

Analyzing cryptocurrency volatility: an EGARCH model

Guillermo Arroyo Jiménez*

Julia Juárez García**

Recibido: mayo, 2024/Aceptado: noviembre, 2024

Abstract

The aim of this article is to examine the reasons why cryptocurrency volatility hinders its potential to replace fiat money as legal tender. We focus on Bitcoin and Ethereum for this analysis. By applying an augmented Dickey-Fuller stationarity test, we demonstrate that cryptocurrencies lack a long-term trend; instead, their movement is erratic and highly volatile. Furthermore, eGARCH models indicate that volatility tends to decrease and is expected to persist in this pattern. In summary, theoretical and empirical analysis suggests that, due to their nature based solely on supply and demand and their high volatility, cryptocurrencies are not suitable as primary investment instruments or stores of value.

Keywords: Cryptocurrencies, fiat money, blockchain technology, volatility, eGarch.

JEL classification: G32, E51, E42.

*Profesor-investigador, adscrito a la División de Estudios de Posgrado de la Facultad de Economía de la UNAM. <act.guillermo.arroyo@gmail.com>; ORCID: <https://orcid.org/0009-0007-4596-5534>

**División de Estudios de Posgrado de la Facultad de Economía de la UNAM; <julia.juarez.garcia@comunidad.unam.mx>; ORCID: <https://orcid.org/0009-0002-8269-6066>.

Un análisis de la volatilidad de las criptomonedas: un modelo EGARCH

Resumen

El propósito de este artículo es examinar las razones por las cuales la volatilidad de las criptomonedas obstaculiza su potencial para reemplazar al dinero fiduciario como curso legal. Nos enfocamos en Bitcoin y Ethereum para este análisis. Al aplicar una prueba de estacionariedad aumentada de Dickey-Fuller, demostramos que las criptomonedas carecen de una tendencia a largo plazo; en su lugar, su movimiento es impredecible y altamente volátil. Además, los modelos eGARCH indican que la volatilidad tiende a disminuir y se anticipa que persistirá en este patrón. En resumen, el análisis teórico y empírico sugiere que, debido a su naturaleza basada únicamente en la ley de oferta y demanda y su alta volatilidad, las criptomonedas no son adecuadas como instrumentos principales de inversión o reserva de valor.

Palabras clave: Criptomonedas, dinero fiduciario, Blockchain, volatilidad.

Clasificación JEL: G32, E51, E42.

1. Introduction

Humans are social beings with a natural inclination to help others and exchange material goods. Historically, various items such as metals, cattle, cowries, and cocoa beans have been used as currency. At this time, at the beginning of trade, it is not necessary that currencies be anchored in a precious metal (see Hermele, 2014, p. 14), even when gold and metals are easy for everyone to measure –by size or weight, and, with more specialized knowledge, by fineness–, and it is possible to see when they have been tampered with.

Money can take many forms and does not require complexity or innovation. However, for something to be considered as money, it must be recognized as a valid form of payment, accepted as a means to pay taxes, and used throughout a country's territory as a social convention. The existence and effectiveness of money are determined by social law rather than the material used to make coins. Prior to government monopolies on legal currency, people had to accept the currency as a valid means of payment. It is important to note that the use of a currency cannot be forced upon individuals.

During the Reign of Terror in France, 1793, the punishment for refusing to accept the official means of payment or to carry another currency was the confiscation of property and the death penalty. But at the end, these measures failed because people preferred precious metal-backed means of exchange, and no government policy was enough to counter society's desire.

After the First World War, the reichsmark was devalued to stratospheric levels. People needed a stable currency, anything was good to make payments, there were thousands of currencies, merchandise, commodities, different in circulation. Until the Rentenmark arrived, whose success was based on a social desire to have a unique currency and on its scarcity.

With Breton Woods agreement, the monopoly of dollars enabled the US to harvest a seigniorage estimated at 10-20 billion USD annually (Cohen 1998, p. 124). Converting, in addition, the dollar as reserve currency worldwide and allowing the United States to export its inflation. This gives the United States the possibility of financing itself with foreign resources, instead of charging taxes to its citizens. That is, having a preponderance of monetary policy instead of fiscal policy. After, in the seventies, US unilaterally abandoned the Bretton Woods agreement by breaking the promise to redeem dollar holdings in gold, obtaining with it even more benefits, at least, the benefit of not having obligations.

Hayek (1976) proposes a solution to protect money from political influence for events like this. According to him, people should have the freedom to choose the currency they want to use, and the government should not have a monopoly on monetary issue. This feature is the fundamental aspect of a truly free country. Additionally, cryptocurrencies are significant because they offer a new consensus to make payments globally, providing reliability and efficiency.

In this sense, the purpose of this paper is, to prove why the volatility of cryptocurrencies does not allow them to replace fiduciary money as a legal tender, at least not yet. To put in clear terms which properties they fully comply with and which they do not, to distinguish the opportunity that they have as a currency, investment instrument and technology. To explore how the current monetary and fiscal policy would have to be modified for a cryptocurrency to be installed as a new legal tender.

The article is divided into six sections, in addition to this brief introduction. Firstly, we define blockchain technology and cryptocurrencies, highlighting their most relevant characteristics. Subsequently, a theoretical comparative exercise between cryptocurrencies and fiat money is conducted.

Section three engages in a theoretical reflection on the long-term price formation law, followed by an exploration of the fundamentals of fiat currencies

and cryptocurrencies' volatility. Combining aspects related to the foundation of these currencies, we analyze controversial elements such as financial bubbles and monetary policy in the fourth section.

The econometric exercise in the fifth section analyzes the behavior of Bitcoin and Ethereum, aiming to test the research hypothesis regarding the erratic and volatile nature of these cryptocurrencies. We use an augmented Dickey-Fuller stationarity test to illustrate that cryptocurrencies do not exhibit a long-term trend and an eGarch model to reveal that volatility is currently on a downward trend. Finally, some controversies arising from the use of cryptocurrencies are presented in order to identify some concluding remarks.

2. Blockchain technology and cryptocurrency

Blockchain technology is a distributed, immutable, unique, autonomous, and open-source software based on cryptographic algorithms. It is a network that stores all the information produced by users over time, making it auditable. It is, at the same time, a ledger system that requires a minimal structure.

The steps to run the network are as follows (see Nakamoto, 2008, p.3):

1. New transactions are broadcast to all nodes;
2. Each node collects new transactions into a block;
3. Each node works on finding a difficult proof-of-work for its block;
4. When a node finds a proof-of-work, it broadcasts the block to all nodes;
5. Nodes accept the block only if all transactions in it are valid and not already spent;
6. Nodes express their acceptance of the block by working on creating the next block in the chain, using the hash of the accepted block as the previous hash.

Each of the participants in the network contributes to the verification process by means of a blockchain that grows larger as exchange transactions are carried out between the different participants. These blocks are encrypted to avoid the double-spend problem –potential flaw in a digital cash scheme in which the same single digital token can be spent more than once–, but the information is protected in each of the nodes/users of the network to avoid alterations to the system. The whole story is protected in each added block. It has many applications, one of them is cryptocurrencies.

Cryptocurrencies meet the essential characteristics of money, namely, a means of exchange, a unit of accounting, and a store of wealth. It is the first of those three characteristics the most important to understand the role of society in the acceptance of a currency.

According to Pernice & Scott (2021), the term cryptocurrency gained popularity with the emergence of Bitcoin in 2008, while the original proposition presented by Nakamoto (2008) was a project peer-to-peer currency in a cryptography mailing list. Our starting point, beyond tracing a definition of cryptocurrencies, is to present an overview of their disadvantages and advantages, in general terms, some characteristics of cryptocurrencies in favor of cryptocurrencies to replace fiat money are detailed below:

Consistency: This property ensures the non-deformation of the coin over time in its quality material.

Stability: The opportunity for cryptocurrencies to replace fiat money lies in the fact that with the current currency there is a risk of counterfeit, insecurity and have high transaction fees, even with the digital currencies –not cryptocurrencies– there are instabilities, thefts, and frauds. In addition, centralized systems require a large investment in infrastructure, and they are also very difficult to audit. Cryptocurrency-based systems promise to solve all these difficulties at low cost and in consensus.

Durability: Cryptocurrencies cannot be destroyed; they can last infinitely as long as the network and the nodes that support the information exist.

Security: The Network of a cryptocurrency is highly secure because its cryptographic based algorithms. It is a decentralized system, with different checkpoints and storage. The Network has mechanisms to ensure the impossibility of counterfeiting assets.

Transparency: All members of the network have access to information; an immutable record of all activity exists.

Decentralized payments: The system does not need a third party to validate payments. This is one of the main differences with the traditional systems payments.

Lower cost of transactions: The creation of cryptocurrencies within the system is done through mining or adding a new block to the network, this reduces the cost of money supply to a minimum. There are no transaction costs and no fees to access to the system. This feature constitutes one of the most valuable opportunities for cryptocurrencies to replace fiat money.

Verification: Each added block implies a verification in each one of the nodes that participate in the network. Blockchain technology resolves the Byzantine

General's Problem, a condition of a computer system, particularly distributed computing systems, where components may fail and there is imperfect information; to avoid catastrophic failure of the system, the system's actors must agree on a concerted strategy, but some of these actors are unreliable. So, all the nodes have to reach a consensus regarding which component has failed in the first place to exclude it. In blockchain only verified blocks go to the next stage. The owners cannot double-spend the coin (see Nakamoto, 2008, p.2), because the system is aware of all transactions, every coin is in only one place inside the network.

Auditable information: All the generated information is saved in the system; the auditor can track all the movements and owners that a cryptocurrency has had over time. This information is always available to all members of the network.

No risk of chargeback fraud: Once sent and cleared, a transaction cannot be reversed or changed by the sender. Transactions are done almost instantly and there is no exposure of financial data.

However, the characteristics against of cryptocurrencies to replace fiat money are:

Expansive supply: Cryptocurrencies can expand their money supply, not contract it. This is due to the network design. So, the supply is inelastic and previously determined.

Limited access technology: First, a device is required to access the system. In the world, not all people have one. Secondly, the network is difficult to use, even when is open to enter and participate. This makes payments for out-of-network purchases difficult, especially in countries where a large percentage of the population does not have access to financial services.

No protection against mistakes: There is no going back or clarification of erroneous payments, transactions cannot be reversed. And if someone duplicates the entry key to the wallet, the funds may be lost. Banks currently consider errors/frauds to be "normal" within a percentage operating range. This is accepted as inevitable.

No institutional support: Governments and banks do not support any cryptocurrency. Cryptocurrencies are not illegal –in the US are recognized by the Department of Justice and regulated in some states like New York–, but people cannot pay taxes with them.

In summary, the control that cryptocurrencies provide to the economy can be significantly threatened by institutional and social factors. Asymmetries in access to digital infrastructure in different regions of the world play

a decisive role in the accessibility of this tool. Likewise, the impossibility of fiscal contribution through this means would pose a risk to public finances.

3. A comparison between fiat money and cryptocurrencies

The dilemma arising from the coexistence of two currencies and the revolutionary impact of blockchain is the potential erosion of government control over currency and its creation. This implies a loss of resources that could otherwise be allocated to execute monetary policy, settle debts, or redeem bonds. Regardless of its democratic nature, no government is likely to consent to the displacement of its currency by another it cannot regulate. Therefore, the adoption of a technology revealing real-time global insight into the quantity and whereabouts of money remains a formidable challenge for any government.

Gresham's Law is a theorem about the composition of money in an economy, said Mundell (1998), and the correct sentence of this theorem is not "bad money drives out good", but its opposite: "good money drives out bad". The only way that weak money drives out good is when the currencies are exchanged to the same price. In the history, only strong currencies survive.

The secret of paper money to drives out gold was its easy handling, less costly, and its intrinsic characteristic of being a bank credit. Fiat money is elastic at least in the short term.

There is a preference of investors for hard currencies. In all his essay, Yotopoulos & Sawada (1999) argue that investors' preference for strong currencies does not respond to economic fundamentals but to an "asymmetric reputation" of currencies. Investors prefer to have their investments in denominations of strong currencies since there is a constant depreciation that affects the weak ones.

So, it could happen 3 scenarios in the long run:

1. Cryptocurrency displaces fiat money: This case could happen when the cryptocurrency gains more acceptance in society than traditional fiat currency. However, for this to occur, it is imperative to stabilize its volatility to instill trust among both the public and businesses. Governments and banks must provide backing, and the cryptocurrency should be widely accepted for settling debts and paying taxes.
2. Cryptocurrency is accepted at the same price of fiat currency. This is an unrealistic scenario because it requires both currencies to exhibit

identical volatility and value, essentially necessitating them to be one.

3. Fiat money displaces cryptocurrency. This is the most plausible scenario, as cryptocurrencies lack widespread liquidity, acceptance in numerous businesses, and the ability to be used for debt payments. Consequently, their value is anticipated to remain volatile, and trend negatively compared to fiat money.

There is no compelling reason to prevent a currency from circulating as a means of payment alongside the legal tender, but in the long run, one will end up displacing the other. Since debts are paid with the less costly money (see Mundell, 1998), there is an opportunity for cryptocurrencies to replace currencies as means of exchange. The cost of paper money must be higher than that of cryptocurrencies, even covering the cost of accessing blockchain technology.

Due to the chaos that a truly democratic consensus would cause, governments have been forced to use a legal tender, which has later served to assert their sovereignty. This monopoly is strongly supported by the fact that the legal tender is the only one with which taxes can be paid, and in general, it is accepted to pay any debt.

4. Long-term price formation law

The law of long-term price formation, put forward by classical economists, tells us that the market price oscillates around the price of production and is its anchor. There may be short-term distortions, but the balance in the long run is at the point where these prices converge. Although there are distortions in the short term, prices are rigid in the long term. Production prices, then, are regulatory prices.

For Smith, the natural price is defined by what we know as the price of production, that is, the rent of the land, the wages of labor, and the benefits of capital that were used to obtain, prepare, and distribute the merchandise. And he tells us (Smith, 2017 [1776], p.56) that: “The market price will decrease more or less with respect to the natural price, as the abundance or scarcity of the genus more or less increases the competition among sellers, or depending on whether they are more or less likely to immediately discard the merchandise.” Then he adds what we have pointed out, it is the law of long-term price formation (Smith, 2017 [1776], pp.56-57): “The natural price becomes, therefore, the central price, around the which continually gravitate to the prices of all merchandise”.

For Ricardo, the prices of goods are subject to rise and fall due to two things: 1) The supply and demand of the good and 2) the variations in the goods necessary to produce this good. However, he thinks that the price of the merchandise must be regulated.

The classical economists then propose a dynamic price system, where production cycles create oscillations in values and prices; and equilibrium, then, occurs when the market price converges to the production price or the natural price. Although the price distortion is not symmetrical, but tends to be positive and divergent, because if the market price falls below the price of production for a long time, production is interrupted, it is not maintained.

With the intention of making an accurate comparison and seeing what price theory cryptocurrencies follow, it is necessary to explain the marginalist theory.

The marginalist price theory is based mainly on the law of supply and demand and on the scarcity of the product to determine the price. In his book III, study of wants and their satisfaction, Marshall (2013 [1890], pp. 70-114) delineate the marginalist price theory, in which the principal idea is that the demand and supply play the most important role in the determination of value.

The demand is always determined by the consumers, their desires and their purchasing power reflected in the maximization of individual utility. But when this desire is satisfied, the increase of a stock of a thing decreases in importance each time, precisely, because its need is already satisfied, this principle is called by Marshall as the marginal utility principle.

The marginal utilities of the various commodities bought must be proportional to their prices. Marshall, then, formulate the law of demand: The greater amount to be sold, the smaller must be the price at which it is offered in order that it may find purchasers; or, in other words, the amount demanded increases with a fall in price, and diminishes with a rise in price.

There will not be any uniform relation between the fall in price and the increase of demand. So, given the individual scales of preference for a time and a space determined, and given a supply curve, is possible to find the equilibrium for everyone, even if the price change in the short run; and then the total demand or the aggregate demand is the sum of all individual demands.

We can formulate the law of supply in similar terms: higher price will induce producers to supply a higher quantity to the market and vice versa. Provided the average cost is not higher than the price, for obvious reasons, otherwise the industry could disappear.

The equilibrium point, defined by Walras (see Hicks, 1978 [1939]), is one at which the supply and demand curves intersect. The long-period supply curve of the industry is a horizontal line and demand can only determine the quantity produced by the industry in a long-period equilibrium. The equilibrium of one market could affect other markets, but the fully general equilibrium is achieved in the same way (see Kurz & Salvatori, 1995, p.28). In summary, for the marginalist price theory, the demand is the principal factor in the determination of prices.

In this context, understanding the functioning of price theory, we observe that the value of a cryptocurrency is solely determined by its demand and supply, influenced by expectations, the number of merchants and users accepting them, and lacks fundamental determinants. This poses an inconvenience for individuals, as stable currencies are generally preferred for investment.

5. Exploring the fundamentals of fiat currencies and cryptocurrencies volatility

Now we will delve into the fundamentals of national currencies in comparison to their absence in cryptocurrencies. The factors that influence exchange rates of fiat currencies around the world are (see Madura, 2015, pp.112-120):

Relative inflation rates: If inflation increases in the local country with respect to the foreign country, its currency is likely to depreciate due to increased demand for foreign goods.

Relative interest rates: If the interest rate increases in the local country with respect to the foreign country, its currency is likely to appreciate due to the inflow of investment capital.

Relative income levels: If income level increases in the local country with respect to the foreign country, its currency is likely to depreciate due to increased demand for foreign goods.

Government controls: Governments can intervene in the exchange rate marking in the following ways: 1) exchange barriers; 2) barriers to foreign trade; 3) intervention in the foreign exchange markets; 4) monetary policy.

Expectations: What the agents expect in the future and the political-economic news may affect the level of exchange rates, as well as the speculative attacks of some economic agents.

However, the fundamentals of a cryptocurrency either do not exist or are very weak. The integration of a new block in blockchain technology requires a significant amount of energy. Every Bitcoin has a certain dollar cost at any given moment. Nevertheless, the energy or the fiat money expended does not adequately explain its value since the fluctuations or magnitude of these factors do not correlate with the movement of the cryptocurrency's price.

The value of a cryptocurrency is exclusively derived from its demand and supply, shaped by expectations, along with the number of merchants and users accepting them. Notably, cryptocurrencies lack a physical presence; instead, they embody a subjective value, in line with the principles of the Austrian school of economics.

In the essay published by Scholer (2016) it can be read:

“In contrast to fiat currencies –the value of which is driven by the backing of the applicable government– and precious metals –the value of which are linked to historic industrial and commercial applications and cultural investment traditions–, critics argue that bitcoins have limited or no inherent or objective value. Bitcoin proponents often counter that bitcoins have value based on their ability to provide access to the Bitcoin Network and their use as a store of value and medium of exchange” (p. 11).

Thus, we can observe that cryptocurrencies do not have fundamental determinants that explain the volatile movement of their prices. In this sense, in modern finance, risk is typically assessed through the volatility of historical series.

However, this approach not only imposes technical constraints but also fails to encompass all potential risks associated with the subject valuation. It is a daring endeavor to assume that uncertainty is both controllable and measurable, equating uncertainty to risk and further defining risk as the volatility of historical series. Additionally, this method confines volatility to a specific historical timeframe, whether one year, three years, five years, ten years, etc., thereby excluding valuable information that may recur in the future. Furthermore, a more severe limitation is the assumption of similarity in products or assets, using the volatility of a comparable entity to simulate the risk of the asset in question.

Until now, cryptocurrencies have been characterized by high volatility and limited liquidity. This feature can be exploited by speculators to generate substantial profits. The value of cryptocurrencies is largely determined by their volatility; at any given moment, they can skyrocket and then quickly lose their worth.

Volatility is undesirable as people generally prefer stable currencies (see Hayek, 1976, p. 20). An individual with no inclination to invest their money is not interested in exposing their income to risks. Moreover, a volatile currency would lead to continual fluctuations in prices, both downward and upward.

The following table shows the volatility achieved by the two main cryptocurrencies in the market:

Table 1
Annual volatility

Cryptocurrency	Volatility
Bitcoin	1418
Ethereum	104

Source: own elaboration with data from the Ethereum and Bitcoin websites. Link: <https://ethereum.org/en/> and <https://bitcoin.org/en/>

This high volatility with respect to his value is properly of risky assets (see graphs 3 and 4).

There are two rules in the exchange markets, the first is that the more liquidity, the less sensitivity of the supply and demand curves to few commercial transactions and vice versa. The second, to more members of the market with operations of low amount less volatility and vice versa (see Madura, 2015, p. 120). So, the cryptocurrency markets do not have enough participants yet nor do they have a large number of transactions compared to what a national currency market can have.

6. Some controversies of cryptocurrencies

One of the most significant apprehensions regarding the utilization of cryptocurrencies, which lack institutional backing and as demonstrated, display erratic behavior, is the elevated probability of a financial bubble. Let us delineate the potential causes.

According to Evannof et al. (2012), a bubble exists when the market price of an asset exceeds its price determined by fundamental factors by a significant amount for a prolonged period. Excitement about a new product could create an overestimation of demand, the people trust that the product represents a viable instrument of sustained growth, and this leads to high prices, the “momentum” when the price of assets reaches its climax (see Chang et al., 2016, p. 2). Normally, the price curve of a new technological product has a positive slope, due to expectations and advertising. Then comes the price spike and the market disappointment. If the product works, a gradual recovery comes to give way to the productivity stage, where the product is consolidated.

On the other hand, say Tikhonov *et al.* (2016, p.6811), the characteristics of a financial bubble are high price volatility and a high trading volume with few members in the network. Both present in the cryptocurrencies that are traded in the markets. Additionally, bubbles tend to have excess liquidity and credit, although in the case that concerns us, it is rather scarce. In the assumption that cryptocurrencies are a bubble, for now there is no bank intervention. But even in this case, it could create distortions in investments and consumption.

A bubble is created over a promising asset, when investors place their trust in certain instruments because of their ability to capitalize profits quickly, where profits come from asset trading, rather than their productive capacity. Financial bubbles are consistent with the rational behavior of economic agents, but mainly with the optimism of investors. Easy money

is synonymous with unproductive money. Investments deviate from those businesses that can produce tangible goods within the real economy. This does not mean that cryptocurrencies cannot become a currency, but nowadays, they seem more like a financial bubble.

Risk-averse investors should be very careful with these types of instruments. We must remember that in its beginnings all technological developments have had great volatility and there has been speculation with them. This is since the way of financing the projects is through venture capital, some are achieved, others are not.

Remember that cryptocurrencies are not illegal, the government could intervene but only to regulate the market, it is the responsibility of each investor to take the risk according to their investment plans. This does not mean that cryptocurrencies are a financial bubble, it means that they have some of their characteristics and that they can become one.

On the other hand, a controversy surrounding cryptocurrencies involves monetary policy. With the use of cryptocurrencies, monetary policy would change radically, because the current banking system is based on credit, but credit is determined by the interest rate and interest rate would disappear with cryptocurrencies. In the digital currency system, there is no monetary expansion and no contraction too, the supply is always determined by the blocks generated in the system, the main determinant of the price of money is supply and demand. The supply of credits would be determined by the accumulation of cryptocurrencies by economic agents, mainly banks, not by the interest rate.

The interest rate is the price of money. The interest rate defines the monetary system by establish the money supply, because through it, credit expands from central banks to commercial banks and from these to companies and holders.

Using cryptocurrencies as the official currency would put us in a perpetual liquidity trap, where the interest rate would no longer be effective as a monetary policy instrument. However, the fiscal policy would be more effective, since the withholding of taxes would be automatic. On the other hand, this will prevent any government in the world from benefiting at the expense of other countries by the mere fact that its currency is used in international trade transactions.

The advantage of having a cryptocurrency is that there would be no monetary inflation. The process to issue cryptocurrencies (see Nakamoto, 2008, p. 4) does not generate inflation as in the case of fiat money.

The monetary issue to increase employment generates inflation. One of the premises of Keynesian economics par excellence is to increase the existing money supply to increase the level of employment, but this path is artificial and unstable, says Hayek (1976, p.11), because it results in permanent

fluctuations in the economy and a sustained increase in inflation. In this scenario, it is necessary to protect the value of the currency against ineffective short-term policies and governments prone to waste and to obtain easy money. Recall that a *sine qua non* for currency overvaluation is the power to monopolize the coinage and to mandate its use as legal tender (see Mundell, 1998).

Although in theory inflation targeting systems around the world serve to contain inflationary pressures, cryptocurrencies are a way to alleviate definitely monetary inflation since, the governments lose the sovereignty about money. Cryptocurrencies appear to be decoupled from the economy, as current macroeconomic policies cannot be applied. To resolve this question, it is necessary to create a new macroeconomics or adapt cryptocurrencies to the flexibility of a fiat currency.

7. Econometric tests

The contribution of this empirical study, compared to other proposals [Jumde & Cho (2020); Levulytė & Šapkauskienė (2021); Yu (2023)], is its focus on the volatility of cryptocurrencies. Despite the existence of alternative forms of analysis in these comparisons, we believe that this aspect is central through theoretical articulation and enough to argue its invalidity to replace fiat money.

Furthermore, our argument about volatility is part of the literature that explores this condition [Conrad *et al.* (2018); Yen & Cheng (2021); Woebbecking (2021); Yin & Han (2021)] applying an eGarch model to incorporate the asymmetric effect of volatility. However, they do not directly apply a comparative analysis with theoretical reflections on fiat money. In this regard, unlike Othman *et al.* (2019), we argue that cryptocurrencies do not have the necessary characteristics, at least not at the moment, to replace fiduciary money.

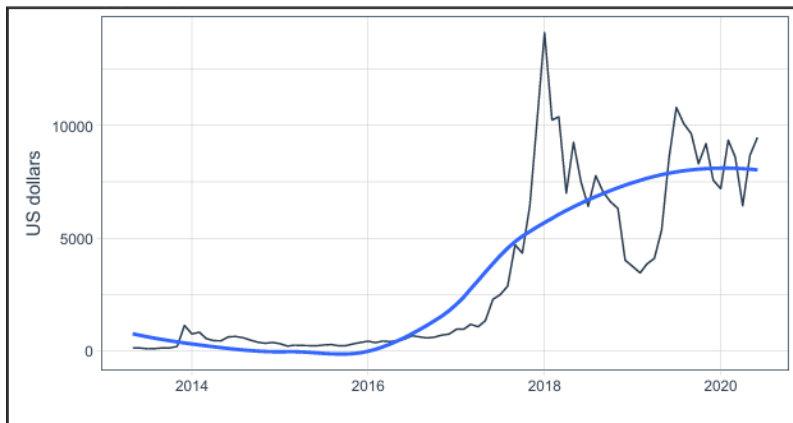
Firstly, the monthly historical logarithm series of Bitcoin price (from 05/01/2013 to 06/01/2020) and Ethereum price (from 08/01/2013 to 06/01/2020) were taken. First, an Augmented Dickey-Fuller test was performed to determine if the series are stationary or not, but also with the second objective of determining if the series errors are correlated over time, which would mean that overshooting at a certain moment has effects of long term, in case the series are not stationary.

In this scenario, supply and demand would play a very important role over time determining the price of cryptocurrencies. Further, to determine the direction of volatility, eGarch tests were performed for the selected cryptocurrencies.

Graphs 1 and 2 show the trajectories over time that the prices of the cryptocurrencies studied have followed. The first thing we can observe is that they do not follow a well-defined trend, they follow an erratic path, that is, a path of sudden rises and falls, typical of risky assets; nor do they follow a well-defined cyclicity, that is, assets whose demand and supply are variable but known in each season. But in this case, there are no signs of a cyclical pattern.

In general, cryptocurrencies seem to follow general patterns of behavior. They start with a very low value, close to 0, and begin to rise little by little, until a point comes where their value increases rapidly –this due to market demand and its shortage– then they reach a maximum peak and collapse. The price reached a peak of nearly \$20,000 per Bitcoin in late 2017, and nearly \$12,000 per Ethereum in early 2018. After that, its trajectory recovers and is erratic with a decreasing trend, which gives us evidence of their future behavior.

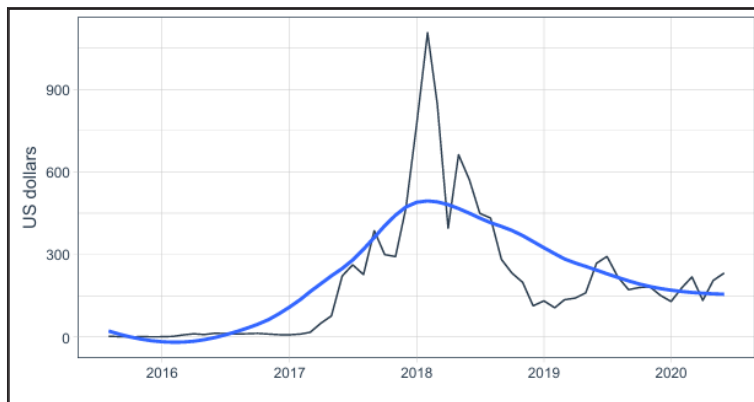
Graph 1
Evolution of the Bitcoin price (US dollars)



Source: own elaboration with data from the Bitcoin website.

Link: <https://bitcoin.org/en/>

Graph 2
Evolution of the ethereum price (US dollars)



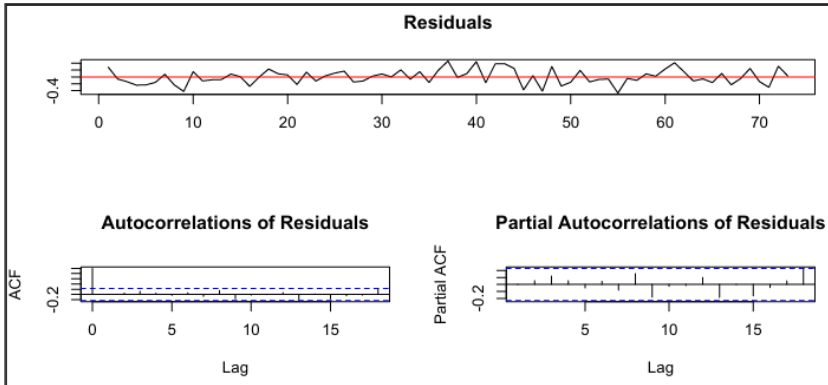
Source: own elaboration with data from the Ethereum website.
Link: <https://ethereum.org/en/>

We aim to substantiate the main hypothesis: the cryptocurrencies studied are not stationary. This implies that its trajectory is difficult to predict. The fundamentals of cryptocurrencies are very weak compared to those of legal tender currencies. Therefore, if this is true, coupled with the fact of excessive volatility, we can assure that cryptocurrencies follow a marginalist price theory, where the laws of supply and demand are the main factor in determining prices, versus a classical theory of prices.

A time series is said to be stationary when its distribution and parameters do not vary over time. More precisely, the mean and variance of a stationary series do not change over time, nor do they follow a trend.

In the graphs 3 and 4 referring to the errors of the series, the errors do not follow a uniform path, there is evidence of heteroscedasticity, and according to the autocorrelation and partial autocorrelation diagrams, exist indications that the errors are correlated over time.

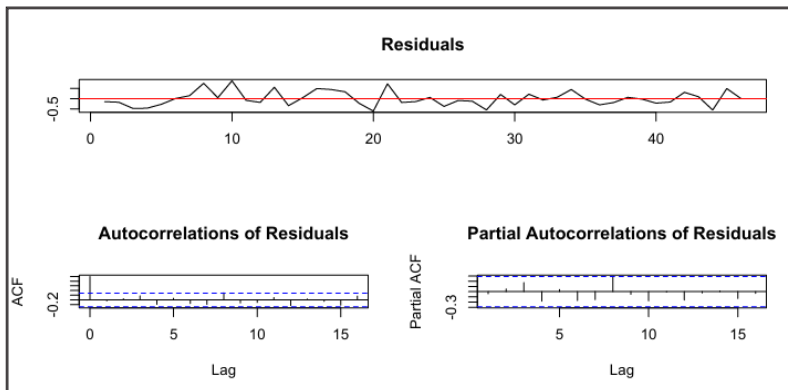
Graph 3
Residuals, autocorrelation, and partial autocorrelation for Bitcoin series



Source: own elaboration with data from the Bitcoin website.

Link: <https://bitcoin.org/en/>

Graph 4
Residuals, autocorrelation, and partial autocorrelation for Ethereum series



Source: own elaboration with data from the Ethereum website.

Link: <https://ethereum.org/en/>

Table 2 shows the critical values and statistics of the augmented Dickey-Fuller tests for cryptocurrencies. Since the critical values turned out to be greater in absolute value than their corresponding statistics, the two series were non-stationary. This confirms the main hypothesis of this work: the main determinant in the price of cryptocurrencies is supply and demand.

Table 2
Augmented dickey-fuller test for granger stationarity

Cryptocurrency/Lags	Test-statistic	Critical values	p-value	Stationarity
Bitcoin	-0.53	-2.89	0.52	Not
Ethereum	-2.04	-2.89	0.05	Not

Source: own elaboration with data from the Ethereum and Bitcoin websites.

Link: <https://ethereum.org/en/> and <https://bitcoin.org/en/>

Then, we recall the secondary hypothesis: the volatility of cryptocurrencies is not symmetric, tends to be negative, that is, the cryptocurrencies studied here have downward pressure in the study period.

To incorporate the asymmetric effect of volatility, change in cryptocurrencies, we test the hypothesis using an eGarch (Exponential Generalized Autoregressive Conditional Heteroskedasticity) model proposed by Nelson (1991). The model could be specified as follows:

$$y_t = \varepsilon_t = \sigma_t z_t, \quad z_t \sim \text{distribución } T(\nu, \Gamma)$$

$$\ln(\sigma_t^2) = \omega + \beta \ln(\sigma_{t-1}^2) + \alpha \left[\left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| - E(|\varepsilon_t|) \right] + r \frac{\varepsilon_{t-1}}{\sigma_{t-1}}$$

$$\text{Where } E(|\varepsilon_t|) = \frac{2\sqrt{\nu-2}\Gamma\left(\frac{\nu-1}{2}\right)}{(\nu-1)\Gamma\left(\frac{\nu}{2}\right)\sqrt{\pi}}, \quad \omega, \beta, \alpha, r > 0$$

Among several models, we chose the one with the highest maximum likelihood, the lowest Akaike information criterion, and a p-value greater than .05 to ensure model correctness. The most important parameter is gamma, which determines the direction of the volatility bias. In both cases, it is less than 1, which confirms our secondary hypothesis: the volatility of cryptocurrencies tends to decline.

Table 3
eGarch models

Cryptocurrency	ARFIMA	eGarch	Dist.	Bias	Likelihood	AIK	p-value Box-Ljung test
Bitcoin	(2,0,2)	(2,4)	Sstd	0.441	16.266	-0.006	0.744*
Ethereum	(1,0,1)	(3,4)	Sstd	0.037	-12.122	0.970	0.902*

Source: own elaboration with data from the Ethereum and Bitcoin websites.

Link: <https://ethereum.org/en/> and <https://bitcoin.org/en/>

If there are no events that change the economic conditions of the cryptocurrency markets, in the short term we can say that Bitcoin will maintain a constant trend, with erratic oscillations in the price and downward pressure. In the short term, Ethereum will remain on a downward trend, with erratic fluctuations in price and downward pressure.

If conditions do not change, in the long-term cryptocurrencies will tend to devalue due to the downward pressure exerted by volatility, the distrust of the markets, the low liquidity and acceptance of them in other markets and their inability to constitute themselves as real competitors of legal tender currencies.

The utilization and consolidation of blockchain technology on an international scale can have a significant impact on the value of cryptocurrencies. For instance, Ethereum provides a platform for smart contracts, which can increase the value of the cryptocurrency. Additionally, China launched its own official cryptocurrency, the e-RMB, as a recognized method of payment used mainly in foreign operations. This development could potentially lead to a resurgence in the value of cryptocurrencies.

7. Final remarks and recommendations

Despite exhibiting many desirable characteristics for a currency, such as consistency, stability, high quality, durability, security, and transparency, cryptocurrencies do not meet some of the broadest definitions of the term. There is a fundamental paradox associated with these currencies: Anyone theoretically could make purchases with cryptocurrencies, but hardly anyone does. The reasons behind this phenomenon are manifold.

Primarily, cryptocurrencies lack institutional support, both from the government, as accepting a decentralized currency would entail a loss of sovereignty and crucial resources, and from other financial institutions, as

the interest rate would lose its efficacy as a tool for monetary policy and credit regulation. The supply curve is rigid, with cryptocurrencies having the ability to issue currency but not to retract it. Moreover, they exhibit high volatility and high trading volume, characteristics typical of risky assets and financial bubbles. Due to their limited liquidity, cryptocurrencies face challenges in gaining widespread acceptance for commercial transactions. Furthermore, being intangible and complex, they present usability challenges for many people.

Cryptocurrencies' behavior lacks long-term trends, showing erratic and volatile movement. Their prices are mainly determined by the law of supply and demand, following the marginal theory of value. This is strongly supported by the augmented Dickey-Fuller stationarity tests, which demonstrated that cryptocurrencies exhibit correlated lags. Therefore, the upward or downward overshooting effect persists over time, and this effect is more significant than the impact of fundamental determinants of the currency's price. Moreover, the eGarch models presented illustrate that volatility is trending downward and is expected to continue on a short-term and medium-term basis if there are no major shifts in the market conditions for cryptocurrencies.

Cryptocurrencies, being solely based on the law of supply and demand, are highly volatile and therefore cannot primarily serve as an investment instrument or store of wealth. Instead, they have a speculative nature that carries inherently high risk. For this reason, risk-averse individuals, and those with little knowledge of financial markets are advised not to invest in these instruments.

The implementation of alternative uses of blockchain technology is recommended. Like Blockchain Bond System, Blockchain Public Contracts Management System and Payment system in the real estate sector.

References

- Chang, V.; R. Newman; R. J. Walters, & G. B. Wills (2016). Review of economic bubbles. *International Journal of Information Management*, 36(4), 497-506. <https://doi.org/10.1016/j.ijinfomgt.2016.02.007>.
- Cohen, B. J. (1998). *The geography of money*. Ithaca: Cornell University Press.
- Conrad, C.; A. Custovic, & E. Ghysels (2018). Long-and short-term cryptocurrency volatility components: A GARCH-MIDAS analysis. *Journal of Risk and Financial Management*, 11(2), 23. <https://doi.org/10.3390/jrfm11020023>.
- Evanoff, D. D.; G. G. Kaufman, & A. G. Malliaris (2012). Asset price bubbles: What are the causes, consequences, and public policy options? *Chicago Fed Letter*, (nov).
- Hayek, F. (1976). *Choice in currency. A way to stop inflation*. The Institute of Economic Affairs.
- Hermele, K. (2014). Commodity Currencies vs Fiat Money - Automaticity vs Embedment. *Fessud Working Paper Series*, vol. 44. Fessud, University of Leeds.
- Hicks, J., R., 1978 (1939). *Value and Capital*. Oxford University Press.
- Jumde, A., & B. Y. Cho (2020). Can cryptocurrencies overtake the fiat money?. *International Journal of Business Performance Management*, 21(1-2), 6-20. <https://doi.org/10.1504/IJBPM.2020.106107>.
- Kurz, H. D., & N. Salvadori (1997). *Theory of production: a long-period analysis*. Cambridge University Press.
- Levulytė, L., & A. Šapkauskienė (2021). Cryptocurrency in context of fiat money functions. *The Quarterly Review of Economics and Finance*, 82, 44-54. <https://doi.org/10.1016/j.qref.2021.07.003>
- Madura, J. (2015). *Administración Financiera internacional*. Cenage Learning Editores, S.A. de C.V. México.
- Marshall, A. (2013 [1890]). *Principles of Economics*. Palgrave Macmillan, London.
- Monsegny, M. C., & E. C. Cuervo (2008). Modelos ARCH, GARCH y EGARCH: aplicaciones a series financieras. *Cuadernos de economía*, 27(48), 287-320. <https://repositorio.unal.edu.co/handle/unal/22789>.
- Mundell, R. (1998). Uses and Abuses of Gresham's Law in the History of Money. *Zagreb Journal of Economics*, 2(2), 3-38.
- Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. *Available at SSRN 3440802*. <http://dx.doi.org/10.2139/ssrn.3440802>.
- Nelson, B. D. (1991). Conditional Heterocedasticity in Asset Returns: A New Approach. *Econometrica*, 59(2): 347-370 <https://doi.org/10.2307/2938260>.
- Othman, A. H. A.; S. M. Alhabshi, & R. Haron (2019). Cryptocurrencies, Fiat money or gold standard: an empirical evidence from volatility structure analysis using

- news impact curve. *International Journal of Monetary Economics and Finance*, 12(2), 75-97. <https://doi.org/10.1504/IJMEF.2019.100262>.
- Pernice, I. G. A., & B. Scott (2021). Cryptocurrency. *Internet Policy Review, Glossary of decentralised technosocial systems*, 10(2).<https://ssrn.com/abstract=3899258>.
- Ricardo, D. (1994 [1817]). Principios de Economía Política y Tributación. Obras y correspondencia (ed.) Piero Sraffa. *Fondo de Cultura Económica*. Quinta reimpresión. Ciudad de México.
- Scholer, K. (2016). An introduction to Bitcoin and Blockchain technology. *Kaye Scholer LLP*, 3-22.
- Smith, A. (2017 [1776]). Investigación sobre la Naturaleza y Causas de la Riqueza de las Naciones. Vigésima reimpresión. *Fondo de Cultura Económica*. México.
- Tikhonov, Y.; O. Pudovkina, & J. Permjakova (2016). 'Financial Bubbles' and Monetary Policy. *International Journal of Environmental & Science Education*, 11(14), 6811-6819. <https://ssrn.com/abstract=2848827>.
- Woebeking, F. (2021). Cryptocurrency volatility markets. *Digital finance*, 3(3-4), 273-298. DOI: 10.1007/s42521-021-00037-3.
- Yen, K. C., & H. P. Cheng (2021). Economic policy uncertainty and cryptocurrency volatility. *Finance Research Letters*, 38, 101428. <https://doi.org/10.1016/j.frl.2020.101428>.
- Yin, L.; J. Nie, & L. Han (2021). Understanding cryptocurrency volatility: The role of oil market shocks. *International Review of Economics & Finance*, 72, 233-253. <https://doi.org/10.1016/j.iref.2020.11.013>.
- Yotopoulos, P. A., & Y. Sawada (1999). Free currency markets, financial crises and the growth debacle: is there a causal relationship? (vol. 94). *Stanford Institute for Economic Policy Research*.
- Yu, Z. (2023). On the coexistence of cryptocurrency and fiat money. *Review of Economic Dynamics*, 49, 147-180. <https://doi.org/10.1016/j.red.2022.08.001>