

Kerolly Kedma Felix do Nascimento

**Modeling and behavioral analysis of the cryptocurrencies
market**

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UNIVERSIDADE FEDERAL RURAL DE PERNAMBUCO
PRÓ-REITORIA DE PESQUISA E PÓS-GRADUAÇÃO
PROGRAMA DE PÓS-GRADUAÇÃO EM BIOMETRIA E ESTATÍSTICA APLICADA

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This thesis was considered suitable for obtaining the title Ph.D. in Biometrics and Applied Statistics defended and approved unanimously on 09/09/2021 by the examining committee

Concentration area: Biometrics and Applied Statistics

Orientador: Prof. Ph.D. Tiago Alessandro Espínola Ferreira

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Advisor:

**Prof. Ph.D. Tiago Alessandro
Espínola Ferreira**
Advisor

Examining Board:

Prof. Ph.D. Jader da Silva Jale
**Universidade Federal Rural de
Pernambuco**

Prof. Ph.D. Tatijana Stosic
**Universidade Federal Rural de
Pernambuco**

**Prof. Ph.D. Sílvio Fernando Alves
Xavier Júnior**
Universidade Estadual da Paraíba

Prof. Ph.D. Francisco de Sousa Ramos
Universidade Federal de Pernambuco

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*“Success is the sum of small (sometimes large) repeated efforts day after day”
(adapted from Robert Collier).*

Abstract

With the creation of virtual currencies known as cryptocurrencies, it was possible to develop an alternative form of payments. Although there are more than 2000 cryptocurrencies today, four assets (Bitcoin, Ethereum, Litecoin, and Ripple) are pretty popular. They often hold the largest capitalization in the cryptocurrency market. Such popularization has attracted curious investors and researchers to deepen their knowledge in this subject or make investments in these digital assets. In this perspective, one of our objectives in this work was to study the behavior of financial agents participating in a simulated cryptocurrencies market. We used the Particle Swarm Optimization algorithm to implement this market. Two groups of financial agents were investigated concerning their gains in the environment. The first group had a “degree of belief” in forecasting the assets for the next day. On the other hand, the second group did not have this “degree of belief”. We observed that forecasting by financial agents provides more significant gains in average wealth with the experimental results. However, the number of shares and capital of these agents varies according to the cryptocurrency investigated. Subsequently, we used the Transfer Entropy and Effective Transfer Entropy methods to compare the flow of information transfer between cryptocurrencies outside and during today’s most prominent international financial crisis: the pandemic crisis of the new Coronavirus (COVID-19). We found that outside the pandemic (in the first half of 2019), Bitcoin proved to be the dominant cryptocurrency. It was transferring more information on the market than the other cryptocurrencies analyzed. On the other hand, during the pandemic (in the first half of 2020), Ethereum was the dominant cryptocurrency concerning the others investigated. In addition, we use Markov chains from first to tenth order to extract rules of behavior in time series dynamics and plot possible future scenarios. We observed with the results obtained that the historical series studied revealed long-range persistence. Litecoin has nine memory steps, while Bitcoin, Ethereum, and Ripple hold seven memory steps.

Keywords: Simulation, Particle Swarm Optimization algorithm, Effective Transfer Entropy, pandemic, Markov Chains, long-range persistence.

Resumo

Com a criação das moedas virtuais conhecidas como criptomoedas foi possível desenvolver uma forma alternativa de pagamentos. Embora na atualidade existam mais de 2000 criptomoedas, Bitcoin, Ethereum, Litecoin e Ripple são bastante populares e detêm frequentemente a maior capitalização no mercado de criptomoedas. Tal popularização tem atraído curiosos, investidores e pesquisadores a aprofundarem seus conhecimentos nesse assunto ou realizar investimentos nesses ativos digitais. Nesta perspectiva, um de nossos objetivos nesse trabalho foi estudar o comportamento dos agentes financeiros participantes de um mercado de criptomoedas simulado. Utilizamos o algoritmo Particle Swarm Optimization para implementação deste mercado, no qual dois grupos de agentes financeiros foram investigados em relação aos seus ganhos individuais no ambiente. O primeiro grupo tinha um “grau de crença” na previsão dos ativos para o dia seguinte. Em contrapartida, o segundo grupo não tinha esse “grau de crença”. Com os resultados experimentais observamos que a utilização de previsão pelos agentes financeiros propicia maiores ganhos de riqueza média, apesar da quantidade de ações e de capital destes agentes variar de acordo com a criptomoeda investigada. Posteriormente, utilizamos os métodos Transfer Entropy e Effective Transfer Entropy para comparar o fluxo de transferência de informação entre criptomoedas fora e durante a maior crise financeira internacional da atualidade: a crise ocasionada pela pandemia do novo Coronavírus (Covid-19). Verificamos que fora da pandemia (no primeiro semestre de 2019), Bitcoin revelou-se como criptomoeda dominante, transferindo quantidade maior de informação no mercado do que as demais criptomoedas analisadas. Por outro lado, durante a pandemia (no primeiro semestre de 2020), Ethereum foi caracterizada como criptomoeda dominante em relação às demais investigadas. Ademais, utilizamos cadeias de Markov de primeira à décima ordem para extrair regras de comportamento na dinâmica das séries temporais e traçar possíveis cenários futuros. Observamos com os resultados obtidos que as séries históricas estudadas revelaram persistência de longo alcance. Litecoin possui nove passos de memória, enquanto Bitcoin, Ethereum e Ripple detêm sete passos de memória.

Palavras-chaves: simulação, algoritmo Particle Swarm Optimization, Effective Transfer Entropy, pandemia, Cadeias de Markov, persistência de longo alcance.

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