: though cryptocurrencies were initially designed as a blockchain-based digital currency, however, its market dynamic is more similar to the stock market, thus it is currently a high-risk market. Our analysis illustrates the nature of the price fluctuations in the cryptocurrency market and provides guidance for investment, regulation, and legislation.

II. Datasets and Methodology

In this paper, we consider the daily close price of different financial markets. The time span is from January 1, 2015 to November 30, 2018, and all prices are based on the US dollar.

In terms of cryptocurrencies, from the complete list of more than 2,000 cryptocurrencies in the website Cryptocurrency Market Capitalizations [1], we select 50 representative currencies and the sum of the market capitalization of these currencies account for more than 90% of the total value. As a comparison, we analyze 50 currencies (including Gold, Silver, and Platinum) in the foreign exchange market provided by the University of British Columbia [2]. Regarding the stock market, we analyze 102 stocks comprising the S&P 100 Index obtained from Yahoo! Finance [3].

[1] Cryptocurrency Market Capitalization | CoinMarketCap, available from https://coinmarketcap.com/all/views/all/

[2] Pacific Exchange Rate Service - Database Retrieval System, available from http://fx.sauder.ubc.ca/data.html

[3] Yahoo Finance - Business Finance, Stock Market, Quotes, News, available from https://finance.yahoo.com/

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TABLE I
PEARSON'S CORRELATION OF FOUR INDICATORS BETWEEN CORRELATION MATRIX AND ASSET TREE.

	Mean	Variance	Skewness	Kurtosis
Foreign exchange market	-0.777	0.493	-0.595	0.484
Stock market	-0.965	0.742	-0.797	0.696
Cryptocurrency market	-0.984	0.428	-0.897	0.438

TABLE II
SURVIVAL RATIOS AMONG MARKETS

	Single-step	$T(1/2)$	$T(1/3)$	$T(\leq 0.1)$
Foreign exchange market	0.932	18	39	154
Stock market	0.925	16	34	153
Cryptocurrency market	0.916	14	28	85

Based on the datasets, we first construct the correlation matrix and asset tree. Then we examine 1385 windows generated by rolling windows method to analyze the dynamics of the cryptocurrency market from five aspects: temporal volatility, centrality, robustness, clustering structure, and portfolio risk as mentioned in [5]. We further compare the cryptocurrency market with traditional financial markets.

III. RESULTS

Temporal Volatility: We characterize the distribution of the correlation matrix and asset tree using four descriptive statistics: mean, variance, skewness, and kurtosis. In addition, we calculate the Pearson's linear correlation of the four indicators between the two and list them in Table I.

In times of market uncertainty and turmoil, these indicators are in changes, indicating that the effect of financial events on the correlation matrix and asset tree is obvious. -0.984 illustrates that the mean correlation coefficient and the normalized tree length are strongly anti-correlated. Consequently, the asset tree can maintain most, but not all, of the properties of the correlation matrix and it is a good representation by reducing the element number from $N(N-1)/2$ to $N-1$.

Regarding the temporal volatility, the three financial markets are consistent. Specifically, the correlation of variance and kurtosis is positive, while the correlation of mean and skewness is negative.

Centrality Structure: The central node is considered as the parent node of all the other nodes in the asset tree. We identify the central node with the highest influence strength (the sum of correlation coefficients of edges) as shown in Fig. 1.

In the cryptocurrency market, Bitcoin is the central node in the early days, as it was the earliest and almost all major cryptocurrencies had to use Bitcoin as a medium to exchange with fiat currency or other cryptocurrencies. Its dominant role weakened over time and the central node becomes diversified as more than 30 of 50 cryptocurrencies have been the central nodes. A possible reason is that when bitcoin becomes overvalued, volatile and some defects appear, people look for alternative cryptocurrencies.

In terms of the behavior of central nodes, the cryptocurrency market is more similar to the stock market, as changeable central nodes indicating that the market is in a continual transformation and development stage.

Robustness: We use the single-step/multi-step survival ratio to measure the short-term/long-term behavior of the asset tree.

In the cryptocurrency market, the average value of the single-step survival ratio is 0.916, implying that a large majority of links between trees survive from one window to the next and the trees are stable overall. The half-life, the concept from physics indicating the time it takes to halve the ratio, is 14 days. About 1/3 of the links remain after nearly 1 month, and less than 10% of the links survive after nearly 3 months.

As seen in Table II, we can conclude that the survival ratio of the foreign exchange market is the highest, followed by the stock market, and the ratio of the cryptocurrency market is the lowest, illustrating that the cryptocurrency market is more fragile than the traditional financial market.

Clustering Structure: can obtain a meaningful economic taxonomy of the assets and identify assets that are actively in play and effectively dominating the financial market.

The left side of Fig. 2 shows an example of an asset tree with a 3-month time window in September 2017, the nodes from the same cluster are marked by the same color and the node size is determined by its weighted degree. The equivalent asset tree 3 months later shown on the right side of Fig. 2 indicates that the trees do change over time. In the ZEC cluster, a central node and several nodes around it survive, while the other clusters are newly generated by merging, separating, and recombining as follows: the ETH and the ETC cluster are merged to a new cluster, and three new clusters have been formed. The obvious changes in the tree topology indicate financial events.

Regarding the clustering structure, in the foreign exchange

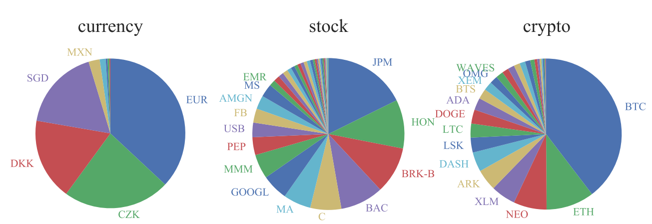

Fig. 1. Distribution of central nodes in different financial markets.

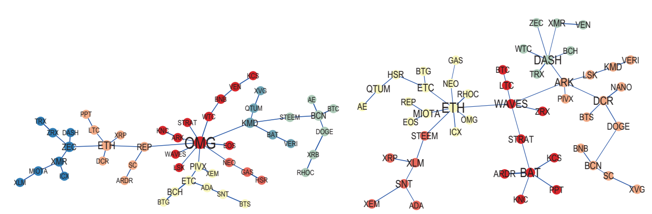

Fig. 2. The asset tree in September 2017 (left) and December 2017 (right) in the cryptocurrency market.

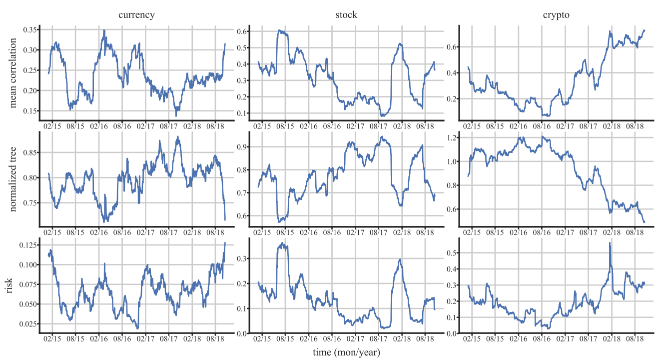

Fig. 3. Minimum risk, mean correlation coefficient, and normalized tree length.

market, clusters are consistent with geographical regions, and in the stock market, clusters are in accordance with business sectors. Nevertheless, the cryptocurrency market does not have evident clustering rules and clusters change more rapidly.

Portfolio Risk: measures the influence of occurrence of an event on a certain number of assets in the market.

First, we determine how the assets included in the minimum portfolio risk are located with respect to the central node. We find that the weighted portfolio layer is higher than the mean occupation layer most of the time, and the differences between the layers in the three markets are 0.67, 1.38, and 0.31 respectively. That is, the assets are consistently distributed on the outskirts of the tree, as measured against the corresponding mean occupation layer. Also, the behavior of the three markets is consistent in the weighted portfolio layer.

From Fig. 3, in the stock market and the cryptocurrency market, the three curves show remarkable similar correlations. By calculating the correlation coefficients between the three coefficients listed in Table III, we find that the cryptocurrency is more similar to the stock, so the normalized tree length is able to explain the diversification potential of the market, though not as strong as the mean correlation coefficient. In the foreign exchange market, though the correlations between the two curves are not evident, these curves are correlated or anti-correlated during the fluctuations.

TABLE III
PEARSON'S CORRELATION OF THREE COEFFICIENTS

Correlation coefficient	Risk vs Mean correlation	Risk vs Normalized tree
Foreign exchange market	0.195	-0.001
Stock market	0.952	-0.920
Cryptocurrency market	0.903	-0.843

IV. Conclusion

In this paper, we analyzed the dynamic characteristics of the cryptocurrency market and compared it with two traditional financial markets, foreign exchange, and stock. Through experiments, we validated that correlation matrix and asset tree are effective tools to analyze the cryptocurrency market, just as good as be employed to analyze the markets of foreign exchange and stock . By applying these two tools, we found that there exist similarities and differences among these markets, which may shed some light on investment decisions, regulation, and legislation.

First, as to the temporal volatility and the location of the assets included in the minimum risk portfolio, the behaviors of the three markets are similar.

Second, the behavior of the cryptocurrency market is more similar to that of the stock market with respect to the diversity of the central nodes, and the correlation between the minimum risk and the mean correlation coefficient/normalized tree length in the portfolio risk.

Third, the cryptocurrency market is more fragile than traditional markets based on the robustness and the clustering structure. Regarding robustness, we found that the foreign exchange market is a stable market and the stock market is less stable, while the cryptocurrency market is a fragile market. As to the clustering structure, unlike the foreign exchange market which is clustered based on the geographical region and the stock market which is clustered in accordance with economic taxonomy or geographical region, the cryptocurrency market exhibits no apparent clustering rule and changes more rapidly. The fragility of the cryptocurrency market may result from economic drivers, public recognition and interest, and technical drivers.

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