Analysis of Financial Assets in Colombia: Hedging Positions with Bitcoin

Análisis de activos financieros en Colombia: cobertura de posiciones con bitcoin

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Abstract

Purpose: This study aims to infer which financial assets in Colombia can be hedged with Bitcoin positions and determine their correlation with that cryptocurrency. In addition, it seeks to improve our understanding of cryptocurrencies (Bitcoin in particular) in order to promote their use and applicability as investment vehicles.
Design/methodology: This study used a Dynamic Conditional Correlation (DCC) model, which can capture the dynamic correlations and variability of time series when they are volatile. Furthermore, this model offers the univariate flexibility of the Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) model, which can be used to find moments that make volatility tend to a balance. In this methodology, pairs of variables were evaluated to obtain coefficients that improve the distinction between and interpretation of diversifier, hedge, and safe heaven.

Findings: The results show that the coefficients produced by the model can be employed to determine the properties of Bitcoin as a hedging mechanism against some fixed- and variable-income instruments in the Colombian market. They also indicate that Bitcoin should not be used as a safe haven against any of the assets studied here. This gives investors more arguments for decision-making.

Conclusions: This study supports the idea that Bitcoin is suitable to be used as an innovative investment product in the Colombian economy because, thanks to its characteristics, it can be employed to build portfolios and hedge against financial risks.

Originality: According to the application of this econometric model and the analysis of its outputs, education on digital assets should be promoted. This is because, in the long term, digital assets become solid and profitable, providing an opportunity to generate earnings at an adequate risk level—which is interesting to investors.

Keywords: bitcoin, DCC model, hedging, safe haven, portfolio diversification.

JEL classification: F30, G10, G11, G12.

Highlights

- The DCC model can be applied to determine the type of relationship between pairs of assets in the Colombian stock market.
- Bitcoin is a strong hedge against fixed-income investments and Credit Default Swaps (CDS).
- Despite their investment risk, cryptocurrencies are a business alternative with potential in the digital transformation.

Resumen

Objetivo: inferir los activos financieros del mercado colombiano que pueden ser cubiertos mediante posiciones con bitcoin, determinando el vínculo frente a dicha criptomoneda, así como contribuir al entendimiento de las criptodivisas (en este caso en particular, al bitcoin), en pro de su uso y aplicabilidad como vehículo de inversión.

Diseño/metodología: este estudio usó un modelo de correlación condicional dinámico (DCC), el cual tiene capacidad para recoger las relaciones dinámicas y la variabilidad de las series en el tiempo cuando son volátiles y brinda la flexibilidad propia univariante del modelo autorregresivo generalizado condicional heterocedástico (GARCH), que permite encontrar momentos donde la volatilidad tienda a un equilibro que proporcione coeficientes, el cual, al evaluar pares de variables, favorece la diferenciación e interpretación entre diversificación, refugio seguro y cobertura financiera.

Resultados: los hallazgos evidenciaron que los coeficientes proporcionados por el modelo permiten concretar las propiedades del bitcoin como mecanismo de cobertura de riesgo frente a algunos instrumentos de renta fija y variable del mercado nacional, así como la inhabilidad de su uso como refugio seguro para todos los activos estudiados, por lo que contribuye para que los inversionistas cuenten con más bases para la toma de decisiones.

Conclusiones: esta investigación soporta que el bitcoin es apto para ser utilizado como un innovador producto de inversión en la economía nacional, dado que posee características que lo convierten en activo financiero, con enfoque hacia la construcción de portafolios y generación de coberturas frente a riesgos financieros.

Originalidad: a través de la aplicación del modelo econométrico y el análisis de sus salidas, surge la necesidad de comenzar a difundir educación en activos digitales, debido a que en el largo plazo desarrollan solidez y rentabilidad, lo que genera la oportunidad de lograr beneficios bajo un adecuado nivel de riesgo, siendo materia de interés para inversionistas.

Palabras clave: bitcoin, modelo de correlación condicional dinámico (DCC), cobertura de riesgo, activo refugio, diversificación de portafolio.

JEL classification: F30, G10, G11, G12.

Highlights

- A través de la aplicación del modelo DCC se puede determinar el tipo de relación existente entre pares de activos del mercado de capitales colombiano.
- El bitcoin presenta una fuerte cobertura frente a las inversiones en renta fija y en permutas de incumplimiento crediticio (CDS).
- A pesar del riesgo de inversión, las criptomonedas son una alternativa de negocio con potencial en la transformación digital.

1. INTRODUCTION

All investors around the world need to mitigate their losses, or at least maintain the value of their portfolios—especially in times of economic crises, such as the recent health crisis derived from the COVID-19 pandemic. However, traditional safe-haven assets (e.g., gold) have lost investors' trust because their behavior during the different stages of the pandemic was not constant. As a result, their capacity to serve as hedging or safe-haven assets depended on the particular conditions of the macroeconomic environment when the virus was spreading, offering hedging for different assets at each stage (Akhtaruzzaman et al., 2021). Consequently, we should evaluate the possible benefits of having a portfolio diversified with other kinds of assets, hedging it with positions in non-traditional assets such as Bitcoin (Callens, 2021)—whose share amounts to 42.32% of the market capitalization of the cryptocurrency market (CoinMarketCap, s. f.).

Technological progress constantly brings about new innovations (Zhukov et al., 2019) that are increasingly difficult to understand, replace traditional problem-solving models, and make different daily life aspects more efficient. Some examples of this are Artificial Intelligence (AI), Virtual Reality (VR), the internet, data mining, and Bitcoin, among others (López Jiménez, 2020). Taking this into consideration and in accordance with Ordoñez Sánchez (2021), investors—and society in general—can have an advantage if they learn about technology, cryptocurrencies in particular. This can be basic knowledge about their operation or a deeper understanding that they can use to make a profit by investing in different financial assets. To support their conclusions, they should use tools such as statistical methods—that is the case in this study.

Currently, the phenomenon of cryptocurrencies is growing stronger (Ivanovski & Hailemariam, 2023; Blahušiaková, 2022), and these digital assets are also used to make transactions in the economy (Almasri & Arslan, 2018). Their main characteristic of cryptocurrencies is that they use cryptography (Almasri & Arslan, 2018), thus securing the property of the holder. Transactions using these assets are verified by a decentralized network of voluntary nodes that records the history of transactions in a public database known as the *blockchain* (Álvarez Díaz, 2019). Nevertheless, due to their disruptive and novel characteristics—compared to widely accepted assets in the market—they are not usually integrated into institutional portfolios as investment vehicles (Smales, 2022). Another factor that produces aversion toward these assets is their volatility. Al Guindy (2021) concluded that part of this volatility can be generated by the erratic behavior of individual investors because their attention to a particular asset produces noise. This is in agreement with Barber and Odean (2008), who determined that, when assets receive enough attention from institutional and individual investors, the latter are more prone to distraction.

In recent years, cryptocurrencies have become especially relevant for investors and financial markets (Rathee et al., 2023), and their disruptive operation has facilitated their exchange and applicability and contributed to their globalization. Despite their decentralization and almost no regulation, their current trading volume exceeds 1.8 trillion dollars (CoinMarketCap, s. f.)—which puts them in a special place in the world of financial assets. Their volatility may be perceived as unsafe and risky, but it can be a virtue because their market dynamics can become attractive to diversify a portfolio or hedge positions. Thanks to the benefits of the digitalization of banking, financial markets, and transactions, cryptocurrencies have started to play an important role as their utilization is making markets more dynamic. Despite the risk perceived in them, these investment vehicles should be studied and analyzed due to their exchange volume and special relevance in recent times.

Taking this into account, this study—unprecedented in the local context—uses a Dynamic Conditional Correlation (DCC) model to determine it there are financial assets in the Colombian market that can hedge Bitcoin positions, thus exploiting its decentralized operation and using it as a diversifier or safe-haven asset. For that purpose, we will isolate the possible economic, environmental, and operational risks of cryptocurrencies, as well as those regarding illegal activities and other related factors. This is because we will try to evaluate the benefits of Bitcoin as a hedge, examining similarities, differences, and possible correlations with other assets. That is, this study aims to evaluate hedge relationships between assets—but it leaves aside the discussion about the way it would be applied, recorded in the books, and legalized as investment within the law, which can be investigated in future research.

2. THEORETICAL FRAMEWORK

Bitcoin

Due to its characteristics, there are multiple definitions of Bitcoin. However, it is clear that it has had an impact on the financial field, is considered to be the result of globalization, and works as a system of digital money. Bitcoin is a digital currency that only works over the internet, and, for this reason, it is known as decentralized digital money. In addition, it is accepted and used in at least 154 countries (Rodas Portillo and Núñez Gil, 2021). Bitcoin is highly relevant and, in general, its importance and influence are equated to those of traditional currencies (coins and bills), mainly when used as a

payment method. Importantly, this cryptocurrency has some characteristics that encourage people to acquire it. Basically, it is intangible (Powell & Hope, 2018) and does not need a central bank to be issued. Bitcoins are issued automatically, and their value is determined by the market through its use, as if it were any other currency that works under the economic theory of supply and demand (Domínguez Jurado & García Ruiz, 2018). Bitcoin presents legal vacuums such as a lack of regulation and a central bank that supports its issuance around the world. Nevertheless, in recent years, it has been more widely accepted as a payment method for goods, services, and investments. Furthermore, it has been predicted that a large part of the world population will normalize its use (Pilacuán Cadena et al., 2021).

Uses

When Bitcoin was created in 2008 as the first cryptocurrency, incentives were offered to use it in commerce due to its novel (although questionable) characteristics—so much so that a sector of the population now thinks that this is the currency that will change the world, while others hold that it is a new speculative bubble that will burst at some point (Vásquez Leiva, 2014). Its role is that of an exchange mechanism because it has the characteristics of a virtual currency (Palacios Cárdenas et al., 2015). The fact is that the statistics of its operation indicate that it is viable to develop monetary theory and policy for cryptocurrencies, which will generate more demand for them (Urdaneta Montiel et al., 2020). Therefore, some studies have investigated aspects such as returns and found that, currently, there is no consensus among scholars and financial analysts on the efficiency of Bitcoin (Lengyel-Almos & Demmler, 2021). Regulation is another key aspect due to the growing demand for this cryptocurrency. However, regulating it requires a new approach, with new laws and institutions that can correctly capture what users do with cryptocurrencies (Barroilhet Díez, 2019).

Regulations

The topic of the regulations on and self-management capability of this cryptocurrency covers other broad concepts, such as the determinants of trust and risks. As this virtual currency has only existed since 2008, its acceptance and use have not been thoroughly studied (López & Camberos, 2020). Nevertheless, recent research indicates that structural guarantees (safety and regulations) and familiarity are the most significant factors that explain its variability in trust and usage intention (López-Zambrano et al., 2021). The desire to use an encrypted payment method can be seen from another perspective, that of the stock market, because the world is facing a supply of virtual currencies. However, Colombia does not have a legal system that can regulate them correctly as they emerge as a way to raise money from the public (Echavarría Wartenberg, 2019). Another study (Chica Ramírez et al., 2018) found that, in Colombia, people have basic knowledge of Bitcoin because the information that circulates is mainly taken from generalist media, which sometimes do not fully explain how this crypto-asset works.

Acceptance

Bitcoin was a pioneer as the first decentralized cryptocurrency, and it continues to lead cryptocurrency markets in terms of market capitalization and the interest it draws in the scientific literature (Aysan et al., 2021). Nowadays, it is possible to discuss its utilization as a safe haven, but, for that purpose, we should consider the characteristics that an asset should possess to be used and

recognized as currency: universal acceptance; ease of transportation and storage; divisibility; and incorruptibility (Valencia Marín, 2021). Bitcoin has most of these characteristics, except for "universal acceptance" because it still creates mistrust in many economies. Now, to use it as a safe haven, it is necessary to analyze its volatility, which has been the source of high expectations among investors but also limitations to its functionality (Altamira Vásquez et al., 2020). Therefore, it is not necessarily the currency of the future that will replace traditional money because it is not supported by the general public, which—added to its volatility—makes it an unreliable safe haven (Mecheba Molongua, 2016).

Investment

It is well known that there is no definite set of variables that can provide the exact price of Bitcoin because there are systematic and unsystematic factors that also affect its value considerably (Merkaš & Roška, 2021). In this regard, Bitcoin is more focused on being a speculative digital asset than a safe haven because there is no relationship between the volatility of its price and gold, which has been traditionally used as a physical hedging asset (Doumenis et al., 2021). This leads to the following discussion: *Is Bitcoin a better investment than gold and other commodities?* However, this depends on the type of comparison being drawn. For example, in emerging markets, gold and commodities act as weak safe-haven assets, but this pattern is not observed in Bitcoin (Hussain-Shahzad et al., 2019). Hence, Bitcoin should be investigated more as an investment than as a safe haven, as in the case of currencies and gold. This is especially true because it has been established that Bitcoin does not have its own fundamentals that justify variations in its price. Nevertheless, there are signs that indicate that its profitability is partially affected by variations in Ether and the MSCI Emerging Market Index (Gómez Salazar, 2021).

Price

Its benefits and disadvantages, as well as the diversity of its uses, make it impossible to estimate the price of Bitcoin, which has been studied using predictive models. These models have concluded that the important variation in its price hinders the construction of a stable model that can make projections in accordance with reality (Herrero Amorós, 2018). As a consequence, the only available option is to describe its behavior using empirical analyses. The latter can be based on the Elliott Wave Theory, which—although it offers a rather experimental technical analysis—is still an important tool in the field of financial trading (Sánchez Ascanio & Arredondo García, 2020). This can be complemented with mathematical analysis and graph analytics to design a fuzzy system to predict the Bitcoin price signal (Roa Mora, 2019). Knowing about the determinants of the cryptocurrency price is advantageous as well because it is a good complement to the study of its behavior in the market. This is especially relevant as it has been found that the Bitcoin price, in the long term, does not tend to be justified by speculation (Amaris Peñuela, 2015). What has been established indeed is that Bitcoin is a financial innovation because it meets the conditions to be considered innovative and it enables cheaper transactions (Montoya Ramírez, 2020).

Nature

From a monetary perspective, cryptocurrencies have the characteristics of some currency structures to be considered a payment method. However, their economic nature has not been defined because

they exhibit a small positive dependency between some of them, such as Bitcoin, Ether, and Ripple (Mota Aragón & Núñez Mora, 2019). From the financial point of view, the scarcity and limitations of Bitcoin have made it an alternative asset for investments with different time horizons thanks to its risk-return ratio—measured using the Sharpe ratio (Rodríguez Gómez, 2020). Cryptocurrencies can be acquired for the short, medium, or long term depending on the kind of investors and their risk aversion. Nevertheless, we should consider that, in the future, their value may tend to stabilize as a result of a noticeable increase in their demand. This would globalize their use and acceptance, at least in the biggest economies worldwide (Portero Lameiro & Teixeira Pereira, 2019). As a result, their profitability may change.

Blockchain

Bitcoin and the blockchain technology in general can bring efficiency, transparency, and security to financial markets (Bañón González, 2018; Daulay et al., 2017). Moreover, one of the novelties of blockchain is that it can be used in forward contracts to make their processes faster and lower their costs compared to their traditional counterparts, especially in Colombia (Sandoval Arisa & Rodríguez Piraquive, 2020). A study conducted in the United States found that some cryptocurrencies—Bitcoin among them—have hedging characteristics against downward trends in the S&P 500 index and its ten variable-income sectors (Bouri et al., 2020). Nowadays, there are crypto funds outside Colombia. These hedge funds—which are defined as a new kind of financial institution—trade in cryptocurrencies and cannot be governed by traditional hedge fund regulations because they are not designed to cover the operational and technological features of cryptocurrencies, which are unique in the market (Mokhtarian & Lindgren, 2017).

Hedge accounting

Another argument in favor of using Bitcoin as a hedge is that hedge accounting can be performed applying the International Financial Reporting Standards (IFRS). In this regard, the IFRS 9 establishes three cases to proceed: cash flow hedge, fair value hedge, or net investment hedge. The goal of the first kind of hedge is to prevent accounting asymmetry, considering that, under the circumstances, it is preferable to show the constant results over the accounting period, without the impact of volatility (Sánchez Castaños, 2019). One of the principles of this accounting standard is hedge effectiveness. Therefore, it is necessary to assess if the hedge ratio indeed covers the risk (Gaviria Rada, 2018). At this point, it is important to highlight that the purpose of a hedge accounting strategy is managing market risks by using financial derivatives. The main characteristic of the latter is that their value is derived from variations in another asset—called *underlying asset*.

Diversifier, hedge, and safe haven

A financial asset in an investment can have three possible uses. First, it can be a *diversifier*, that is, an asset that is, on average, positively correlated to another asset. Second, a *hedge* is an asset that is, on average, uncorrelated or negatively correlated to another asset. Third, a *safe haven* is the same as a hedge, but limited to specific periods of time, such as moments of market stress or economic crises (Baur & Lucey, 2010). Considering that Bitcoin is already used as a hedge in other countries, a hedging mechanism should be found for the Colombian market. Nevertheless, the relationships between Bitcoin and other assets should be further investigated because international studies have

suggested including cryptocurrencies in investment portfolios thanks to a strong correlation between them and their small linear association with other assets. Hence, it is possible to use them as short-term diversifiers (Corbet et al., 2018). The evidence indicates that including cryptocurrencies in investment portfolios is favorable because they improve the Sharpe ratio and, in combination with other assets, reduce risk (Chambi Condori, 2021).

As it is well known, cryptocurrencies are not part of the Colombian stock market, and the regulated institutions are not authorized to trade in them. This—in addition to the price instability, speculation, and anonymity that surrounds them—produces uncertainty in many investors (Jaramillo Echeverry, 2021). However, investors could consider the risk–benefit ratio described in investment theory, where agents seek to obtain the maximum benefit in a scenario of lower risk. New ideas can emerge as a result. For instance, portfolios can be built with financial assets that respond in a direction that is different from that of the Bitcoin price. For that purpose, we should establish if these assets serve as hedges, even though the Colombian government has adopted a conservative stance regarding cryptocurrencies and has not considered regulating them (Sarmiento Suárez & Garcés Bautista, 2016).

3. METHODOLOGY

Bitcoin is attractive due to its profitability—derived from the high and significant variation in its price. Therefore, it has drawn the attention of a group of investors that have low risk aversion and expect to benefit from its sudden price fluctuations. In this scenario, this study aims to investigate a group of financial assets that can reduce the variance in Bitcoin yields, serving as a counterweight to this digital asset and minimizing the risk in this kind of investment. This study aims to investigate the behavior of these assets over time using, first, descriptive statistics and, second, the Dynamic Conditional Correlation (DCC) model. The DCC model includes the univariate flexibility of the Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) model to investigate correlations (Engle, 2002). It is also very helpful when we are working with a large number of assets because it contributes to forecasting the conditional variance and covariance matrix. In the economic literature, this method has been used to determine relationships between assets (e.g., stock indices, bonds, oil, gold, and currencies, among others) and thus provide evidence of the diversifying properties of Bitcoin (Bouri et al., 2017).

This model has been implemented to establish if Credit Default Swaps (CDS) serve as hedges against risk in stock market sectors (Ratner & Chiu, 2013). Therefore, the DCC model facilitates the differentiation between and interpretation of the terms *diversifier*, *hedge*, and *safe haven* because it can be used to assess a group of assets—in this case, financial instruments that are traded in the Colombian market. In this study, the DCC model is implemented to analyze time series and thus infer if there is any asset or set of assets that can serve as a hedge against Bitcoin positions.

Data

This study aims to analyze the relationship between Bitcoin and several financial assets/indicators in the Colombian market. Therefore, the first data series in this study is the daily yields of Bitcoin. In addition, the yields of ten other assets/indicators are analyzed by pairs of variables. These fixed- and

variable-income assets and indicators represent the behavior of the Colombian market. The data cube employed in this study contains 1,180 daily observations for each variable, which cover the period from January 4, 2017, to December 30, 2021. In Colombia, December 31 is a business but non-banking day. As a result, there are no observations of the assets on that date. The daily yields (variation with respect to the previous price) were calculated using the natural logarithm of the quotient between the final price and the starting price. That is, we work with a logarithmic profitability to eliminate the problems of the simple profitability in statistical models.

Most variables selected in this study represent assets and indicators in the fixed-income market. Colombian treasury bonds were included because these public debt securities exhibit the highest trading volume in the Colombian Stock Market (BVC in Spanish) compared to corporate securities and shares. Therefore, we assume that these assets are the ones that best reflect the market sentiment. The sample takes the Zero-Coupon Curve (ZCC) of Colombian government treasury bonds (called TES) with maturities in the short, medium, and long term in order to capture the market sensitivity along the curve. These TES can have fixed-term (FT) maturities of 1, 5, or 10 years, as follows: 1Y FT TES, 5Y FT TES, and 10Y FT TES. Additionally, this methodology includes the J.P. Morgan Emerging Markets Bond Index Global (EMBI), which represents the returns of the debt instruments (bonds) of emerging markets, as well as the 10-year Credit Default Swaps (CDS) of the Colombian government. These CDS reflect the cost of hedging for bondholders in Colombia, that is, they reflect the market expectations regarding country risk due to sovereign default.

For variable-income securities, the reference index in the sample is the COLCAP index, which is the main stock index in Colombia (recently adopted as the MSCI COLCAP index). Additionally, three securities were taken separately: Ecopetrol (ECOPETL CB), Interconexión Eléctrica SA (ISA CB), and Bancolombia preferred stock (PFBCOLO CB). According to their share in the COLCAP index, these are the three most liquid stocks in the Colombian market. The purpose was to select stocks liquid enough to adequately reflect the behavior of the market. In addition, these companies belong to sectors that drive the Colombian economy, such as energy (oil and electricity) and banking.

Regarding indicators, this study used the currency exchange rate that represents the price of 1 US dollar in Colombian pesos—called *TRM* in Spanish. The TRM is calculated and certificated by the Financial Superintendence of Colombia based on the purchases and sales of US dollars reported by financial intermediaries the previous business day.

Descriptive statistics

As a preliminary analysis of the market variables mentioned before, this study assessed their main individual characteristics in terms of the historic behavior of their returns. Table 1 summarizes their main statistics, which provide information about the location, dispersion, and shape of the data. The minimum and maximum values show that the yields can fall within a considerably wide range. In this table, Bitcoin is the variable with the lowest minimum percentage and the highest mean and standard deviation. It is followed by CDS, except for its mean percentage, which is lower than that of other assets/indicators. Only two out of the eleven variables in the table present negative mean yields: EMBI and ZCC 1Y FT TES. Among the equities, ISA CB exhibits the highest mean yield, the lowest standard deviation, and a positive asymmetry coefficient. In general, all the series have positive or negative asymmetries and are leptokurtic. This indicates that these assets are attractive to investors

who are building portfolios that are more likely to produce higher yields, although exposed to greater risk (Santillán-Salgado et al., 2017).

Table 1. Descriptive statistics of daily yields
Tabla 1. Estadística descriptiva de los rendimientos diarios

Serie	Minimum	Maximun	Mean	Standard deviation	Asymmetry coefficient	Kurtosis
BITCOIN	-46,473%	22,512%	0,323%	5,129%	- 0,704	7,947
TRM	-2,493%	5,931%	0,026%	0,707%	0,604	5,028
EMBI	-8,857%	16,017%	- 0,008%	1,628%	1,648	14,226
CCC TES TF CP (1 Y)	-17,904%	13,808%	- 0,026%	2,100%	- 0,260	14,761
CCC TES TF MP (5 Y)	-12,464%	18,131%	0,018%	1,533%	1,701	37,757
CCC TES TF LP (10 Y)	-11,729%	12,529%	0,014%	1,329%	0,902	31,404
MSCI COLCAP	-16,290%	12,470%	0,002%	1,288%	- 2,062	45,382
ECOPETL CB Equity	-15,363%	13,997%	0,036%	1,832%	- 0,541	10,341
PFBCOLO CB Equity	-22,399%	12,260%	0,079%	2,297%	- 0,924	12,291
ISA CB Equity	-8,406%	13,868%	0,094%	1,805%	0,600	6,097
CDS	-24,354%	29,866%	0,011%	2,703%	0,623	21,276

Source: Own work, 2022.

Based on the trends of the yields observed over the period analyzed here, we tend to infer that TES and CDS present variations opposite to those of Bitcoin—except during the pandemic, where a possible positive correlation is perceived. However, a priori, we could think that, in general, these assets have some hedging component. In turn, the EMBI apparently offers a better hedge because, over time, it shows a sustained behavior that is contrary to that of the Bitcoin price. Figure 1 shows the log returns of the assets/indicators over time.
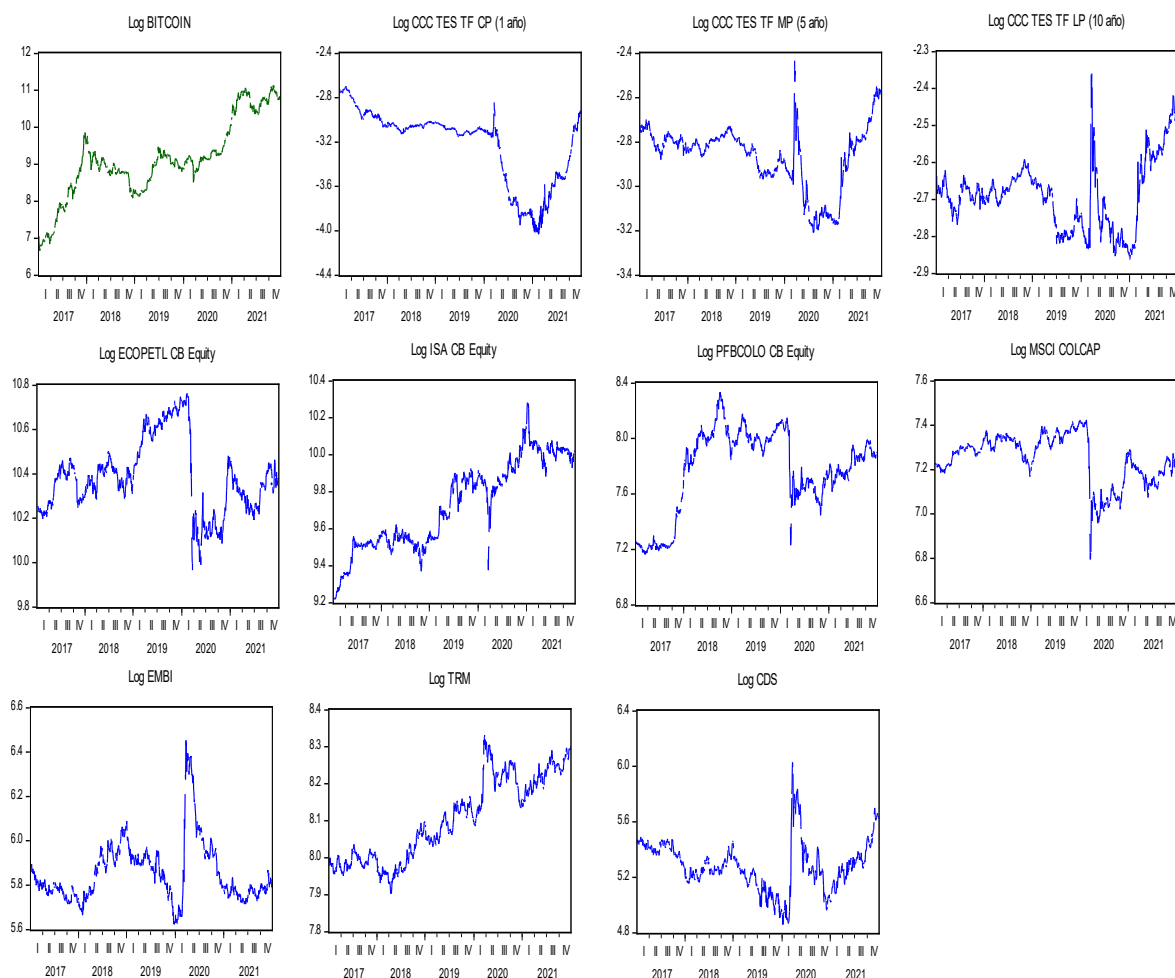
Figure 1. Behavior of the yields
Figura 1. Comportamiento de los rendimientos
Source: Own work, 2022.

DCC model

To ease the application of the DCC model given the volume of data examined here, the estimation is performed by pairs of assets. As a result, the model is composed of five equations divided into two steps. In the first step, an univariate GARCH (1,1) model is estimated. In the second one, the conditional correlations over time are obtained based on the standard residuals generated in the first step (Bouri et al., 2017).

The model is detailed in Equations 1 and 2, as follows:

$$r_t = \mu_t + \omega r_{t-1} + \varepsilon_t \tag{1}$$

$$H_t = D_t + \rho_t + D_t \tag{2}$$

where r_t is the vector of the price return of Bitcoin; μ_t, the conditional vector of returns; ωr_{t-1}, the return of the other asset, which is obtained as the first difference of the logarithm of closing prices; ε_t, the vector of the standardized residuals; H_t, the conditional covariance matrix; D_t, a diagonal matrix of conditional time-varying standardized residuals, which are obtained from the univariate GARCH (1,1) model; and ρ_t, the matrix that contains the conditional correlations.

To get the DCC (1,1) model, we start from Equation 3 $\boldsymbol{\rho_t}$, which is a square positive-definite matrix:

$$\rho_t = (1 - \alpha - \beta)\,\overline{\rho} + \alpha\,\varepsilon_{t-1}\,\varepsilon'_{t-1} + \beta\rho_{t-1} \tag{3}$$

where ρ_t is the time-varying conditional correlation matrix of ε_t; α and β are parameters that represent the effects of previous shocks and previous DCCs on the current DCC; and $\overline{\rho}$ is the value that ρ_t would take when α and β are equal to zero.

The DCC between financial assets X and Y is obtained as follows in Equation 4:

$$\rho_{xy,t} = \frac{\rho_{xy,t}}{\left(\sqrt{\rho_{xx,t}}\right)\left(\sqrt{\rho_{yy,t}}\right)} \tag{4}$$

Finally, to determine if Bitcoin is a diversifier, hedge, or safe haven against a variety of Colombian financial assets, we used the same method applied by Ratner and Chiu (2013), Bouri et al. (2017), and Stensås et al. (2019). First, the dynamic conditional correlations are extracted from the DCC model into separate time series (see Equation 5), and then regressed on dummy variables (D) representing extreme movements, which are equal to one if the assets return exceeds a certain threshold given by the lower 1st, 5th, and 10th percentile of the return distribution.

$$DCC_t = F_0 + F_1 D(r_{activo}q_{10}) + F_2 D(r_{activo}q_5) + F_3 D(r_{activo}q_1) \tag{5}$$

From this, we can establish that Bitcoin is a weak hedge against another asset if F_0 is zero, or a strong hedge if F_0 is significantly negative. It is a diversifier against the other asset if F_0 is significantly positive. In turn, it is a weak safe haven if the factors F_1, F_2, and F_3 are not significantly different from zero, or a strong safe haven if they are significantly negative.

4. RESULTS

To obtain the final equation of the DCC model, we first established a simple linear regression model for each return variable. Then, the residuals were obtained, and, using the heteroscedasticity test, the series were classified as suitable to be treated in a GARCH (1,1) model. Afterward, these series became part of the DCC model, which is estimated in two steps. The main result of this was the dynamic conditional correlation of each pair of series. Next, the dummy variables were generated by extracting the percentiles from the initial return series.

The outputs of the final model were calculated using EViews software and are presented in Table 2. This is the result of running a multiple linear regression model with the components found in Eq. (5). Thus, we obtained the coefficients that are necessary to analyze factors $F_0, F_1, F_2,$ and F_3 and then validate the properties of Bitcoin. That is, we can establish its usefulness as a hedging mechanism against other assets in Colombia or vice versa. We can also determine the possibility of using it to diversify portfolios and as an investment vehicle for safe haven—the latter considering that its volatility should be lower than that of the other assets.

Table 2. Estimation of the DCC-GARCH (1,1) model
Tabla 2. Estimación del modelo DCC-GARCH (1,1)

Serie	F_0 (Hedge)	F_1 q (10%)	F_2 q (5%)	F_3 q (1%)
TRM	0,685157***	- 0,801637***	- 0,954382***	0,364564
EMBI	- 0,068149***	- 0,251017**	- 0,556723***	0,568688**
CCC TES TF CP (1 Y)	- 0,610034***	- 0,530399***	0,001522	0,003032
CCC TES TF MP (5 Y)	- 0,391580***	- 0,608095***	0,000574	0,003091
CCC TES TF LP (10 Y)	- 0,177155***	- 1,121682***	- 0,020376	0,003198
MSCI COLCAP	- 0,009041	- 0,818121***	0,198053	0,723640***
ECOPETL CB Equity	0,052545**	- 0,885138***	0,260139*	0,265986
PFBCOLO CB Equity	- 0,339893***	1,356429***	0,007469	- 0,255640
ISA CB Equity	0,617309***	0,431792***	0,130651	- 0,289030
CDS	- 0,248808***	- 0,724228***	0,246201	- 0,215644

Source: Own work, 2022.
Note: ***, **, * indicates statistical significance at the 1%, 5%, and 10% levels, respectively.

Analysis of the final model

The data in the model above indicate that, in general, Bitcoin can be a solid hedging alternative against several assets in the Colombian market: TES with different maturities, Bancolombia preferred stock, and CDS. All of them exhibited negative coefficients in their series. This is explained by the fact that TES are free from credit risk because they are public debt, and CDS serve their purpose as financial derivatives that hedge against the default risk of another asset. In turn, Bitcoin seems to be a weak hedge against the EMBI because the parameter of the latter is close to zero, which can be due to the lower volatility of its returns compared to those of Bitcoin. It should be noted that, although the factors of TRM, ISA CB Equity, and ECOPETL CB Equity were positive and not close to zero, Bitcoin does not provide a hedge against them. Nevertheless, Bitcoin can be a diversifier for them because their yields (although positive) have a lower volatility than those of Bitcoin. Finally, there is no statistically significant evidence that indicates that this cryptocurrency is a hedge against the MSCI COLCAP index.

The positive and negative coefficients far from zero of the factors that represent the different percentiles in the model indicate that, in general, Bitcoin cannot be considered a strong or weak safe haven against any of the variables examined here or vice versa. This can be justified by phenomena that are not considered in the regression, e.g., the effect of the coronavirus on the economy, the impact of oil prices, or inflation. Together with other macroeconomic aspects, these phenomena have had an impact on the returns of the ten assets/indicators analyzed here, even Bitcoin—which has been demonstrated to respond with greater price variation to market forces (supply and demand) and speculation.

Considering this, it can be argued that, in the last five years, the Colombian market has had (fixed- and variable-income) instruments that can be hedged with Bitcoin. Nevertheless, when they opt for these assets, investors are exposed to interest rate, reinvestment, inflation, credit, liquidity, and market risks, among others. Table 3 summarizes the possible uses of Bitcoin against the assets analyzed here.

Table 3. Summary of results
Tabla 3. Resumen de resultados

Serie	Hedge	Diversifier	Safe haven
TRM	✘	✓	✘
EMBI	✓	✘	✘
CCC TES TF CP (1 Y)	✓	✘	✘
CCC TES TF MP (5 Y)	✓	✘	✘
CCC TES TF LP (10 Y)	✓	✘	✘
MSCI COLCAP	✘	✘	✘
ECOPETL CB Equity	✘	✓	✘
PFBCOLO CB Equity	✓	✘	✘
ISA CB Equity	✘	✓	✘
CDS	✓	✘	✘

Source: Own work, 2022.

5. DISCUSSSION

This study investigated the diversification, hedging, and safe-haven properties of Bitcoin against some Colombian financial assets. Statistically significant evidence was found to argue that Bitcoin can be a new alternative investment instrument in the Colombian economy due to its financial sustainability over time and volatility—which make it a suitable hedging mechanism against other assets in the market. This can include assets other than those ten evaluated in this study, especially because part of the data used here were obtained during the COVID-19 pandemic, a time when atypical data were to be expected. However, the values were not affected by the possible noise. What was indeed observed was a general strengthening of the Bitcoin price, although volatile. Clearly, the DCC model

served as an adequate tool to achieve the research objectives of this study. In addition, this article sets a precedent so that Colombia starts to generate a culture of investment in digital assets because it has been proved that hedging strategies and diversification with other assets in the market can produce benefits with a lower risk.

Stensås et al. (2019) implemented this same quantitative methodology to study a sample of thirteen developed and developing countries. They found that Bitcoin acts as a hedge for investors in most developing countries, but only as a diversifier in developed nations. This study reaffirms the hedging characteristics of Bitcoin in developing markets and countries, such as Colombia. In this case, the coefficients obtained in the model enabled us to determine the type of relationship between Bitcoin and each relevant asset and indicator in the Colombian stock market, highlighting its strong hedging against public fixed-income securities. In addition, in line with Ratner and Chiu (2013), CDS—which go hand in hand with public fixed-income securities in terms of market expectations— are among the ideal hedging assets. This can be justified by the high volatility generated by strong depreciations in the market curves at the end of the third quarters of 2020 and 2021, which were produced by the coronavirus disease. Indeed, Bitcoin was found to be a weak hedge against the EMBI (which reflects the behavior of bonds from emerging markets). Therefore, future studies should analyze the relationship between this pair of variables in different periods because there could be biases due to the response of fixed-income securities to particular market conditions.

This study was based on that by Bouri et al. (2017), who demonstrated that Bitcoin can often be used as a portfolio diversifier against some assets in the United States and, in a few cases, as a hedge or safe haven. Likewise, the results obtained here for Colombia highlight the hedging and diversifying characteristics of Bitcoin, but they make it clear that this cryptocurrency is in no case a weak or strong safe haven for portfolios composed of Colombian financial assets.

The analysis presented above can serve as a basis for building portfolios with different Colombian financial assets. It can also be helpful for those who were constantly fearful of investing in cryptocurrencies so that they become interested in their operation. They can employ tools such as the findings of the DCC model, which, among others, can be used to explain the concept of investment risk and the need to mitigate it, thus contributing to more efficient decision-making.

6. CONCLUSIONS

From a financial perspective, these findings encourage investors in general to invest capital in the Colombian economy because there is another investment alternative, different from traditional ones: the world of crypto assets. Despite the implicit risks that investors run when they use cryptocurrencies as investment vehicles, we cannot ignore the opportunities that this market offers and its potential as part of the digital transformation. Therefore, due to the dynamics of cryptocurrencies and their growing relevance in society, we should expand our knowledge of them and understand them better. In other words, objective research in this field should enable different market agents to have a clear framework to make decisions, manage their portfolios, and, as a consequence, use better tools to generate strategies—all of this allowed by a definite regulatory system. Therefore, beyond any statistical or technical conclusion that indicates the viability of using

cryptocurrencies, multidisciplinary research should close this knowledge gap and define their applicability.

Although the findings in this article enable investors to consider Bitcoin as an alternative to hedge their positions, their viability analysis should also take into account other important aspects; for example, Bitcoin liquidity and its applicability according to the regulations and the law depending on the type of investor, which were not explored in this study. Another important aspect is the impact of Bitcoin on the environment as it has been proved that using it requires high power consumption, which goes against environmental protection. Additionally, its network generates electronic waste. The characteristics of the cryptocurrency market pose a regulatory challenge for market agents, especially institutional investors who must necessarily comply with the regulations. It is a challenge because the regulating agencies should advocate for the existence of policies and limits for market risk management; liquidity; the money laundering and terrorist financing risk management system in Colombia (known as Sarlaft); and the operational risk management system in Colombia (known as Saro); among others. It is also a challenge because it is impossible to analyze cryptocurrencies using credits and counterparty risk due to their nature. Future studies should further examine the causes behind the floating nature of Bitcoin to clearly define its relationship with other financial assets over time. In any case, as institutional investors enter the scene, the dynamics and variability of its price could change.

Finally, the relative novelty of Bitcoin and its uses open the door to the construction of new theories about its benefits and risks. Future research should aim to explain the behavior of this cryptocurrency over time because, in order to decide if this digital resource should be accepted in different economies, it is essential to learn about the characteristics of its volatility. Thus, investors can determine if there are opportunities to assume this investment risk in the long term.

CONFLICTS OF INTEREST

The authors declare no conflict of financial, professional, or personal interests that may inappropriately influence the results that were obtained or the interpretations that are proposed here.

AUTHOR CONTRIBUTIONS

In this study, all the authors made a significant contribution, as follows:

Christian Daniel Escobar Anduquia: literature review, construction and interpretation of the statistical model, data analysis, results, discussion, and writing – original draft.

Sebastián Darío Avella Jiménez: introduction, conceptualization, data collection and analysis, conclusions, and writing – original draft.

Brayan Ricardo Rojas Ormaza: supervision, conceptualization, and writing – review and editing.

Christian Daniel Escobar Anduquia / Sebastián Darío Avella Jiménez / Brayan Ricardo Rojas Ormaza

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