CERTIFICATE

Certificamos que o trabalho: "Blockchain Technology and Panel Data Regression Methods: applications to Accounting and Auditing" de autoria de Eduardo Alexandre Natividade, Leonardo Flach, foi apresentado no 52TH WORLD CONTINUOUS AUDITING & REPORTING SYMPOSIUM, realizado em 21 de setembro de 2022 em Florianópolis- SC, carga horária de 10 horas.

Florianópolis, 21 de Setembro de 2022

ICP-Edu

Documento assinado digitalmente
Fabricia Silva da Rosa
Data: 06/11/2022 07:12:43-0300
CPF: ***.548.659-**
Verifique as assinaturas em https://v.ufsc.br

PROFª DRA. FABRICIA DA ROSA - UFSC

Realização

UNIVERSIDADE FEDERAL DE SANTA CATARINA

RUTGERS THE STATE UNIVERSITY OF NEW JERSEY

CRCSC CONSELHO REGIONAL DE CONTABILIDADE DE SANTA CATARINA

Apoio

FEPESE FUNDAÇÃO DE ESTUDOS E PESQUISAS SOCIOECONÔMICOS

BRDE BANCO REGIONAL DE DESENVOLVIMENTO DO EXTREMO SUL

Blockchain Technology and Panel Data Regression Methods: applications to Accounting and Auditing

Eduardo Alexandre Natividade
Universidade Federal de Santa Catarina (UFSC)
e-mail: edualexandre@hotmail.com

Leonardo Flach
Universidade Federal de Santa Catarina (UFSC)
e-mail: leonardo.flach@ufsc.br

Abstract

This study aims to propose a regression methods applied to evaluate Blockchain technology. Among the statistical methods proposed, we applied a panel data regression model with 7,300 observations, with 10 blockchain variables. The main variable adopted for the study was the daily variation in the value of cryptocurrencies, which was obtained through a calculation involving the opening and closing price of each day. Using big data, results show several informations applied to accounting and auditing, extracted from the 10 most valuable cryptocurrencies. These cryptocurrencies make use of Blockchain technology, considered by experts an innovation as important as the internet itself, through which information can be stored and interconnected with each other, and are already changing accounting and auditing.

Keywords: Blockchain; accounting; auditing; cryptocurrencies; big data.

Research Method: Archival

1 Introduction

The great advances of digital technologies have provided the interaction and connection of various devices and intelligent systems. This constant evolution has presented itself as a great challenge for companies and industries to adapt to new technologies, which are in constant development (Negri, Fumagalli & Macchi, 2017).

The industrial production of the future is characterized by the great individualization of products and highly flexible productions. In this context, there is the concept of industry 4.0, which adopts the most recent technological innovations in the most varied areas. One of these innovations is the Cyber-Physical Systems (CPS), which allow integration with other systems in order to provide greater control over production, uniting the real and virtual worlds through artificial interconnection (AI) (Gomes et al., 2016).

According to Gomes (2016), these technologies should be increasingly present in the coming years, uniting devices and systems, enabling them to communicate in a faster and more dynamic way. Allied to this, still in compliance with Gomes, these devices generate data that will require processing and storage that may cause changes in known business models and in the form of interaction between company and customer.

From this context of technological renovations and the 4.0 industry itself, the correct collection and analysis of the data generated becomes essential, in order to obtain reliable and useful information, which makes it necessary to have systems that can collect, process and manage all this data in a timely manner to assist in the decision-making process (Santos et al., 2017).

According to Grand (2019), it is of fundamental importance that people can prepare themselves to deal with the large volume of data (Big Data) and information that are generated by industry 4.0. With this in mind, Blockchain can be mentioned as a source to obtain data, since it stores transaction information in batches (or blocks) that receive a unique identification code and are linked together, chronologically.

This paper aims to propose a regression methods applied to evaluate Blockchain technology. Among the statistical methods proposed, we applied a panel data regression model with 7,300 observations, with 10 blockchain variables. The main variable adopted for the study was the daily variation in the value of cryptocurrencies, which was obtained through a calculation involving the opening and closing price of each day. Using big data, results show several informations applied to accounting and auditing, extracted from the 10 most valuable cryptocurrencies. These cryptocurrencies make use of Blockchain technology, considered by experts an innovation as important as the internet itself, through which information can be stored and interconnected with each other, and are already changing accounting and auditing.

According to the Future of Money portal (2021), Blockchain is considered by experts as the most important technological innovation since the internet. Also according to the portal, Blockchain is no longer a technology used only to transact cryptocurrencies and has been demonstrating a gigantic potential for use. Experts estimate that the global market for applications of this technology will accumulate around US$ 20 billion in revenue by the year 2024.

In the field of cryptocurrencies, Blockchain is directly linked, as it was one of the main responsible for providing storage, archiving and transactions involving these digital currencies. (Future of Money, 2021). As they work in a decentralized way, cryptocurrencies operate through exchange offices around the world, which can generate differences in the price of the same

currency, even varying its price over the course of a single day. This behavior can be observed, measured and studied using statistical methods focused on Big Data analysis (Murray, 2013).

Considering the importance of the study and analysis of large databases, the objective of this work is to propose a method of evaluating Big Data through statistical methods, using a database collected from the Coin Market Cap portal, which stores and makes available information about cryptocurrencies from around the world, and that make use of Blockchain technology.

2 Theoretical Foundation

Schwab (2016) explain that the terminology of the new industry, or Industry 4.0, was initially used at a fair in Germany in 2011, and referred to an idea of "smart factories". In a future perspective, several categories of professions are prone to automation, that is, algorithms will be able to perform functions that are currently performed by a person, in a faster and more effective way (Schwab, 2016).

Also in accordance with Schwab (2016), the fourth industrial revolution does not only concern industrial systems, but also other topics that range from genetic sequencing, nanotechnology to renewable energies. The union of all these technologies, as well as their interaction with other physical, digital and biological spheres is what characterizes and distinguishes the fourth revolution from the others.

According to Gelbert (2015), for companies to adapt to the changes that industry 4.0 has brought, it is extremely important that internal and external productive factors are integrated into physical and digital systems. For this, it is necessary to use technologies such as Big Data, Artificial Intelligence (AI), among others, making it possible for algorithms to be able to make their own decisions in an accurate way.

Among the biggest advantages that industry 4.0 brings, we highlight the impacts for customers, who will have greater power of customization over the chosen products, increase in the efficiency of factories, possibility of faster decision-making by producers who work in this sector. new industry concept, in addition to greater inventory control and cost reduction during processes (Gelbert, 2015).

According to the International Data Corporation (IDC), global cats with big data and business analytics (BDA) solutions reached US$ 215.7 billion in 2021, representing an increase of more than 10% compared to the year 2020. IDC also predicts that global spending related to the matter will gain a lot of strength over the next five years, especially as the world economy recovers from the COVID-19 pandemic. The forecast is that the compound annual growth rate (CAGR) for worldwide spending on big data and BDA will be 12.8%.

According to IDC (2011, p.6), “Big Data is the new generation of technologies and architectures, economically designed to extract value from large volumes of data, from a variety of sources, allowing high speed in the capture, exploration and analysis of data."

According to the portal O Scala (2022), Big Data has five fundamental pillars that act in the creation of its new technologies, namely: a) Speed: Related to the speed of data collection, organization and analysis; b) Volume: At a global level, the volume of information collected can be colossal, and this is precisely what drove the creation of Big Data; c) Variety: Differentiation of structured and unstructured data, ranging from spreadsheets to audio, images, texts, among other varied formats; d) Veracity: It is critical to know whether the data is reliable; the purpose of Big Data is to find logical and reliable order amidst the randomness of a large database; e) Value: the return of these solutions for the management of the company.

An example of the performance of Big Data in the business world is the entertainment network Netflix. According to Marquesone (2016), Netflix makes use of Big Data to analyze the behavior of its users and what they watched the most, in order to be able to give recommendations that will be more interesting to them. In the financial sector, this technology is commonly used to verify customer satisfaction with the services offered, in order to reduce the rate of change in current accounts. In addition, Big Data often has an application related to cryptocurrencies (Hekima, 2015).

Watters (2016) explain that Blockchain is a distributed database that provides an unalterable (semi) public record of digital transactions. It is often described as a digital ledger, made up of blocks identified by a cryptographic signature.

Bitcoin cryptocurrency is commonly related to blockchain, but these technologies did not come together. The idea of blockchain dates back to the 1990s with the work of Scott Stornetta and Stuart Haber, "How to time-stamp a digital document". It is a discussion of protecting the past for future generations. In this context, the idea of blokchain, Hash and of encrypting this information arises in order to guarantee the absence of fraud on the network (Whitaker, 2018).

Created in 2008, bitcoin would serve as a peer-to-peer electronic currency system (A Peer-to-Peer Electronic Cash System). It was an innovative model, but what revolutionized it even more was the technology used behind it, the blockchain (Swenson, 2018).

Basically, this technology is based on four "Cs": Encryption, Sharing, Consensus and Contract. The idea is that transactions are encoded so that only users directly involved in the transaction receive the information in a readable form (Swenson, 2018).

Bitcoin has a blockchain that acts as a digital wallet that stores and encodes, through cryptography, the transactions (at their exact moments) involving bitcoin. In this context, this information is shared and validated by all its participants who interact with this Peer-to-Peer network (Swenson, 2018).

According to Greenberg (2013), Cryptocurrency is a type of digital currency that makes use of blockchain technology and cryptography to ensure the security and validity of transactions. The emergence of cryptocurrencies took place in 2008, through a group of unidentified programmers who created a decentralized online transaction system using Peer-to-Peer technology and blockchain.

3 Research Method

Among the statistical methods proposed, we applied a panel data regression model with 7,300 observations, with 10 blockchain variables. The main variable adopted for the study was the daily variation in the value of cryptocurrencies, which was obtained through a calculation involving the opening and closing price of each day. Using big data, results show several informations applied to accounting and auditing, extracted from the 10 most valuable cryptocurrencies.

A review was carried out, as well as a survey of the contents mentioned above in the work, from works on industry 4.0, to cryptocurrencies and blockchain technologies, in order to support the proposed study. In addition, a survey was carried out on articles that addressed this topic.

The statistical methods chosen for this study were the descriptive method, correlation analysis and multiple linear regression analysis with panel data, since they were identified as the most appropriate for the proposal.

The present study is based on a Big Data evaluation method, and the chosen base was the cryptocurrency bases that make use of blockchain technology. These bases were selected because they are easy to access and made available by the cryptocurrency-specialized website Coin MarketCap.

The software defined for the use and application of the statistical methods was the Stata software, as it is a very complete and specific program for this type of analysis/study.

After defining the software, the procedures that would be adopted to carry out the study with the data were defined. The main procedures defined were correlation analysis, descriptive analysis, regression with panel data and analysis of variable behavior graphs. These procedures were presented and evidenced below, demonstrating the chosen statistical method.

4 Analysis and Discussion

The data were collected directly from the specialized website Coin Market Cap, which has information about cryptocurrencies that make use of blockchain technology, which has been gaining notoriety and relevance in companies, as mentioned above, especially with the advent of industry 4.0. In addition, the mentioned site was chosen because it provides, with easy access, the necessary information for the purpose of this study. The 10 cryptocurrencies with the highest market cap at the time of this research were selected, namely: Bitcoin, Ethereum, Tether, Currency USD Coin, BNB, Binance USD, XRP, Cardano, Solana and Dogecoin. Once collected, the data were organized into a balanced panel, consisting of 7,300 observations and 10 variables. The analyzed period comprises 2 years, starting on August 20, 2022.

Table 1 – Ranking of Cryptocurrencies. Values referring to 08/20/2022 in dollars

Ranking	Cryptocurrency	Price	Market value	Volume
1	Bitcoin	$21,186.22	$406,169,136,412	$30,006,428,266
2	Ethereum	1,631.09	$199,159,554,102	$16,155,541,401
3	Rope	$1.00	67,555,528,665	44,544,325,130
4	USD currency	1.00	52,223,169,199	7,175,314,629
5	BNB	292.61	47,111,093,819	891,395,173
6	Binance USD	1.00	19,213,834,720	6,038,905,399
7	XRP	0.3525	17,595,710,360	1,164,712,525
8	cardano	0.4657	15,686,678,061	791,016,241
9	Solana	34.21	11,899,730,008	778,314,738
10	dogecoin	0.0673	8,891,366,357	442,746,497

Source: Own elaboration (2022).

The variable “Variation” was adopted as the dependent variable (Y) and deals with the daily variation (in percentage) of the value of the cryptocurrency, which was obtained by the reason of two other variables, the value of the variable “Last” (final value of the currency on the day) and the value of the “First” variable (the value that the cryptocurrency represents at the beginning of the day).

This study also comprises the variables “ID”, which is a currency identification code, “Cryptocurrency”, which deals with the name of the specific currency, “Date”, which represents the days. This variable starts at 1 and ends at 730, representing the existing days in the 2-year period. The variables “High” and “Low”, which represent, respectively, the highest value that a given currency reached that day, and the lowest value. Finally, the variables “Volume” and “MarketCap”, which represent, respectively, the total value traded on the day and the total value

of the available currencies, multiplied by the final price of the day. Below, Table 2 helps to better understand these variables and their representations.

Table 2 - Variables

Variable	Meaning
ID	Cryptocurrency identification code
cryptocurrency	Cryptocurrency name
Date	Exact day of the 2 year period
First	First cryptocurrency value of the day
High	Highest cryptocurrency value on the day
Low	Lowest cryptocurrency value on the day
Last	Last value or closing value of cryptocurrency on the day
Volume	Total transactions involving cryptocurrency on the day
MarketCap	Total value of the sum of available cryptocurrencies times the final value on the day
Variation	Daily percentage change in cryptocurrency value

Source: Own elaboration (2022).

According to Maia (2005), working with panel data makes it possible to identify effects that would not be detected in isolation with cross-sectional data or time series. The panel was then applied in the Stata software, and from then on it underwent several analyses. Right from the start, there was the labeling of the mentioned variables, in order to facilitate the understanding of what each one is about.

At first, a general summary of the characteristics of the database was performed, as shown in Table 3 below. It is possible to perceive the total number of observations (which total 7,300), in addition to the number of 10 variables and a total size of 511,000 observations. In addition to this basic information, it is possible to perceive the labels of each variable, in order to facilitate the understanding of what each independent variable (X) represents in the analyzed database.

Table 3 - General Summary of Characteristics

Contains data			
Note:		7,300	
Vars:		10	
Size:		511,000	
	Storage value	Display	
variable name	Type format label		label variable
ID	byte %10.0g		ID
cryptocurrency	str11 %11s		cryptocurrency
Date	int %10.0g		Date
First	double %14.2f		First
High	double %14.2f		High
Low	double %14.2f		Low
Last	double %14.2f		Last
Volume	double %14.2f		Volume
MarketCap	double %14.2f		MarketCap
Variation	double %6.4f		Variation

Source: Own elaboration (2022).

Next, as shown in Figure 2 below, it is possible to observe that the database is strongly balanced. This command was also given to plot the number of periods (Data) for each individual (ID), and to inform the Stata software that the database worked is in the data panel format.

Then, a decomposition of the variables was performed, as can be seen in Table 4, below. Observing the table, it is possible to notice some aspects, such as the different values related to "between" and "within". When the first is greater than the second, that is, between > within, it means that the variation of that variable is greater among the individuals themselves in a cross-section (cross-sectional data) than over time. Likewise, when within > between, the reverse is true.

Table 4 - Decomposition of variables

Variable		Mean	Std. Dev.	Min	Max	Obs.
ID	overall	5.5	2.872478	1	10	N = 7300
	between		3.02765	1	10	n = 10
	within		0	5.5	5.5	T = 730
cryptocurrency	overall	.	.	.	.	0
	between		.	.	.	0
	within		.	.	.	0
Date	overall	365.5	210.7471	1	730	N = 7300
	between		0	365.5	365.5	n = 10
	within		210.7471	1	730	T = 730
First	overall	3972,292	12051.16	0.002517	67549.74	N = 7300
	between		11671.65	0.1377539	37132.61	n = 10
	within		4754,892	-23026.17	34389.42	T = 730
High	overall	4077,726	12360.67	0.00253	68789.63	N = 7300
	between		11975.35	0.1460241	38100.1	n = 10
	within		4868,293	-23671.84	34767.25	T = 730
Low	overall	3852,546	11696.49	0.002452	66382.06	N = 7300
	between		11326.55	0 .1296753	36033.31	n = 10
	within		4618,469	-22264.28	34201.29	T = 730
Last	overall	3973,093	12049.98	0 .002517	67566.83	N = 7300
	between		11673.71	0 .137868	37139.24	n = 10
	within		4747,323	-23034.63	34400.68	T = 730
Volume	overall	1.57e+10	2.69e+10	6139511	3.51e+11	N = 7300
	between		2.40e+10	1.38e+09	7.46e+10	n = 10
	within		1.42e+10	-2.98e+10	3.27e+11	T = 730
MarketCap	overall	1.21e+11	2.29e+11	5.61e+07	1.27e+12	N = 7300
	between		2.16e+11	1.00e+10	6.99e+11	n = 10
	within		1.01e+11	-3.91e+11	6.97e+11	T = 730
Variation	overall	0.0001638	0 .054831	-0.7804871	0.7324053	N = 7300
	between		0 .0009129	-0.0015404	0.0022518	n = 10
	within		0.0548241	-0.7807466	0 .7303173	T = 730

Source: Own elaboration (2022).

For a better understanding of Table 5, it is possible to take the analysis of the Variation variable as an example. The arithmetic mean of the 7,300 observations of this variable was 0.0001638. Its calculated standard error was 0.054831, the smallest among all, which denotes that this variable had the values closest to the mean, while variables such as Last, Low, High and First showed large variations, compared to their respective averages, due to its high standard deviation. The Variation also presented the lowest value of -0.7804871 and a maximum value of 0.7324053.

Table 5 - Descriptive Analysis

Variable	Obs.	Mean	Std. Dev.	Min	Max
Variation	7300	0.0001638	0.054831	-0.7804871	0.7324053
MarketCap	7300	1.21e+11	2.29e+11	5.61e+07	1.27e+12
Volume	7300	1.57e+10	2.69e+10	6139511	3.51e+11
Last	7300	3973,093	12049.98	0.002517	67566.83
Low	7300	3852,546	11696.49	0.002452	66382.06
High	7300	4077,726	12360.67	0.00253	68789.63
First	7300	3972,292	12051.16	0.002517	67549.74

Source: Own elaboration (2022).

Table 6 below presents the results of the correlation between the variables, using the Stata software, using the Pearson method with a confidence interval of 95%. The correlation between the Variation variable and the MarketCap, Volume and the Last variable is inverse, which was already expected. In addition, in general, it is observed that the correlation of the dependent variable with the others is weak, while the MarketCap variable presented a direct correlation with all other variables, and very strong with the vast majority of them. The same behavior was observed in the variables Last, Low and High, with the exception of Volume, which showed a weak correlation.

Table 6 - Descriptive Analysis

	Variation	MarketCap	Volume	Last	Low	High	First
Variation	1,0000						
MarketCap	-0.0210	1,0000					
Volume	-0.0890	0.3313	1,0000				
Last	-0.0190	0.9485	0.2946	1,0000			
Low	0.0110	0.9481	0.2917	0.9996	1,0000		
High	0.0220	0.9482	0.2967	0.9996	0.9994	1,0000	
First	0.0590	0.9477	0.2952	0.9992	0.9994	0.9997	1,0000

Source: Own elaboration (2022).

In the next step, a Multiple Linear Regression was applied, the results of which are shown in Table 7, applying all data with all variables in a single model, as shown in the Table below. Among some aspects that can be observed from the regression is the value of Prob > F equal to 0, that is, considering that the confidence interval of this analysis is 95%, this result indicates that it is possible to reject the null hypothesis, characterizing that the dependent variable significantly impacts the others. The F value determines whether the model is associated with the response, and because it has a value greater than 10, in this case, it is possible to say that the model is well adjusted. In addition, another value observed is that of R^2 (R-squared), which has an explanatory character.

Table 7 - Multiple Linear Regression Results

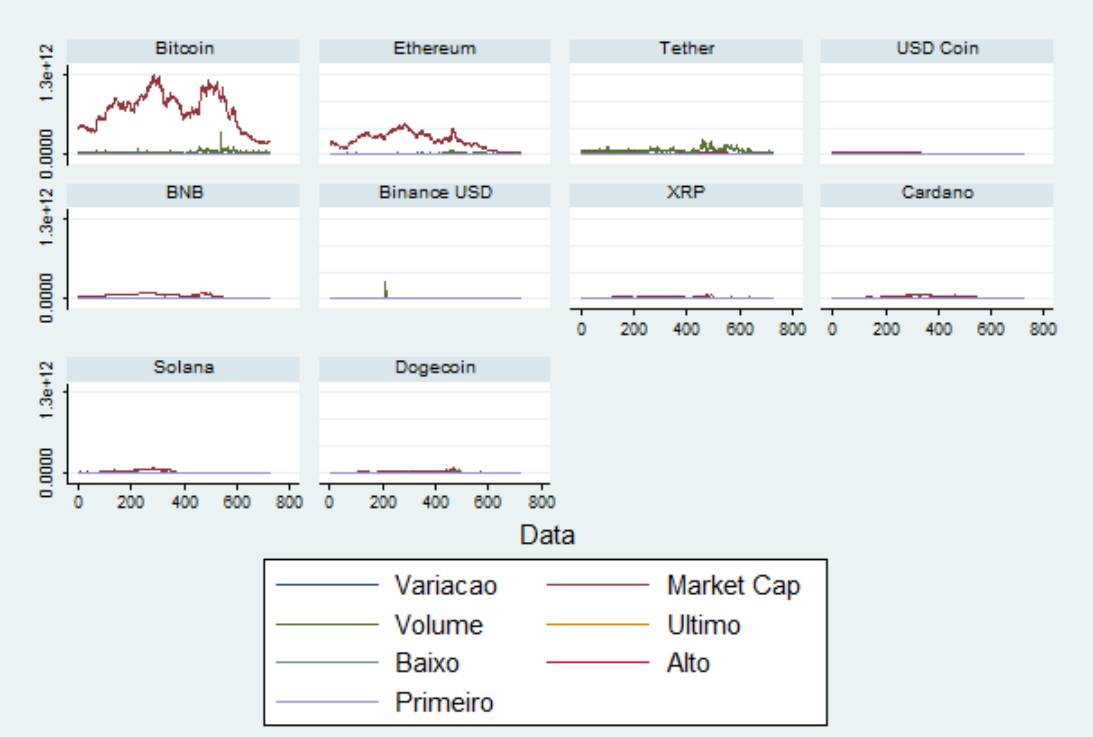
Source	SS	Df MS		Obs.	7300
				F (7, 7292)	41.67
Model	0.844111	7 0.1205		Prob > F	0.0000
Residual	21.099871	7292 0.0028		R-squared	0.3850
Total	21.9439	7299 0.0030		adj R-squared	0.3750
				Root MSE	0.05379
Variation	Coef.	Std. Err.	t	P > | t | [95% Conf.]	
MarketCap	-4.35e-15	9.07	-0.48	0.632 -2.21e-14	1.34e-14

Volume	-2.27e-14	2.53	-0.90	0.370 -7.22e-14	2.69e-14
Last	-0.0000021	3.09	-6.88	0.000 -0.000027	-0.000015
Low	-8.62e-07	2.54	-0.34	0.735 -5.85e-06	4.13e-06
High	1.18e-07	3.58	0.03	0.974 -6.90e-06	7.13e-06
First	0.000022	2.84	7.76	0.000 0.000165	0.000027
constant	0.003580	0.0014	0.01	0.014 0.000713	0.006447

Source: Own elaboration (2022).

Figure 1 represents a graph generated with all the study variables. It is possible to notice that the biggest variations occur with the first two cryptocurrencies, Bitcoin and Ethereum. They are also the two most valuable currencies at the time of this survey. The other charts, related to other currencies, show similar behavior, with more regular variations.

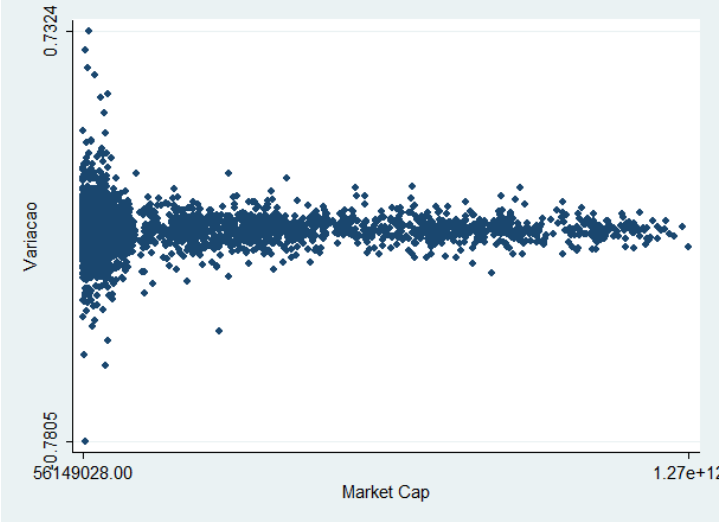
Figure 1 - Behavior of variables



Source: Own elaboration (2022).

Due to the greater variation of the variables occurring with Bitcoin, some graphs were generated in order to better understand the behavior of this cryptocurrency. Below, Figure 4, represents the scatter plot between the dependent variable and the MarketCap. It is noted that the large peak of values of the Variation variable occurs with the lowest values of the MarketCap, and that it stabilizes with the increase of this independent variable.

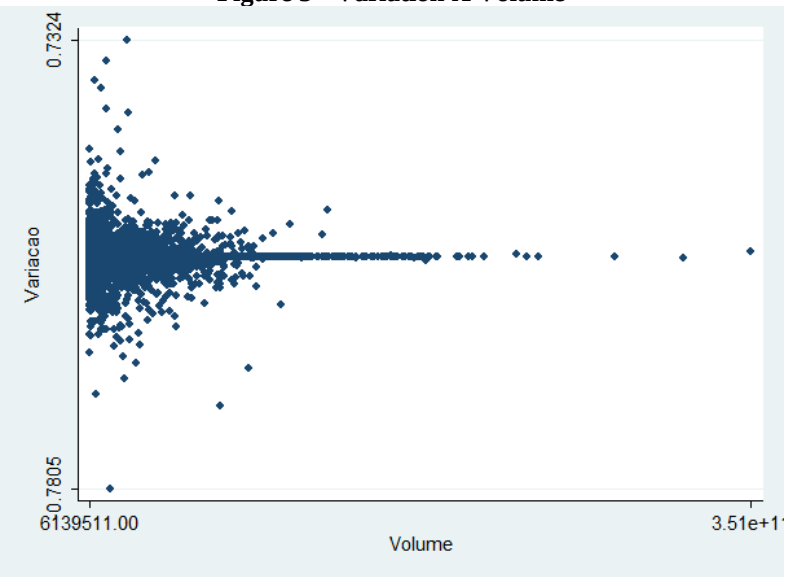
Figure 2 - Variation X MarketCap



Source: Own elaboration (2022).

Similar behavior is seen in Figure 2 below. This time, the variable compared with the daily change in the value of the shares is the Volume. The highest and lowest values of the daily variation are achieved with the lowest volumes of currency transactions, and it ends up stabilizing as the volume increases. This behavior was already expected, given that more stable stock price values tend to be more attractive for transactions.

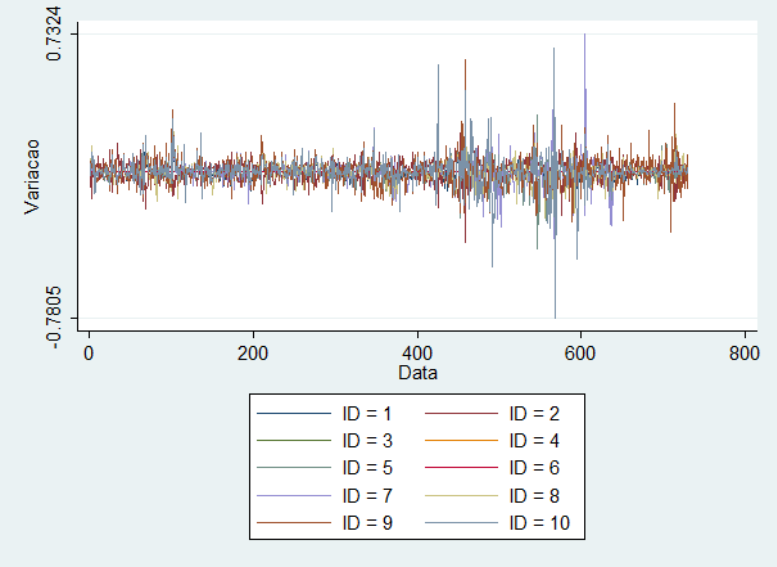
Figure 3 - Variation X Volume



Source: Own elaboration (2022).

The next Figure 3 represents the behavior of the daily price variation of cryptocurrencies over the two-year period. The number zero represents the most current date of this study (August 20, 2022), and it is possible to notice that in this period the variation in the price of coins remains smaller, with closer values, while a year ago these variations were greater. , reaching much higher or much lower values.

Figure 4 - Variation X Volume



Source: Own elaboration (2022).

The purpose of the graph represented by Figure 4 is to observe, individually, the behavior of the dependent variable in question, making it possible to perceive a pattern of behavior throughout the analyzed period.

5 Final Considerations

After the completion of the statistical methods, as well as their analyzes and observations, it is concluded that the objective of the study was achieved. Through various statistical techniques, a procedure for evaluating Big Data of cryptocurrencies that make use of blockchain technology was established, using a data panel that was collected from information available on a website specialized in the subject.

The database was organized in a balanced data panel, to be worked on in the Stata software properly. The choice for the topic of cryptocurrencies that make use of blockchain was due to the importance that this subject has had in companies, as mentioned earlier in this study. It is worth remembering that there were no difficulties in accessing the information, since it was available through the specialized website. The option for the 10 coins with the highest accumulated value was made in order to bring the most valued coins into the study. The 2-year period was chosen to increase the reliability of the study.

It is worth mentioning that Blockchain is currently a highly valued technology, but relatively recent, in the process of maturing in the industry, with great potential for development and which needs to be explored further. Big Data is already a more present reality in several branches of activities, necessary in several segments of companies and areas of activity.

Furthermore, this study has limitations due to analyzing only the variables chosen and addressed, but this analysis method can be replicated to other organizations and variables, regardless of the sector of activities.

References

Antonopoulos, Andreas M. (2022). *Mastering Bitcoin Unlocking digital cryptocurrencies.*

O'reilly, London.

Araya, Asrat; Dahalan, Jauhari; Muhammad, Barudin. (2021). Blockchain technology and regression methods: a case of conceptual framework. *International Journal of Business Society*. Available at: https://doi.org/10.1007/978-3-030-74575-2_3. Accessed in: January 2022.

Bost, R., Popa, R.A., Tu, S., Goldwasser, S.: Machine learning classification over encrypted data. In: Proceedings of Network and Distributed System Security Symposium, San Diego, California, 23–26 February 2014 (2014).

Coinmarketcap. Available at: <https://coinmarketcap.com/>. Accessed in: August 2022.

Gerbert, Philipp et al. (2015). Industry 4.0: The Future of Productivity and Growth in *Manufacturing Industries*. 2015. Available at: <https://www.bcg.com/publications/2015/engineered_products_project_business_industry_4_future_productivity_growth_manufacturing_industries.aspx>. Access at: January 2022.

Goldreich, O.: Foundations of Cryptography: Volume 2, Basic Applications. Cambridge University Press, Cambridge (2009)

Greenberg, Andy (2022). Cryptocurrency. Available on: <https://www.forbes.com/forbes/2011/0509/technology-psilocybin-bitcoins-gavinandresen-crypto-currency.html#400e4a35353e>. Accessed in: January 2022.

IDC (2022). Extracting Value from Chaos (2022). Available at: https://www.yumpu.com/en/document/view/3703408/extracting-value-from-chaos-emc. Accessed in: January 2022.

Kolowich, Lindsay What is a Whitepaper [FAQ] Mar. 2018. Available at: <https://blog.hubspot.com/marketing/what-is-a-whitepaper-examples-for-business>. Accessed in: January 2022.

Lima, Marcela Cristina; Almeida, Rafaela Madureira; Valim, Stéfane Ribeiro; Miranda, Wederley Mendes. The importance of Data Analysis in Production Engineering. 2021. Available at: https://www.abepro.org.br/biblioteca/TN_STO_359_1852_42030.pdf. Accessed in: January 2022.

Nakamoto, Satoshi. (2009). Bitcoin: A Peer-to-Peer Electronic Cash System. Accessed in: January 2022.

Negri, Elisa; Fumagalli, Luca; Macchi, Marco. (2017). A Review of the Roles of Digital Twin in CPS-based Production Systems. *Procedia Manufacturing*, 11, 939-948.

Santos, C. F.; Piechnicki, F.; Loures, E. F. R., Santos, E. A. P. (2017), Mapping the Conceptual Relationship among Data Analysis, Knowledge Generation and Decision-making in Industrial Processes. *Procedia Manufacturing*, 11, 1751-1758.

Shen, M., Tang, X., Zhu, L., Du, X., Guizani, M.: Privacy-preserving support vector machine training over blockchain-based encrypted IoT data in smart cities. IEEE Internet Things J. 6, 7702–7712 (2019). https://doi.org/10.1109/JIOT.2019.2901840

Watters, Audrey. (2018). The Blockchain for Education: An Introduction. Hasheducation. Available at: http://hackeducation.com/2016/04/07/blockchain-education-guide.

Whitaker, May. (2019). Blockchain, Fractional Ownership, and the Future of Creative Work. 2019. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3100389.
WHITAKER, Amy. (2022). The Eureka Moment That Made Bitcoin Possible. *Wall Street Journal*. Available at: https://www.wsj.com/articles/the-eureka-moment-that-made-bitcoin-possible-1527268025