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Do Investors Value Firm's Application of Cryptocurrency and Blockchain Technology?

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DO INVESTORS VALUE FIRM'S APPLICATION OF CRYPTOCURRENCY AND BLOCKCHAIN TECHNOLOGY?

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Abstract

This paper examines how investors view a firm's involvement with cryptocurrency or blockchain technology, measured by 10-K disclosures containing the related keywords. I find that investors negatively react to the information related to cryptocurrency or blockchain in the three-day window, but the negative trend is reversed after day four. Surprisingly, the topic analysis indicates that the market reacts positively to all topics related to cryptocurrency and blockchain, except for the "competition environment," suggesting that factors outside adopting cryptocurrency or blockchain affect the negative correlations observed before.

Keywords: cryptocurrency, blockchain technology, financial disclosure, market reaction

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Introduction

Due to the advent of artificial intelligence (AI), cryptocurrency is a rising and controversial market. A cryptocurrency is a digital currency that is a substitute system of payment fashioned by employing encryption algorithms (Houben & Snyers, 2018). Encryption technologies require cryptocurrencies to perform as a currency and a simulated accounting system, which aims to help professionals better understand accounting principles and practices through hands-on experience and practical application. Further, it is designed as a medium of exchange through a decentralized computer network, which verifies that the parties to a transaction have the money they claim to possess.

The cryptocurrency growth can be viewed when 2010 Bitcoin's price never broke $0.4 per bitcoin, while it reached $16,259 per bitcoin at the end of 2022. However, due to the lack of regulation and volatility of cryptocurrency, the value of cryptocurrency does not change based on economic situations but fluctuates based on speculation (Macey, 2023). For example, Shahzad et al. (2022) and Ante (2023) find that Elon Musk's tweets significantly affect cryptocurrency's trading volume and price, even though the impact level differs by the cryptocurrency type.

The derivative technology of cryptocurrency, blockchain, receives great attention since it can help improve cybersecurity, increase the work efficiency of operations, and improve data integrity. However, blockchain technology is subject to criticism, too. Adopting blockchain technology is costly and has high technological requirements. Companies using blockchain technology may fail to maintain profitability in the long

run because they must pay significant fees constantly (Islam et al., 2023).

This study applies the Throughput model in analyzing investors' reactions to a firm's involvement with cryptocurrency or blockchain technology, measured by the cryptocurrency or blockchain-related 10-K disclosures. The Throughput Model illustrates AI algorithmic pathways to examine each pathway's quality trade-offs and the relationship among patterns, which is currently broken into separate pathway collections (Rodgers, 2020). AI is portrayed as a set of algorithms with an array of instructions representing a postulated, strict, coded recipe that gets executed when it comes upon an activation (Rodgers, Murray, Stefanidis, Degbey, & Tarba, 2023; Rodgers & Nguyen, 2022). Machine learning, an essential component of AI, can characterize a set of algorithms, which diverge conditionally on whether the data it collects is structured or unstructured. The synopsis of AI algorithmic pathways, represented by the Throughput Model, across different publications, can assist the architects and designers in traversing from the pathway to the pathway until a suitable amalgamation of patterns that can meet the design goals is established. In addition, the perception, information, judgment, and decision-choice concepts portrayed in the Throughput Model can be beneficial design and background knowledge that can help designers make cogent and reasonable decisions (Figure 1).

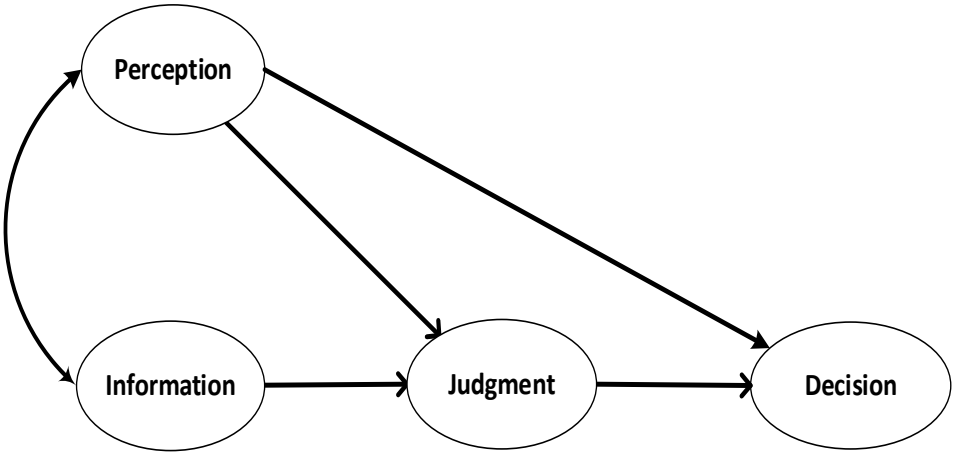

Figure 1 The Throughput Model

Moreover, the Throughput Model has been applied to solve issues related to decision-making and is considered to be new tool and technique in the decision-making cycle in the era of the fourth industrial revolution (e.g., Attah-Boakye, Costanzo, Guney, and Rodgers, 2021; Foss & Rodgers, 2011; Rodgers, Alhendi, & Xie, 2019; Ishaque, Attah-Boakye, & Yusuf, 2022; Rodgers, Economou, and Hudson, 2023; Rodgers, Murray, Stefanidis, Degbey, & Tarba, 2023). Further, as depicted by the Throughput Model in Figure 1, I aim to detect which AI algorithmic pathways can be applied to structure the patterns to assist architects in the blockchain-based application design.

Emphasizing an algorithmic decision-making model is essential in understanding cryptocurrency and blockchain is critical, especially with the recent speedy development of AI. Knowing how a company applies blockchain technology is vital to stakeholders due to the following reasons: 1) Financial analysts and investors need to evaluate the market reaction to the blockchain's initiatives in the short term and firm performance in the long run (Stratopoulos et al., 2022; Chen et al., 2022); (2) A firm's adoption of blockchain technology affects its suppliers and retailers' strategies that

deal with increased production costs and competition environment (Zhou et al., 2022; Stratopoulos et al., 2022); (3) Regulators have more chances to formulate rules and update regulations that encourage the new technology to enhance social value while avoid providing fake secure feelings to incoming customers (Macey, 2023); (4) Firm managers can better evaluate the potential risks associated with the new technology and exploit the most value of it. Thus, the disclosures released by adopting firms become a critical channel for investors to understand the application of the technology. Current studies find that investors are more likely to respond positively to blockchain-related disclosures (Yen and Wang, 2021; Chen et al., 2022; Bourveau et al., 2022) because investors believe adopting blockchain technology benefits firm operations (Yen and Wang, 2021), mitigates information asymmetry between investors and managers (Howell et al., 2020), and improves innovations (Guo et al., 2020).

Disclosing cryptocurrency-related and blockchain-related information will likely be considered good or bad news by investors. Considering cryptocurrency's technological specialties, specialty design, and its connection with opportunity behaviors (Macey, 2013; Kethineni and Cao, 2020), investors may have extra concerns when a firm uses cryptocurrency. Thus, examining how investors react to firms' cryptocurrency and blockchain technology applications is crucial for business management since managers can better align their technology development strategies with investors' expectations and address their concerns.

Given the mixed opinions regarding cryptocurrency-related and blockchain technology-related disclosures, this paper is motivated by the need to examine the

relationship between the application of blockchain or cryptocurrency and the market reaction. Using the blockchain or cryptocurrency-related keywords of 10-K disclosures as the proxy of a firm's application of blockchain or cryptocurrency, I find that adopting blockchain or cryptocurrency is negatively associated with abnormal returns in a three-day window. The coefficients turn positive after day four, suggesting that investors overreact to the information related to blockchain or cryptocurrency in the first place. Also, I observe that investors do not have different attitudes regarding whether firms disclose cryptocurrency or Bitcoin for the first time. Considering that containing keywords of cryptocurrency or blockchain does not guarantee that a company applies the related technology, I adopted topic analysis. Surprisingly, the regression results of the topic analysis indicate that investors positively react to all cryptocurrency or blockchain technology topics, except for the topic "competition environment," suggesting that the previous negative correlations are likely driven by factors other than adopting cryptocurrency or blockchain technology.

The "Throughput Model," implemented in this research, provides the algorithms to analyze the fundamentals of cryptocurrency and blockchain technology. The Throughput Model consists of six sets of algorithms that import four concepts: Perception (P), information (I), Judgement (J), and Decision (D). Each algorithm presents a unique process of decision-making. Perception relates to the decision-maker's prior experience, potential bias, and other factors affecting how they frame a problem, such as culture and language. Information refers to financial or non-financial information (i.e., policies) available to a firm's decision-makers. Judgment is the

process in which the decision-maker weights and classifies the information, with or without the influence of the perception stage. Finally, the decision stage is whether to take action.

Based on the four concepts, the Throughput Model generates six different unique AI algorithm pathways in deciding to commit a fraud action arriving at a decision choice (Rodgers & McFarlin, 2017; Rodgers, Attah-Boakye, & Adams, 2020). The ethical algorithms can be portrayed as follows: (1) P→D: the expedient algorithmic pathway; (2) P→J→D: the ruling guide algorithmic pathway; (3) I→J→D: the analytic algorithmic pathway; (4) I→P→D: the revisionist activist-based algorithmic pathway.; (5) P→I→J→D: the value-driven algorithmic pathway; and (6) I→P→J→D: the global perspective algorithmic pathway. Decision-makers may value a specific algorithm more than others. By understanding other algorithms, decision-makers have more opportunities to improve or modify their strategies and select the algorithm that suits their company's situation better.

This study contributes to the literature as follows. First, prior studies have mixed evidence of the relationship between firm value and cryptocurrency or blockchain-related disclosures. My study provides further evidence about how investors view a firm's involvement with blockchain or cryptocurrency and explains why mixed results exist. Second, I integrate accounting-based performance and market-based performance measures. Consistent with Rodgers et al. (2013), I analyze a firm's accounting performance from quick ratio, profitability, leverage, and liquidity. These three dimensions provide a more comprehensive view of the current performance

situation. Third, the Throughput Model provides a new perspective in analyzing the relationship between adopting cryptocurrency or blockchain technology and investor decisions. The Throughput Model, developed by Rodgers (1997), captures the different pathways and stages affecting the decision-maker's choices. Compared to the traditional event study analysis applied in prior studies, applying PLS models provides more reliable predictions by reducing dimensionality. In this study, I apply the I→P→D pathway to reflect investors' decision process, representing investors using limited information but relying more on their perceptions to make decisions regarding a firm's cryptocurrency or blockchain technology application. I observe that investors are more likely to overreact to the information at first, which is consistent with the implication of the revisionist algorithmic pathway (I→P→D). Fourth, my research can inspire researchers or investors to develop related algorithms to make more precise investing decisions, especially when facing newly appeared items, such as cryptocurrency or blockchain technology. The subsets of PLS models are parts of machine learning. Investing giants like Blackstone have adopted AI to analyze market trends and improve the investing process (Sahota, 2024[1]). However, no one-fit-for-all analyzing solutions suit different investors' needs since each company adopts different algorithms in their machine learning. By understanding how the algorithms work, investors can better train machine learning to satisfy their needs and mitigate the possibility of overreaction.

Section 2 introduces detailed information on the Throughput Model. Section 3 reviews

[1] https://www.forbes.com/sites/neilsahota/2024/02/07/futuristic-finance-ais-seductive-power-in-reshaping-private-equity/?sh=489b19dc4f62

the current literature regarding the relationship between cryptocurrency-related or blockchain technology-related disclosures and firm performance and hypothesis development. Section 4 presents the research methodology. Sections 5 and 6 present the empirical results. The last section summarizes and concludes.

2. The Throughput Model and the Six Pathways

The Throughput Model contains six decision-making pathways relating to six critical ethical positions (Rodgers, 1997):

1) P→D: the expedient algorithmic pathway
2) P→J→D: the ruling guide algorithmic pathway
3) I→J→D: analytical algorithmic pathway
4) I→P→D: the revisionist algorithmic pathway
5) P→I→J→D: the value-driven algorithmic pathway
6) I→P→J→D: the global perspective algorithmic pathway

Four critical stages, Perception (P), Information (I), Judgement (J), and Decision (D), are posited in the Throughput Model, but not all concepts are necessarily presented in each pathway. The first concept is Perception (P), which describes the factors that frame the decision environment (Rodgers, 2010). Experience, educational background, and personal knowledge can affect how a decision-maker processes a topic. The second stage is Information (I), which could include "the storage of partial results of complex consequential computations, such as cash inflows, cash outflows, and trend analysis comprehension (Rogers, 2010)." The third concept is Judgment (J). In this stage, all information will be analyzed and compared, and decision-makers can use the results to make selections. The fourth stage is Decision (D), which contains a series of actions or the best alternative solutions. Yates (1990) proposed three types of decisions: choices, evaluations, and construction. In the first scenario, a decision-maker must choose a solution among several alternatives. In the evaluation situation, the decision

"represents indications of worth for an individual's alternatives (Yates, 1990)." Finally, the construction situation indicates that a decision-maker tries to assemble the most satisfactory solution.

1) P→D represents the expedient algorithmic pathway, reflecting the most direct way one makes decisions. In this position, the importance of information (I) and judgment (J) is downplayed, and decision-makers decide based on self-interest and their years of experience with an organization, educational background and received qualifications.

2) P→J→D depicts the ruling guide algorithmic pathway position emphasizing moral rules or duties. This pathway examines the effect of the judgment stage on the final decision. The algorithm encodes regulations or obligations in the decision maker's perception (P). Decision-makers then can analyze their perception of their environment (J) and make strategic decisions (D) when significant information is absent.

3) I→J→D illustrates the analytical algorithmic pathway. In this position, the perception of decision-makers is ignored. A possible reason is that they lack related experience in this area or face a new situation where no prior examples can be used as a reference. In this situation, decision-makers view existing information as a reliable source, which is less likely to affect their perception and make decisions by weighing all available information.

4) I→P→D is the revisionist algorithmic pathway. This pathway updates the perception of decision-makers by providing new information. In this pathway,

decision-makers are not under time pressure since the final decision does not require detailed analysis. If the decision-maker has a certain degree of expertise or educational background, they can conclude without further assessment.

5) P→I→J→D depicts the revisionist value-driven algorithmic pathway. In this situation, decision-makers select information suited to their perception, developed through years of experience, educational background, or expertise qualifications. In other words, a decision-maker's perception overrides the analytical process (I→J→D), impacting their judgment and final decisions.

6) I→P→J→D presents the global perspective algorithmic pathway, whereby a decision-maker's perception is subjective to the available information. In this pathway, new pieces of information have a compelling position with current rules, making decision-makers refine their perception before concluding. Since information sources may determine the motivations of the decision-making, they can positively or negatively influence the current situation.

The Throughput Model provides six foremost AI algorithmic pathways that are essential for stakeholders. It may help investors understand the cryptocurrency disclosure released by companies and then modify their investing decisions. The Throughput Model allows managers to determine a more suitable strategy for disclosing cryptocurrency information (Rodgers, 2010). Also, the Throughput Model can assist in building a conceptual algorithm to improve decision-making efficiency. Therefore, the throughput model can be applied to analyze the decision to disclose cryptocurrency.

3. Literature Review

In this study, I use cryptocurrency disclosures as the proxy to show how a firm is involved with technologies related to cryptocurrency or blockchains. Current research generally examines three types of cryptocurrency disclosures: financial reports (i.e., 10-K and 8-K), whitepapers for Initial Coin Offering (hereafter, ICO), and traditional or social media content. Financial reports release a firm's adoption stage of blockchain technology, the application of cryptocurrency (i.e., payment service or cryptocurrency mining), and potential risks associated with cryptocurrency (Stratopoulos et al., 2022; Yen and Wang, 2021; Zhang and Zhang, 2022). The whitepaper is disclosed with the ICO, which includes all the information about the ICO project an investor wants to know. Companies that publish whitepapers to attract the attention of potential investors and users. The third type differs from the first two types of cryptocurrency disclosure since it is generally not disclosed by the company. Due to the specialty of cryptocurrency, even a Twitter post from a business celebrity can significantly impact the price of cryptocurrency (Mirtaheri et al., 2021; Shahzad et al., 2022; Ante, 2023). Social media or forums discussions are also likely to immediately influence cryptocurrency's value and trading volumes (Zhang & Zhang, 2022). Compared with the quick information flow of social media, traditional media may have less impact on cryptocurrency since firms or investors can strategically exploit the slow information flow speed following the event announcement to extract the best value of cryptocurrency (Hashemi Joo et al.,2021).

This section will present studies examining three types of cryptocurrency disclosure

and discuss current problems with cryptocurrency regulations.

3.1. The Positive market reactions and blockchain technology-related disclosure

Current studies have examined the impact of innovation and investment in new technology on firm values. On the one hand, having R&D investment can have a positive influence on firm value since it serves as an indicator of expected profitability growth (Johnson & Pazderka, 1993) and improves a firm's productivity (Tambe, 2014) and innovation (Ehie and Olibe, 2010).

Adopting blockchain technology is likely to improve firm value. Even though blockchain technology is still in its early adoption stage, the development of generative Artificial Intelligence (AI) can enhance its value. According to KPMG[2], companies now face a significant challenge to protect their intellectual property (IP) when others use generative AI, such as ChatGPT, for model training. Also, they must carefully avoid infringing others' IPs when practicing their AI model. For example, Getty Images sued Stability AI in London because "Stability AI unlawfully copied and processed millions of images protected by copyright and the associated metadata owned or represented by Getty Images absent a license to benefit Stability AI's commercial interests and to the detriment of the content creators (Getty Images Statement[3])." To avoid the potential legal risk associated with AI technology, blockchain technology is viewed as the possible solution to this challenge. Thus, adopting blockchain technology may

[2] Our thinking: Blockchain and generative AI. Advisory-Marketing.us.kpmg.com. https://advisory-marketing.us.kpmg.com/speed/povblockchainai.html?gclid=EAIaIQobChMIlN7Jv_i8gQMVuzzUAR1dsQqaEAAYASAAEgL_HfD_BwE

[3] https://newsroom.gettyimages.com/en/getty-images/getty-images-statement

positively influence a firm's value, given the current situation.

Releasing blockchain technology-related disclosures can help investors and users better understand a firm's plan for the new technology, its current adoption stage (Stratopoulos et al., 2022), and possible benefits generated by blockchains. For example, Yen and Wang (2021) find that investors tend to view blockchain disclosures that contain technology applications and risk factors positively. They argue that these types of blockchain disclosures are more related to business operations so that they can enhance firm values. Chen et al. (2022) find that the market has positive feedback to blockchain announcements. Bourveau et al. (2022) examine the topics in the whitepapers and find that the amount of information disclosed positively correlates with a firm's ability to raise capital, suggesting that blockchain technology-related disclosures help reduce information asymmetry between managers and investors (Howell et al., 2020). By analyzing SEC filings and conference calls, Stratopoulos et al. (2020) conclude that firms adopting blockchain technology to improve their operational efficiency. Guo et al. (2020) find that adopting blockchain technologies positively impacts a firm's innovation. All the information conveys positive signals to the market; thus, the market is likely to react positively to blockchain technology-related disclosures.

3.2. The positive market reaction and cryptocurrency disclosure

Cryptocurrency is derived from blockchain technology. More and more companies have applied or plan to adopt cryptocurrency in their firms (SEC disclosure trends in

crypto and digital assets, PwC). According to the PwC 2022 US Metaverse survey, 48 percent of the managers responded that they combined or planned to combine cryptocurrencies into firm strategies. In the meantime, SEC continues to release new guidelines to protect the users of crypto assets. For example, in March 2022, SEC released in Staff Accounting Bulletin No.121 (SAB 121) a "guidance for reporting entities that engage in activities in which they have an obligation to safeguard customers' crypto assets." Updated regulations like SAB 121 can enhance investors' and users' security feelings if a firm adopts blockchain technology, increasing the opportunity for the market to view such an action positively.

Besides, compared with traditional currency, cryptocurrency has its unique advantages. First, the inflation protection. Many types of cryptocurrency have a mechanism to restrain the number of coins that can be mined. Such a protection mechanism can efficiently reduce the impact of inflation, thus reducing the chance of value decline. Second, transfer speed and costs. Unlike traditional wire transfers that may take hours or even days, transferring cryptocurrency takes only several minutes. Also, the transaction fees of cryptocurrency are minimal or even zero. Third, it is easy to access. Users can simply use their smartphones or laptops to open a cryptocurrency account. Unlike traditional bank accounts, users do not need to go through credit scores or background checks when opening a cryptocurrency account. Fourth, cryptocurrency is easy to track. Since most types of cryptocurrency are decentralized, investors can track live transfers by applying blockchain technology provided by the platform. The process is transparent and "corruption-free" (Advantages and

Disadvantages of Cryptocurrency in 2023, Forbes Advisor).

Considering the advantages of cryptocurrency applications, adopting cryptocurrency will likely improve the efficiency of business operations. For example, Chuen et al. (2018) argue that cryptocurrency investment helps diversify portfolio risks and generates higher daily returns than traditional entity investments. Carrick (2016) states that cryptocurrency is a complement of currencies, and it helps to add balance to currency portfolio markets. Applying cryptocurrencies in business operations increases transaction efficiency, lowers transaction costs, and improves users' experience since companies have more time to focus on crucial matters and customer satisfaction (Sartipi, 2021). For multinational companies, cryptocurrency eases the burden of international transactions (Kinami et al., 2020). Thus, cryptocurrency applications may benefit a firm's operating performance in certain aspects.

Disclosing cryptocurrency information will likely affect firm value positively. High-quality reporting, which contains sustainable information (Rodgers et al., 2019), is valued more than other disclosures. For example, an ICO is more likely to be successful and raise funds if the company has disclosed high-quality whitepapers and source codes (Deng et al., 2018; Bourveau et al., 2018; Bourveau et al., 2022). Most companies that adopt blockchain technologies also apply cryptocurrency (Kinami et al., 2020); thus, cryptocurrency disclosures may receive the same market reactions as blockchain technology-related disclosures. For example, Kanikuma (2021) and Akyildirim et al. (2021) find that the market responds positively to a cryptocurrency announcement and has a significant price premium in the short term. However,

research in this area is limited and waiting to be further examined.

3.3. The negative relationship between blockchain disclosure and market reaction

The market can view Investing in new technologies as a negative event. First, unlike capital investment, R&D investment is less flexible and subject to high adjustment costs. R&D-intensive companies are more likely than other companies to face financial constraints, and thus, the R&D activities are likely to be suspended or canceled, increasing the distress risks associated with these firms (Zhang, 2015; Li, 2011). Furthermore, Zhang (2015) finds that R&D expenditures positively correlate with the chance of desilting. Second, R&D investment impacts enterprise risks (Wang et al., 2016) since it generally requires a long cycle to generate profits, and a firm must invest many funds into the project. Inappropriate application of capital will lead to financial constraints, resulting in enterprise risks associated with R&D investment.

Even though blockchain technology is becoming popular and has many advantages, it still faces three significant challenges. First, blockchain technology has high energy consumption, primarily related to cryptocurrency mining. Golosov and Romanovs (2018) mention that “The network’s miners are attempting to solve a lot of solutions per second in efforts to validate transactions. They are using substantial amounts of computer power.” Although some recent studies argue that blockchain technologies are not homogeneous and only blockchain involving cryptocurrency mining consumes a lot of energy (Sedlmeir et al., 2021; Sedlmeir et al., 2020), Sedlmeir et al. (2021, 2022) admit that the energy consumption of blockchain technology is massive, especially

when comparing to the significant number of transactions the blockchain can handle. Reducing energy consumption and protecting the environment are substantial parts of corporate social responsibilities (CSR), and ignoring CSR may negatively impact firm value. For example, Lewen and Warren (2023) find that shareholders reduce their investments by receiving negative CSR information from internal and external channels. Also, if the information is discussed on social media, the firm will likely receive further punishments from investors and suffer reputation costs since social media broadcasts messages quickly.

Second, the high technology requirement. Once data is coded, modifying it with blockchain technology is not easy. Making adjustments or revising an error is difficult and time-consuming. Companies adopting blockchain technology are looking to move from private to public blockchains since the latter provides better transparency, security, and sustainability and the essential infrastructure for the decentralized, user-centric vision of web3. However, they "should do their due diligence and conduct a deep dive analysis to see if the blockchain technology fits their needs and then plan the development or migration to web3 accordingly (Advantages And Disadvantages Of Blockchain Technology, Forbes).", suggesting that adopting blockchain has an advanced request on a firm's information technology level. Azgad-Tromer (2018) finds that investors must have a specific technology background to understand the source coding disclosed by cryptocurrency issuers, or they may face entry obstacles when making investment decisions. Blockchain technology-related disclosures may have similar background requirements for investors. Investors who lack related knowledge

are likely to interpret blockchain technology information, especially negative information, in a more passive way, which may broadly and negatively impact firm value.

Third, the high costs of blockchain technology are another big challenge. The initial implementing fees are expensive compared with traditional databases. Adopting blockchain technologies incurs additional costs, and the new technology may not directly generate profits. For instance, Islam et al. (2023) find that blockchain miners struggle to maintain sustainable profitability in the long run without paying significant fees. Since some investors value financial information, they will likely pay less attention or even ignore technology adoption when making investment decisions.

Fourth, security considerations. With the development of blockchain technology, various types of cyberattacks have emerged. According to the statistics released by SlowMist, 231 blockchain-related cyberattacks happened in 2021, resulting in over $9.8 billion in losses worldwide. Besides, cyberattacks may cause the leakage of the customer and other secret information, reducing customer satisfaction. Major customers will likely end their relationship with attacked suppliers. Suffering cyberattacks can significantly reduce a firm's profitability and, thus, harm its firm value (Nelson and Wang, 2024). Ramos et al. (2021) classify cyberattacks into different types and conclude that 51% of attacks (Attack on a blockchain by a group of miners who control more than 50% of the network's mining hash rate.) results in negative market reactions.

3.4. The negative relationship between cryptocurrency disclosure and market reaction

Cryptocurrency has been successfully adopted in the blockchain technology system and applied by more and more companies. However, it brings additional concerns compared with blockchain technology. First, it contributes to extreme volatility. The cryptocurrency price is difficult to predict and has become enormously volatile since 2017. Current researchers have tried to figure out factors that drive cryptocurrency volatility. For example, Yen and Cheng (2021) find that the change in economic policy uncertainty (EPU) can be used to predict cryptocurrency volatility in China, but they fail to find such a relationship in the US, Japan, and Korea. Fang et al. (2020) find that investor behaviors have a more profound influence on cryptocurrency volatility than uncertainty of economic fundamentals. Other scholars even conclude that cryptocurrency is a speculative asset whose values are unaffected by economic fundamentals like traditional financial assets (Baur et al., 2018; Macey, 2023; Ciaian et al., 2016; Ante, 2023). Social media content posted by celebrities can quickly impact the cryptocurrency price. By investigating 47 cryptocurrency-related tweets from Elon Musk, Ante (2023) identifies significant positive trading volumes and abnormal returns following Musk's tweets for Dogecoins. He finds that "Within 2 min after a tweet, there is a significant abnormal return of 3.58 % and a highly significant increase in the trading volume of the cryptocurrencies mentioned in the tweets. Within the first hour after a tweet, the abnormal return even increases to 4.79%." Huynh (2021) investigates Donald Trump's tweet activities and finds that his negative Twitter

sentiment can be used to predict the Bitcoin market. The high volatility of cryptocurrency will likely convey more risks to firms. Thus, investors are likely to interpret cryptocurrency-related disclosures negatively.

Second is the lack of regulations. 2022 is a disaster year for the cryptocurrency market. In May, the collapse of stablecoin TerraUSD wiped out $45 billion of market capitalization (Terra $45 Billion Face Plant Creates Crowd of Crypto Losers, Bloomberg). Following the failure of the FTX group, the crypto market lost almost $3 trillion in market value. The Bitcoin market suffered a one-year decline of 65%, and Ethereum's value dropped by about 20%. The original decentralized design of cryptocurrency contradicts the need for centralized market protection for investors and customers (Arner et al., 2023). The current crypto market does not have regulations or policies to maintain market trust, confidence, and sufficient resources to meet stakeholders' requirements. Without proper regulations and policies, the crypto market is challenging to improve market efficiency and functioning. Therefore, market trust and confidence are difficult to recover after a market collapse like FTX (Arner et al., 2023). After analyzing the stock price after three-month of the end of the fiscal year, Yen and Wang (2021) find that investors negatively value cryptocurrency-related disclosures. They argue that one possible reason is that current accounting regulations on cryptocurrency are still under debate, and investors may have extra concerns about cryptocurrency. For example, Anderson et al. (2022) find that firms opportunistically select the fair value accounting measure or indefinite-lived intangible assets when reporting values of crypto assets. Momtaz (2021c) concludes

that investors do not fully trust the information disclosed in whitepapers since token issuers generally exaggerate information disclosed to lure investors. Without proper regulation, investors lack the feeling of security and, thus, interpret cryptocurrency-related disclosure negatively.

Third, security challenges. As I mentioned before, blockchain technology is subject to cyberattacks, and cryptocurrency is the primary target for attackers (Apostolaki et al., 2017; Ramos et al., 2021). Rognone et al. (2020) find that Bitcoin investors generally react positively to good news and ignore bad news. However, the return of Bitcoins will be significantly reduced if the news is related to cryptocurrency cyberattacks. Since opening a cryptocurrency account does not require identity recognition like traditional bank accounts, anonymity gives attackers more chances to work on ransomware attacks (Berry, 2022). Also, the number of cyberattacks aimed at cryptocurrency will increase, creating more associated risks for investors.

Finally, owning cryptocurrency may expose companies to high legal risks. Due to the lack of regulations on cryptocurrency mentioned earlier, the policies and regulations related to cryptocurrency can be changed at any time. For example, the Chinese government required all companies that completed crypto asset financing to terminate the investment contracts in 2017 (Xie, 2019). The 2017 Announcement attempts to discourage cryptocurrency investment because the Chinese government worries that cryptocurrency's high risk and fraud would interrupt economic health. Also, current registration and reporting requirements related to cryptocurrency are burdensome and costly for registers (Minks, 2018). Thus, the compliance costs are high, and the

token holders can easily make mistakes due to the complexity. Currently, the SEC views cryptocurrency as securities and punishes companies with unregistered sales of securities. For example, in August 2021, "the SEC announced that Poloniex LLC would pay more than $10 million to settle charges for operating an unregistered online digital asset exchange in connection with its operation of a trading platform for digital asset securities (Cryptocurrency and anti-money laundering enforcement, Reuters)."

In summary, cryptocurrency has extra disadvantages compared with blockchain technologies. Investors will likely interpret cryptocurrency-related disclosures with additional concerns and treat them differently from blockchain disclosures without cryptocurrency.

Based on the above discussion, I establish my hypothesis without predicting direction as follows:

Hypothesis 1: cryptocurrency-related disclosures are associated with change in market value.

Hypothesis 2: blockchain-related disclosures are associated with change in market value.

4. Research Methodology

4.1. Sample

I started sampling by downloading regulated firm 10-Ks from the SEC Edgar database. After obtaining all the 10-K fillings, I used Python to identify 10-Ks that contain the keywords “blockchain,” “cryptocurrency,” “digital currency,” “virtual currency,” and “bitcoin” (case insensitive and plural form is included) from the beginning of 2014 to the end of 2021. 2014 is the first year that has 10-K disclosures that contain related keywords. To obtain more convincing samples, I selected 2014 as the beginning year. Consistent with Yen and Wang (2021), I kept only the original fillings. The history of Bitcoin’s daily price is from *Investing.com*.

The financial information is obtained from Compustat. After removing observations with missing values, the sample consists of 48,080 firm-year observations from 9,911 individual firms. The stock price data is obtained from the Center for Research in Security Prices (CRSP). The resulting sample consists of 26,105 firm-year observations from 6,909 individual firms after the first merging. Finally, I merged the dataset with the counted word frequency. The final sample consists of 833 observations from 329 individual firms reporting cryptocurrency or blockchain, and the remaining 25,272 observations are from 6,581 unique firms without such reports. Table 1 summarizes the sampling process. Examples of the keyword-related 10-K paragraphs are given in Appendix B.

Insert Table 1 here.

Table 2 presents my sample's firm-year distribution of all blockchain and cryptocurrency-related keywords.

Insert Table 2 here.

4.2. Perception Measure

I created dummy variables for each keyword. I assume that containing related keywords of cryptocurrency or blockchain means the company adopts related technology. The value is coded as one if a firm's 10-K report contains the related keyword (cryptocurrency, blockchain, Bitcoin, virtual currency, or digital currency).

4.3. Information and Judgment

Consistent with Rodgers et al. (2013), I apply four dimensions to represent a firm's information: profitability, asset turnover, liquidity, and leverage. Rodgers et al. (2013) argue that the financial health status "measures the contribution of the perception to the overall market value of a firm relative to the financial viability."

The first dimension, profitability, is measured by the profit margin (net income to total sales). Asset turnover (sales to total assets) reflects how efficiently a company generates revenues from its assets. The third dimension, liquidity, is measured by the quick ratio (the ratio of cash, marketable securities, and account receivables to current

liabilities). The fourth dimension, leverage, contains two proxies: the ratio of total debts to total shareholder's equity and the ratio of long-term debt to total assets. Outside the four dimensions of financial health, I also controlled for Bitcoin's daily price and firm size, calculated as the natural log value of total assets.

The judgment is the z-score of all indicator variables from Information (I).

4.4. Firm Value

The firm value is measured by daily abnormal returns. I used the daily abnormal returns in a three-day window, where day 0 is when a company discloses its 10-K. A three-day window is considered sufficient to capture most of the immediate market reaction to significant events or news releases (Lee, 2001). Also, longer periods can bring more noise and interpretation challenges, making a three-day window more manageable.

The abnormal returns of the three-day windows reflect the construction side of a decision made by investors, which presents how investors manage to assemble the best alternative solutions regarding a firm's application of cryptocurrency or blockchain technology.

5. Empirical Results

To understand the overall relation among each latent variable, I first used Partial Least Squares (PLS) to analyze the research models. The PLS method is used to model the relationships among sets of variables. It improves interpretability by reducing the dimensionality of the predictor set and is helpful for detecting underlying data structure. Since the Throughput Model contains multiple latent constructs with multiple indicators, PLS is proven efficient and helpful in analyzing the overall relationship in a case like this. Table 3 presents the descriptive statistics of the whole sample, with 27,272 firm-year observations. The average abnormal return of the day 10-K disclosed (day 0) is -0.1%, with a standard deviation of 0.038. Table 4 presents the Pearson correlations. Blockchain and cryptocurrency-related keyword proxies, except for virtual currency, all have negative relationships with the abnormal returns in the three-day window, providing the initial evidence that investors' attitudes toward the values of cryptocurrency or blockchain are negative.

Insert Tables 3 and 4 here.

5.1. Measurement Validation

Before running the regressions, I examine each latent and indicator variable's reliability and validity. The results are reported in Table 5.

First, I examine the indicator reliability and composite reliability. The indicator

reliability is measured as the square of each standardized indicator variable's loading value. The benchmark of indicator reliability is 0.4. According to Table 4, most indicator variables have a value above 0.4. However, most indicator variables from Judgment (J) have values lower than the benchmark, indicating that Judgement (J) is unreliable. The second is composite reliability. According to Nunnally (1978), the benchmark of composite reliability is 0.7. All constructs of the model present a composite variability above or close to 0.7, except for Judgment (J) (0.455). I keep the indicator variables with low values from Perception (P), Information (I), and Decision (D) since they do not significantly affect the composite reliability of the latent variable. Also, I evaluated the convergent validity within the PLS model. The convergent validity is reflected by the average variance extracted (AVE), which evaluates whether one construct's indicators are distinct from others. All latent variables' AVE is close to or higher than the acceptable benchmark value 0.5. Also, my model shows satisfactory discriminant validity since the HTMT value of each path is significantly below the benchmark 0.9, except for the correlation between **I** and **J**, suggesting the constructs of Information and Judgment conceptually similar.

After confirming the reliability and validity, I assessed the severity of multicollinearity among predictor variables by calculating the Variance Inflation Factor (VIF). A value higher than five indicates a high level of collinearity. The VIF ranges from 1 to 1.003 in my model, so my model does not appear to have construct collinearity problem.

Insert Tables 5 here.

5.2. Path Analysis and Significance of Relationships

First, I tested how each independent variable (P, I, J) affects the decision variable (D). Table 6 summarizes the path coefficients and related t-statistics and P-values for inner models using the PLS method.

In Table 6, the t-statistics between P and D, I and P, and I and J are significant at least at a 5% level, while the relationship between J and D is insignificant (t-statistics=1.091). The indirect path I→P→D is also significant at the level of 5% (t-statistic=2.698). These results indicate that investors mostly use the information and their perceptions to decide whether engaging in cryptocurrency or blockchain technology is positive or negative news without running a deep analysis. Thus, I select I→P→D as my PLS analysis model. In the later section, I will further analyze how each latent variable affect the decision variable. Figure 2 presents the I→P→D model.

Insert Tables 6 & Figure 2 here.

5.3. Main Results

The PLS path coefficients for my columns 1, 2, and 3 are presented in Table 7. The regression results suggest that investors respond negatively to firms with cryptocurrency or blockchain disclosures in the short term. In Column 1, I examine the correlation between blockchain or cryptocurrency disclosure and three-day

abnormal returns for the whole sample. The regression results show that higher profitability (β_4=0.003, p<0.01), higher asset turnover (β_3=0.001, p<0.01), and higher liquidity (β_6=0.003, p<0.1) will motivate companies to apply blockchain technology or cryptocurrency. In sum, the abnormal returns in the three-day window negatively and significantly correlate with each keyword dummy variable of cryptocurrency.

Contrary to Yen and Yang (2021) and Chen et al. (2021), I find that investors even process 10-Ks discussing blockchain negatively. While Yen and Yang (2021) used the stock price three months after the end of a fiscal year as the dependent variable, I focused on investors' immediate reaction within the three-day window. This discrepancy may suggest that investors overreact to the disclosures of blockchain and gradually revise their reactions after a long period.

In Column 2, I test investor's reactions to the cryptocurrency-related disclosures. While Yen and Yang (2021) fail to find a significant relationship between cryptocurrency disclosure and stock prices and Kakinuma (2023) reports a positive relationship, my regression results show that investors react strongly and negatively when disclosures mention cryptocurrency-related keywords. Two reasons may drive the conflict: first, Kanikuma (2023) examines based on only 27 cryptocurrency announcements, while I focus on the entire reactions over the market. Second, Kanikuma (2023) focuses on announcements about investing in cryptocurrency. My research examined the relationship between cryptocurrency disclosure and the change in firm values without classifying topics. Thus, it may suggest that investors may react differently to different topics of cryptocurrency applications.

In column 3, I focus only on blockchain-related disclosures. Interestingly, the correlation between blockchain-related disclosures and abnormal stock returns in the [-1,1] window turns insignificant, even though the coefficients are still negative. This result may indicate that the combination of cryptocurrency mainly drives the negative effect between blockchain-related disclosures and market values in Column 1.

Overall, the results of Table 7 suggest that investors negatively process the application of blockchain technology or cryptocurrency in a short period.

Insert Table 7 here.

To check whether investors revise their reaction to a firm's adoption of cryptocurrency or blockchain technology later, I examined the coefficients' change of each keyword indicator variable in the following ten days after the date of disclosure. Figure 2 presents the change of coefficients.

According to Figure 2, all keyword indicator variables' coefficients turn positive from day four and keep increasing after that. This result conforms to Cheng et al. (2019), which indicates that investors overreact to the disclosure of cryptocurrency or blockchain and correct their selections quickly in the following days.

Insert Figure 2 here.

---

6. Additional Analysis

6.1. The Adoption of Cryptocurrency and Blockchain at First Time vs. Non-First Time

Prior studies examining the correlation between market reaction and cryptocurrency or blockchain-related disclosure focus on the overall situation. However, investors may have different attitudes on a firm's first cryptocurrency and blockchain technology adoption and its application in the following fiscal years due to the following considerations: first, the adoption of cryptocurrency or blockchain technology may indicate the company values innovation, has forward-thinking, and plans to enhance their operation capabilities (Kakinuma, 2023). These indicators will likely lead to positive sentiment among investors. However, this positive sentiment can diminish as the novelty wears off. Second, the market's reaction to adopting cryptocurrency or blockchain technology in the future will significantly depend on a firm's operation. If a firm suffers from significant loss or is subject to risks associated with cryptocurrency usage, investors can negatively view the application of cryptocurrency or blockchain technology. Third, the policy change of cryptocurrency and the potential policy challenges may change investors' minds.

In Table 8, I present the market reactions to firms' first-time adoption of cryptocurrency or blockchain technology and their adoption in the following years. Interestingly, investors positively view the first-time adoption of blockchain and cryptocurrency, except for digital currency. Investors' attitudes to Bitcoin and cryptocurrency turned negative in the following years, but they remain optimistic

about blockchain and virtual currency. Also, Bitcoin price (β_1=-0.008, P<0.05), firm size (β_2=-0.013, P<0.001), asset turnover β_3=-0.003, P<0.001), and quick ratio β_5=-0.008, P<0.05) are all pushing a firm to reduce using cryptocurrency or blockchain. These results may indicate that companies in good financial health are reluctant to use cryptocurrency in the long run since it is generally considered risky due to its high volatility and policy uncertainty (Vincent & Wilkins, 2020; Macey, 2023; Field and Inci, 2023) and large companies must be more careful since they are subject to significant scrutiny, have a more complex operation structure, and must maintain long-term sustainability.

Insert Table 8 here.

6.2. Topic Analysis

One drawback of applying keywords as the proxy for cryptocurrency or blockchain technology applications is that mentioning related keywords For example, Trustmark Corp mentions, “Additionally, fintech developments, such as distributed ledger technology (or ***blockchain)***, have the potential to disrupt the financial industry and change the way banks do business” in their 2016 10-K report, whose purpose is to underscore the potential competition brought by the emergence of blockchain. Therefore, I adopted topic analysis to better understand the content of the cryptocurrency and blockchain disclosures.

To classify each 10-K into one topic, I read paragraphs containing the related keywords of cryptocurrency or blockchain from 10-Ks of the first three years. I summarized the major topics discussed based on the key terms detected in these paragraphs. Then, I assign the remaining 10-Ks to one topic based on the key terms detected before. If a 10-K disclosure does not contain the key terms summarized, I will assign them as a new topic. In the end, I summarized 14 topics and the top terms of each topic identified are present in Table 9.

Appendix B provides an exemplary example for each topic, and Table 9 summarizes the topic distribution from 2014 to 2021.

Insert Table 9 here.

Even though the total number of disclosures of cryptocurrency and blockchain increased from 2014 to 2021, the majority increase is from the topic of the "competition environment." Since 2016, the number of disclosures mentioning "competition environment" has occupied around 50% of the total disclosure number of each fiscal year. These results suggest that the purpose of most companies discussing cryptocurrency or cryptocurrency in their 10-K reports is not to apply these high technologies.

Insert Table 10 here.

Table 11 presents the PLS regression results of the topic analysis. Surprisingly, I observe that all topics positively correlate with the daily abnormal returns in the [-1,1] window, except for the topic of "competition environment." The topic "competition environment" significantly and negatively correlates with the market values in the three-day window, suggesting that factors other than cryptocurrency and blockchain lead to negative feedback from investors. It may also indicate that these reports drive the negative correlations in Table 7.

Insert Table 11 here.

6.3. Event Study

Prior studies on the relationship between firms' application of cryptocurrency or blockchain and the market reaction mainly apply the event study as their methodology. Thus, to compare the differences between the event study and PLS regression, I ran the OLS model to present the event study regression results. The results are presented in Table 12.

Insert Table 12 here.

In Table 12, even though I observe that investors negatively react to the cryptocurrency and Bitcoin in the three-day window, the effects are insignificant. The market reaction

to blockchain is positive but insignificant on day 0.

Comparing the regression results of Table 12 and Table 7, the significant results presented in Table 7 indicate that applying the PLS model fits more for analyzing the correlation between the market reaction and the firm's cryptocurrency and blockchain technology application. Using a latent variable set, the PLS model can maximize the covariance between the predictors and the response variable. Also, PLS can better explain complex relationships by focusing on components that explain both the predictors and the response variable well, whereas OLS strictly focuses on minimizing residuals without considering the structure of the predictors.

Conclusion

This study examines investors' reactions to firms' involvement in cryptocurrency or blockchain technologies, measured by the cryptocurrency-related or blockchain-related 10-Ks. By applying the Throughput Model, I find that investors have an initial negative reaction to blockchain-related or cryptocurrency-related disclosures in the [-1,1] window, but the negative reaction is reversed after day four. Having good financial health is crucial for adopting cryptocurrency and blockchain technology. Besides, I find that investors have different attitudes about whether a firm should adopt cryptocurrency or Bitcoin for the first time.

Surprisingly, the topic analysis shows that the market only views the topic of "competition environment" negatively, suggesting that factors other than cryptocurrency and blockchain drive the negative feedback of investors, and investors generally have a positive attitude to firms' adoption of cryptocurrency and blockchain, such as using them for technology development or investment. This finding may explain why more companies decide to or plan to adopt cryptocurrency in the future despite the potential high risk and uncertainty involved with it.

I note several limitations to my study. First, due to the limited sample size, I did not control for the industry differentiation. Second, the information disclosed in 10-Ks is limited and is not as frequent as what is mentioned in the media. Future studies shall consider cryptocurrency or blockchain-related information disclosed in other channels, such as social media. Finally, the PLS method has weaknesses compared with other estimate methods, such as oversimplified assumptions.

Appendix A Variable Definitions

Information	
turnover	sales/total asset
profit	net income/total assets
Price	Daily price of Bitcoin
quick	Quick ratio, calculated as (cash+AR+marketable securities)/current liabilities
lev1	debt/total assets
lev2	debt/equity
Perception	
bitcoin	Equals one if a firm's 10-K contains "bitcoin" and zero otherwise.
crypto	Equals one if a firm's 10-K contains "cryptocurrenc*" and zero otherwise.
virtual	Equals one if a firm's 10-K contains "virtual currenc*" and zero otherwise.
digital	Equals one if a firm's 10-K contains "digital currenc*" and zero otherwise.
block	Equals one if a firm's 10-K contains "blockchain" and zero otherwise.
Judgment	
bitcoin_z	The z-score of variable *bitcoin*
crypto_z	The z-score of variable *crypto*
virtual_z	The z-score of variable *virtual*
digital_z	The z-score of variable *digital*
block_z	The z-score of variable *block*
Investor Decisions	
day(-1)	The abnormal daily return of one day before the disclosure was released
day0	The abnormal daily return of the day that the disclosure was released
day1	The abnormal daily return of one day after the disclosure was released

Appendix B Examples of blockchain- or cryptocurrency-related disclosures

This appendix presents exemplary examples of each topic.

Topic 1 Service & Operation: 2017 Net1 UEPS Technology, Inc.

Our internally developed range of PIN encryption devices, card acceptance modules and hardware security modules are primarily aimed at the financial, retail, telecommunication, ***cryptocurrency***,utilities, and petroleum sectors.

…

We have recently established a dedicated research and development team focused on ***blockchain technology*** and the development of solutions and products for the rapidly growing ***cryptocurrency*** industry. Our research and development efforts also focus on taking advantage of improvements in hardware platforms that are not proprietary to us but form part of our system.

…

We also offer end-to-end payment services through IPG in Europe, the U.K., Asia and the United States. We are also collaborating with Bank Frick on exploiting opportunities in the ***blockchain*** and *cryptocurrency* environments.

Topic 2 Competition environment: 2016 Trustmark Corp.

Trustmark also faces competition from many other types of financial institutions, including savings and loans, credit unions, finance companies, brokerage firms,

insurance companies, factoring companies and other financial intermediaries. Additionally, fintech developments, such as distributed ledger technology (or ***blockchain***), have the potential to disrupt the financial industry and change the way banks do business. The financial services industry could become even more competitive as a result of legislative, regulatory and technological changes and continued consolidation.

Topic 3 Technology development: 2018 Advanced Credit Technologies, Inc.

Finally, the Company is able to develop secure databases for clients by developing and attaching a private ***blockchain*** to the SQL database and further securing the database through use of the Company Cyber technology. The *blockchain* being developed by the Company is a private ***blockchain*** and is an invitation-only network governed by a single entity.

…

On January 28, 2019, the Company entered into a contract with a software developing company in Poland for the creation of a ***blockchain*** network. The agreed upon fee is $15,750, and the completion date is estimated to be March 10, 2019.

On January 31, 2019, Advanced Credit Technologies, Inc. (Company) entered into an agreement with The Diabetic Help Centers LLC (TDHC) to provide TDHC with an interactive database for use in the keeping and safeguarding of medical records. The

Company will also be developing and attaching a private ***blockchain*** to the SQL database and further securing the database through use of the Company's Cyber technology.

Topic 4 M&A: 2019 Noble Vici Group, Inc.

On August 8, 2018, we consummated the acquisition of Noble Vici Private Limited, a corporation organized under the laws of Singapore, which was wholly owned by Eldee Tang, our sole director and Chief Executive Officer. NVPL is engaged in the IoT, Big Data, ***Blockchain*** and E-commerce business. As a result of our acquisition of NVPL, we entered into the IoT, Big Data, ***Blockchain*** and E-commerce business. We are headquartered in Singapore and operate a branch office in Taiwan. Certain of our resellers are operating branded satellite offices in Shenzhen, China.

Topic 5 On-site shopping: 2015 MeetMe, Inc.

Our Social Theater product enables publishers to incentivize their users to take certain actions in exchange for the hosting platform's ***virtual currency***. Social Theater advertising runs not only on MeetMe, where our users can watch videos and otherwise engage with brands in exchange for Credits, but also on social games and applications across other social networks, including Facebook. Social Theater can also be used by marketers to drive video views, application installs, and likes and shares on Facebook, Twitter, and other social platforms. When a Social Theater campaign is distributed outside of MeetMe on a different platform, we consider it Cross-Platform Revenues.

...

We believe our revenue and financial results are materially dependent on industry trends, and any changes to the revenue we earn per thousand advertising impressions (CPM) could affect our revenue and financial results. We expect to continue investing in new types of advertising and new placements, especially in our mobile applications. Additionally, we are prioritizing initiatives that generate revenue directly from users, including new ***virtual currency*** products and a premium subscription product, in part to reduce our dependency on advertising revenue.

Topic 6 ICO (Initial Coin Offering): 2020 Stone Point Credit Corp

Transactions involving ***virtual currency*** and ***cryptocurrency*** coins and/or tokens to be acquired in an initial public offering, a private placement, or any security on the Pre-Clearance.

...

For purposes of this Code of Ethics, ***virtual currency*** and ***cryptocurrency*** coins and/or tokens, including those offered, or previously were offered, as part of an initial coin offering, will be treated as securities. As a result, transactions involving such currency, coins and tokens must be pre-cleared (where acquired in an initial public offering or a private placement) and reported in accordance with this Code of Ethics.

Topic 7 Cybersecurity: 2021 Shell Midstream Partners, L.P.

While the arrangements described above are in place, we cannot guarantee against

compromise. A significant cyber-attack, should it be successful, could have a material effect on our operations. We maintain incident response and business continuity plans to mitigate any impact should such an attack occur.

For example, on May 7, 2021, the computerized equipment managing the Colonial pipeline was the target of a ransomware attack. We have a 16.125% ownership interest in Colonial, which owns and operates a pipeline that runs throughout the southern and eastern United States. Colonial proactively took certain systems offline to contain the threat and it paid a ransom in ***cryptocurrency*** to regain control of the equipment.

Topic 8 Investment: 2019 Marathon Patent Group, Inc

We intend to power and secure blockchains by verifying blockchain transactions using custom hardware and software. We are currently using our hardware to mine ***bitcoin*** (BTC) and expect to mine BTC and ether (ETH), and potentially other ***cryptocurrencies***. Bitcoin and ether rely on different technologies based on the blockchain. Wherein ***bitcoin*** is a digital currency, and ether is generally associated with smart contracts and digital tokens, we will be compensated in either BTC or ETH based on the mining transactions we perform for each, which is how we will earn revenue.

…

Subject to raising additional capital, our digital asset initiatives will compete with other industry participants that focus on investing in and securing the ***Blockchains*** of ***bitcoin*** and other digital assets. Market and financial conditions, and other

conditions beyond the Company's control, may make it more attractive to invest in other entities, or to invest in ***bitcoin*** or digital assets directly. Companies have raised substantial capital this year seeking to enter the digital assets business.

Topic 9 Social Capital: 2018 GreenBox POS

Ben Errez, Chairman of the Board of Directors, Executive Vice President
Mr. Errez has had a storied career as a pioneer in the tech industry. His past positions have included positions at large companies like Microsoft and Intel. He has brought this expertise to the Company to help build the Company into being at the forefront of ***blockchain*** financial software, services, and hardware.

Topic 10 Business Shut Down: 2019 THC Therapeutics, Inc.

On January 23, 2017, the Company experienced a change of control, and new management determined to shift the Company's focus and changed the Company's name to THC Therapeutics, Inc., focusing on wellness operations and development of a herb dryer for use with cannabis. On May 30, 2017, the Company formed Genesis Float Spa LLC, a wholly-owned subsidiary, to market its float spa assets purchased for wellness centers. On January 17, 2018, the Company changed its name to Millennium ***BlockChain*** Inc. and began to also focus on acquiring digital equity or digital assets of ***blockchain*** technology companies. On September 28, 2018, because of the regulatory environment surrounding ***blockchain*** technology companies, the

Company changed its name back to THC Therapeutics, Inc., abandoned its blockchain technology focus, and refocused its efforts on its wellness operations.

Topic 11 Policy Change: 2017 ChinaNet Online Holdings, Inc.

The Internet Finance Association of China also issued a series of notices to remind the potential risks of ICO and the ***cryptocurrency*** trading to the PRC residents, including the Risk Warning on Guarding against the "***Virtual Currency***" such as ***Bitcoin*** on September 13, 2017, Risk Warning on Guarding against the Disguised Initial Coin Offering Activities on January 12,2018 and Risk Warning on Guarding against the Offshore Initial Coin Offering Activities and the Cryptocurrency Trading on January 26, 2018.

Although our ICO structure will be set up out of the PRC, given we are a PRC-based company, the PRC government may still have jurisdiction over the project and it may require us to suspend the ICO if the PRC government deems there are huge potential risks to the PRC residents.

Topic 12 Lawsuit: 2019 DPW Holdings, Inc.

PW Holdings, Inc., a Delaware corporation (DPW or the Company), formerly known as Digital Power Corporation, was incorporated in September 2017. The Company is a diversified holding company owning subsidiaries engaged in the following operating businesses: commercial and defense solutions, commercial lending, ***cryptocurrency blockchain mining***, advanced textile technology and restaurant

operations.

…

On November 28, 2018, ***Blockchain*** Mining Supply and Services, Ltd a vendor who sold computers to our subsidiary Digital Farms, Inc. (Super Crypto Mining, Inc.), filed in the United States District Court for the Southern District of New York against us and our subsidiary (Case No. 18-cv-11099). The Complaint asserted claims for breach of contract and promissory estoppel against us and our subsidiary arising from the subsidiary's failure to satisfy a purchase agreement.

The Complaint seeks damages in the amount of $1,388,495, which approximates the amount of the reserve that we have established. To date, the Court has not set a briefing schedule in connection with our anticipated motion to dismiss.

On April 29, 2020, ***Blockchain*** Mining filed an amended complaint (the Amended Complaint). The Amended Complaint asserts the same causes of action and seeks the same damages as the initial Complaint.

Topic 13 Payment Method: 2021 Messagebgone, Inc.

The Company will set up servers in various countries, depending on the most favorable hosting and security issues. (For example, Germany does not require severs to store a traffic logs of IP addresses and visitors.) The website that will be designed to allow customers to subscribe to and download the MBA service and will accept both traditional (Credit Cards, PayPal) and alternative (***Bitcoins***, hyper wallets) payment methods that will give customers additional levels of security with the option of total

anonymity. If an MBA customer should choose to use an anonymous payment system such as ***Bitcoins***, this MBA user would be anonymous even to us.

Topic 14 Business Plan: 2017 On Track Innovation, LTD.

Management's Discussion and Analysis of Financial Condition and Results of Operations, as well as elsewhere in this Annual Report and include, among other statements, statements regarding the following:

...Our intention to continue to invest in research and development; Information with respect to any other plans and strategies for our business; and our development of capabilities to implement ***Bitcoin*** acceptance and other ***cryptocurrency*** and our intention to become ***Bitcoin*** and other ***cryptocurrency*** acceptable in transactions via NFC, Bluetooth or QR code.

...

OTI continually strives to discover the technology of the future and keep abreast of new developments in the fintech marketplace. At this time, we are trying to develop ***Bitcoin*** capability in the ***Cryptocurrency*** marketplace, and we intend to become ***Bitcoin*** acceptable in transactions via NFC, Bluetooth, or QR code.

Table 1 Sampling Process

	Obs	**# of unique firms**
All yearly data reported from 2014 to 2021 by Compustat	101,690	11,306
Less: Missing values	(58,080)	
Subtotal	43,610	9,911
Less: Cannot be merged with CRSP	(16,338)	
Subtotal	26,105	6,909
Final Sample:		
Firms reported cryptocurrency or blockchain	833	329
Firms not reported cryptocurrency or blockchain	25,272	6,580

Table 2 Keyword and year breakdown

keywords	2014	2015	2016	2017	2018	2019	2020	2021
blockchain	0	13	33	80	147	165	176	281
bitcoin	0	13	14	37	40	42	49	81
Cryptocurrency	0	5	6	67	93	131	165	309
Digital currency	1	29	56	78	90	113	109	145
Virtual currency	3	32	28	24	30	41	49	46

Table 3 Statistics

	N	mean	s.d.	p25	p75	p50
Price	26,105	375.433	144.949	249.800	423.500	408.200
Size	26,105	7.598	2.343	6.160	8.996	7.615
Profit	26,105	-0.726	4.992	-0.006	0.208	0.090
turnover	26,105	0.469	0.603	0.049	0.686	0.227
Quick	26,105	1.401	2.631	0.185	1.316	0.517
Lev1	26,105	0.200	0.217	0.020	0.341	0.109
Lev2	26,105	0.373	21.724	0.203	1.337	0.605
Block	26,105	0.018	0.133	-	-	-
Bitcoin	26,105	0.006	0.074	-	-	-
Crypto	26,105	0.016	0.124	-	-	-
Digital	26,105	0.012	0.111	-	-	-
Virtual	26,105	0.005	0.071	-	-	-
Day (-1)	26,105	-0.001	0.038	-0.012	0.010	-0.000
Day0	26,105	-0.001	0.038	-0.012	0.011	-0.000
Day1	26,105	-0.001	0.037	-0.011	0.010	-0.000

The detailed variable descriptions are presented in Appendix A. All continuous variables are winsorized at the 1st and 99th percentile.

Table 4 Correlation Matrix

	price	size	profit	turnover	quick	lev1	lev2	block	bitcoin	crypto	digital	virtual	day(-1)	Day0	day1
price	1.000														
size	0.012	1.000													
profit	0.012	0.256	1.000												
turnover	0.060	-0.204	0.106	1.000											
quick	-0.039	-0.308	-0.312	-0.291	1.000										
lev1	-0.008	0.104	0.043	0.089	-0.238	1.000									
lev2	0.005	0.014	0.004	-0.009	-0.002	-0.022	1.000								
block	0.019	0.062	0.011	-0.024	-0.007	-0.045	0.000	1.000							
bitcoin	-0.011	0.013	0.001	-0.001	0.003	-0.026	0.002	0.208	1.000						
crypto	-0.009	0.070	0.010	-0.039	-0.001	-0.053	-0.004	0.353	0.371	1.000					
digital	0.001	0.074	0.010	-0.046	-0.009	-0.048	-0.001	0.196	0.194	0.154	1.000				
virtual	-0.009	0.027	-0.003	0.003	-	0.004	-0.007	0.216	0.234	0.187	0.163	1.000			
day(-1)	-0.022	0.002	-0.001	-0.000	-0.001	0.004	0.002	-0.005	-0.014	-0.008	-0.009	0.007	1.000		
day0	0.010	0.005	0.003	0.007	-0.004	0.007	0.004	-0.004	-0.014	-0.010	-0.014	0.007	0.103	1.000	
day1	-0.008	0.002	0.005	0.002	0.003	0.013	-0.002	-0.004	-0.003	-0.008	-0.008	0.011	0.001	0.106	1.000

Table 5 Reliability and Validity of Outer Models

Latent Variables	Indicator Variables	Loading	Indicator Reliability	Composite reliability	AVE
D	day (-1)	0.530	0.281	0.737	0.478
	day 0	0.778	0.605		
	day 1	0.748	0.560		
	turnover	0.785	0.616		
	profit	0.644	0.415		
I	quick	-0.758	0.575	0.668	0.585
	lev1	0.650	0.423		
	lev2	-0.044	0.002		
	size	0.766	0.587		
	price	0.093	0.009		
J	turnover	0.760	0.578	0.455	0.216
	Profit_z	0.653	0.426		
	quick_z	-0.758	0.575		
	lev1_z	0.650	0.423		
	lev2_z	-0.044	0.002		
	RD_z	-0.536	0.287		
	price_z	0.093	0.009		
P	bitcoin	0.708	0.501	0.704	0.53
	block	0.662	0.438		
	crypto	0.769	0.591		
	digital	0.640	0.410		
	virtual	0.237	0.056		

Table 6 Path Analysis

	Coefficient	SD.	t-stats.	P-values
I →J	0.983	0.001	13.08	0
I → P	-0.005	0	11.29	0
J → D	0.007	0.007	1.091	0.276
P → D	-0.176	0.067	2.613	0.009
P → J	-0.055	0.008	7.108	0
I →P → D	0.001	0	2.698	0.007

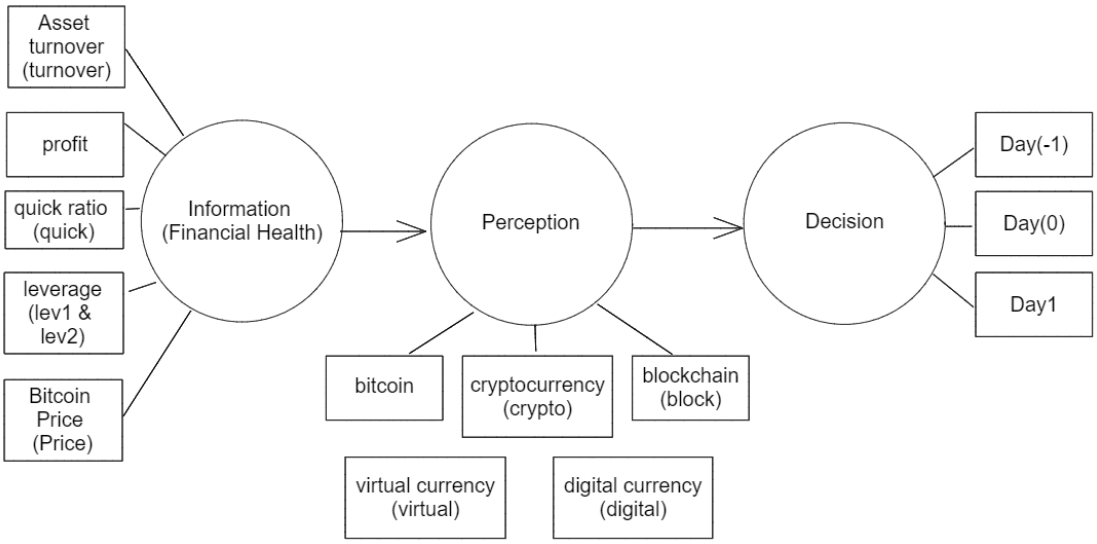

Figure 2 The proposed PLS Analysis Model

Table 7 Investor Decision and Blockchain or Cryptocurrency disclosures

	Full Sample		**cryptocurrency only**		**Blockchain only**	
Price->P	0.000	***	0.000	***	0.000	***
size->P	0.001	***	0.001	***	0.000	***
profit->P	0.001	***	0.001	***	0.001	***
turnover->P	0.003	***	0.003	***	0.002	***
quick->P	-0.004	***	-0.004	***	-0.002	***
lev1->P	0.003	***	0.003	***	0.002	***
lev2->P	-0.000	**	-0.000	**	-0.000	**
block->day(-1)	-0.060	**			-0.016	
block->day0	-0.089	***			-0.039	*
block->day1	-0.057	***			-0.027	
bitcoin->day(-1)	-0.044	**	-0.052	**		
bitcoin->day0	-0.064	***	-0.076	***		
bitcoin->day1	-0.041	***	-0.048	***		
crypto->day(-1)	-0.070	**	-0.082	**		
crypto->day0	-0.103	***	-0.121	***		
crypto->day1	-0.103	***	-0.076	***		
digital->day(-1)	-0.058	**	-0.073	**		
digital->day0	-0.086	***	-0.108	***		
digital->day1	-0.055	***	-0.067	***		
virtual->day(-1)	-0.022	**	-0.020	**		
virtual->day0	-0.032	***	-0.030	***		
virtual->day1	-0.020	**	-0.019	**		
R-Square:						
(I→P)	0.094		0.095		0.057	
(P→D)	0.107		0.119		0.084	

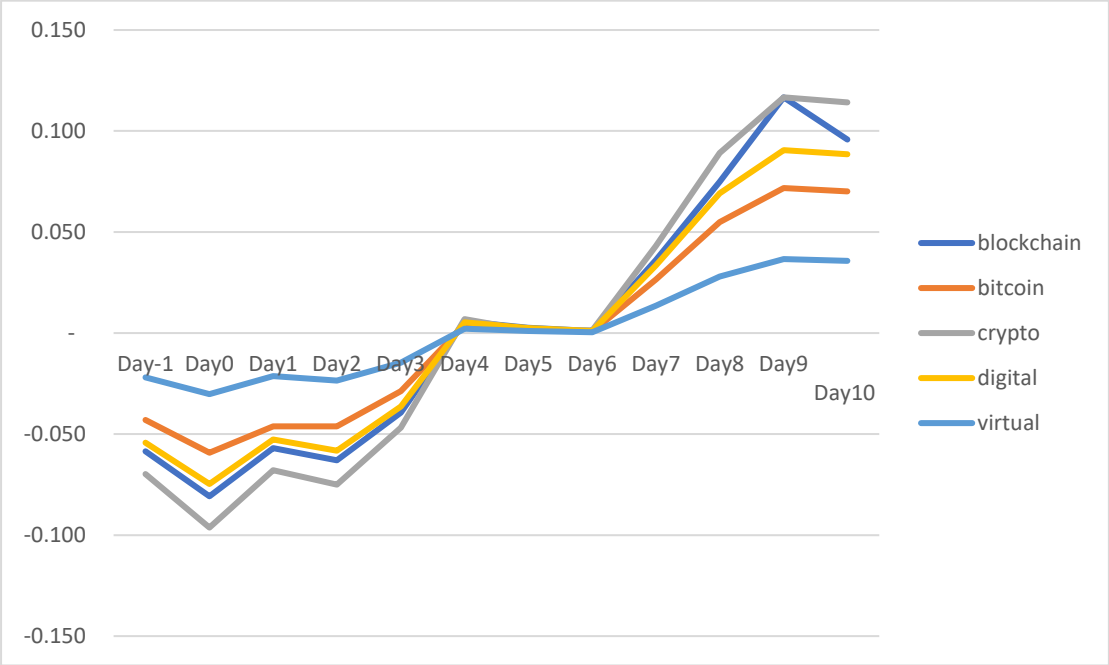

Figure 3 Coefficients of blockchain & cryptocurrency change in window [-1,10]

Table 8 Investor Decision in Firms' First Time Report vs. Other Times of Report in Cryptocurrency and Blockchain

	First		**Non-First**	
Price->P	0.016	*	-0.008	**
size->P	0.004		-0.013	***
profit->P	-0.005		-0.003	**
turnover->P	-0.042	**	0.064	***
quick->P	0.038	**	-0.012	**
lev1->P	-0.047		0.078	***
lev2->P	0.010	*	-0.050	***
block->day(-1)	0.028	*	0.090	*
block->day0	0.026	**	0.148	**
block->day1	0.016	**	0.133	**
bitcoin->day(-1)	0.139	**	-0.037	**
bitcoin->day0	0.128	**	-0.061	**
bitcoin->day1	0.079	**	-0.055	**
crypto->day(-1)	0.008	**	-0.021	**
crypto->day0	0.008	**	-0.035	**
crypto->day1	0.005	**	-0.031	***
digital->day(-1)	-0.293	*	-0.033	**
digital->day0	-0.271	**	-0.055	***
digital->day1	-0.168	**	-0.049	***
virtual->day(-1)	0.278	**	0.132	**
virtual->day0	0.256	**	0.218	**
virtual->day1	0.159	**	0.196	**
R-Square:				
I→P	0.033		0.094	
P→D	0.041		0.053	

Table 9 Extracted Topics

	Topic	**Top 5 terms**
1	Service & Operation	product, platform, user, customer, revenue
2	Competition environment	competit*, ledger technolog*, financial technolog*, alternative, loss
3	Technology development	develop, enhance, technolog*, new, solution
4	M&A	merge, acquisition, acquire, agree, enter
5	On-site Shopping	virtual, purchase, in-app, play, mobile
6	ICO	Initial Coin Offering, ICO
7	Cybersecurity	threat, ransom, attack, cyber, risk
8	Investment	invest, mine, network, network, crypto
9	Social capital	serv*, board, appoint, position, offic*
10	Business shut down	auction, not, monitor, change, discontinue
11	Policy change	rule, predict, outcome, law, regulat*
12	Lawsuit	file, complain*, attorney, amend, contract
13	Payment method	payment, transfer, bank, money, accept
14	Business Plan	will, future, expand, expect to, opportunit*

Table 10 Topic Distribution

Topic	2014	2015	2016	2017	2018	2019	2020	2021
Service & Operation	0	2	4	15	27	30	28	43
Competition environment	0	8	21	46	62	75	81	112
Technology development	0	1	2	7	13	11	17	20
M&A	0	0	1	0	0	2	0	3
On-site Shopping	3	10	11	8	10	13	15	11
ICO	0	0	0	1	0	0	1	0
Cybersecurity	0	1	0	0	0	1	3	8
Investment	0	1	2	2	3	5	5	15
Social capital	0	0	0	1	3	2	4	5
Business shut down	0	0	0	0	0	0	0	2
Policy change	0	2	1	3	2	3	7	9
Lawsuit	0	0	0	0	0	1	1	0
Payment method	0	0	0	1	1	0	0	5
Business Plan	0	1	0	7	4	2	2	4
Total	**3**	**26**	**42**	**91**	**125**	**145**	**164**	**237**

Table 11 Topic Analysis

	Day(-1)		**Day0**		**Day1**	
Service & Operation	0.091	***	0.118	***	0.120	***
Competition environment	-0.164	**	-0.212	***	-0.217	***
Technology development	0.057	**	0.073	**	0.076	**
M&A	0.018	**	0.024	**	0.024	**
On-Site Shopping	0.070	***	0.091	***	0.092	***
ICO	0.009		0.012		0.012	
Cybersecurity	0.023	*	0.030	**	0.031	**
Investment	0.024	**	0.031	***	0.032	**
Social Capital	0.012	*	0.015	**	0.015	**
Business Shut Down	0.005		0.006		0.006	
Policy Change	0.036	***	0.048	**	0.049	**
Lawsuit	0.005		0.006		0.006	
Payment Method	0.011		0.014		0.014	
Business Plan	0.020	***	0.026	**	0.026	**

Table 12 Event Study Analysis

	Day (-1)	**Day 0**		**Day (-1)**
block	-0.006	0.002		-0.001
bitcoin	-0.004	-0.001		-0.005
crypto	-0.006	-0.005		-0.000
digital	0.000	-0.011	*	0.005
virtual	0.004	0.003		0.000
quick	0.000	0.000		-0.000
profit1	-0.000	-0.000		-0.000
turnover	-0.001	0.002		-0.003
lev1	0.000	0.005		0.002
lev2	0.000	0.000		-0.000
size	-0.002	0.000		-0.000
Obs	21,122	21,122		21,122
Year FE	Y	Y		Y
Firm FE	Y	Y		Y
Adj R^2	0.041	0.030		0.032

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Vitae

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Shensi Wang is a dedicated and accomplished scholar who will receive her Ph.D. in Business Administration from the University of Texas at El Paso in 2024. She earned her Master's in Taxation from Fordham University in 2019 and her B.B.A. in Business College of Shanxi University. Shensi's research has focused on the firm's application of advanced technology, cybersecurity, and artificial intelligence.

In addition to her research, Shensi has demonstrated a strong commitment to education through her teaching roles. She has taught courses on individual income tax during the 2022-2023 academic year and principles of accounting in 2023-2024 at the University of Texas at El Paso.

Before moving to the academic area, from 2018 to 2020, Shensi Wang was worked at Bertelsmann Inc. as a tax intern, mainly responsible for federal and international income tax return preparation. She also worked as a graduate assistant at Fordham University from 2018 to 2019.

Shensi and her mentor, Dr. Waymond Rodgers, worked for the national research project granted by the Department of Homeland Security. The two working papers related to this project are Examining Anti-ethical Behavior Types Tied to AI Algorithm and Surveying Anti-Ethical Decision-making Types Tied To AI Algorithms.