Risk translation: how cryptocurrency impacts company risk, beta and returns

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Abstract

Purpose – As cryptocurrencies continue to gain viability as an asset class, institutional investors and publicly traded firms have started taking investment positions in digital currencies. What firms may not be considering, however, is the effect these assets may have on their risk profiles. This study aims to (1) measure the effect of cryptocurrencies on the risk and return characteristics of publicly traded companies; (2) decipher the motives behind holding cryptocurrencies as an asset class; and (3) determine whether one reason for holding is more effective than another. To conduct this research, the four largest publicly traded holders of cryptocurrency as well as four of the most prominent cryptocurrencies are explored.

Design/methodology/approach – The cross-sectional analysis approach has been used to analyze the daily returns, volatility, betas and Sharpe Ratios of firms during periods without cryptocurrency strategies and during periods with cryptocurrency strategies.

Findings – The impact of the cryptocurrency asset class on common stock performance and corporate disclosures are documented. The importance of risk disclosures on cryptocurrency holdings is emphasized: Firms must better inform their stakeholders through comprehensive disclosures in financial statements. Firms utilize cryptocurrencies for various reasons such as treasury management tools or as direct sources of income. Consequently, the impact on returns and risks varies substantially.

Originality/value – To the best of the authors' knowledge, this is one of the first studies on cryptocurrency investments in the treasury departments of publicly traded companies. The study contributes to the literature by extracting relevant information regarding company risk reporting and cryptocurrency risk at firms. The conclusions also promote firm transparency with detailed reporting of cryptocurrency holding risks.

Keywords Cryptocurrency, Corporate disclosure, Bitcoin, Corporate treasury, Risk management

Paper type Research paper

1. Introduction

The increasing popularity of cryptocurrencies in recent years has been substantial. This is particularly true not only for individual investors but also for institutional investors, governments and publicly listed firms as well. Cryptocurrencies, such as Bitcoin, Ethereum, Tether and Dogecoin, are digital assets whose values are derived from different sources. Whether from forces of supply and demand, or from complex algorithmic technologies (such as blockchains), or from a mixture of the two, the underlying worth of cryptocurrencies has been an enigma for investors and politicians alike.

JEL Classification — G01, G11, O16, O33

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As an example, one of the most widely recognized cryptocurrencies, Bitcoin, has seen enormous fluctuations in price over its lifespan. Like Bitcoin, many other cryptocurrencies have seen massive swings in value over short periods of time, forcing the aspect of volatility to become synonymous with the asset class. Some may argue this price volatility to be a motivating factor in cryptocurrency investing. Investors that are able to capture short-lived price spikes can cash in on returns uncharacteristic of those observed in equity and/or fixed-income markets.

With the increasing popularity of cryptocurrencies coming to fruition, investors have begun exploring methods of diversifying portfolios to incorporate this technology into their current holdings. While there has been substantial research on the viability of cryptocurrency investments within individuals' portfolios, the impacts of cryptocurrency holdings on company balance sheets have not been examined in depth. This is one of the first academic research papers where the effects of cryptocurrency holdings as an asset class at corporate treasuries will be measured with the changes in company risk profiles and equity prices.

In order to ensure the comprehensiveness of the study, multiple factors are explored: the characteristics of the publicly traded corporation including risk profiles and equity price dynamics over time; the properties of the specific cryptocurrencies held at corporate treasuries including their risk characteristics and price dynamics; and the strategic, economic, marketing and financial reason(s) for cryptocurrency holdings.

The overall goal of this study is to determine whether the risk profile of a company accurately reflects the risks inherited by cryptocurrency holdings. Being such a volatile asset class, cryptocurrencies can introduce uncertainty into a company's balance sheet, as the value of said assets can change drastically in short periods of time. It is necessary not only for a firm's managers to understand the implications of cryptocurrencies on total asset values but also for shareholders to have the right to know the true risk in owning equity shares of a company. If the current risk indicators of a company such as betas, standard deviations or the coefficient of variations do not also accurately reflect the risks of cryptocurrency holdings, then adjustments and updates to risk calculations and risk management strategies would be necessary.

We document that cryptocurrencies used as part of the treasury portfolio exhibit the most positive effects on common stock risk and returns. Sharpe Ratios, taking both the positive in returns and the negative in volatility, go up, following such strategic incorporations. On the other hand, strategies where cryptocurrencies are used as a medium of exchange, or a commission-based asset yield relatively poorer outcomes with deteriorating Sharpe Ratios.

The rest of the paper is organized as follows. Section 2 presents the literature review with an overview of cryptocurrencies, along with their profiles, valuation methods, perceived flaws and impact of external factors. Section 3 is about research methodology. Section 4 presents the results and the discussion. Section 5 explains the Conclusion of this study.

2. Literature review

2.1 Overview of cryptocurrencies

While the mainstream popularity of cryptocurrencies may be fairly new, the technology behind these assets has existed for quite some time. Cryptocurrency is an intangible, digital form of currency that can be used as a medium of exchange for products and services. Some cryptocurrencies are familiar to a large group of investors such as Bitcoin, introduced in 2008, and Ethereum; however, the number of listed cryptocurrencies stretches into the thousands and continues to grow daily. With an abundance of different coins to possess, the question of usage and value comes into play: why should one own cryptocurrency?

Traditional viewpoints on cryptocurrencies typically focus on their investment opportunities; although as time has progressed and the introduction of crypto wallets has

emerged, the utilization of these digital assets has expanded. With the value, scale and volume of cryptocurrencies varying widely, it is difficult to assign a comprehensive list of practices that encompasses all cryptocurrencies. Inherently, as Selimovic *et al.* (2021) explain, all cryptos provide a storage of value and a medium of exchange amongst its users, regardless of their volume or worth.

Aside from their practical use, cryptocurrencies have demonstrated viability as legitimate investments. Inci and Lagasse (2019) discuss how investment portfolios can be enhanced, both in terms of risk diversification and overall returns, with holdings in cryptocurrencies such as Ripple, Bitcoin and Litecoin. Individual and institutional investors, as well as private companies and publicly traded firms have caught on to this trend, investing vast amounts of capital into these assets. The motivations behind owning cryptocurrencies can vary widely for businesses, ranging from investment purposes to supporting future plans of accepting digital currencies as payment for goods and services.

Regardless of intentions, cryptocurrencies provide advantages and disadvantages, to their users and holders. As Guo *et al.* (2018) note, Bitcoin, like many other cryptocurrencies, provides investors and consumers with an asset that is fast, flexible, transparent and, most significantly, decentralized. Whether the decentralized nature of the cryptocurrency ecology is an advantage or a disadvantage may be irrelevant for market participants. However, the essential feature of decentralization is the foundation for many of these assets' subsequent pros and cons. For example, decentralization forces cryptocurrencies like Bitcoin to operate on peer-to-peer networks that permit the transaction and storage of coins for anyone, at any time (Selimovic *et al.*, 2021).

While decentralization and speed are considered as indisputable pros for some market participants, the consequent lack of steady framework and stability are serious disadvantages to owning cryptocurrencies for other market participants that need structure. The lack of centralization in cryptocurrencies leads to another potential disadvantage: high volatility. Without a formal support system under cryptocurrency markets, owners must be prepared for the possibility of the value of their holdings drop significantly over short periods of time (as observed in the second half of 2022). In the worst extremes of coin bankruptcy or abnormal drops in coin value, owners are left without any centralized agency to recoup at least some of their losses (Selimovic *et al.*, 2021). The distinctive risk characteristics of cryptocurrencies have led to the construction of an uncertainty index by Lucey *et al.* (2022). The news events and policy changes are incorporated within the index and the index demonstrates the unique risk aspects of these securities. In this research, the authors provide an index capturing uncertainty beyond Bitcoin that can be used for academic, policy and practice-driven research.

The lack of safety measures is also another concern of investors and government institutions. If hackers can successfully access crypto wallets, digital asset holdings could be taken over, leaving owners with no insured claims on their rightful assets. Hackers may also exploit the "double-spending problem," discussed by Guo *et al.* (2018), allowing them to reuse and "double-spend" crypto-coins. These risks have led many governments to restrict or outright ban the use and ownership of cryptocurrencies altogether, according to Selimovic *et al.* (2021).

While the complete ban on cryptocurrencies does not seem to be on the table in the USA, lawmakers have commenced cryptocurrency regulatory mechanisms and other policy initiatives, as this asset class has started to become part of investor portfolios and the balance sheets of US firms. The legislative attempts on taxation and regulation of cryptocurrencies naturally undermine some of the reasons these digital assets have been created. The potential imposition of regulatory mechanisms on cryptocurrencies reduces the attractiveness and the benefits provided by the decentralization of this digital asset universe that firms and investors would enjoy.

2.2 Cryptocurrency profiles and differentiators

Bitcoin and Ether are two of the most well-known cryptocurrencies. However, the crypto universe is vast, consisting of coins of all sizes, values and purposes. The wide spectrum of access and applications of cryptocurrencies grants a uniqueness to these securities unlike other traditional investments. For example, while Ethereum may be similar to Bitcoin, it provides investors and owners with significant additional improvements, including reliable blockchain structures and transaction functions (Song *et al.*, 2019). Such differences increase the viability and attractiveness of new cryptocurrencies for a variety of investment purposes.

In addition to the improvements over Bitcoin, Beneki *et al.* (2019) also note that Ethereum supports a significantly larger volume of transactions (up to one million) per day and offers more attractive incentives in mining and utilization relative to Bitcoin. While the flexibilities in collection techniques may be important for those actively engaged in mining cryptocurrencies, traditional financial institutions and individual investors may favor cryptocurrencies with financial stability and steady value. Such 'stablecoins', a class of cryptocurrencies experiencing relatively less volatility, may be the preference for risk-averse investors (Jarno and Kolodziejczyk, 2021).

An example of a stablecoin is Tether, one of the most popular stablecoins in terms of market capitalization. Tether is a unique cryptocurrency: it is backed by a private organization and is 'tethered' to the US dollar (Jarno and Kolodziejczyk, 2021). This relationship effectively removes the volatility associated with decentralization. The confidence in Tether is so high that nearly all 23,100 cryptocurrencies (as of March 2023) are traded against Tether, similar to how foreign currencies are traded against the US dollar.

All cryptocurrencies are characterized by their speculative nature, but some coins have the potential to exhibit higher volatility patterns and momentum swings than others. Dogecoin, the cryptocurrency popularly endorsed by Tesla, Inc. CEO Elon Musk, is an example of this. Dogecoin is considered by many to be a 'meme-coin' due to its frequent link with the meme of a dog picture. Memes are characterized by virality and hype. The shifts in the entertainment value and community sentiment over time have a large role in explaining Dogecoin's historic volatility and price manipulation. Nani (2022) examines the sentiment regarding Dogecoin among users of the social media platform Reddit, the social media platform users, which inherently builds hype around the cryptocurrency and can intensify price momentums leading to irrational bubbles.

Another important reason for volatility in the Dogecoin price is the lack of codes in its manifesto that limits coin production (Nani, 2022). The theoretically infinite supply of Dogecoin leads to significant difficulties in its valuation and exposes the valuation process to a plethora of exogenous factors.

Not every cryptocurrency experiences the hype-factor seen in Dogecoin. However, other risk sources, and ultimately accentuated volatility, plague a majority of coins. Armknecht *et al.* (2015) examine Ripple. Khan and Hakami (2021) summarize the operational risks such as transaction cancellations and theft as serious concerns in cryptocurrency ecology. Liquidity is another concern for this asset class, particularly when a significant price change can materialize almost instantly (Khan and Hakami, 2021). For institutional and individual investors alike, these are important issues to take into account before investing in cryptocurrencies.

The role of publicly held firms in cryptocurrency markets has been increasingly scrutinized and studied. Frankovic *et al.* (2021) explore the relationship between cryptocurrency prices and equity prices of the firms holding these cryptocurrencies in Australia. Firms that invest in cryptocurrencies assume positions that are susceptible to cryptocurrency price swings. Frankovic *et al.* (2021) report that firms that invest in cryptocurrencies are strong inheritors of the spillover effects of cryptocurrency volatility. While Frankovic *et al.* (2021) focus on the relationships and influences between cryptocurrency market returns and corporate returns

utilizing cryptos, this paper concentrates on the strategic use of cryptocurrencies by corporations and the reasons for corporate treasuries expanding into cryptocurrencies. A related important study by Xu *et al.* (2022) reports the occurrence of jump behaviors in the returns of cryptocurrencies and in the returns of US corporations with exposures to cryptocurrencies. They further document that the occurrence of jumps in cryptocurrencies increases the probability of jumps in the returns of said US corporations. While the Xu *et al.* (2022) paper examines the return relationships in a highly technical and sophisticated manner, the goal of this study is to examine the strategic reasons for incorporating cryptocurrencies by the treasury departments of firms and to explore the risk and return outcomes of such decisions and strategies.

2.3 Valuation methods of cryptocurrencies

In order to determine whether the risks in cryptocurrencies are accurately taken into account in the risk profile of the firm, cryptocurrencies must first be valued properly. Liu (2021) has categorized cryptocurrency valuation models into three distinct groups: (1) the monetary theory and income approach, (2) the market pricing approach and (3) the cost approach.

The monetary theory and income approach describes crypto-valuation methods characterized by coin-specific attributes such as price, volume and supply. Liu (2021) associates this category with the Quantity Theory of Money (QTM) economic model that has been used for the valuation of centralized currencies. According to this valuation approach, the economic value of the token transaction, the overall token supply and the token velocity are the three characteristics in the derivation of the cryptocurrency market price. This model assumes that the value of holding a coin is associated with its utility instead of the material cash flows. Such an approach is typical in cryptocurrency valuation since cryptocurrencies do not provide cash flows. Therefore, most if not all cryptocurrency pricing models/strategies are based on aspects such as volume and token market capitalization.

The market pricing approach embodies both volume and market cap, deriving a valuation method from network value (i.e. cryptocurrency market cap) and daily transaction volume according to Liu (2021). The competence of the cryptocurrency as a medium of exchange and its duration of existence are considered as two important hurdles for using this valuation model.

The sheer cost that goes into acquiring a single cryptocurrency through mining is assessed with cost approach valuation methods. Cryptocurrencies can be acquired by purchasing using traditional currencies such as the US dollar or by mining. Mining requires individuals to program and operate multiple computers in order to solve algorithms and 'blocks' and consequently acquire cryptocurrencies. This is a costly process both in terms of the necessary technological equipment and in terms of energy costs.

Researchers can develop the valuation method of a single cryptocurrency from the cost it takes to acquire one by mining. As discussed by Liu (2021), the cryptocurrency value is decoded as the product of the electrical costs, the number of hours per day spent on mining, the energy efficiency and the computational power allocated to mining.

The notable absentee in these methods is the explicit representation of the risk of the cryptocurrency. To fully understand the impact of a cryptocurrency asset on the firm's risk characteristics, such as its beta or its standard deviation, a valuation model created by Shen *et al.* (2020) has used distinct risk factors such as the cryptocurrency size, the reversal effect and general profitability to demonstrate their effects on the coin value.

In the asset-pricing function proposed by Shen *et al.* (2020), the endogenous variable is the weekly returns of the cryptocurrency portfolio, and the exogenous variables are excess market return, a size factor derived from the market cap and volume of the coin and a reversal factor derived from the intensity of coin price movements. The explicit consideration of such

risk factors has helped firms realize their importance in the valuation process of the cryptocurrency. The results of such studies have allowed market participants and firms to decipher the risk factors influencing coin prices and to decide the types and quantities of cryptocurrencies to invest in.

2.4 Perceived flaws in cryptocurrency valuation models

The majority of the valuation models for cryptocurrencies lack some fundamental components that make them susceptible to being incomplete. The failure to effectively account for risk (for the market, the asset or any other factor) is the primary shortcoming of these models. Even though this issue is not uncommon in the development of valuation models for new financial securities, it is important that risk be properly accounted for when examining new investment opportunities.

The valuation models developed previously for cryptocurrencies were based on data linked to a single perspective such as income-related data, market-related data or the volume of trade. One of the more recent and arguably more successful pricing models for cryptocurrencies has been the application of the prevalent capital asset pricing model, the CAPM. The comparison of the valuation procedures by Shen *et al.* (2020) demonstrates that the incorporation of market risk into a model helps the value estimation become more accurate and precise. However, most cryptocurrency valuation methods, including the one utilizing the CAPM, fail to account for other risks, notably downside risk.

Dobrynskaya (2020) reinforces this point by documenting that the traditional CAPM model fails to capture the downside risk notoriously associated with cryptocurrencies. With the CAPM being a starting point for many cryptocurrency valuation models, the lack of downside risk recognition poses a major flaw for interested investors. Moreover, the beta calculated as a measure of risk for publicly traded firms derived from the firm returns against market returns inherently overweighs the upside risk when applied to cryptocurrencies, while in reality, the downside risk should be a larger input. As Dobrynskaya (2020) has presented, this is because the market beta is the weighted average of the downside beta and upside beta, with the typical insignificant upside beta for cryptocurrencies.

For a risk to be properly represented through the firm beta, the risks of the firm's underlying assets and investments must be properly assessed as well. In the case of companies such as Tesla and MicroStrategy, cryptocurrencies make up a fair portion of the balance sheet. Similar to Tesla and MicroStrategy, cryptocurrencies are exposed to market risk as well, some more exposed than others.

Market risk is not the only form of risk that is missing from a majority of valuation methods for cryptocurrencies. Default risk, inflation risk, term spread risk and foreign exchange risk are some of the other types of risk that can affect cryptocurrencies (Koutmos, 2019). Default risk refers to the risk of default of corporations on BAA bonds (the average rating of corporate debt securities) and 10-year treasury yields. Inflation risk is about the risk associated with the decline of an asset's worth due to inflationary pressures. Term spread risk is the inversion of the yield curve associated with government securities. Foreign exchange risk stems from currency dynamics. Many of these risk sources play an important factor in the pricing of traditional financial securities, such as equities and fixed-income securities. Cryptocurrencies represent a growing financial asset class and they have started to be considered as alternative investments. Therefore, the additional risk sources mentioned above must be considered in their valuation processes.

Another very important risk that is prevalent in financial securities markets, which is especially relevant for cryptocurrencies is volatility risk. Koutmos (2019) summarizes volatility risk as the general impact of investor sentiment on the price of an asset. One may be familiar with the impact of investor sentiment on equity stocks, manifesting through the

concept of speculation. Stocks may exhibit unwarranted price pressures due to the feelings and emotions of investors that are not rationally supported by the fundamentals or through changes in income. Cryptocurrencies have regularly experienced wild fluctuations in their values due to investor sentiments over relatively short periods of time. Accentuated variations in value due to the extreme behaviors of market participants (e.g. irrational exuberance or irrational sadness) have occurred repeatedly for cryptocurrencies.

2.5 Impact of external factors on cryptocurrencies

The impact of exogenous factors on the price of various cryptocurrencies has been well-publicized, with media moguls such as Elon Musk inflating the price of Dogecoin substantially after mentioning the cryptocurrency on Twitter. Factors that may impact a cryptocurrency's price are plentiful; however, the extent to which a coin's price is altered appears to be more intense than those resulting from speculations on traditional financial securities. As publicly traded firms continue to incorporate cryptocurrencies into their treasury department portfolios, there needs to be better clarity on the relationship between the change in the firm value and the adjustment in the cryptocurrency holdings price. For example, when one of Tesla, Inc.'s cryptocurrency assets inflate tenfold within a very short period of time with the posting of a couple of tweets, it is imperative to understand the risks that go along with the price changes of the firm's stock.

One of the most scrutinized factors that affect cryptocurrency prices is the social media impact. Reddit and Twitter have served as the main hubs for discussions regarding perceived opportunities in cryptocurrencies. These conversations have had the power to significantly alter the prices of digital assets. Tesla's founder and CEO Elon Musk has been vocal about cryptocurrencies, particularly, Bitcoin and Dogecoin. A study conducted by Ante (2022) documented that Musk's Twitter activity has had the power to change the trading volume of Dogecoin and create returns of over 25% within the hour of posting a message.

Similar to Musk's tweets, social media activity on other platforms influences asset returns. Such activities seem to contrast with the long-standing efficient market hypothesis (EMH), which states that the price of an asset or security reflects all publicly available information, discouraging investors from engaging in short-term price manipulation. Because of the influence of social media platforms on cryptocurrencies, Ante (2022) has advocated the adaptive market hypothesis that considers the activity of market participants and environmental conditions more heavily. This approach seems to be a prerequisite of cryptocurrency markets, as prices can be influenced at scales rarely seen in traditional financial securities markets.

The impact of the actions of market participants on cryptocurrency prices can be highlighted during the Bitcoin crash between 2017 and 2018. The 90% decline in the price resulted from the server failure of a leading cryptocurrency exchange for more than 8 h, sending Bitcoin owners into a panic selloff (Doumenis *et al.*, 2021). While traditional financial securities may exhibit similar reactions to the failure of market mechanisms, the technological framework and the collective 'herd behavior' mindset of market participants complementing the crash have been unique to Bitcoin and other cryptocurrencies. Even Bitcoin investors who did not have their holdings in the affected cryptocurrency exchange contributed to the herd behavior, forcing the price to drop further.

Investments of publicly traded firms into cryptocurrencies and/or incorporating cryptocurrencies as acceptable methods of payments have increased interest and demand, which in turn positively affected values. As documented by Irimia *et al.* (2021), Tesla's investments in Bitcoin have created a spotlight on the investment potential of the cryptocurrency. Moreover, Tesla's decision to accept Bitcoin as a form of payment for its goods and services has further increased interest in the cryptocurrency market.

As publicly traded corporations continue to integrate cryptocurrencies into their investments, assets and operations, transparency for shareholders and regulators is increasingly becoming more of a priority. The accurate representation of cryptocurrency risk is necessary for the risk profile of public entities that use them not only as investment mechanisms but also as a means of exchange. Firms highlight the sensitivity of their revenues and profits to the government-driven exchange rate policies on traditional currencies (devaluation by printing money or revaluation by reducing the money supply). Cryptocurrencies are mentioned as a preferred medium of exchange since they are not impacted by such government policies. Once the risk profiles are reconciled and fully transparent, investors will have a better understanding of the true nature of the risk exposure of publicly traded companies to these highly volatile assets.

3. Research methodology

3.1 Research questions

The objective of this study is to determine whether the risk profiles of companies accurately reflect the risk associated with their positions in cryptocurrencies. To address this issue, cryptocurrency characteristics, valuation methods and risk measurements must all be effectively explored, as well as the valuation of these publicly traded companies and the weight of cryptocurrencies in their asset holdings.

While the cryptocurrency holdings of the firm may not have a material impact on the stock price or the beta measure, it is important to determine and categorize the actual motivations behind owning cryptocurrencies. This is the second main motivation of the paper.

The third aim of the study is to emphasize the importance of transparency in information dissemination from the firm to the shareholders. This is achieved by first filling the gaps in research regarding the relationship between cryptocurrency risk and firm risk. And once a company can better understand how a cryptocurrency asset affects the overall firm risk, this should be fully shared with the stakeholders in order to enhance risk management strategies.

The general scope of the research here will focus on the four largest public holders of cryptocurrencies: MicroStrategy Inc. (MSTR), Tesla, Inc. ([TSLA), Square Inc. (SQ) and Marathon Digital Holdings, Inc. (MARA), and five of the largest cryptocurrencies by market cap: Bitcoin, Ether, Tether, Ripple and Dogecoin. Narrowing the focus to these nine dimensions allows for more in-depth proprietary data collection and analysis.

Aside from the emphasis on firm transparency, the findings shed light on how impactful digital asset investments are on the risk profile, profitability margins and the overall value of a firm. The results presented in the paper will help firms enhance their risk management and investment strategies.

3.2 Methodology and data

The publicly traded firms, their respective cryptocurrency investment holdings and their risk structures must be analyzed. The holding periods of the cryptocurrency investments of the four companies listed in the above section are characterized by when the firm first mentions the term "cryptocurrency" in the 10-K or 10-Q filings. This is set as the beginning of the holding period. Proprietary data are collected and synthesized up to the middle of September 2022 for a consistent end point of the holding period for all firms. In order to measure the effects of cryptocurrency holdings on the firm and stock fundamentals, an early and adjacent non-holding time period (equal in length to the above holding period) is selected and analyzed, during which cryptocurrencies were not held by the firm.

The stock price dynamics and the return data are analyzed for both periods for each of the firms with the top cryptocurrency holdings. These analyses allow a clearly matched

comparison of the results from each period for the company. The streamlined results also allow for cross-sectional analysis to determine the effectiveness of cryptocurrency investments, implementation strategies and risk management strategies. The individual metrics used for the assessment include the standard deviation and the average of daily equity returns, the firm's beta against the S&P 500 index and the Sharpe Ratio, covering the return, risk profile and volatility dimensions.

The dynamic evolutions of beta, Sharpe Ratio, standard deviation and the average equity returns provide us with an understanding of how cryptocurrency strategies impact a firm's risk and return profiles. The quarterly and annual financial statements and additional financial disclosures are utilized for qualitative interpretations.

In order to compile the propriety data, (1) cryptocurrency markets data from the Bloomberg database are used to extract the prices and returns of the top five cryptocurrencies; (2) company financial statements and disclosures from the U.S. SEC EDGAR database are used to obtain firm-specific information and data; (3) the S&P Global is used to collect data on equity indices; (4) CRSP/Compustat database is used to collect stock prices and firm-specific data; (5) The screening processes for cryptocurrency holdings of the firms are executed at CoinGecko and similar web applications.

4. Results and discussion

The analyses are presented cross-sectionally, where firms with more effective cryptocurrency implementation strategies are presented first. Those with less effective strategies follow, along with the reasons for poor outcomes. The dynamic evolution of the risks, returns and Sharpe ratios are presented without cryptocurrency holding periods and with cryptocurrency holding periods. The discussion of the differences includes respective holding rationales.

We find that MicroStrategy Incorporated (MSTR) exhibits the most effective use of cryptocurrencies. The beginning of MicroStrategy's venture into the cryptocurrency asset class began with the introduction of a new 'Treasury Management Strategy' in July 2020. MicroStrategy first disclosed the treasury strategy within its FY2020 Q3 10-Q. The disclosure outlined the firm's initiative to include a $250mn investment in alternative assets, namely cryptocurrencies including Bitcoin (MicroStrategy, Inc., 2020). MicroStrategy clarified to note that Bitcoin was to serve as the firm's forefront treasury asset from that point onward, serving as a hedge against inflationary pressures, amongst other purposes. In accordance with the GAAP, MicroStrategy disclosed a variety of risks associated with the incorporation of Bitcoin into the balance sheet, namely the effect it may have on the stock price via the change in the asset's underlying value.

Since this first mention of cryptocurrency in the company policy and disclosures, the average daily stock returns of MicroStrategy increased from 0.04% to 0.29% as seen in Figure 1 and as reported in Table 1. This statistically significant increase in average daily returns (at 1% level) is also the largest across the firms examined in this research. The excess return calculated as the difference between the daily average return and the daily average stock market return provides the exact same conclusion. However, even though the period of the incorporation of cryptocurrencies has been characterized by extraordinary growth compared to before, the volatility of the returns has increased almost threefold, from a standard deviation of 2.39%–6.51% (statistically significant at 1% level).

The increased volatility of the MicroStrategy daily returns has translated into an increase in another risk measurement, the beta of the stock, from 0.74 to 2.87 (a fourfold increase). Both the updated beta and standard deviation measurements display a definitive increase in the overall stock volatility once cryptocurrencies were introduced. MicroStrategy equity has become a riskier financial security either as an individual investment opportunity or as part

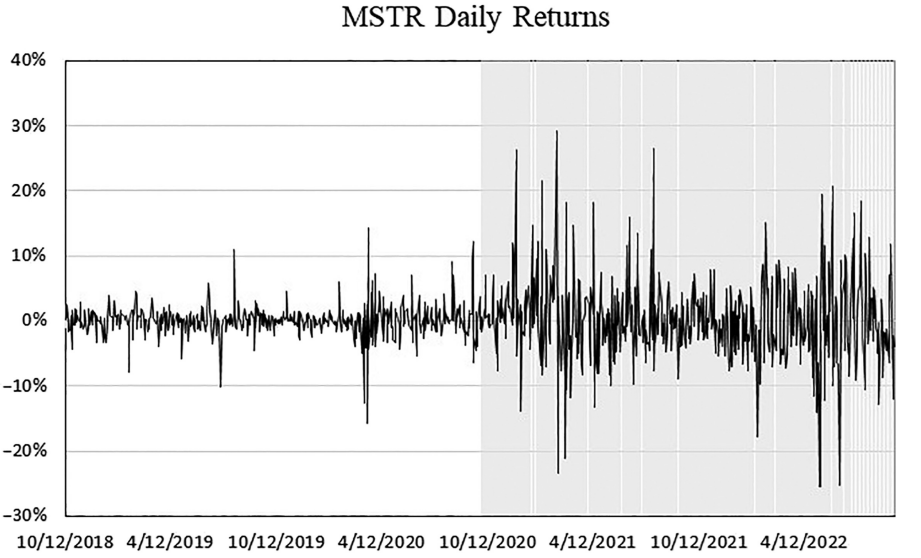


Figure 1.
MicroStrategy return volatility

Note(s): Shaded Areas Represent Cryptocurrency Holding Periods
Source(s): Authors' own work

	Without cryptocurrencies	With cryptocurrencies
Average Daily Return, R_{MSTR}	0.000384	0.00286
Excess Daily Return	−0.00021	0.002477
Standard Deviation, σ_{MSTR}	0.023884951	0.065098565
Beta, β_{MSTR}	0.735231	2.869382
Sharpe Ratio, SR_{MSTR}	0.016087	0.043934

Note(s): The table presents the risk and return characteristics of MicroStrategy equity during the periods where the firm did not utilize cryptocurrencies and where the firm utilized cryptocurrencies within its corporate treasury strategies. The average daily returns (arithmetic average of the daily returns based on adjusted closing prices), the standard deviation of the returns (the square root of ratio: the sum of squared deviations of the daily returns from the arithmetic average return divided by the number of returns minus one), beta of the stock (covariance of the daily returns of the stock with the daily returns of the market and then divided by the variance of the daily return of the market) and the Sharpe Ratio (as the ratio of the difference between the average daily return of the stock and the average risk-free rate divided by the standard deviation of the daily returns of the stock) of the equity are presented for each period separately. The excess daily return is the daily average return minus the daily average stock market (S&P500) return
Source(s): Authors' own work

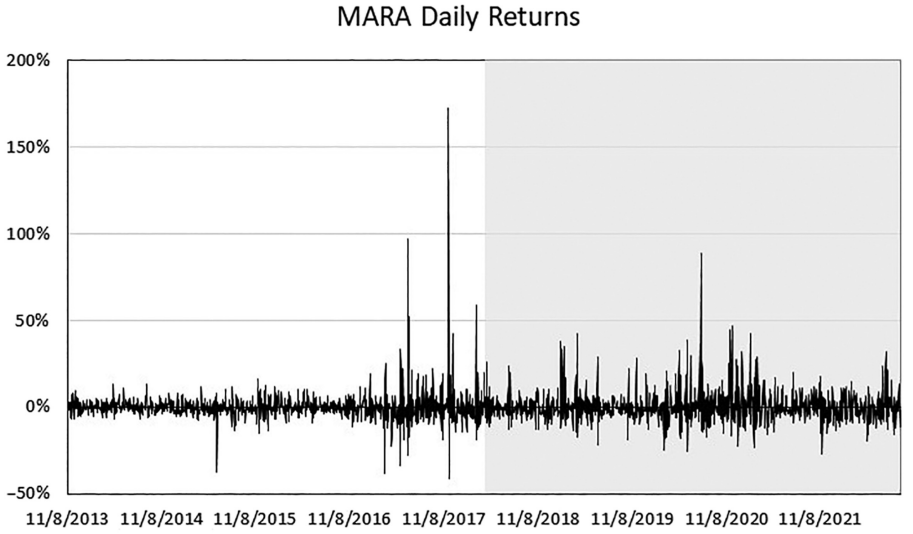
Table 1.
MicroStrategy equity returns

of a part of an investment portfolio. To determine the overall impact (by taking into account both the increased return and the increased volatility), the Sharpe Ratio is evaluated for each period. Prior to the incorporation of cryptocurrencies, the MicroStrategy Sharpe Ratio is documented as 0.016 in Table 1. After the implementation of cryptocurrency strategies, MicroStrategy Sharpe Ratio has increased almost three times to 0.044, demonstrating that the return generated during the cryptocurrency holding period has outweighed the increased volatility.

The second most effective use of cryptocurrencies within the corporate organization is noted in Marathon Digital Holdings, Inc. (MARA). Marathon Digital Holdings management has taken a different approach to cryptocurrency implementation than that MicroStrategy. This allows the opportunity to obverse the qualitative differences and the impact of these differences on stock performance. Formerly Marathon Patent Group, Marathon Digital Holdings underwent a significant shift in its business model in late 2017 and disclosed its venture into "Digital Asset Mining" in the FY2017 annual report (2017). The change in the business structure succeeded the firm's merger agreement with Global Bit Ventures Inc. (GBV), a firm dedicated to the mining of digital assets, namely Bitcoin and Ether.

After the completion of the merger between Marathon Digital Holdings and Global Bit Ventures, the management revised the business strategy further to focus on generating revenue through digital asset mining. As outlined in the annual 10-K report in 2017, Marathon Digital Holdings "will be compensated in either BTC or ETH based on the mining transactions [they] perform for each" (Marathon Patent Group, Inc., 2017). This corporate strategy is quite different from that of MicroStrategy, as Marathon Digital Holdings utilizes cryptocurrencies as a direct source of revenue as opposed to a liquidity tool.

Despite the differentiated implementation strategy, Marathon Digital Holdings has experienced similar changes in terms of average daily stock returns, betas and Sharpe Ratios when compared to MicroStrategy and as seen in Figure 2 and Table 2. The excess return calculated as the difference between the daily average return and the daily average stock market return provides the exact same conclusion. However, the notable difference is a reduction in the volatility of the equity returns in Marathon Digital Holdings during the period involving cryptocurrencies. After the implementation of Bitcoin and Ether into the business strategy, the standard deviation of the daily stock returns decreased from 9.02% to 8.93%. On the other hand, the structural changes in business operations have altered the beta of the stock substantially from −0.21 to 0.64 as documented in Table 2.



Note(s): Shaded Areas Represent Cryptocurrency Holding Periods
Source(s): Authors' own work

Figure 2.
Marathon digital holdings, Inc. Return volatility

Table 2.
Marathon digital holdings, Inc. equity returns

	Without cryptocurrencies	With cryptocurrencies
Average Daily Return, R_{MARA}	0.001295	0.004283
Excess Daily Return	0.000892	0.00385
Standard Deviation, σ_{MARA}	0.090241	0.0893
Beta, β_{MARA}	−0.20687	0.64222
Sharpe Ratio, SR_{MARA}	0.014345	0.047962

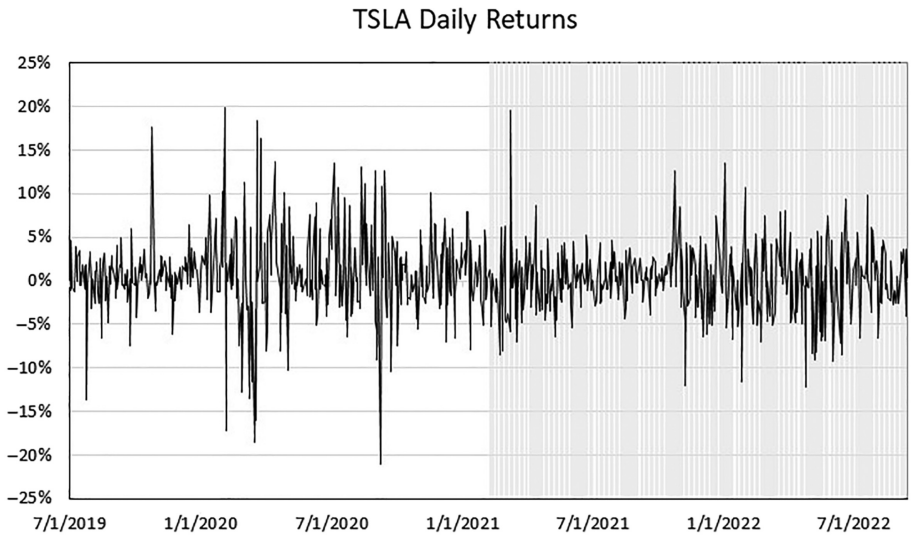
Note(s): The table presents the risk and return characteristics of Marathon Digital Holdings, Inc. equity during the periods where the firm did not utilize cryptocurrencies and where the firm utilized cryptocurrencies within its corporate treasury strategies. The average daily returns, the standard deviation of the returns, beta of the stock and the Sharpe Ratio of the equity are presented for each period separately. The excess daily return is the daily average return minus the daily average stock market (S&P500) return
Source(s): Authors' own work

The non-holding period beta of −0.21 states that the price movements between Marathon Digital Holdings equity and the S&P 500 benchmark index have overall been in the opposite direction. Implementing the new business operations and the new revenue strategy centered around cryptocurrencies effectively flipped Marathon Digital Holdings stock price movements and has led to a beta coefficient of 0.64. The statistically significant threefold increase in the average daily equity returns from 0.13% to 0.43% coupled with the decline in the total risk of the stock returns has changed the Marathon Digital Holdings Sharpe Ratio from 0.014 to 0.048.

In both cases examined thus far, incorporating cryptocurrencies into the structure of the firm has increased investment attractiveness. The third case, Tesla, Inc. (TSLA), presents yet another example of a differentiated cryptocurrency implementation strategy than the preceding two firms. Similar to the MicroStrategy corporate plan, Tesla has also introduced their cryptocurrency initiative as an addition to their overall corporate asset strategy; namely, as an investment vehicle focused on generating returns off of idles cash reserves. However, Tesla has also declared the policy of accepting digital currencies as a form of payment for their products. Not only have cryptocurrencies become part of the investment portfolio of the treasury department of the firm, but also the medium of transaction exchange for the firm's products and services has been declared to include cryptocurrencies. As for the comparison with Marathon Digital Holdings, Tesla has not specifically utilized crypto mining as part of its corporate strategy (unlike Marathon).

Tesla's updated investment strategy and payment strategy were disclosed in the firm's FY2020 10-K statement. In addition to the details about the cryptocurrency payment strategy, the report has also made clear that the cryptocurrency received by the firm 'may or may not [be] liquidate[d] upon receipt' (Tesla, Inc., 2020). This has left the door open for additional cryptocurrency revenue generation strategies. To support their cryptocurrency foray, Tesla has made an initial investment worth around $1.5bn in Bitcoin, allowing for the immediate implementation of the investment strategy and also providing the foundation for future payment strategies.

Tesla's cryptocurrency implementation is deemed to be one of the less effective strategies, particularly when considering the effects it has had on the firm's beta, Sharpe Ratio and general returns in Figure 3 and in Table 3. Throughout the cryptocurrency holding period, the average daily stock return has decreased from the non-crypto holding period average daily return of 0.85% down to 0.09% (statistically significant at 1% level). The excess return calculated as the difference between the daily average return and the daily average stock market return provides the exact same conclusion. At the same time, however, this shift was accompanied by a statistically significant decrease in volatility. As seen in Table 3,



Note(s): Shaded Areas Represent Cryptocurrency Holding Periods
Source(s): Authors' own work

Figure 3.
Tesla, Inc. return volatility

	Without cryptocurrencies	With cryptocurrencies
Average Daily Return, R_{TSLA}	0.008485	0.00087
Excess Daily Return	0.007636	0.000793
Standard Deviation, σ_{TSLA}	0.048595	0.037675
Beta, β_{TSLA}	1.247451	1.910114
Sharpe Ratio, SR_{TSLA}	0.17461	0.023101

Note(s): The table presents the risk and return characteristics of Tesla, Inc. equity during the periods where the firm did not utilize cryptocurrencies and where the firm utilized cryptocurrencies within its corporate treasury strategies. The average daily returns, the standard deviation of the returns, beta of the stock and the Sharpe Ratio of the equity are presented for each period separately. The excess daily return is the daily average return minus the daily average stock market (S&P500) return
Source(s): Authors' own work

Table 3.
Tesla, Inc. equity returns

the standard deviation of daily equity returns decreased from 4.86% during the non-cryptocurrency period to 3.77% during the cryptocurrency policy period. However, the combination of the two effects has resulted in a lower Sharpe Ratio during the latter cryptocurrency subsample. With the Sharpe Ratio declining from 0.175 during the early subsample of no cryptocurrencies down to 0.023 during the recent subsample period involved with cryptocurrencies, Tesla has failed to make positive changes within its comprehensive risk profile.

Tesla's inferior recent subsample period Sharpe Ratio is a depiction of implementation imperfections in corporate cryptocurrency policies. The substantial decline in the average daily stock returns could not be offset by the modest improvement in the volatility of the returns aid returns, which was reflected in the firm's Sharpe Ratio decrease from 0.175 to 0.023. Not only did Tesla's stock performance deteriorate under its cryptocurrency strategy, but it also increased its comprehensive investment attractiveness. Finally, while the total

volatility has somewhat declined with cryptocurrency policies, the relevant risk in the context of diversified portfolios, beta, has increased from 1.25 during the non-cryptocurrency subsample to 1.91 during the cryptocurrency policies subsample. Therefore, the overall impact of digital asset policies on the volatility characteristics has been mixed.

With Tesla, the unique cryptocurrency strategy has been the introduction as a medium of exchange for customer payments in return for the firm's goods and services. One interpretation of the results from Tesla may be the premature consideration of using cryptocurrencies in the revenue system. The volatile nature of cryptocurrencies manifesting both in the revenue stream, as well as in the investments of the treasury department of the firm might have substantially mitigated any potential benefits.

Block, Inc. (SQ), formally referred to as Square, Inc., exemplifies the worst implementation strategy in this research; the consequences of deteriorating volatility and deteriorating returns. Block's involvement with cryptocurrencies has primarily been a software tool, Cash App, a mobile application dedicated to supporting electronic payments between users and businesses. As an extension of the platform, Block has introduced the ability for users to trade Bitcoin. This approach has some similarities with Tesla and Marathon since Block introduces a channel for revenue generation from cryptocurrencies. More precisely, Block utilizes transaction fees as the source of revenue, not the digital currency itself.

In addition to facilitating cryptocurrency transactions, Block has been providing additional liquidity services by purchasing cryptocurrencies from their users. In summary, Block has provided a cryptocurrency trading platform and generated revenues from cryptocurrency transaction processes. Unlike previously examined firms, there are no specific corporate treasury initiatives. And by establishing its own local platform, Block differentiates from Marathon's and Tesla's dispersion of some risk through using established platforms.

As indicated in Figure 4 and Table 4, Block's facilitation of cryptocurrency payments on their Cash App platform has led to a statistically significant decline (at 1% level) in the

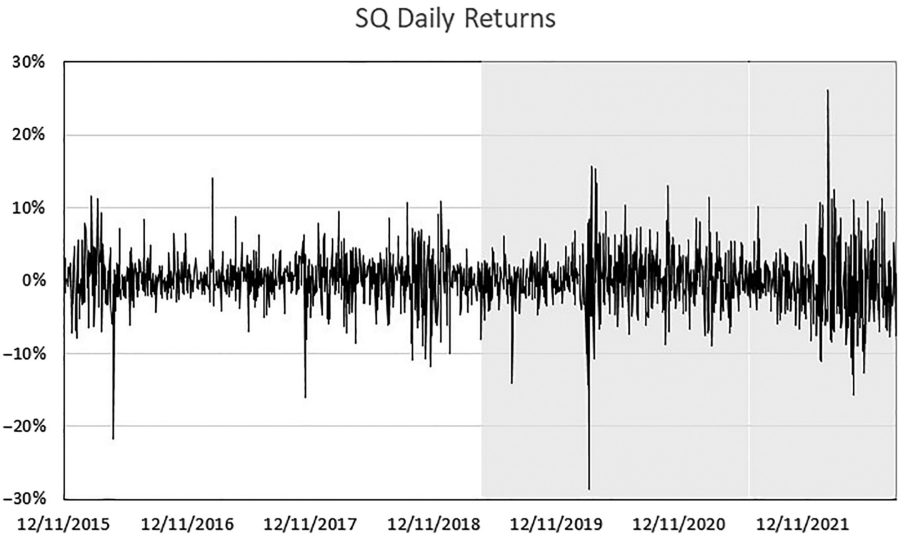


Figure 4.
Block, Inc. return volatility

Note(s): Shaded Areas Represent Cryptocurrency Holding Periods
Source(s): Authors' own work

	Without cryptocurrencies	With cryptocurrencies
Average Daily Return, R_{SQ}	0.002625	0.000819
Excess Daily Return	0.002175	0.000369
Standard Deviation, σ_{SQ}	0.031297	0.042139
Beta, β_{SQ}	1.823726	1.801276
Sharpe Ratio, SR_{SQ}	0.083864	0.01944

Note(s): The table presents the risk and return characteristics of Tesla, Inc. equity during the periods where the firm did not utilize cryptocurrencies and where the firm utilized cryptocurrencies within its corporate treasury strategies. The average daily returns, the standard deviation of the returns, beta of the stock and the Sharpe Ratio of the equity are presented for each period separately. The excess daily return is the daily average return minus the daily average stock market (S&P500) return
Source(s): Authors' own work

Table 4.
Block, Inc. equity returns

average daily equity returns from 0.26% to 0.08%. The excess return calculated as the difference between the daily average return and the daily average stock market return provides the exact same conclusion. Moreover, there is also a statistically significant increase (at 1% level) equity return volatility from 3.13% to 4.21%. Coupled together, the Sharpe Ratio has decreased substantially from 0.0839 to 0.0194 leading to the worst outcome for the firms examined firms in this study. The slight decline in beta from 1.82 to 1.80 is a minimal change. Overall, it seems that the cryptocurrency policies of Block; mainly the unique strategy of the creation of a local quasi-trading platform has helped neither the returns nor the volatility of the firm. The cryptocurrency holding period is an inferior ownership environment for the stakeholders.

5. Conclusion

The literature on cryptocurrencies is relatively new and the major focus has been on the investments area of finance. These digital assets represent a new technology in the FinTech universe. And as new cryptocurrencies are introduced to the marketplace continually, cryptocurrency indices have difficulty keeping up and sometimes lack full representation. Research on cryptocurrency use in corporate finance is an even more novel research area. Therefore, this study provides unique contributions to the corporate finance area of the literature.

An important challenge of cryptocurrency research in corporate finance is the lack of transparency and lack of the availability of data. Therefore, research needs to start with the collection of proprietary data through machine learning and web-crawler programs. It is important to note that the successes and the failures of the strategies represented within this paper provide a guideline and do not span the full spectrum of policies. However, the results and conclusions here provide important insight. Tied to this discussion, it should also be suggested that companies that hold cryptocurrencies have a primary responsibility of transparency and of accurately informing their stakeholders of any risks associated with their holdings and their effects on the firm's stock price and enterprise value.

We document that cryptocurrency strategies tailored around the utilization of these assets as part of the treasury portfolio exhibit the most positive effects on common stock risk and returns. Both MicroStrategy, Inc. and Marathon Digital Holdings, Inc. managed to increase their average daily equity returns under their respective strategies. The volatility may very well increase with these strategies but the Sharpe Ratio (taking both the positive in returns and the negative in volatility) goes up, indicating successful implementation of the strategies.

Strategies utilizing cryptocurrencies as a medium of exchange, or a commission-based asset yielded relatively poorer outcomes. Tesla's introduction of Bitcoin into its business as a

mode of revenue payment for its goods and services was followed by a dramatic decrease in average daily stock returns. Block's facilitation of bitcoin payments through its Cash App platform and effectively creating a local cryptocurrency trading platform was followed by a substantial decrease in average daily stock returns and an increase in volatility. The Sharpe Ratios have deteriorated for both firms.

The findings this paper presents contribute to existing academic research through several avenues. First, the research clearly demonstrates the need and the importance of risk disclosures by firms dealing with cryptocurrencies. Whether these assets are viewed as a treasury management tool or as a direct source of income, it is clear that firms must better inform their investors through more comprehensive disclosures in their financial statements. If corporations properly recognize all associated risks with cryptocurrencies, then this will pave the way for a more informed interaction between firm and shareholder, effectively decreasing informational asymmetry.

Second, the research provides evidence of effective cryptocurrency implementation strategies and utilization from a corporate perspective. While the research focused on a small scale of four companies, these are at the forefront firms in corporate finance cryptocurrency strategies and implementation. Thus, the study provides an initial overview of these corporate strategies and evidence of their successes and failures. An extension of future research would be the inclusion of other firms utilizing cryptocurrencies in their corporate structure, both domestically and internationally. The limited number of firms used in the study, however, forefront they are, needs to be enriched by other firms' strategies as data become available. Then, more concrete crypto strategies will be formulated. This would be useful in confirming the effectiveness of the strategies examined in this study and in identifying other unique strategies. The lack of transparency and clarity in cryptocurrency policies would be hindrances but as data become more readily available over time, such issues would be mitigated.

Another area of future research with the availability of data would be the examination of the specific cryptocurrencies used by corporations. In this paper, we considered cryptocurrencies altogether with a focus on the five most popular ones: Bitcoin, Ether, Tether, Ripple and Dogecoin. These have been mentioned by the firms of this study in their cryptocurrency strategies. Other risk factors have not been considered in detail because the primary purpose has been to see the overall impact on firms with cryptocurrencies versus without cryptocurrencies. The specific impact of a particular cryptocurrency on firm returns and firm volatility, the correlation of the cryptocurrencies relative to each other, other risk factors and optimizing the composition of the cryptocurrency portion of the corporate treasury portfolio are future areas of research as data become available.

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