Cryptocurrencies and Finance theories

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Abstract

The cryptocurrency (CCY) as a new key player in the currency system draws the attention of the literature to examine the influences, relations and opportunities that CCY may provide. However, a financial theoretical framework to connect CCY with financial theory is missing. This paper fills this gap by providing a review of the theoretical framework introduced in the literature to position CCYs in investment and finance theories. This is done by studying the CCY literature and providing critical feedback on the overall contributions in the area and possible avenues of improvement. We report a need for a long-term analysis for CCY as this asset class is new and sufficient data may not be available. Moreover, a better connection and linking with finance theories is required as it is significantly deficient. The promising potential of blockchain/ CCY stresses the need for interdisciplinary research including with business, legal and information technology disciplines. In addition, the Covid-19 pandemic opens the door for further research to investigate the role of CCY as a hedge in crises times.

Keywords: digital ledger technology, cryptocurrency bitcoin, finance theory, investment, fintech

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1. Introduction

Investors are usually searching for opportunities to generate income and to diversify their risk (Peters & Panayi, 2016). Financial innovation created new types of securities and technology available in the form of cryptocurrencies (CCY). This innovative asset class can offer investment alternatives that drew the attention of practitioners and financial experts (Dwyer, 2015). It may help in diversifying or hedging wealth through appropriate streamlining of portfolios with less information asymmetry. It also generates a possible asset that is more efficient than traditional commodities and other currencies (Collomb & Sok, 2016; Zhao, Fan, & Yan, 2016). The future of CCY and related digital ledger technology (DLT) is being given prominence in many fields of study including finance. It can shift power dynamics to who can understand and make the best use of this tool of financial technology (fintech).

This paper investigates the underlying theory and possible research avenues in the area of blockchain based CCY. What are the financial theories linked to the CCY/DLT? What is the extent of CCY application on both an individual and business level? Is it safe to deal with this system? Is the transparency and improved governance claim by blockchain valid over traditional method of disclosure? How much can CCY help in diversifying the investments? Does it have the capacity to replace the traditional financial assets? Still, answering the above highlighted questions in the previous research are limited. Thus, the initial step of an exploratory research from a grounded theoretical application basis has to be established in order to guide and advance the research in this paradigm (Nargundkar, 2003). This study shall pursue this significant gap of identifying the pertinent studies in the area of finance/investment-CYY and highlighting the potential areas of improvement, contribution and development. Therefore, the most appropriate question is to understand the extent of finance theory related CCY contribution in this novel fintech paradigm by providing constructive observations on various publications and literature.

Technology in finance has been a contributing factor in development of the area (Shiller, 2009). Nakamoto (2008) proposed the DLT and its potential use in currency exchange and payments that is mainly decentralized and is different from the propriety/central systems that have more control on its policies and movement. Collomb & Sok (2016) describe a basic model on the functionality and features of blockchain/ DLT. It is basically a decentralized system that bases the trust on the users that are connected on a peer-to-peer basis that has multiple copies of the transaction available to the public. All these overcome the particular issues that can be found in the centralized system (that involves humans). Therefore, aiding the transfer of money in a more controlled fashion.

With the rise in the e-commerce and digital transactions all over the globe, hard cash and currency may disappear or be extremely limited in use. This will encourage individuals and institutions to start dealing more with the advent of CCY due to some of its benefits over fiat currency (Polasik, Piotrowska, Wisniewski, Kotkowski, & Lightfoot, 2015). At the time of drafting this paper, the value of the entire CCY market was approximately more than US$300

billion and in excess of 3,500 CCYs trading with Bitcoin having the highest market value of around US$210 billion. CCY market is highly volatile market. The value of this market reached US$650 billion in the beginning of 2019, however, the price dropped by around 60% by mid-2019. The most traded CCYs were Bitcoin, Ethereum, Ripple (XRP), Tether and Bitcoin-Cash among the many others (Coinmarketcap, 2020).

CCYs are based on the blockchain technology and the distributed ledger technology (used by XRP), which outperforms the current swift method for money transfer that takes more time in clearance and transfer. Hence, the CYY will be the appropriate representations of blockchain technology-based products/ services (Collomb & Sok, 2016). The CCY is advancing at such a fast pace that many central banks around the world (such as in China, Japan, Sweden, Singapore) have already started working on the strategic plan for its implementation. However, the issue of personal information and privacy related to CCY is under question if the CCYs issued and controlled by central banks (Lee, 2020). Another important reason why we have to understand the concept of DLT as a new financial technology (fintech) is due to its emergence and acceptance in the market through the use of CCYs. By mid-2020s, the traditional bank profits may be reduced by almost a hundred billion dollars due to market share distribution of important products and services offered by banks to DLT based firms (Mckinsey, 2016). The push for CCYs has been extremely strong, leading the G20 nations to have a special meeting to discuss the CCY standards and proposed regulations and possible issuance/ implementation in the near future (Helms, 2020). Hence, it is important f or banks and financial sector along with academicians to understand the theoretical and empirical basis to this new technology (Goodell, 2020; Philippon, 2016).

With the recent global pandemic of COVID19, the application of CCY initiates some important discussion for its widespread use and application (Abdelrhim, Elsayed, Mohamed, & Farouh, 2020; Goodell, 2020). The use and development of fintech has been encouraged in some countries during this time. However, the focus can also be pushed towards the general use and enhancement of existing fintech as it has become more of a necessity than a choice primarily due to the hygiene requirements and need to pay for life's basic necessities (Fu & Mishra, 2020; Goodell, 2020; Smeets & Zeisberger, 2020). As most of the financial assets are studied in its diversity, such as speculation, volatility, spillover, hedge, safe-havens, etc. in turbulence times COVID19 pandemic shall provide an opportunity for researchers to study the possible diverse applications of CCY via the finance and investment perspective, especially under the hedge and safe-haven options (see; Mariana, Ekaputra, & Husodo (2020); Conlon, Corbet, & McGee (2020)).

There is a limited literature review in the area of fintech that are mainly related to economics and financial theories (such as Dwyer 2015; Farell 2015 and Yermack 2015). Still DLT and its relation to finance in terms of investment and diversification is limited (Lemieux, 2016). The importance of conceptual ideas and the need to understand the concept of CCYs/DLT by its

financial and technological basis is highlighted by previous studies; this has been highlighted in this study as part of its recommendations and gaps for future research.

This study focuses on main theoretical aspects of CCY and how it can be positioned in the investment and financial theories. This paper shall be based on an exploratory research pattern and to an extent the literature review process for certain key finance and investment-based theories that shall be explained in relation with the CCYs and assist in furthering the subject area that has not been covered in earlier literature. Hence, this paper should benefit researchers in identifying new and missing areas of relevant research. On the other side, investors and market participants can learn about CCY in terms of diversification and other governance possibilities. This study can support regulators to develop rules and guidance for the CCY operations that can be very well extended at the micro level of the sector. Based on the analysis of more than forty pertinent papers of CCY-finance theories, we find a lack of research in the theoretical foundation for the mechanisms of CCY from one side and long-term data studies from the other side. In addition, there is a need for studies that consider different shock periods (such as crisis, COVID19, etc.) and their impact on CCY from different perspectives including the behavioral aspect of investors, CCY as a medium of exchange. Furthermore, there is a lack of multi-disciplinary research and the links between CCY and financial theory. The contribution of this paper can be tracked on two-levels, firstly offering a constructive analysis of the theoretical framework of the CCY in the literature. On the second level, this paper offers a germane summary of the finance-CCY theoretical relation along with the potential areas of further research.

The paper sections are divided as following – section 2 describes the methodology; section 3 provides a background on DLT/ blockchain; section 4 details the links between finance theories, the CCY and suggests future research avenue, finally section 5 summarizes and conclude the paper.

2. Methodology

This paper applies the exploratory research approach for advancing and identifying the literature based on the financial and investment theories that cointegrate with the CCY. This method is used due to the reason that CCY subject is still new in the fintech research area that limits us from formulating a full-fledged literature review. The concept of exploratory research is not to reach to a conclusive outcome; however, it is to provide certain basis for the research area in addition to being a guide for further research (Nargundkar, 2003). Moreover, an exploratory research assists the researchers in knowing the research that is already conducted and what more can be done that principally lays a groundwork such as a grounded theory, which is an important contribution of this paper. Furthermore, the aim by using an exploratory research method is not to be decisive, rather it is to explore the topic at "various depths" guiding others in various levels from methodological basis to data collection that can lead to a conclusive outcome (Singh, 2007). However, a brief literature review procedure is applied due to the proximity of the two methods

of exploratory and literature review, as the available matter on the subject of CCY is limited to certain theories only, while most of the concepts are under-researched in the CCY stream. The information is gathered from various sources that include published journal articles, relevant books, conference proceedings, reports and related research. Most of the studies are closely related to more than one theory which normally are not explicitly mentioned in the papers and other sources that makes it difficult to identify, dispense and explain. However, certain papers have a special focus on a particular aspect of a financial theory (which maybe implicit) that is dictated by its presence in a certain section of the paper. Figure 1 summarizes the methodology used in this study.

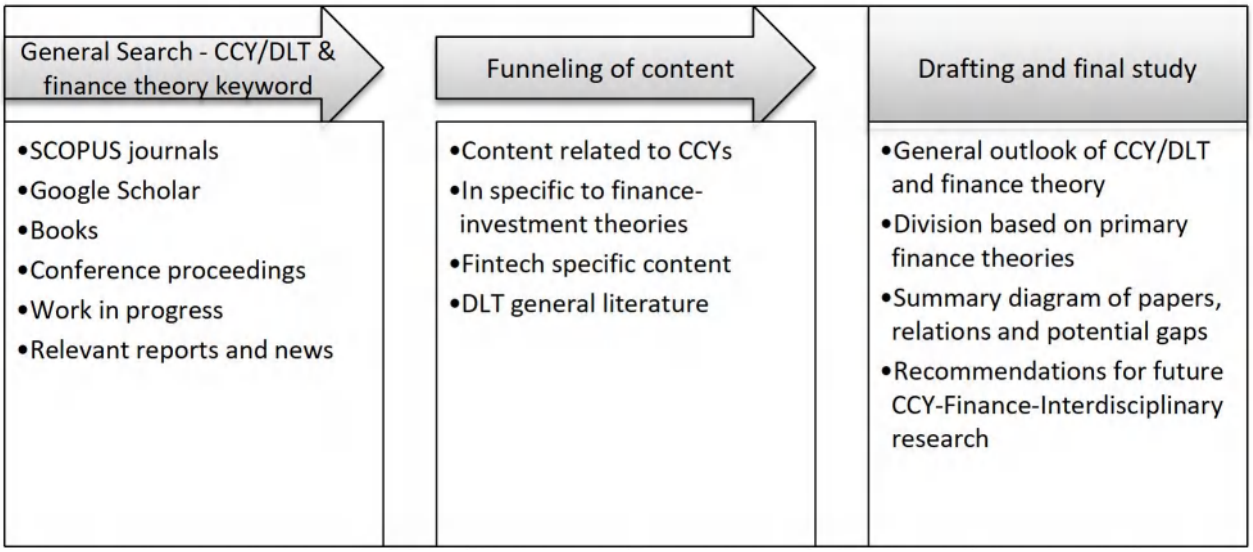

Figure 1-Summary of paper methodology

Financial theories related to investment, governance and a general approach of economics is applied in the paper wherein relevant literature is gathered through a Google Scholar and SCOPUS database search that can explain the subject matter in its general purview rather than a detailed study on relevant papers in the CCY-financial investment paradigm. The keywords related to cryptocurrency such as bitcoin (and variants), digital currency in addition to financial theory related terms such as investment, volatility, diversification, efficiency (and similar words) are used on above websites to extract the journal studies without limiting to published or unpublished research in order to incorporate the different outcomes that maybe insignificant. This step is followed by reading the abstracts and analyzing the relevance of the paper to the objective of this study to relate the literature with finance theories. Once the link is established, the paper contribution and theoretical link is incorporated in our study to find the development of CCY related literature in terms of finance and find the gaps (See Figure 2 for more details).

3. Cryptocurrency and blockchain: A background

The literature on blockchain is generally limited to mainly its economic and general financial contribution. In terms of CCYs, much focus has been put towards bitcoins while other CCYs

have been slightly ignored in the literature (Tapscott & Tapscott, 2017; Zhao et al., 2016). The area of DLT based applications and CCY is still being explored and studied by both academics and practitioners, however, the theoretical basis in terms of investment and related financial aspect has been inadequate (Lemieux, 2016; Lindman, Tuunainen, & Rossi, 2017; Zhao et al., 2016). Experts realize the growth and influence of CCY not only at an advanced business level, but also at the individual level. Perhaps, this timely understanding of DLT based CCY in terms of its theory shall encourage and lay the foundation for further development and empirical analysis of the same in the finance and investment literature.

The fintech sector is growing at a fast pace. This has caused many new entrepreneurs and businesses to come up with new financial services and products that cater the needs of people in the status quo in the backdrop of advanced and fast information technology demand amid the COVID19 pandemic. This has also caused a shift in the mindset and approach of the customers in the financial sector market due to which an urgency to develop and understand the DLT and related facets have to be studied (Arner, Barberis, & Buckley, 2015; Zalan & Toufaily, 2017; Zhao et al., 2016). Therefore, studying the probable links and mainly the opportunity of hedge/ safe-haven and other investment related financial theories need to be analyzed to identify the possible gaps and areas of improvement related to CCY.

The financial world has been in a constant development and looks forward for business innovations through fintech and has been researching and studying a new frontier known as blockchain. In a simple sense, the advent and development of blockchain that is highly related and applied through CCY, also known as digital currency which was developed by Satoshi Nakamoto in 2008 (Nakamoto, 2008). CCYs operate on the concept of cryptography using the peer-to-peer technology. Users registered in the blockchain should have both a public and private key to verify the trustworthiness, completion and addition of the transaction to the public ledger that is available to the registered DLT participants of that particular CCY. Zhao et al. (2016) believe that blockchain has many applications other than just cryptocurrencies, applications that can be tailored in fields such as accounting, finance, law, supply chain, medicine, databases, etc. The first version of blockchain was that of the digital currency, as we are currently in the second stage of blockchain development, it shall take more time from both the academicians and professionals to develop, understand and adapt the new technology of contracts and high-end dealing (Campbell-Verduyn & Goguen, 2018; Peters & Panayi, 2016). Through the advent of "internet of things" with continuous development in technology, the 5G network is becoming the new requirement of the future fast-paced technological world in synchronization with DLT and CCY with each requiring the other to deliver more impact with artificial intelligence. As the former requires the security, privacy and functionality offered by DLT while the latter operates more effectively with faster network speeds enabled by 5G that can lead to efficient resource sharing and handling (Dai et al., 2019; Fan, Ren, Wang, Li & Yang, 2017 and Lugano, 2019).

As blockchain is based on a distributed database concept that uses the public and private key, the addition or acceptance of a fraudulent act or transaction on a consensus on the digital ledger is incredibly low to occur. This means that the possibility to manipulate the data, logs and share ledger, is difficult to occur. This idea is further elaborated in the agency theory section of this paper where the impression of reduction of fraud and strengthening of a firm's governance are discussed. Looking at the design of blockchain that adds each verified transaction to the chain once approved by the majority of its participants and updates shared database with all of them, hence making it difficult for a security breach to occur by a hacker or any other technological threat. This improves the data security and more importantly improves the efficiency of a transaction by reducing the time to confirm the same. However, one drawback could be the limited availability of transaction verification networking capacity of general users with the increase of the load of multiple transaction requests that can be possibly creating business based blockchain systems, wherein specialized transactions are approved, mainly applied in Bitcoins (Atzori, 2017).

Collomb and Sok (2016) mention that, out of all sectors, blockchain/ DLT has a great influence especially on the finance sector and its impact to further develop and reach its potential is huge for both the individuals and institutions. Kakavand, Kost De Sevres, and Chilton (2017) and Peters and Panayi (2016) discuss the blockchain development and innovation in financial services sector such as in payment mechanism systems, improvements in drafting of smart contracts, and to an extent managing the operational risks of the financial market and institutions. Coeckelbergh (2016) emphasizes on the importance of normative orientation required to analyze the *"ethical implications of financial technologies*". Nasdaq had started developing a blockchain application by the name 'chain.com' that can be used as a platform for equity exchange in 2016. Thus, DLT application in the stock exchange is not far away, however its empirical implications are yet to be tested completely (NASDAQ, 2017). Some institutions such as Bitcoin Foundation suggests that blockchain may add more transparency to the voting process. Hence its application is currently being studied, although the voting initially was cancelled due to logistics and permissions related to the process, the overall concept of improving the transparency by giving each participant the key and choice in the voting process with DLT based record-keeping is interesting (Rizzo, 2015).

Recently, the financial firms focus on incorporating this technology and currency within their business to utilize first entrant advantage over its competitors. DLT and CCY may have the potential to offer the needed diversification and hedging option in the investment sector and governance. However, certain major challenges do remain in its wide acceptance through regulation, application and security (Eyal, 2017; Fanning & Centers, 2016; Zhao et al., 2016). Moreover, in terms of CCY competition, Bornholdt and Sneppen (2014) argued that bitcoin is competing with other cryptocurrencies and the market is developing at a fast pace, hence bitcoin may well be replaced by other cryptocurrencies in the near future. Moreover, Scott (2016)

concludes that it is important to study the societal aspects of CCYs and DLT as it may assist in improving the financial inclusion.

The further advancement in global technology and the absent of regulations (Bornholdt & Sneppen, 2014) motivate a potential increase in transaction of the CCYs in e-commerce markets along with the increase in the use of DLT in the banking sector. The traditional investment assets such as stocks, oil, gold, etc. among others have a significant base of data and information available to almost all stakeholders based on which investment and finance related decision can be made in a more informed manner. Moreover, central banks of a few nations along with the G20 countries have already initiated the regulatory and operational strategies for CCYs (Del Castillo, 2017; Helms, 2020 and Lee, 2020). Therefore, it is worthwhile for researchers and stakeholders to understand these concepts at its basis. This paper suggests a theoretical buildup of the CCYs shall assist and guide researchers and portfolio managers in identifying the basis of this particular asset-class in the overall finance literature that can enhance the new studies in the field as also supported by Eyal, 2017; Gjermundrød & Dionysiou, 2017; Polasik et al., 2015; Zhao et al., 2016.

Hence, it is encouraging to further the existing studies and understand the vast possibilities of DLT/ CCY application in various fields, especially in the field of finance, which has certain established theories that needs to be linked and explained in relation with this novel fintech. As this specific area is comparatively new, some aspects in terms of finance that needs to be understood from both a broader perspective of empirical analysis and the theoretical base that can assist the various stakeholders to further the familiarity with the subject.

4. Finance theories and CCYs

As theories are an integral part of this study, Figure 2 provides the summary and key relation between the finance/ investment theories and the CCYs literature. The possible gaps and areas of further study and improvement have also been identified. To describe certain direct and key relations between the theories, it can be observed that a common connection between all of them is the assistance for decision making for the stakeholder. The different diversification and asset pricing theories such as capital asset pricing model (CAPM), behavioral portfolio theory (BPT) and arbitrage pricing theory (APT) are related with efficient market hypotheses (EMH) on the key basis of decision-making support and providing choice to the investor. EMH and adaptive market hypotheses (AMH) have a more approach-based association, as these are based on the active and passive investment strategies that can be either applied independently or be diverse based on the investor's choice. AMH and risk-return trade-off have a traditional relation of investors risk and return preference that can vary over time or stay fixed. The relation between risk-return and agency theory is detailed by many studies and the Bowman's risk-return paradox, that suggests a negative relation between risk and return, which is contrary to most traditional

risk-return hypotheses. Overall, the theories are also related with each other based on the information sharing, and human factors such as emotions (Bell, 2009; Bowman, 1980; Chari, David, Duru & Zhao, 2019; Greenblat, 2018; Lo, 2004; Sherlock, 2018).

Figure 2 also highlights the main relations found in the current literature associated with CCYs/DLT. The diversification theories related studies mainly provide the different investment alternative possibilities including the potential hedging and/ or safe-haven option with CCYs in comparison with other traditional assets (such as gold, oil, stock). The EMH is related with its traditional approach of studying the CCYs based on possible efficient investment information and transaction exchange and activities. As suggested by AMH, the behavioral perception of investors and stakeholders and their investment decision that has been scantly studied. The typical understanding of risk-return trade-off from the traditional assets has been extended to study the speculative and return nature of CCYs. Lastly, the agency theory perspective via CCYs have been researched in the areas of possible governance both at the firm level and national level as well as the internal trail of transactions. The diagram is completed by the potential gaps and areas for future research in this paradigm that has been detailed in each theoretical section and subsequently in the conclusion. More details are follow.

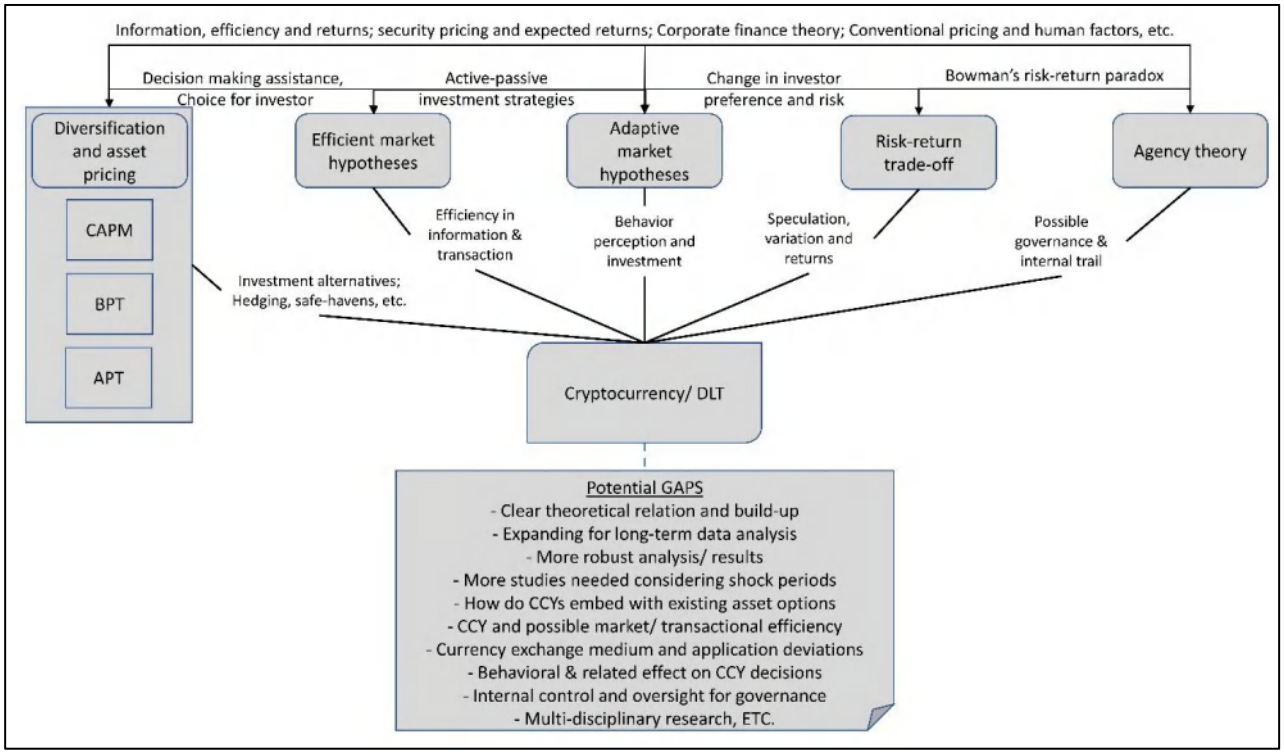

Figure 2 - Finance/ Investment theory and CCY relations and potential GAPS

4.1.Diversification theories/ asset pricing

As this study is based on the theoretical basis of CCY in finance, it would be important to understand the concept of CAPM. To connect finance theory with CCY, a brief look at the

capital asset pricing model (CAPM) is required. CAPM is one of the most widely used model that assists investors in decision making in forming a well-diversified set of portfolios. Along with the concept of CAPM proposed by Sharpe (1964) and Lintner (1965), is the behavior portfolio theory (BPT) proposed by Shefrin and Statman (2000). BPT is considered as an alternative or even an upgraded version to the traditional CAPM and arbitrage pricing theory (APT) proposed by Ross (1976) that shall be further discussed.

Where the CAPM focuses on a single factor and beta, the APT considers multiple factors other than return of an asset using the linear relationship between the expected return of the asset and certain other factors that are based on macroeconomic nature. As mentioned by Li and Wang (2017) the CCY are affected and influenced by multiple factors that are macroeconomic in nature. Hence, this suggests that APT my captures the CCY determinants and pricing in a more holistic manner in compared to CAPM. For example, Mehta and Afzelius (2017) apply the CAPM on four assets from different sectors (Google, silver, bitcoin and Pokémon cards) to find that the CAPM can only explain the return on the former two assets. Bitcoins returns cannot be predicted using CAPM. They conclude that the APT and advanced International Capital Assets pricing model (ICAPM) can be better for the analysis of Bitcoin (BTC). The reason they suggest that prices and returns of bitcoins can be better estimated by macroeconomic factors due to the nature of CCY.

In order to reach a robust conclusion, the assumption differences between the CAPM and APT gives us an advantage and reason to study DLT based CCY on both models. As the former looks at the market and assumes market efficiency, the latter model accepts that the market may sometimes misprice the securities due to the volatile nature of CCY. Therefore, it has been suggested that further research should be conducted under both concepts and model of CAPM and APT (Katsiampa 2017 and 2018).

The next advancement on the diversification and investment concepts is the BPT proposed by Shefrin and Statman (2000). Unlike earlier financial models and theories that are based on a key concept of return and risk from a static perspective, the BPT looks at investment from different perspectives as it divides the investment strategy of the investor into different layers. The layers are generally divided into a general financial disaster prevention goal at the bottom, leading up to the uppermost layer that has the goal of maximizing the returns of the investor. Under BPT, considering the high risk and high-return nature of DLT based CCY, we can suggest that the uppermost layer can be allocated towards the CCY in the status quo based on its high demand and limited supply in the market. The BPT acts as another alternative, which may be suitable for investors that would like to safeguard some of the investment, however they would also like to take a certain risk in order to maximize the returns, hence providing the optimal basis to diversify their investment.

Due to the high volatility experienced by the bitcoin and other CCYs in the recent past years (Bouri Molnár, Azzi, Roubaud, & Hagfors, 2017), the understanding of CAPM, APT and BPT are important. In general, these assist in describing the relationship between the risk and the expected return of the assets in order to price them efficiently to make the investment a profitable venture. Kristoufek (2015) studied the possible drivers of bitcoin as a proxy of the blockchain technology. Although he commented that bitcoin maybe regarded as a speculative asset, it does have certain long-term fundamental factors such as its regular usage in trade affecting its price and movement. The author eventually declares that bitcoin maybe not affected by either the US or Chinese markets, however, the CCY has features of both a speculative and standard asset, that may possibly offer an incentive to diversify. However, long-term regular trade of the CCYs may need substantial analysis and cannot be generalized based on limited current data even with sophisticated methodologies that have limited robustness support.

Dwyer (2015) mentioned that due to the blockchain technology that CCYs are based upon, a possible reduction in transaction cost is observed. Using the "VARMA-DCC-GJR-GARCH" model, Guesmi, Saadi, Abid and Ftiti (2018), found that bitcoin in not the ideal option to be used in exchange process due to its high volatility. They also found that portfolios which contain bitcoin along with other traditional assets, such as oil, gold and stock equities, offer a better diversification option for risk. Although, a short-term data analysis should not be a basis for a significant investment unless the model outputs are verified and substantial, that is extremely limited in the existing literature.

Demir, Gozgor, Lau and Vigne (2018) studied the possibility of identifying the hedging option using bitcoins and the economic policy uncertainty (EPU). They conclude that it is possible to use bitcoins to diversify the investment since it had a significant negative relation with the EPU. However, in some cases a significant positive relation between the two variables are found. In order to understand the possible similarities and differences between bitcoins and established investment options of gold and US dollar, Baur, Dimpfl and Kuck (2018) replicated an earlier study by Dyhrberg (2016) using the same sample while applying the GARCH (generalized autoregressive conditional heteroscedasticity) and GARCH family models. The outcome was different from the original contributor Dyhrberg (2016) found. Overall, BTC have a different mechanism of operations that make it volatile and speculative in nature than the US dollar and gold as investment options. As the values of these currencies mainly depend on supply/ demand and the mining that has almost no backing of an actual asset, many countries have banned dealing with cryptocurrencies (Zhao et al., 2016). However, due to the recent world condition of COVID19 and movements of international banks in further dealing with CCYs, this may create a new pathway to further the research in the area with relevant theoretical development (Arner et al., 2015; Zalan & Toufaily, 2017). As empirical analysis with a relevant theoretical buildup can be more useful in further decoding the subject, which needs improvement in current research. This notion further supports the contribution of this paper in the new area of DLT/ CCY and the likely next generation of investment and process of using this technology.

Bouri, Jalkh, Molnár, and Roubaud (2017) looked at the safe-haven, hedging or diversifications options that bitcoin could provide in comparison to the commodities and the energy assets during its bad course of 2013 due to its direct involvement as an input for mining the CCY. Considering the overall commodity (inclusive of energy) and the singular energy index by using the dynamic conditional correlation (DCC) and asymmetric dynamic conditional correlation (ADCC) models, bitcoin proved to be a "strong hedge and safe-haven" option for the pre-crash period while it was mere a diversification option in the post-crash era. Overall, as mentioned earlier for most of the studies, there is a lack of finance theory development and its relevant association with CCYs in most of the studies. These connections and relations is important to be highlighted to support the empirical stance and develop the fintech paradigm that needs theory contribution. Moreover, the limited time period of CCY operations needs to be expanded for a better outlook on this new asset class, as most of the studies have a short period data and outcome that can be difficult to generalize on the CCYs.

Multiple studies discuss the existence of arbitrage in CCY market and portfolio diversification possibility using CCYs (especially bitcoin) when considered as a set with other traditional investment asset markets (such as gold, oil, equities and bonds) to reduce the risk of CCY due to its nature and low correlation with other markets (Anyfantaki & Topaloglou, 2018; Hattori & Ishida, 2018; Kajtazi & Moro, 2018; Makarov & Schoar, 2018; and Trautman & Dorman, 2018). However, certain other stream of literature argues that CCY (bitcoins mainly) do not offer much in terms of hedging capabilities to the investors (Klein, Thu & Walther, 2018), while Guesmi et al. (2018) and Bouri et al. (2017) find evidence that the hedging function of CCY is subject to data, market, and selected assests.

Overall, research in terms of diversification using CCY is sufficient enough for decision-making mainly in the short-term basis as this asset-class is relatively new compared to commodities and equity investments. This means more research over a long-term horizon has to be conducted to find more significant and appealing outcome that can be related with more long-term established investment assets such as gold, oil and world equity markets, etc.

Due to COVID19 pandemic, certain studies have focused and elaborated on testing the "resilience" and possible understanding of how CCYs operate under the extra-ordinary circumstances. The COVID19 pandemic is an important junction and test for CCYs in terms of finance and investment, as most of common assets such as gold, oil, stock markets are tested in various turbulent periods such as oil crisis in the 1970s, Asian crisis in late 90s and Financial crisis 2007 to understand the viability of these assets.

Conlon, Corbet, and McGee (2020) studied the possible use of CCYs of BTC, ETH and Tether as safe havens in a diversification set with global equity markets. The safe-haven properties may behave differently across the world depending on various factors. Using a conditional value at risk measurement to study the downside risk that relates to the high risk-high return theory. The

international indexes used were MSCI world, S&P 500, FTSE 100 from April 2019 to April 2020. It was found that none of the CCYs provided any significant safe-haven options as compared to the international equity investments. Considering the basic analysis, it can be noted that the variance of the prices between the CCYs and international equity markets was significantly different. The international equity markets show a more stable outlook on the investment than the CCYs that are highly varied, as shown in multiple studies earlier. It has to be noted that the window of data is extremely small to reach to a significant outcome, especially understanding the fact that the pandemic start in January 2020 and end of data period in April 2020 with different duration of country lock-downs (Kaplan, Lauren, Mcfall Johnsen & Morgan, 2020). This factor needs to be taken into consideration as the loss threshold identification under value at risk may not cover the entire extent of loss due to the confidence level (Bejda, 2014). However, using a wavelet coherence analysis on BTC for four months ending April 2020 to study the possible safe-haven option of CCYs, Goodell and Goutte (2020) found that BTC prices had risen in the later part of the data period (April 2020) than the initial four months of COVID19. The length of data analysis however maybe further improved in order to cover a sufficient timeline to have a better outlook on the features of CCYs during the pandemic.

Based on the above analysis, we suggest that both the APT and BPT perspectives are yet to be explored to advanced levels due to the macroeconomic variables affecting the pricing of CCY. In additional, the risk and return distribution behavioral aspect of investors shall further attract using the BPT to explain CCY behaviour. This requires further research as the current output is limited in terms of short-term data and various market conditions that (may) have influenced the CYY market. Moreover, with COVID19 pandemic, the importance of theory relation and its empirical connection in application is evident that can assist in making relevant decisions to safeguard the investment. It can be noticed that most of the studies during COVID19 has data limitation due to time and sufficient data points availability.

4.2.Efficient market hypotheses

Efficient market hypotheses (EMH) introduced by Malkiel and Fama (1970) is based on the assumption that the stocks are a reflection of all the possible available information in the market that leads us to understand that it is difficult for investors to earn an abnormal return, in other sense it is difficult to ‘beat the market’. EMH is divided to three levels, weak, semi-strong and strong form of markets that reflect the efficient and transparent transfer of information into the market price at a particular level. DLT is much faster and transparent based technology that can reach and even reflect the data of the market into the asset prices at a faster pace than the current technology. This technology has the capability to reflect information changes on the stocks and currency exchange (mainly cryptocurrency and some banking transactions) quicker than the traditional fiat currencies and exchanges, thus the possibility of making the information transfer much more efficient, timely and transparent. It has to be understood that making this sort of an asset (CCY) an important investment option that can be considered as a basis of stock market news and event reflection is valuable in terms of cost efficiency and transparency not only for the

stock exchanges, but also the corporates and individuals. In addition, there is a contrary behavior that was noticed in the investors that were dealing with the CCY more than the rational behavior assumption under EMH (Coeckelbergh and Reijers, 2016; Garcia, Tessone, Mavrodiev and Perony, 2014). The investors were buying an asset that was valued way below its face value with an irrational expectation that it may give a huge return in the future. Although, this expectation came true for a lot of investors, but in the later stages, the bitcoin value experienced a sharp decline in its price value by almost 50%. Therefore, at a basic level of analysis we could say even with the irrational behavior of the investors based on the three variants of the market, the concept of EMH may need to be further elaborated and examined using the CCY. The basis of EMH under pure efficiency is the case of random walk and inability to predict the future prices due the random nature of the asset.

The literature, however, has provided a certain degree of similar output in regard to CCY and its market response and functionality that mainly discusses the market efficiency. Urquhart (2016) uses five different methods to test the possible inefficiency in the bitcoin prices and returns including Ljung-Box for autocorrelation, runs test and Bartels test for independence of returns, variance ratio test for random walk presence, and BDS test for serial dependence of stock returns. Urquhart (2016) found evidence of bitcoin market being inefficient. However, when the sample was divided into two periods, the latter half indicated to be more efficient, which means that as time duration of bitcoin business increases, the bitcoin market may turn to be efficient overall. Nadarajah and Chu (2017) revisited the study conducted by Urquhart (2016) by employing the power test transformation of bitcoin returns and found a rejection of EMH.

Using the Hurst exponent, Bariviera (2017) focused on the long-term informational inefficiency of bitcoin market. Similar to the earlier paper by Urquhart (2016), Bariviera (2017) reports twofold results, before 2014, the bitcoin market was informationally inefficient, however the market turn to be efficient after that indicating a possible transformation in the market to be more aligned with the EMH. Consistent with both Urquhart (2016) and Bariviera (2017), Tiwari, Jana, Das, and Roubaud (2018) found that bitcoin market is informational efficient.

Analyzing the return on bitcoin and litecoin using GARCH, Alam (2017) found that both currencies are not consistent with the weak form of market efficiency. On similar lines, using AR-CGARCH model, Vidal-Tomás and Ibañez (2018) found that even without the central authority control, bitcoin market has grown to be more efficient over time although it falls in the semi-strong efficient form of market. They also concluded that the CCYs nature being speculative which is further created into a bubble due to excessive speculation by the investors and market players. Caporale, Gil-Alana, and Plastun (2018) applied the R/S analysis and the fractional integration methods to identify the long-memory of four CCYs. They found that the market is inefficient, and the investors can use multiple ways in order to generate abnormal returns and profits, hence a possible relation with BPT can be observed. Cheah, Mishra, Parhi, and Zhang (2018) use the cointegrated VAR framework and found that bitcoin market is not

efficient. On similar lines of studying the long memory of bitcoin through volatility and potential presence of structural breaks, Bouri, Gil-Alana, Gupta, and Roubaud (2018) found that shocks had a long-memory effects that are found in the absolute and squared returns measure for the volatility. They supported the argument of presence of inefficiencies in the bitcoin market based on the conclusion of absence of mean reversion and long memory. Kristoufek (2018) studied the bitcoin efficiency using the US and Chinese currencies and found that both markets portray an inefficient basis with certain glimpses of efficiencies in small portions based on an efficiency index created by Kristoufek and Vosvrda (2013).

On a more comprehensive approach for CCY, Wei (2018) studied more than 450 CCYs. Using the Hurst exponent, Wei (2018) argues that the CCY with a high market liquidity factor have a low return predictability, in which most of the new CCYs fall that also influences the overall CYY market efficiency. Expanding on earlier idea of herding under diversification concept, Bouri, Gupta, and Roubaud (2018) also examined the herding effect based on different methodologies suggesting an influence on market efficiency and risk management that can be induced from the outcome. Using the static model, they did not find any significant herding effect; however, applying the rolling-window effect due to the inappropriateness of static model suggested a significant time-varying herding effect. A third measurement of logistic regression suggests the existence of herding with an increase in uncertainty.

In order to give a small preview on the potential of DLT apart from CCY, EMH and the DLT could be combined and seen in a tandem. As DLT seems to be a better alternative to the current news and event reflection mechanism on the market prices of different assets and investment alternatives due to its nature of being more transparent as its availability on the public spectrum. This concept of EMH leads us to other possible outcomes and basis that it assumes, it is the market efficiency establishment through the invisible hand of competitive markets, achieving efficiency and equilibrium in the market, production efficiency, the exchange efficiency, etc. However, the researchers and investors should consider the highly volatile nature of the current CCY, although the DLT may be a better technological basis of application with a sound foundation in other investment areas. As mentioned by Zalan and Toufaily (2017), the DLT has been internationally accepted by various organizations as a trusted resource in the banking sector. Hence, the same can be applied in the stock market and the foreign exchange market as well. This may encourages testing the validity and the reliability of DLT application in the financial sector (Fanning & Centers, 2016).

Understanding the CCYs market efficiency from a COVID19 perspective, Mnif, Jarboui, and Mouakhar (2020) studied how the CCY market has performed using a multifractal analysis considering the CCYs have an almost analogous nature. This study had a more direct approach with respect to the EMH theory in terms of analysis and output as market efficiency was the primary objective with an underlying approach of the herding effect under the COVID19 conditions for five CCYs (BTC, ETH, XRP, Litecoin and Binance). The study applied three

methodologies – the "Multifractal detrended fluctuation analysis", generalized Hurst exponent and magnitude of long-memory – to cover the different time series (mainly long-term) characteristics that has the potential to find possible implicit information and trends. The five CCYs studied in the paper were found to be influenced by herd behavior as also found in similar studies for the period up until May 2020. However, the efficiency of certain CCYs differ from one to the other, as BTC were found to be less efficient during COVID19 as compared to ETH whilst the former showed better efficiency pre-COVID19 conditions. This possibly could be due to the enormous market share of BTC and trade volume that it possesses in the CCY market (Coinmarketcap, 2020). Moreover, the use of traditionally long-term methodology to identify a during (post) COVID19 efficiency over a span of five months data of volatile CCYs may not be an adequate and significant result to base decisions upon, therefore, more time-series relevant data-based output should be pursued.

It can be observed that the outcome of the studies in this area of finance is not completely conclusive to be significantly applied and needs more research, it can be seen that the efficiency of CCY is enhanced with the maturity of their markets. The available research shows that the CCY market (especially the bitcoin) is acting more like an alternative investment asset and its efficiency tests produce mixed results based on different methods and time periods. However, more evidence is required in order to reach to a more satisfactory outcome with use of different EMH testing models that can assist in determining the efficiency for not only bitcoins but also CCYs in general as the expansion of the CCY is expected. The limited time-series based evaluation that may need more data points to provide a more applicable outcome. As described above in relation to the characteristics of DLT and CCY, it would be a winning bet to adapt technology by the institutions (such as stock exchanges, banks, other financial institutions, etc.) with sufficient regulation.

4.3.Adaptive market hypotheses

Adaptive market hypotheses (AMH) was developed by Lo (2004), which is an evolutionary version of the EMH. The basic concept of EMH as mentioned earlier is about the basic efficiency of markets based on various events and no party involved in the transaction can make an abnormal return with all the information available to the market. However, Lo (2004) provided a reconciliated theory that combines the economic aspect as well as the behavioural aspect of the decision makers. This hypothesis also relates to the risk-return model as it assumes that the risk-return relation may not always remain in tandem and certain models and strategies may work well in certain markets than others with possibility of arbitrage. Hence, with advancement in finance and related aspects, it has to be expected that the advent of DLT and CCY may lead to a certain arbitraging in the CCY market for the investors with advanced skills. However, like the expectation of the increase in market efficiency in EMH, it can be expected that AMH will ensure that markets and stakeholders will eventually adapt and overcome the barriers in the CCY market that may hinder the application of financial and investment theories.

A study by Khuntia and Pattanayak (2018) is one of the limited publications that have specifically examined AMH in relation to bitcoin (BTC). They applied the Dominguez-Lobato consistent test and generalized spectral test in order to capture the time-varying linear and non-linear dependence in the BTC returns. Similar to the outcome of studies in EMH section (Bariviera, 2017; Tiwari et al., 2018 and Urquhart, 2016), they found that overtime the efficiency of the bitcoin improves that also validates the different implications of the AMH. With little reference to the AMH, Koutmos (2018a) looked at the microstructure of the BTC market in relation to the liquidity uncertainty and the aspects that can describe this behaviour over time. Using the ARMA-GARCH model and the Markov regime-switching model, Koutmos (2018a) found changes in different regime based on uncertainty. These changes creates a difficulty in determining the factors affecting the adaptation of liquidity uncertainty through bitcoin prices and other factors (volume, size, fees, volatility, hash rate, unique bitcoin addresses). Which creates a need for revisiting for these determinants sometime in the future with more stable data set. In support of applying AMH models in order to study CCY market improvement, Köchling, Müller, and Posch (2018) studied the possibility of efficiency improvement in bitcoin market and find that bitcoin market had turned price efficient generally. This also supports the EMH and also encourages researchers to study the same effect on other CCYs.

Khursheed, Naeem, Ahmed and Mustafa (2020) study the time varying market efficiency with relation to AMH. The paper uses three different methods including generalized spectral, automatic portmanteau and Dominguez-Lobato tests. Four CCYs were studied for a period of five years. Certain CCYs (such as BTC, Litecoin, Monaro) have a comparatively longer efficiency period than Steller (which has a more inefficient run). In line with similar research, this study suggests that the CCY price variations are impacted by varying market periods. The paper also suggests the use of AMH for a better forecast of market efficiency due to the changes in market conditions. This paper has a more elaborate approach towards AMH and market efficiency. However, the paper may need to support the inclusion of the mentioned CCYs as there are other CCYs that are traded more with a higher market value (such as Ethereum, XRP, etc.). Therefore, the possible benefit to the stakeholder based on the outcome of the study may be limited as the market influence of these CCYs is small (Coinmarketcap.com, 2020). However, the contribution in terms of analysis could be further applied to other studies that can supplement the method and results.

Abdelrhim et al. (2020) study the possible opportunities to invest during the COVID19 situation by comparing CCYs (BTC, ETH and Tether) and metals (gold, silver and copper). The possible combination of different investment assets may provide an adaptive market approach and risk-distribution, although the paper through its general literature provides some attention on certain EMH papers. While the paper requires deeper literature analysis and theory build-up in relation to investment and finance, it provides a different kind of outlook on the pandemic and its relationship with the investment opportunities in the market. The basic data structure was based on the COVID19 data of deaths (daily and total) and positive cases (daily and total) of more than

200 countries and the returns on the different investment alternatives over a limited time period of 3 months (from end of March 2020 during the pandemic). The results show that CCYs had better returns on investment during the above period with ETH providing returns of more than 70% while silver and BTC gave around 40% return. Other metals (copper and gold) and CCY (Tether) had the least return on investment. However, the paper analysis may need further robustness tests in order to provide additional support to the results for its general applicability. Since the data set was limited to the three months during the pandemic, an increased data set in addition to a pre and post COVID19 would provide a better understanding and comparison of returns. Additionally, it can also provide insights into the changes of returns in the two durations and show how the pandemic among other potential factors may have influenced different investment opportunities and basket of assets.

It is important to understand the standing of CCY under AMH as it can assist the stakeholders in further solidifying the position of CCY as a long-term asset that can adapt to market changes or if it is just a bubble that shall fade away by time due to its speculative nature and rigidness to regulations and other investment and market functionalities. As markets and behaviour of people does not solely depend on price of the asset itself, this theory encourages the analysis of other factors that can have a significant influence on an investor's choice and decision of investment. AMH is a significant theory in this area of research mainly for the fact that the high volatile nature of the CCYs involves the decision and influence of human interaction and speculation that has multiple parameters and objectives. It provides significant influence of human thinking and behavior that other traditional finance theories may not incorporate completely. The outcome of COVID19 studies in relation to investment and diversification via multiple asset options needs further research and analysis. This is mainly due to the short period of time-series data that has been used and the lack of sufficient analysis that can provide adequate support for the results to be taken into significant consideration.

4.4.Agency theory – governance and transparency

The agency theory proposed by Jensen and Meckling (1976) discusses the concept of principal and agent relationship where the agent is responsible to oversee and safeguard the investment of the principal. However, the personal agendas of the agent or manager takes the precedence over the value maximization idea of the principal that have been entrusted upon the agents. In the light of agency theory and issue of information asymmetry, it would be better to discuss the possible benefits that DLT based CCY could bring to the corporate governance aspect of business as it is claimed that DLT is decentralized and is more transparent. This technology can be used in the managerial decision-making process, creating contracts, issuing tenders, making investments on behalf of the company and keeping a track of the operational activities of the firm, etc. that are payment related using CCY. Moreover, this DLT feature of better transparency of information has to be tested empirically. Although it can be assumed that if it does provide that required transparency to business activities, decision making and related aspects, then it has the potential to overcome the agency problem in the firm and would assist the managers and board

of directors in the oversight of the company activities largely. Zhao et al. (2016), argue that blockchain can be used in improving the supply chain, database management, tracking of activities and products and oversight in a firm. The blockchain provides a faster pace than enterprise resource planning systems, and then it would be highly recommended to substitute the existing technological systems. DLT can bring more efficiency, effectiveness, reliability, and transparency of firm data and information with cash inflow and outflow using CCY. This could lead to better governance, oversight and loss deduction that maybe caused due to the unexpected losses through fraud or any other activities that are deemed unethical or illegal by the regulator in the country.

Campbell-Verduyn (2018) argues that analyzing DLT along with its different applications should further the necessary understand of possible profound implications that the nature of the technology can bring on "contemporary global governance." Hence, it is important and essential for users of the DLT (regulators, investors, and institutions) to analyze the potential governance applications that CCY can offer if it is used on a normal course with the underlying basis of DLT of transparency and data availability. Campbell-Verduyn (2018) discusses in detail about the potential monetary value of CCY (especially bitcoin) and how it emerged as an important player as a medium of exchange that, various institutions are trying to integrate into their operations even though regulations relating to it are still shallow. All together suggests a need for further research in this area by collaboration of industry and policy experts that can enhance the use of CCYs in the financially demanding world.

Various central banks are trying to explore the possibility of using DLT as a basis of issuing currency (Del Castillo, 2017). This will give CCY an important platform to flourish should this fintech receive a push from the banking industry. This can be a game changer in the fintech market as a possible new means of monetary transactions. Although Hsieh, Vergne, and Wang (2018) do acknowledge that it will take a while for business community, regulator and fintech developers to come together to understand the potential of CCY and its regular use mechanism in business operations that can change the face of governance and improve the control over decision making calculus within the business realm. We understand the possible delay that can occur for different stakeholders to come together to discuss such an issue that is yet to be understood profoundly. However, this is a time for concerned stakeholders to push for policies and applications prospect of such fintech that can provide space for entrepreneurs in this area. With growing fast pace technology and needs of the users, further delay in the process may dent the best output and use of the fintech.

A detailed approach of DLT/ CCY, its currency basis and governance application can be found in Campbell-Verduyn (2018). To further the concept of CCY in specific application of Ethereum that has various applications that include creation of smart contracts and legal tenders. This is an ideal example of the application of DLT using CCY to achieve a better level of governance. This gives more control and transparency without the need of centralized parties to confirm the

transaction. This trait can also bring the legal, financial and regulatory bodies to work in a collaboration for an improved version of governance (Leonhard, 2017). Böhme, Christin, Edelman, and Moore (2015) document that bitcoins (CCY) do lack a formal 'governance structure'. However, it is expected that in the long-term stakeholders shall realize that the DLT can be incorporated by businesses and other organizations to enhance the overall operational capacity and improve efficiency and effectiveness. Trump, Wells, Trump, and Linkov (2018) acknowledge that in the status quo, the CCYs have their own limitations that should be solved to properly implement it over traditional governance that has its own issues. These issues of high human involvement, lack of transparency, etc. can be covered potentially by DLT/ CCY if its restrictions are improved.

Overall, it is expected that in the coming years, the current limited research will be advanced, and more research will be conducted in studying the DLT/ CCY application under the microscope of governance and transparency. With growing concerns and body of knowledge in governance in different fields of accounting, finance and management, the potential application of DLT and CCYs due to its nature can provide a new stream of knowledge that may change the future of transparency and information sharing with stakeholders. Especially considering the various finance theories that were described and explained in earlier sections, most of these are associated with a better approach and output for the investor, policy maker, firms, etc. Hence, this new fintech needs to be further studied both from the empirical and theoretical perspectives by academicians and practitioners for a more appropriate comprehension. This can enhance the understanding of the stakeholders to better articulate the use of the fintech if it is found to be suitable for application. This potential application in the area of oversight, governance, transaction trailing, improved transparency and related aspects can be further incorporated in the paradigm that can also relate the human/ behavioral perspective.

4.5.Risk-return trade-off and herding

Merton (1973) presented the concept of intertemporal-CAPM (iCAPM) where the expected extra return should have a positively significant relationship with the market conditional variance. This also reflects the idea of risk-return relationship where high risk means high return. This risk-return trade off as a fundamental concept in the area of finance and economics could be termed as the "first fundamental law of finance" (Ghysels, Santa-Clara, & Valkanov, 2005). Although the literature may have mixed results in regards to the relationship between risk and return, we take the concept of high risk and high return as the basis of our theoretical development for the DLT based CCYs. Wherein investors noticed huge surge in the prices of bitcoins in mid-2017 and within a span of 6 months the price reached from a mere US$100 to a high of US$18,000 (Aalborg et al., 2018). This sudden increase with the low risk of investment that was initially taken by the investors who purchased the bitcoins at a lower price does not seem symmetrical. A sharp and sudden increase in the volatility and price with a high abnormal return means that the traditional concept of high risk-high return may have to be tested clearly and additionally to validate this particular theory and concept (Ghysels et al., 2005). Amit and Livnat (1988) state

"Empirical results about the risk-return trade-off are currently inconclusive, with some studies reporting that such a trade-off exists and others that firms can simultaneously increase profitability and reduce risk".

Ji, Bouri, Lau, and Roubaud (2018) examine the interconnectedness and possible spillover effects in terms of returns and volatility between six CCYs over a period of approximately three years. They found that regardless of the sign of relation, bitcoin and litecoin[2] were highly related and affecting other CCY markets, more of negative effect than positive, which means that when the market is facing a shock/ bearish sentiment, the influence is much stronger than when the market is bullish. For diversification purposes, it was found that Dash CCY was weakly related to other CCYs in terms of both returns and volatility. Moreover, the pricing and influence of CCYs were not necessarily based on the market size of the particular CCY in relation to its peers. This suggests that in certain situations, the overall market may have less influence due to certain factors, which needs to be identified as it is unclear from the outcome of the study by Ji et al. (2018) apart from the trading share of the particular CCY. It could assist in improving the understanding of the nature of CCYs and the possible intermarket or external/ macro factors that may have an influence on the market in similar time-period. Hence, further study and research with relevant theory backing may certainly add more significance to the contribution from various disciplines as the paradigm needs more time to establish and study. Similarly, with an investor behavioral perspective of sentiments, Eom, Kaizoji, Kang, and Pichl (2019) find that investor sentiments may assist in both the predictability and information effect on the bitcoin price and volatility. Leclair (2018) assesses the herding effect (more of a BPT perspective) in the CCY market using a set of 12 currencies over an estimated period of 200 days using the CAPM and a herding dynamics estimation method. The study finds a significant herding effect in the CCY market based on the high frequency data used in the measurements.

Using GARCH and GAS for predicting the returns and risk of bitcoins, Troster, Tiwari, Shahbaz, and Macedo (2018) find that the latter method has a better "best out-of-sample forecast and goodness-of-fit properties to bitcoin returns and risk modelling". They also found that the heavy tailed GARCH and GAS models have better performance (in identification) than the normal GARCH model. Troster et al. suggest that the bitcoin can be used as a hedging tool in the investment portfolio, thereby controlling part of risk in the investment. Briere, Oosterlinck, and Szafarz (2015) used the mean-variance spanning test along with the ordinary least squares regression on different investment assets including bitcoins in its initial three years to understand the risk-return relation between the investment portfolios. They found that using bitcoins in a portfolio provides a good diversification basis and also significantly improves the risk and return trade-off that maybe a trait in the short-term dealing of the CCY. Aalborg et al. (2018) find that although the predicted volatility of bitcoins can be linked backed to its lagged values, however

[2] Bitcoin and Litecoin are both mining cryptocurrencies, however the two differ on the mean block time and the algorithm used that influences the mining time. Litecoin has a higher mining limit (84 million) than bitcoin (21 million), but the market value of the latter is higher than the former by almost 20 times (Coinmarketcap, 2020).

the value and volatility is “changing tremendously”. Similarly, Gkillas and Katsiampa (2018) employed the value-at-risk and extreme value analysis to study the tail behavior of five top CCYs. They found that CCYs have different risk share, in which bitcoin cash was found to be the riskiest while bitcoin and litecoin were found to be least risky among the five CCYs compared. Moreover, Koutmos (2018b) studied more than 18 CCYs to test the possible spillover and the risk that it entails on the CCY market in general. The author finds that bitcoin is the largest contributor to the return/ volatility spillover, leading to higher interdependence among the CCYs and also increase in the contagion risk. The study concludes the future ambiguity of the CCYs due to the time-varying relation of interdependence and spillover that is occurring in the market. Looking at the risk-return relation of CCYs from a different perspective, Katsiampa (2018) measured the interdependence of BTC and Ethereum using BEKK model to understand how the two can be used as a hedge for risk together. The proposition was that BTC investment in a portfolio should be more than that of Ethereum, whilst Ethereum should be used in the portfolio to deter the risk of BTC as hedging strategy.

Corbet, Larkin, and Lucey (2020) studied the contagion effect on gold and CCYs (in specific - BTC) among other international markets (Shanghai and Shenzen Stock markets, West Texas Intermediate oil and Dow Jones international) during the COVID19 pandemic. Although the possible diversification is a subtle part of the study, the “flight to safety” in terms of risk shifting via the contagion effect is the primary objective. The authors applied GARCH on hourly and daily traded prices on the above data set and divided it into pre and post COVID19 under a defined timeline. In reference to the Chinese stock markets, neither gold nor BTC were found to have a relation. They found that these assets may not act as possible safe havens or hedging alternative but possibly as “amplifiers of contagion” due to the BTC new entry and its nature in the market. Although the data set used in the paper is approximately one year, the use of daily and hourly prices increases the result application in respect to contagion effect of gold and BTC. However, more time-series data analysis can further add to the robustness of the results.

As discussed earlier, most of the papers analyzed the speculative nature of CCYs (mainly bitcoins) in the current literature; however, the concept is to be applied in case of more CCYs, as there is limited research that specifically tackles with this idea of risk-return. It is advised that researchers conduct more research in risk-return relationship of CCYs and traditional assets and within CCYs with a direct approach and methodology rather than providing findings as a by-product of diversification papers that may not cover the characteristic of risk-return in a comprehensive manner. This will further help in solidifying and establishing a better relation between risk-return with strong and significant results. The COVID19 pandemic situation has added speculation and risk in the investment market where investors are seeking some sort of financial protection, however, with divergent views and information, the research in this area especially concerning the comparatively new CCYs needs to be further studied.

4.6.CCY Operational Aspects

It would be unwise to ignore regulations and economic aspects of DLT based CCYs, discussed in the previous studies. Gjermundrød and Dionysiou (2017) argue that in order for CCYs to compete with fiat currencies, they have to overcome the challenges of financial, regulatory/ legal, societal, as well as the technological factors. CCYs may lead to an economic deflation, hence its application may be hindered on a general economic level. Dwyer (2015) mentions that there is some effect on governments in terms of controlling inflation if the digital currency is used in its foreign exchange operations as a limited number of currencies are available in the market that does not allow for printing more currency notes like in the fiat currencies. Although the number of CCYs has reached to more than 3,500, BTC stands to be the most significant with others such as Ethereum and Ripple catching up that could enhance and develop the whole CCY paradigm in finance, investment and economics. However, its application in the normal economic transaction scheme is still extremely minute with many problems that needs to be overcome (Iwamura, Kitamura, & Matsumoto, 2014).

On the economic policy side, Vidal-Tomás and Ibañez (2018) find that publication of monetary policy news and events do not affect the BTC prices, hence confirming its non-centralized characteristic that may be extended towards other CCYs to an extent. With the wider reach of CCYs, it may replace the other digital payment mechanisms, the main issue lies in its central regulation that by forming a single legal basis, which made it difficult to be formed in the near future. Financial and non-financial institutions may take advantage of the loose rules and oversight to further engage in the CCYs (Peters, Panayi, & Chapelle, 2015). However, in order to have better control and guidance to avoid any possible economic distress, governments should impose regulations on CCYs operations and related aspects to ensure the governance aspects with businesses are not interfered with. In terms of ethics of CCYs specifically, very little work has been conducted on the academic side, however, a few exceptions that include Dierksmeier and Seele (2018) who study the ethical perspective of the DLT and CCY from micro to macro level. They discuss the use of CCYs, role of miners and authorities and the unethical and disruptive use of CCYs in businesses and the role of powerful firms that can possibly disorder the societal level of monetary exchange. In order to overcome this issue, Dierksmeier and Seele (2018) proposes certain general rules that should be agreed at the international level by banks, governments, fintech entrepreneurs and related stakeholders that shall at least ensure the governance application and control by the regulators can be carried out.

Table 1-Summary of finance theories and the elaborated CCY literature in the study

N.	Author	Year	Source/ Journal	Theory/ Goal (Probable-Implicit)	Methodology	Findings/ Understanding
1	Sharpe; Lintner	1964; 1965	The journal of Finance	CAPM proponents	Equilibrium; comparative graphical analysis; expressions	Capital asset pricing model

N.	Author	Year	Source/ Journal	Theory/ Goal (Probable-Implicit)	Methodology	Findings/ Understanding
2	Shefrin and Statman	2000	Journal of financial and quantitative analysis	BPT proponents	Theories; functions; assumptions	Behavior portfolio theory
3	Ross	1976	Journal of Economic Theory	APT proponent	CAPM; expressions; assumptions	Arbitrage pricing theory
4	Malkiel and Fama	1970	The journal of Finance	EMH proponents	Analysis; assumptions	Efficient market hypotheses
5	Lo	2004	The Journal of Portfolio Managemen t	AMH proponent	Psychology; EMH; analysis	Adaptive market hypotheses
6	Jensen and Meckling	1976	Journal of financial economics	Agency theory proponents	Theorems; assumptions; analysis	Agency theory (principal and agent)
7	Mehta and Afzelius	2017	SSRN	CAPM/ APT	CAPM, ICAPM and APT	Prices and returns of BTC can be better estimated by macroeconomic factors; APT and ICAPM better for BTC analysis.
8	Kristoufe k	2015	PloS one	Diversification	Wavelet coherence analysis	BTC maybe not affected by either the US or Chinese markets; CCY has features of both a speculative and standard asset, that may possibly offer an incentive to diversify.
9	Guesmi et al.	2018	International Review of Financial Analysis	Diversification	VARMA-DCC-GJR-GARCH	BTC in not the ideal option to be used in exchange process due to the its high volatility; portfolios with BTC and traditional assets such as oil, gold and stock equities offer a better diversification option.
10	Demir et al.	2018	Finance Research Letters	Hedging	Economic policy uncertainty	Possible to use bitcoins to diversify the investment since it had a significant negative relation with the EPU.
11	Baur et al.	2018	Finance Research Letters	Diversification	GARCH	BTC have a different mechanism of operations that make it volatile and speculative in nature than the US dollar and gold as investment options.
12	Ji et al.	2018	International Review of Financial Analysis	Risk-return; spill-over	Positive/negat ive return and volatility connectednes s; regressions; *H*-step-ahead generalized forecast-error variance decompositio n	BTC and litecoin were highly related and affecting other CCY markets.
13	Eom et al.	2019	Physica A: Statistical Mechanics and its Applications	BPT	Return, volatility, autoregressiv e model framework	Investor sentiments may assist in both the predictability and information effect on the bitcoin price and volatility.

N.	Author	Year	Source/ Journal	Theory/ Goal (Probable-Implicit)	Methodology	Findings/ Understanding
14	Bouri et al.	2017	Applied Economics	Diversification, safe-haven, hedge	Dynamic conditional correlation (DCC) and asymmetric dynamic conditional correlation	BTC proved to be a "strong hedge and safe-haven" option for the pre-crash period while it was mere a diversification option in the post-crash era.
15	Leclair	2018	Research Gate	BPT, CAPM, risk-return	CAPM and a herding dynamics estimation method	Finds a significant herding effect in the CCY market based on the high frequency data used in the measurements.
16	Conlon et al.	2020	Research in International Business and Finance	Diversification, Safe-haven	Downside risk measurement; Modified CVaR	Safe-haven properties may behave differently across the world depending on various factors; international equity markets show a more stable outlook on the investment than the CCY.
17	Dyhrberg	2016	Finance Research Letters	Diversification	GARCH	Possible use of BTC in risk management; can be used by risk-averse investors.
18	Goodell and Goutte	2020	Finance Research Letters	Diversification and co-movement	Wavelet coherence analysis	BTC prices had risen in the later part of the data period (April 2020) than the initial four months of COVID19
19	Urguhart	2016	Economics Letters	EMH	Ljung-Box, runs test and Bartels test, variance ratio test, and BDS test	Generally, BTC market is inefficient; As time duration of BTC business increases, it is possible that the bitcoin market may turn to be efficient overall.
20	Nadaraja h and Chu	2017	Economics Letters	EMH	power test transformatio n	Rejection of EMH in general.
21	Bariviera	2017	Economics Letters	EMH	Hurst exponent	A twofold result, wherein the half before 2014 was informationally inefficient for the bitcoin market, however the latter period was more efficient.
22	Alam	2017	Journal of Engineering and Applied Sciences	EMH	GARCH and multiple unit root and stationarity tests	BTC and litecoin are not consistent with the weak form of market efficiency.
23	Vidal-Tomás and Ibañez	2018	Finance Research Letters	EMH	AR-CGARCH model	BTC market has grown to be more efficient over time ; falls at least in the semi-strong efficient form of market.
24	Caporale et al.	2018	Research in International Business and Finance	EMH; BPT	R/S analysis and fractional integration	CCY market is inefficient, and the investors can use multiple ways in order to generate abnormal returns and profits.

N.	Author	Year	Source/ Journal	Theory/ Goal (Probable-Implicit)	Methodology	Findings/ Understanding
25	Cheah et al.	2018	Economics Letters	EMH	Cointegrated VAR framework	BTC market is not efficient.
26	Bouri, Gil-Alana, et al.	2018	International Journal of Finance & Economics	EMH	Whittle function; Lagrange multiplier test; fractional integration	Shocks had a long-memory effects that are found in the absolute and squared returns measure for the volatility.
27	Kristoufek	2018	Physica A: Statistical Mechanics and its Applications	EMH	Efficiency index	US and Chinese currencies and found that both markets portray an inefficient basis with certain glimpses of efficiencies in small portions in relation to BTC.
28	Wei	2018	Economics Letters	EMH	Hurst exponent	CCY with a high market liquidity factor have a low return predictability.
29	Bouri, Gupta, et al.	2018	Finance Research Letters	EMH - Herding	Static model; Rolling-window; Logistic regression	No significant herding effect; a significant time-varying herding effect; existence of herding with an increase in uncertainty.
30	Mnif et al.	2020	Finance research letters	EMH - Herding	Multifractal analysis; generalized Hurst exponent; magnitude of long-memory	Some CCYs influenced by herd behavior; the efficiency of certain CCYs differ from the other.
31	Khuntia and Pattanayak	2018	Economics Letters	AMH	Dominguez-Lobato consistent test; generalized spectral test	Efficiency of the BTC improves that also validates the different implications of the AMH.
32	Koutmos	2018a	Economics Letters	AMH	ARMA-GARCH model; Markov regime switching model	With changes in different regime based on uncertainty, the factors determining the adaptation of liquidity uncertainty through bitcoin prices and other factors is difficult to measure; more stable data set for future research.
33	Abdelrhim et al.	2020	SSRN	EMH-AMH	Multiple regression; Beta Standardized Coefficients	CCYs had better returns on investment during the COVID19 pandemic period (post March 2020) as compared to traditional assets, generally.
34	Zhao et al.	2016	Financial Innovation	Agency theory and general	Literature overview	Multiple research suggestions and development

N.	Author	Year	Source/ Journal	Theory/ Goal (Probable-Implicit)	Methodology	Findings/ Understanding
35	Campbell-Verduyn	2018	Book	Agency theory and general	Literature development	Contemporary global governance; Monetary value of CCY; Smart contracts and legal tenders.
36	Troster et al.	2018	Finance Research Letters	Risk-Return	GARCH; GAS	BTC can be used as a hedging tool in the investment portfolio; heavy tailed GARCH and GAS models have better performance (in identification) than the normal GARCH; GAS better than GARCH in certain return and risk modelling.
37	Briere et al.	2015	Journal of Asset Management	Risk-Return	mean-variance spanning test; OLS	BTC in a portfolio provides a good diversification basis; significantly improves the risk and return trade-off; maybe a trait in the short-term dealing of the CCY.
38	Aalborg et al.	2018	Finance Research Letters	Risk-return	Regression; HAR-RV model;	Predicted volatility of BTC can be linked backed to its lagged values; value and volatility is changing tremendously.
39	Gkillas and Katsiampa	2018	Economics Letters	Risk-return	Value-at-risk; extreme value analysis	CCYs have different risk share.
40	Koutmos	2018b	Economics Letters	Risk-return	Variance decompositions; Vector autoregression	BTC is the largest contributor to the return/ volatility spillover, leading to higher interdependence among the CCYs and increase in the contagion risk.
41	Katsiampa	2018	Finance Research Letters	Risk-return; Hedge	BEKK model	Ethereum should be used in the portfolio to deter the risk of bitcoin as hedging strategy.
42	Corbet et al.	2020	Finance Research Letters	Risk-Return; contagion	GARCH	These assets may not act as possible safe havens or hedging alternative but possibly as “amplifiers of contagion”
43	Dwyer	2015	Journal of Financial Stability	Multiple	Literature development	Some effect on governments in terms of controlling inflation if the digital currency is used
44	Khursheed at al.	2020	Cogent Economics & Finance	AMH-EMH	Generalized Spectral (GS); Dominguez-Lobato (DL); automatic portmanteau test	Certain CCYs have a comparatively longer efficiency period than other CCYs; CCY price variations are impacted by varying market periods; use of AMH for a better forecast of market efficiency

Legend: CAPM-capital asset pricing model; APT- arbitrage pricing theory; BPT-Behavior portfolio theory; BTC-Bitcoin; AMH- Adaptive market hypotheses; EMH-Efficient market hypotheses

5. Summary and Conclusion

This study provides a review for the CCYs financial literature paradigm and with identification of future research areas. We discuss the position of CCYs in financial theories. The study has analyzed more than forty papers, reports, books and possible literature that relates and provides the most suitable gaps that can be studied and improved. The literature included in this study is not exhaustive, mainly due to the reason that the omitted literature has almost a similar approach and outcome of the included papers. Therefore, the input of these papers is scarcely different from the analyzed literature and has a limited addition to the paradigm and potential gaps. Limited work has been published in the area of theoretical framework of blockchain (DLT) and CCYs (other than bitcoins). Hence, the importance, contribution and implication of this study would mainly be for those investors and policy makers that have initiated various proposals to deal in these currencies. Our work can advices the individual investor who sees the CYS as an opportunity to diversify their investments due to the drive of digitizing the currency and payment mechanisms in various markets. In the current paper, we offered a discussion to the position of CYY in financial theories and how these theories can explain CCY behavior and how this new technology affects the applications of such theories.

As it is evident from the above presented background and literature review, it has to be realized that DLT is the future in financial technology while CCYs are one of the best applications of this technology, at least in the last decade since its inception in late 2000's. Should the regulators and established e-commerce giants initiate its applications for frequent trading, it will be a challenge to establish it worldwide with low theoretical development and basis and a risk to underestimate for global financiers in adapting the potential for application of the same in the financial portfolio and governance areas. This has to be supported by relevant development and analysis of literature and unless the theoretical and empirical analysis of the same is carried out at a competent and comprehensible level, the development and peak of the CCY through DLT will be difficult to achieve (Coeckelbergh, 2016).

The COVID19 pandemic had its medical affects around the world but influenced the financial world as well, mainly in the form of cash and hand to hand movement of money among other consequences. Research in this novel paradigm of medical emergencies and enhanced use and development of digital transactions is still developing. However, this area should have a promising contribution as the introduction of new technologies such as 5G and the push for new financial products and development of fintech may give the necessary impulse for further development and reception of CCYs and other fintech (Fu & Mishra, 2020; Goodell, 2020; Smeets & Zeisberger, 2020). In terms of COVID19 pandemic and how it has influenced the global finance and fintech paradigm has been fairly addressed in Goodell (2020) as a breif contribution. Based on our analysis, it is found that the studies in the area are based on limited data and approach. The overall approach and methodology can be further established via robust tests and inclusion of further time-series data that should assist in better understanding the impact of the pandemic and the stand of CCY in the various finance theories and paradigms.

With all the effort, literature and publications in this novel area of CCYs and fintech relation, most of the area needs further study and research (especially multiple CCYs that may include Bitcoin). As found in this study, there is a lot of scope for improvement and development in the CCY-finance paradigm as most studies were a direct empirical research contribution with limited theoretical and literature build-up. Hence, the contribution and significance of this paper as highlighted earlier needs to be considered. The questions that were posed are the identification of the theoretical relation and link of finance with CCY along with the areas of improvement and gaps in the area that needs further study and providing constructive observation of the authors on the literature covered in this study. Future research areas are mainly highlighted within the text itself, however, on a general level, more financial theories can be studied in order to further the CCY-fintech paradigm by going deeper into the methods and theoretical analysis. Furthermore, the research studies in this paradigm need to establish sufficient theoretical build-up to support the empirical analysis that can relate the theory to CCYs and its related facets in a much better fashion. This can be further improved with long-term data and shock period analysis with appropriate robust outcomes that can be applied and considered by stakeholders on a wider spectrum. The use of CCYs as a possible medium of exchange (in monetary terms) and its implications needs to be addressed whilst considering the governance and control mechanism in the financial system. Similar application needs to be extended into the behavioral perspective of investors and stakeholders, efficiency and embed with traditional investment assets.

Moreover, the CCY and DLT can also be expanded in other business-related subjects such as accounting, management and contracts, transparency and governance, supply chain, fintech-economic integration, information technology and data mining, legal applications, banking and investments, etc. These disciplines are inter-related to the concept of DLT and CCYs can cover each silo in its own terms and theories whilst also having a combined effect on the firm division level. However, an interdisciplinary study between different paradigms and subjects along with DLT/ CCY would be of more importance as these function through different spectrums of business processes. Hence allowing for a broader understanding of its impact and reach as a new tool of the 21st century and during situations such as COVID19. The paper may have the limitation of absence of certain literature in some sections; however, as it is an exploratory research, a general reach of idea is sufficient and shall assist the different stakeholders as a beneficial guide and information source on the topic.

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