

## **Emergence of Bitcoin as an Investment Alternative: A Systematic Review and Research Agenda**

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### **ABSTRACT**

Although Bitcoin has experienced immense popularity and growth since its inception, it has been essentially ignored by researchers because of its volatile and highly speculative nature. Hence, Bitcoin and other cryptocurrencies constitute a highly dynamic but not fully understood field of research. This paper presents a systematic review of the research conducted thus far relating to Bitcoin and cryptocurrencies. Using the databases of Web of Science and ScienceDirect through Boolean criteria, the authors initially identified 246 papers on Bitcoin and cryptocurrencies. After applying multiple acceptance and rejection criteria, the authors selected 121 of these papers for review. Their analysis found that the thematic framework of prior research on Bitcoin and other cryptocurrencies can be constructed around the introduction of concepts, price return and volatility behavior, relationship to other financial indicators and instruments, determinants of Bitcoin, degree of use and value, regulations and accounting framework, and future scope. Based on a review that highlights major trends, directions, and results available from existing literature, this paper identifies five important research gaps and presents a roadmap for future researchers and policymakers.

**Keywords:** Bitcoin, cryptocurrency, systematic review, Boolean, research agenda

## 1. INTRODUCTION

Since its inception as a peer-to-peer cryptocurrency in 2009, Bitcoin has experienced remarkable growth. Nakamoto (2008) originally proposed the idea in a white paper and released the related software as an open-source project. His work has been significantly improvised since then, mainly by volunteers.

Bitcoin facilitates online payments without going through financial institutions. It is understood and used in the form of an asset as well as a currency. As an asset, it acts as a store of value; as a currency, it is also a medium of exchange and a unit of account (Baur, Hong, & Lee, 2018). The success and failure of Bitcoin in both of these formats depends largely on its value compared with existing assets and currencies.

The pathetic value of Bitcoin in its early years is evident from the statement of a Bitcoin user who said in 2010: "I just want to report that I successfully traded 10,000 bitcoins for pizza" (Zohar, 2015). In December 2017, the price of Bitcoin crossed the level of \$19,000. This price rise has generated immense speculative, investigative, and research interest in Bitcoin and other cryptocurrencies. According to the website <https://coinmarketcap.com/>, there are now 1,519 cryptocurrencies in the world (accessed February 26, 2018). The market capitalization of Bitcoin constitutes 37.98% of the total market capitalization of all the cryptocurrencies (after reaching a high of 87.34% in December 2016). Its share is followed by Ethereum (19.36%), Ripple (8.45%), and Bitcoin cash (4.67%).

Academics essentially ignored Bitcoin for several years and informally argued that Bitcoin could not work, based on theoretical models and past experience, despite the fact that it was working in practice (Narayanan & Clark, 2017). Bitcoin and other cryptocurrencies, therefore, have not yet been fully understood in the academic world although they constitute a highly dynamic field of research. Numerous questions with high practical relevance remain to be answered. It is important, therefore, to follow future developments in this field (Tschorsch & Scheuermann, 2016).

Although Bitcoin has been recognized controversially because of criminal purposes, there is still a better picture of the system. Henry, Huynh, and Nicholls (2017) studied the drivers behind the adoption and use of Bitcoin in Canada and its potential implications for cash and concluded that about 64% of Canadians have heard of Bitcoin, but that only 2.9% use it. Bitcoin and other cryptocurrencies have benefits for most marginalized people, merchants, tax departments, and regulatory authorities. It has been considered a secure time-stamping system whose risk can be minimized subject to personal trade-off (Tschorsch & Scheuermann, 2016). It

enables a frictionless commerce and helps detect fraud through authentication of buyer and seller (Albuquerque & Callado, 2015). Dyhrberg (2016a) noted that Bitcoin combines the advantages of both currency and a commodity. Bouri, Azzi, and Dyhrberg (2017b) agreed that Bitcoin is an effective diversifier and a safe investment against risk. Despite its advantages and implications in the real world, more than 95% of all the Bitcoins in circulation are owned by only 4% of the market (Durden 2018). More participants are needed to avoid the concentration of Bitcoins in a few hands.

This paper seeks to consolidate the research conducted thus far relating to Bitcoins and other cryptocurrencies, with a view to setting a research agenda for the future. We start with the observations made by Hart (1998). Reviews conducted in the discipline of management are usually narrative and are criticized for inclusions based on the implicit biases of the researcher. Such reviews serve the interests of the researchers rather than those of policymakers (Davies, 2000). Davies (2000) made a case for systematic reviews by arguing that they allow researchers to overcome the limitations of single studies by highlighting the consistencies and variabilities of seemingly similar studies. Tranfield, Denyer, and Smart (2003) provided methodological inputs on developing systematic reviews for producing a reliable knowledge stock by conducting context-sensitive research.

In this study, we use the methodological rigor and the transparent and thorough process suggested by Tranfield, Denyer, and Smart (2003), Ferreira et al. (2016), and Talan and Sharma (2019) in order to develop our systematic review of the research conducted thus far relating to Bitcoins and cryptocurrencies. Such a review is important because of increased interest in the subject and because it allows us to better understand the research conducted in this field and to set a research agenda for future researchers. For review purposes, we use research studies indexed on Web of Science and ScienceDirect.

The paper is organized as follows. The present section provides a brief overview of the Bitcoin market and introduces the aim of the paper. Section 2 presents the research questions addressed in this paper. Section 3 discusses the methodology for our systematic review with respect to the Boolean criteria adopted to search for papers and the criteria used to select or reject papers for review. This section also explains the coding and classification used for the systematic review. Section 4 discusses the results of the study in terms of the descriptive findings and thematic issues. The paper concludes with Section 5, which sets up the research agenda for future researchers in the field of Bitcoin on the basis of research gaps found in our systematic review.

## 2. RESEARCH QUESTIONS

The focus of the systematic review in this paper is on cryptocurrencies, with explicit emphasis on Bitcoin. To identify and summarize the research gaps as a starting point for our research, we developed the following questions as the basis for our research.

**RQ1:** To conduct a comparative analysis of Bitcoin as an investment instrument in developing economies and across boundaries

**RQ2:** To implement a mixed-methods approach with case studies and user surveys and preferably a longer assessment period, and to produce better models and evaluation techniques to study price returns, volatility, and payment gateways

**RQ3:** To conduct future research directed toward legal and accounting regulations, usability, security, and scalability of the Bitcoin environment, and to focus on the correlation between different cryptocurrencies and other financial market instruments

## 3. METHODOLOGY

This paper proceeds by carrying out the analysis of articles previously published on Bitcoin, providing a brief summary of the contributions made by these articles, categorizing and coding the different parameters, describing the contributions of these studies, and providing the scope for further research to fill the gaps identified in the extant literature.

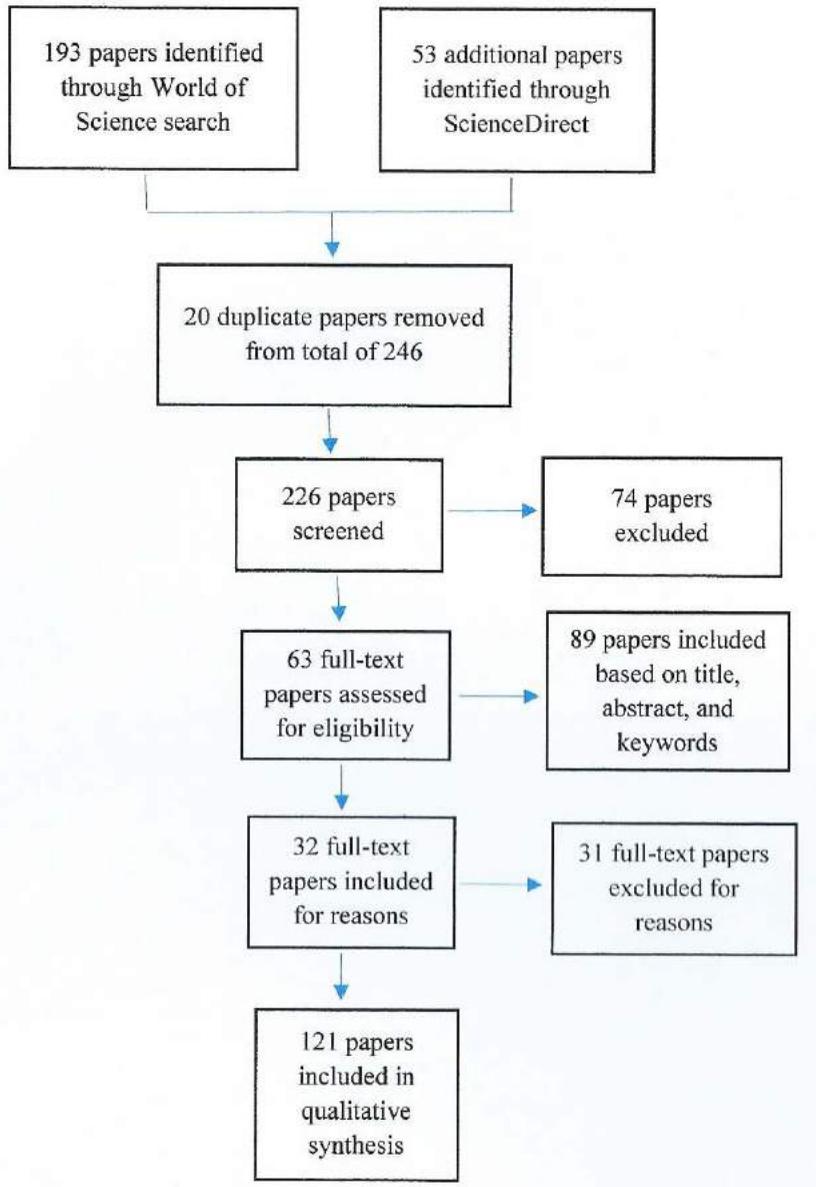
A nine-member panel of reviewers was formed to select the criteria for searching, evaluating, and selecting papers for our systematic review. The panel included the five authors of this paper, two financial sector industry experts, and one investor in Bitcoins.

The panel identified two keywords; namely, “Bitcoin” and “cryptocurrency.” It was decided to use two online databases to search for keyword combinations. These were Web of Science (WoS) and ScienceDirect (SD). The search on the Web of Science database was conducted December 23, 2017, using the following Boolean criterion:

TI=(Bitcoin\* OR cryptocurrency\*)

The search on ScienceDirect was conducted on December 26, 2017, using “Bitcoin” or “cryptocurrency” as the title-abstract-keyword as the search criterion, and selecting “business management and accounting” and “economics,

econometrics, and finance” as the subjects. The two searches resulted in an initial list of 246 papers (193 from Web of Science and 53 from ScienceDirect), as shown in Figure 1.



**Figure 1. Flow Diagram for Selection of Papers**

The review panel used this list to design objective criteria to select or reject papers for review. The authors of the current paper used the panel's criteria to manually include or exclude papers from the results of the searches.

As a result, 121 of the 246 papers were categorized and coded to provide an overall view of the existing literature on Bitcoins and cryptocurrency. Categorization of the papers included seven parameters, numbered 1 to 7 and coded by letters A to L, as shown in Table 1. Given the scope of the papers, some were given more than one code.

As shown in Table 1, category 1 pertains to type of coverage of the research presented in the paper. By considering this aspect, we can determine whether the research is more inclined toward developed countries or toward developing countries. We use the alphabetic codes A through C to indicate coverage. Code C, "no specific coverage," indicates that the paper does not apply to either developed or developing countries.

Category 2 pertains to geographic coverage in terms of specific countries. The alphabetic codes A through H are used to indicate the countries. Code H, "no specific country," indicates that the paper does not apply to any of the countries listed.

Category 3 deals with the focus of the papers in terms of the subject under study, coded as A through C. The intent is to identify papers that are directly or indirectly related to finance or that talk about the stability of price in the market, or that are based on the legal or accounting aspects of Bitcoin.

Category 4 covers the type of method used by the researchers. The codes A through F are used to identify the method and to observe whether there is a combination of methods that have gained popularity over the period.

Category 5 pertains to evaluation of the themes of the selected papers, coded A to K. These subtopics were identified after thoroughly reading all 121 papers selected for review in order to identify the themes of Bitcoin on which the papers focused.

Category 6 deals with the contribution in the field of research in the articles selected, with codes from A to E. This category was established to infer whether the selected papers introduce a new stream of research or whether they are in line with previous literature.

Category 7 pertains to the period covered by the selected papers, using codes A through E.

**Table 1**  
**Coding Categories for Papers Selected for Systematic Review**

<b>Category</b>	<b>Meaning</b>	<b>Codes</b>
1	Coverage	<b>A-</b> Developed countries <b>B-</b> Developing countries or emerging economies <b>C-</b> No specific coverage
2	Geographic Coverage	<b>A-</b> United States of America <b>B-</b> Asia <b>C-</b> England <b>D-</b> Australia <b>E-</b> Korea <b>F-</b> France, Spain & Germany <b>G-</b> Other countries <b>H-</b> No specific country
3	Context	<b>A-</b> It is related to finance. <b>B-</b> It is related to market and pricing theory. <b>C-</b> It is related to law and taxation. <b>D-</b> Other
4	Methodology	<b>A-</b> Quantitative <b>B-</b> Qualitative <b>C-</b> Quantitative/qualitative or qualitative/quantitative <b>D-</b> Survey <b>E-</b> Case study <b>F-</b> Other

*--Continued*

**Table 1** (Cont'd)

Category	Meaning	Codes
5	Themes	<b>A-</b> Introduction to the concepts of the area <b>B-</b> Price return and volatility behavior <b>C-</b> Relationship with other financial indicators <b>D-</b> Hedging capability <b>E-</b> Determinants of Bitcoin price <b>F-</b> Degree of use or value <b>G-</b> Regulations framework <b>H-</b> Accounting issues <b>I-</b> Transaction costs involved <b>J-</b> Research and Development in the area <b>K-</b> Future scope <b>L-</b> Other
6	Contribution	<b>A-</b> New perspectives <b>B-</b> Consistent with previous literature <b>C-</b> Previous model with different dataset/time period <b>D-</b> Comparative study <b>E-</b> Other
7	Period of Analysis	<b>A-</b> Less than 3 years <b>B-</b> Between 3 and 5 years <b>C-</b> Between 5 and 10 years <b>D-</b> More than 10 years <b>E-</b> Not applicable

## 4. FINDINGS AND DISCUSSION

This section presents our descriptive findings, offers a thematic discussion, examines Bitcoin as an investment avenue, explores price return and volatility behavior, describes degree of use and value, and addresses regulations and accounting framework.

### 4.1. Descriptive Findings

The review panel described in section 3 of this paper discussed each of the 121 selected papers and assigned the appropriate code for each of the seven categories explained in Table 1 above. When it was found that a paper did not match any specific code, the panel assigned the last code in each category, such as

“no specific coverage,” “no specific country,” “other,” or “not applicable.” Some papers matched more than one code, and these are shown in Table 2, along with papers that matched only one code.

In terms of category 1 (coverage), our analysis revealed that 84% of the papers have “no specific coverage”; i.e., do not focus on any specific region. We found that the majority of papers concentrate on price volatility, for which Bitcoin prices in U.S. dollars are considered (Trimborn & Härdle, 2016; Yellin, Pagliery, & Aratari, 2016; Ji & Chun, 2016; and Lischke & Fabian, 2016). We found that 12% of the papers cover developed countries (Chowdhury, 2016; Lee, et al., 2016; Kowalski, 2015; and Trimborn & Härdle, 2016), and that only 2% focus on developing countries. Contradictory to these findings, a recent report from Goldman Sachs (Pick, 2015) indicated that 80% of the Bitcoin volume is exchanged into and out of Chinese yuan, clearly suggesting a huge dominance by markets in China (a developing country). This led to identification of the first gap in existing research:

**Gap1:** *There is a need to conduct research on the use of Bitcoin and other cryptocurrencies in developing countries, including studies across countries (Morisse, 2015).*

With regard to category 2 (geographic coverage), we found that the great majority (85.95%) of the selected papers do not focus on any specific country. This finding implies that existing studies have instead focused on many countries together (Donier & Bonart, 2015; Kleineberg & Helbing, 2016b; Peng et al., 2018; Kim et al., 2016; Osterrieder & Lorenze, 2017; Kubat, 2015; Kim et al, 2017b; and Litsevanov, 2017).

Regarding category 3 (context), we found that 33% of the papers focus on market and pricing theory (Urquhart, 2017; Ciaian, Rajcaniova, & Kancs, 2016b; Kristoufek, 2015; and Blau, 2018), and that 29% focus on finance (Balcilar et al., 2017; Bouri, Azzi, & Dyrhberg, 2017b; Dyrhberg, 2016a; Katsiampa, 2017; and Peng et al., 2018). Among the remaining papers, 16% relate to law, and 6% relate to both market and pricing theory and to finance. This analysis reveals that the papers focus on linking Bitcoin to market and price theory in order to analyze the price influencing factors or determinants.

**Table 2**  
**Classification of Papers into Various Categories, Number(Percent)**

Category	Coverage	Geographical Coverage	Context	Methodology	Themes	Contribution	Period of Analysis
A	15(12.4%)	11(9.10%)	35(28.93%)	32(26.45%)	17(14.05%)	23(19%)	20(16.53%)
B	2(1.65%)	1(0.82%)	40(33.06%)	30(24.80%)	19(15.70%)	33(27.30%)	53(43.80%)
C	102(84.3%)	0(0%)	8(6.61%)	38(31.40%)	5(4.13%)	24(19.83%)	15(12.40%)
D	N/A	0(0%)	19(15.70%)	2(1.65%)	5(4.13%)	5(4.13%)	1(0.82%)
E	N/A	1(0.82%)	N/A	2(1.65%)	7(5.78%)	20(16.52%)	32(26.45%)
F	N/A	0(%)	N/A	7(5.78%)	2(1.65%)	N/A	N/A
G	N/A	1(0.82%)	N/A	N/A	6(4.96%)	N/A	N/A
H	N/A	104(85.96%)	N/A	N/A	4(3.30%)	N/A	N/A
I	N/A	N/A	N/A	N/A	3(2.49%)	N/A	N/A
J	N/A	N/A	N/A	N/A	2(1.65%)	N/A	N/A
K	N/A	N/A	N/A	N/A	3(2.49%)	N/A	N/A
L	N/A	N/A	N/A	N/A	N/A	N/A	N/A
M	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N	N/A	N/A	N/A	N/A	N/A	N/A	N/A
O	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Multiple Codes	2(1.65%)	3(2.48%)	19(15.70%)	10(8.27%)	48(39.67%)	16(13.22%)	N/A

N/A – Not Applicable

With respect to category 4 (methodology), we found that 31% of the papers use quantitative/qualitative or qualitative/quantitative methodology (Balcilar et al., 2017; Alvarez-Ramirez, Rodriguez, & Ibarra-Valdez, 2018; Nadarajah & Chu, 2017; Bouri, Gupta et al., 2017; and Osterrieder & Lorenz, 2017); that 26% use quantitative; 25% use qualitative (Boff & Ferreira, 2016; Tan & Low, 2017; Ram, Maroun, & Garnett, 2016); 2% use survey methodology; 2% involve a case study; 6% use other methods; and the remainder use a combination of methods.

These findings led us to identify the second gap in existing research:

**Gap2:** *Research studies using a mixed-method approach (Morisse, 2015) are rare; so, there is a need for future studies using this approach, including use of case studies and user surveys.*

Our analysis of category 5 (themes) revealed that 16% of the papers focus on price return and volatility behavior and that 14% provide a more generic view of the functioning and operations of Bitcoin. Apart from trading, there are other potential determinants of Bitcoin, such as economic drivers; namely, its use in transactions, its supply and price level, and increased public interest as evidenced by search engine queries for the word *Bitcoin* (Kristoufek, 2015).

Considering these factors of determination, the current study found that 6% of the selected papers report economic as well as fundamental factors of price determination. These papers extensively study the relation of Bitcoin to other financial indicators; namely, consumer price index, inflation, stock market indexes, and exchange rates (Dyhrberg, 2016a; Peng, et al., 2018; and Baur, Dimpfl, & Kuck, 2018). We found that papers focusing on legal regulations binding Bitcoin and its relationship to other financial variables constitute 5% of the papers reviewed.

With the emergence of this type of innovation in the financial markets industry, we found that only 3% of the papers focus on the future aspects and scope and provide a detailed description of the cryptocurrency market (Extance, 2015; Luther, 2016; and Kewell & Ward, 2017). We found that 2.48% of the papers jointly discuss future scope in terms of further research and development, along with other themes. Furthermore, we found that only 3% of the papers focus on the accounting treatment of Bitcoin, and that 4% discuss the hedging capabilities of Bitcoin in particular, where it possesses the same capabilities as gold and can therefore be used to hedge against stocks (Dyhrberg, 2016b). All of the other topics and combination of topics account for 40% of the papers reviewed. These findings led us to identify the third gap in existing research:

**Gap3:** *More research is required on legal regulations and the accounting framework, as well as usability from the developer's perspective; e.g., the difficulty of using Bitcoin. In addition, there is a need for studies focusing on the correlation between Bitcoin and other financial market indicators. There is also a need for more innovation and research on, for example, latency, size, bandwidth, and the development of advanced applications to ensure greater security and scalability (Yli-Huumo et al., 2016; and Conoscenti, Vetro, & deMartin, 2016).*

With regard to category 6 (contribution), we found that 28% of the papers reviewed arrive at findings that are “consistent with previous literature” (Albuquerque & Callado, 2015; Ram, Maroun, & Carnet, 2016b; Pinzo & Rocha, 2016; Zimmer, 2017; and Boff & Ferreira, 2016). We found that 20% of the papers used a “previous model with different dataset/time” (Dyrhberg, 2016a; Kondor, Csabai et al., 2014; Baur, Dimpfl, & Kuck, 2018; Ciaian, Rajcaniova, & Kanca, 2016b; and Cheah & Fry, 2015). Furthermore, we found that 5% of the papers conducted a “comparative study” and that 19% presented a “new perspective” (Alabi, 2017; Phillip, Chan, & Peiris, 2018; Al Kawasmi, Arnautovic, & Svetinovic, 2015; Indera et al., 2017; and Chaudhary et al., 2015). These findings led us to identify the fourth gap in existing research:

**Gap4:** *There is a need for studies using comparative analysis and a mixed-method approach (Morisse, 2015; Yli-Huumo et al., 2016) with respect to other cryptocurrencies and Bitcoin in order to produce better models and transactions in other cryptocurrencies.*

With regard to category 7 (period of analysis), we found that only 1% of the papers deal with a longer period of analysis (10 years or more) and that 12% cover a period of 5 to 10 years. This finding may reflect the fact that Bitcoin was in its early stage of evolution just five years ago and that its lack of popularity and use for a longer duration does not have much scope for research. We found that 26% of the papers are in category E (not applicable) because they neither consider a specific period nor have a historical orientation. We found, however, that 44% of the papers try to understand the data for a comparatively short duration of 3 to 5 years (Tiwari et al., 2018; Cheung, Roca, & Su, 2015; Briere, Oosterlinck, & Szafarz, 2015; and Jiang, Nie, & Ruan, 2017). These findings reflect the increased popularity and use of Bitcoin in the last 3 to 5 years, resulting in increased demand

and price and thus generating enough evidence to prompt researchers to undertake further study. The findings led us to identify the fifth gap in existing research:

**Gap5:** *There is a need for studies focusing on a longer period of analysis in order to better understand Bitcoin and cryptocurrencies, to address the problems related to finance and the cryptocurrency market, and to ascertain whether the relationship between the subjects is consistent over time.*

## 4.2. Thematic Discussion

This section begins with an integrative framework and presents a thematic discussion of the Bitcoin market that emerges from the papers analyzed in the systematic review conducted during the current study. Figure 2 depicts the integrative framework developed for this study.

Thematic discussion involves arguments and further details on each of the dimensions through their respective parameters, classified into seven subsections, as shown in Table 3.

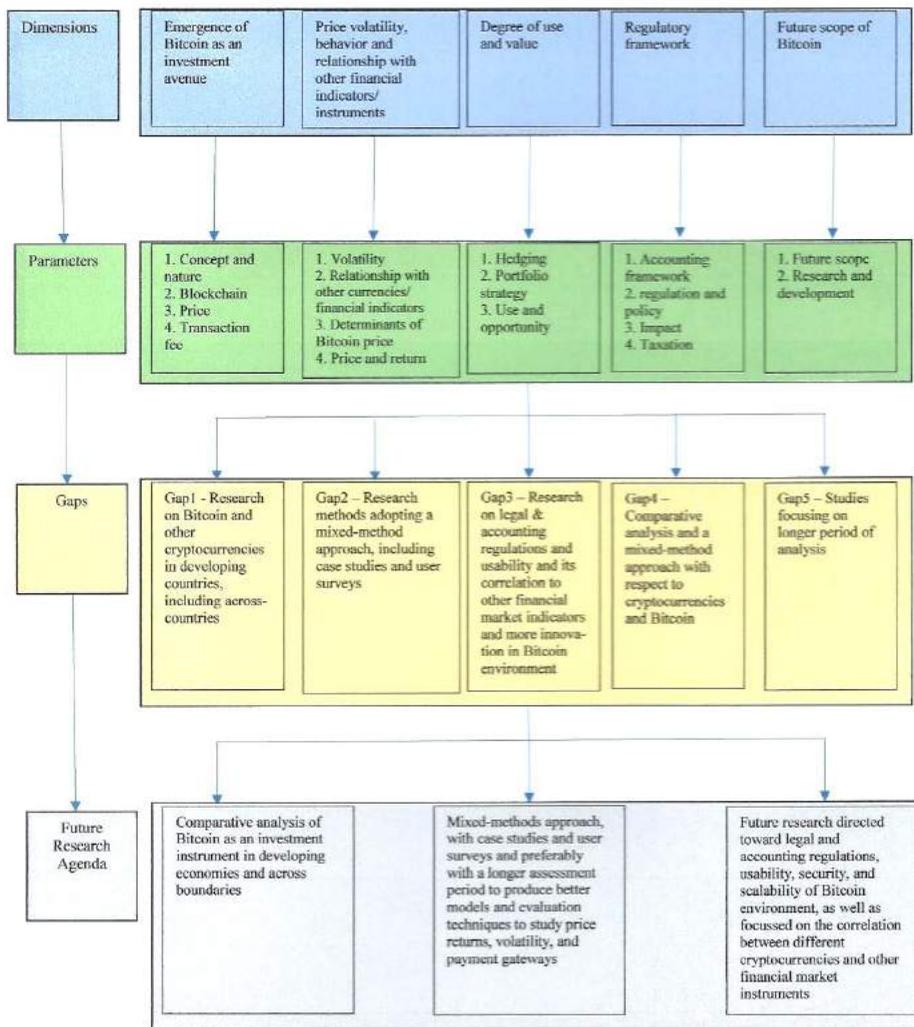
In the following narrative, we discuss briefly the topics and characteristics of the papers on Bitcoin that were included in our systematic review.

### 4.2.1. Emergence of Bitcoin as an Investment Avenue

Bitcoin, which was invented by Satoshi Nakamoto, was the first cryptocurrency created, and was released as an open source software in 2009. The first definition on the Bitcoin portal states: “Bitcoin is an innovative payment network and a new kind of money” (Bitcoin.org, 2014). Bitcoins are created through a process called *mining* and can be exchanged for other currencies, products, and services (Yellin, Pagliery, & Aratari, 2016). Information on its emergence as an investment avenue is presented in Table 4.

When a transaction is requested, it is broadcasted to a peer-to-peer network comprising computers called *nodes*. After verification, the transaction is combined with other transactions to create a block of data for the ledger, which is added to a permanent and irreversible blockchain. In this way, the transaction is completed at this stage (Rosic, 2016). Kondor, Csabai, Szuele, Posfai, and Vattay (2014) found that the time-varying contribution of some of the base networks reflect a clear correspondence with the market price of Bitcoins.

Miners confirm the transactions by including them in the blockchain. Miners perform proof-of-work by using their computers; that is, they find a product of cryptographic function called *hash*, which connects the block to its predecessor. Bitcoin is based on the SHA 256 hash algorithm.



**Figure 2. Integrative Framework for Current Study on Bitcoin**

**Table 3**  
**Dimensions of Research on Bitcoin**

Dimensions	Authors	Research Design(s)	Identified Parameters
2.1. Emergence of Bitcoin as an investment avenue	T. Kim (2017); Kubát (2015); Phillip, Chan, & Peiris (2018); Santos (2017); Smit, Buekens, & DuPlessis (2016); Tiwari, Jana, Das, & Roubaud (2018); Ying, Jia, & Du (2018); Zimmer (2017); Kondor, Csabai et al. (2014); Kondor, Posfai et al. (2014); Li & Wang (2017)	Conceptual and empirical	Concept & nature, blockchain, price, transaction fee
2.2. Price, volatility behavior and relationship to other financial indicators and instruments	Balcilar, Bouri, Gupta, & Roubaud (2017); Baur, Dimpfl, & Kuck (2017); Bouoiyour & Selmi (2016a); Carrick (2016); Ciaian et al. (2016); Hayes (2017); Katsiampa (2017); Kim et al. (2016); Kristoufek (2015); Peng, Albuquerque, Camboim de Sá, Padula, & Montenegro (2018); Pieters & Vivanco (2017); Urquhart (2017); Indera et al. (2017a)	Empirical	Price and return, volatility, determinants of price, relationship to other currencies / financial indicators
2.3. Degree of use and value	Bouri, Gupta, et al. (2017b); Bouri, Jalkh, Molnár, & Roubaud (2017); Bouri, Molnar et al. (2017); Briere, Oosterlinck, & Szafarz (2015); Hong (2017); Lintilhac & Tourin (2017); Dyhrberg (2016a)		Hedging, portfolio strategy, use, and opportunity
2.4. Regulation framework	Hendrickson & Luther (2017); Ram, Maroun, & Garnett (2016b); Tan & Low (2017); Bryans (2014); Dwyer (2015); Gross, Hemker, Hoelscher, & Reed (2017); Hendrickson, Hogan, & Luther (2016); Luther & Salter (2017); Weber (2016); Sotiropoulou & Guégan (2017b)	Conceptual and empirical	Regulation and policy, impact, accounting framework, taxation
2.5. Future scope of Bitcoin	Cocco, Concas, & Marchesi (2017b); Elbahrawy, Alessandretti, Kandler, Pastor-Satorras & Baronchelli (2017); Henwood (2014); Kleineberg & Helbing (2016b); Luther (2016); Pavlovski (2015a)	Conceptual and empirical	Future scope, research & development

**Table 4**  
**Emergence of Bitcoin as an Investment Avenue**

<b>Author(s)</b>	<b>Objectives</b>	<b>Methodology</b>	<b>Identified Parameters</b>
Phillip et al. (2018)	To conditionally measure the varied nature of crypto-currencies using several attributes	Uses stochastic volatility model of Taylor (1986) to describe time-varying nature of volatility	Concept and nature
Zimmer (2017)	To develop historical and political understanding of bitcoin stack	Conceptual paper proposing comparison between colonial South American silver mining and the global currency regime	Concept and nature
Smit et al. (2016)	To examine and argue whether what kinds of things can be considered as money	Conceptual paper arguing that, for all currencies, the object of coordination is exchanged on a relative scale	Concept and nature
Ying et al. (2018)	To analyze the use of blockchain for digitally enabling organizations	Study of Hainan Airlines (HNA) group that implements block-chain-enabled e-commerce platform	Blockchain
Tiwari et al. (2018)	To determine Bitcoin's price efficiency	Uses a battery of long-range dependence estimators from July 18, 2010, to June 16, 2017	Price
Santos (2017)	To evaluate whether Bitcoin / blockchain is complex system based on its likelihood to enter the 2010-Flash-Crash type of chaotic regime	Highlights relevant details of Bitcoin/blockchain using Crutchfield's statistical complexity measure	Blockchain
Kubát (2015)	To review the economic and technical aspects of Bitcoin	First part is conceptual focusing on economic aspects; second part is empirical to study volatility.	Concept and nature

*--Continued*

**Table 4** (Cont'd)

<b>Author(s)</b>	<b>Objectives</b>	<b>Methodology</b>	<b>Identified Parameters</b>
Kondor, Csabai et al. (2014)	To explore how structural changes in the network accompany significant changes in the exchange price of Bitcoins	Principal component analysis of the matrix constructed for the network at different times to identify changes in Bitcoin price	Price
Kondor, Posfai et al. (2014)	To analyze Bitcoin using datasets to reconstruct the network of transactions	Analysis of the structure of the transaction network by measuring network characteristics over time	Transaction fee
Kim (2017)	To examine the empirical transaction costs of Bitcoin in international transactions	Uses Bitcoin quotes in 16 currencies and examines empirical transaction cost of Bitcoin	Transaction fee
Li & Wang (2017)	To conduct a theory-driven empirical study of the Bitcoin exchange rate (against USD), using technological and economic factors	Empirical study of Bitcoin exchange rate using auto-regressive distributed lag (ARDL) model with bounds test approach	Transaction fee

Here, we continue the discussion of the role of miners in Bitcoin transactions. Miners solve cryptographic puzzles to obtain the right to add a transaction, which gives them a specific number of Bitcoins. This is the only way to create valid Bitcoins (Rosic, 2016). Tschorsch and Scheuermann (2016) concluded that, with mining, fake identities would be able to subvert the consensus and destroy the system; hence, there is less than a 50% chance of any such attack. Santos (2017) discussed the philosophy of blockchain technology from its inception to evolution over time and reported that it might be considered algorithmically complicated, though not a complex system.

The transaction fees of cryptocurrency depend mainly on the supply of the network capacity and the demand from the currency holder for a faster transaction. Kim (2017) reported that Bitcoin can be a lower-cost alternative to the foreign exchange market. Hence, a trader might be better off by converting a currency to another, using Bitcoin as the intermediary, at a lower rate than the retail foreign exchange rate.

Although cryptocurrencies are in the early stages of development, they challenge existing systems of currency and payment. As of January 2018, there were more than 1,500 digital currencies in existence.

#### **4.2.2. Price Return and Volatility Behavior**

Table 5 presents information on price relations and its parameters.

**Table 5**  
**Price Relations and Its Parameters**

<b>Author(s)</b>	<b>Objectives</b>	<b>Methodology</b>	<b>Identified Parameters</b>
Osterrieder & Lorenz (2017)	To measure an extreme value analysis of the returns of Bitcoin	In-depth empirical univariate extreme value analysis to compare the exchange rates with those of G10 currencies	Volatility
Carrick (2016)	To examine the use of Bitcoin as a complement to emerging market currencies	Empirical study to evaluate the value and volatility of Bitcoin relative to emerging market currencies	Relationship with other currencies / financial indicators
Baur, Dimpfl et al. (2017)	To analyze the relationship between Bitcoin, gold and the US dollar	Research with GARCH volatility analysis to study relationship between Bitcoins, gold, and U.S. dollar	Relationship with other currencies / financial indicators
Bouoiyour & Selmi (2016)	To examine whether Bitcoin enters new phase after crash of 2015	Application of GARCH models to daily Bitcoin data, 2010 to 2016	Determinants of price

*--Continued*

**Table 5** (Cont'd)

<b>Author(s)</b>	<b>Objectives</b>	<b>Methodology</b>	<b>Identified Parameters</b>
Balcilar et al. (2017)	To analyze the causal relation between trading volume and Bitcoin returns and volatility	Use of non-parametric causality-inequalities test to analyze the relation between volume, volatility, and Bitcoin returns	Price and return
Hayes (2017)	To identify the likely determinants for cryptocurrency value formation	Use of cross-sectional empirical data to examine 66 cryptocurrencies, including estimated regression model	Determinants of price
Pieters & Vivanco (2017)	To identify significant differences in Bitcoin prices across 11 markets representing 26% of global Bitcoin trade volume	Empirical study examining significant differences across 11 markets representing 26% of global Bitcoin trade volume	Price and return
Indera et al. (2017)	To propose a model for Bitcoin price prediction through validation tests	Proposes non-linear auto-regression with exogenous inputs for Bitcoin price forecasting model to predict prices accurately	Determinants of price
Kim et al. (2016)	To propose method for predicting fluctuations in the prices of cryptocurrencies	Analysis of user comments in online cryptocurrency communities in order to predict fluctuations in cryptocurrency prices	Price and return
Urquhart (2017)	To study behavior of Bitcoin prices and the relationship between price and volume and price clustering	Empirical analysis of the daily closing prices of Bitstamp from 2012 to 2017	Price and return

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**Table 5 (Cont'd)**

<b>Author(s)</b>	<b>Objectives</b>	<b>Methodology</b>	<b>Identified Parameters</b>
Garcia & Schweitzer (2015)	To derive insights into the principles behind the profitability of trading strategies	Analysis of economic signals of volume and price of exchange for USD to design algorithm trading strategies for Bitcoin	Price and return
Bariviera, Basgall, Hasperue, & Naiouf (2017)	To investigate various statistical properties of the Bitcoin market	Implements the detrended fluctuation analysis method to compute the Hurst exponent to test memory in time series, 2011 to 2017	Relationship with other currencies / financial indicators
Peng et al. (2018)	To evaluate predictive performance of the volatility of three cryptocurrencies and three currencies	Combines traditional GARCH models with machine learning approach to volatility estimation using support vector regression	Volatility
Ciaian et al. (2016)	To study Bitcoin price formation by considering both the traditional determinants of currency price and digital currencies specific factors	Uses daily data from 2009 to 2015 and applies time-series analytical mechanisms	Determinants of price
Jiang, Nie, & Ruan (2017)	To investigate time-varying long-term memory in the Bitcoin market	Uses a rolling window approach and a new efficiency index on daily dataset from 2010 to 2017	Price and return
Ciaian, Rajcaniova, & Kancs (2018)	To examine inter-dependencies between Bitcoin and Altcoin markets in short and long term	Applies time series analytical mechanisms to daily data for 17 virtual currencies and two Altcoin price indices, 2013 to 2016	Relationship with other currencies / financial indicators

*--Continued*

**Table 5** (*Cont'd*)

<b>Author(s)</b>	<b>Objectives</b>	<b>Methodology</b>	<b>Identified Parameters</b>
Katsiampa (2017)	To compare various GARCH models for estimating volatility of Bitcoins	Explores the optimal conditional heteroskedasticity model with regard to goodness-of-fit test to Bitcoin price data	Volatility
Kristoufek (2013)	To examine the potential speculative or technical drivers of Bitcoin prices	Analyzes the relationship between Bitcoin price and interest in the currency evident from search queries on Google trends and Wikipedia	Determinants of price
Bouoiyour & Selmi (2015)	To identify the main determinants of Bitcoin price by means of rigorous evaluation	Evaluation using the ARDL bounds testing method in the Shanghai stock market	Determinants of price
Bouoiyour et al. (2016)	To assess the issue of Bitcoin price formation from a novel perspective	Implements new technique called empirical mode decomposition (EMD)	Determinants of price

In his empirical analysis of closing prices, Urquhart (2017) found price clustering around whole numbers that is significantly related to price and volume. Bariviera et al. (2017) found that daily returns on Bitcoins exhibited a persistent behavior until 2014, but became informational efficient thereafter. Bariviera et al. (2017) also found that the long memory content of daily volatility is stronger than that of daily returns.

In their study of exchange rate fluctuations and the behavior of Bitcoin in extreme scenarios, Osterrieder and Lorenz (2017) observed that Bitcoin returns are much more volatile, much riskier, and exhibit much higher clustering of extreme events, both for negative and positive returns. Coco, Concas, and Marchesi (2017) presented the first heterogeneous agent model of the Bitcoin market, accurately modeling the characteristics of the real market and reporting the presence of volatility clustering.

The trading phase of Bitcoins can also be characterized in terms of stable network measures. Kondor et al. (2014) identified a scaling relation between the degree and wealth associated with individual nodes. Kristoufek (2013) analyzed

the dynamic relationship between Bitcoin prices and interest in the currency, which is evidenced by search queries on Google Trends and Wikipedia. Kim et al. (2017) analyzed user comments posted on the Bitcoin online forum and found a strong linear relationship to, and effects on, fluctuations in Bitcoin price and transactions. They also proved that China has a strong influence on Bitcoin price.

Bitcoin is used mainly as a speculative investment (Baur, Hong, & Lee, 2018). Economists have compared Bitcoin to gold because they have many similarities. Dyhrberg (2106a) reported, for example, that both Bitcoin and gold react symmetrically to good and bad news and that both act like a currency as well. Dwyer (2015), however, found that the average monthly volatility of returns on Bitcoin is higher than for gold and for a set of foreign currencies.

Baur, Hong, & Lee (2017) analyzed the statistical properties of Bitcoin and found that it is uncorrelated with other asset classes (e.g., stocks, bonds, and commodities), both in normal times and in periods of financial crisis. On the other hand, Bouri, Azzi, & Dyhrberg (2017) reported a negative relationship between the U.S. implied volatility index and Bitcoin volatility. Baek and Elbeck (2015) and Ciaian, Rajcaniova, and Kancs (2016) suggested that Bitcoin is a speculative vehicle driven by Bitcoin exchange participants, the buyers and sellers, and that global macro-financial variables play no role. Donier and Bonart (2015) reported that impact is driven by the simple mechanism of supply and demand and by the pre-existing notion of arbitrage. Hayes (2017) identified three main drivers of Bitcoin value; namely, the level of competition in the network of producers, the rate of unit production, and the difficulty of mining Bitcoins.

#### ***4.2.3. Degree of Use and Value***

Information on the degree of use and its parameters are presented in Table 6. From the studies listed in the table, one can see that, although many virtual currencies have been created in recent years, Bitcoin is the best known, most popular, and the most extensively used. Albuquerque and Callado (2015) observed a lot of criticism of the widespread use of Bitcoins and found that a dichotomy exists between those who think Bitcoin can solve problems in the economic system and those who think that cryptocurrencies could be highly destructive to society. In their study of the price crash of December 2013, Bouri, Azzi, and Dyhrberg (2017b) concluded that, in the pre-crash period, Bitcoin could be added to the U.S. equity portfolio for an effective risk reduction, but this characteristic disappeared post-crisis.

**Table 6**  
**Degree of Use and Its Parameters**

<b>Author(s)</b>	<b>Objectives</b>	<b>Methodology</b>	<b>Identified Parameters</b>
Bouri, Jalkh et al. (2017)	To assess the ability of Bitcoin to act as a diversifier, hedge, or safe haven against daily movements in energy commodities	Uses bivariate asymmetric dynamic conditional correlation model to study diversification properties between Bitcoin and three commodities	Hedging
Bouri, Gupta et al. (2017)	To examine whether Bitcoin can hedge global uncertainty	Empirical study on decomposition of Bitcoin returns into various frequencies (i.e., investment horizons), using quantile-on-quantile regression	Hedging
Dyhrberg (2016b)	To explore the hedging capabilities of Bitcoin against market-specific risk	Uses asymmetric GARCH methodology	Hedging
Lintilhac & Tourin (2017)	To propose an optimal dynamic pairs trading strategy model for a portfolio of cointegrated assets	Uses stochastic control techniques to compute portfolio weights and relate results to static double-threshold strategy	Portfolio strategy
Bouri, Molnar et al. (2017)	To examine whether Bitcoin can act as a hedge and safe haven for world stock indices, bonds, commodities.	Uses dynamic conditional modeling technique on daily and weekly data from 2011 to 2015	Hedging
Hong (2017)	To evaluate the time series momentum in Bitcoin returns and other asset returns.	Considers Bitcoin price data from 2013 to 2015 and uses generalized least squares (GLS) estimation method	Use and opportunity
Briere et al. (2015)	To explore the inclusion of Bitcoin in a diversified portfolio and its impact	Takes weekly Bitcoin data from 2010 to 2013 and uses spanning tests	Portfolio strategy

Lischke and Fabian (2016) concluded that a major share of Bitcoin transactions is involved with gambling services and the dice game SatoshiDICE and that 87% of Bitcoin transactions in China are linked to gambling.

Bouri, Gupta et al. (2017) found that Bitcoin is a hedge against uncertainty that is observable at shorter investment horizons at both the lower and upper ends of Bitcoin returns and global uncertainty. Bouri, Azzi, and Dyhrgerb (2017), however, found that, in the case of Asian stocks, Bitcoins can serve as a safe investment against extreme down movements.

#### **4.2.4. Regulations and Accounting Framework**

As the most popular virtual currency, Bitcoin has attracted extraordinary attention as a financial innovation, but studies have shown that it poses various risks, such as terroristic acts, money laundering, customer theft, fraud, and financial instability in general. Governments, regulators, and law enforcement authorities have been compelled to protect the rights of consumers, businesses, and financial systems. To guard against risks, Sotiropoulou and Guegan (2017) have recommended the development of international standards and best practices such as a financial action task force as a means of clarifying the implementation of standards to virtual currency.

Bryans (2014) stated that regulations should occur where law enforcement can most effectively punish civil and criminal violations without disrupting innovative technologies. Hughes and Middlebrook (2015) suggested a new commercial law covering the rights and obligations of intermediaries involved in cryptocurrency transactions.

With their increasing popularity and innovative characteristics, Bitcoin and other virtual currencies need generally accepted accounting standards. Ram, Maroun, and Garnett (2016) recommended the cost and fair value proposed by models of neo-liberalism and stewardship, respectively, in order to express the economic rationale of holding Bitcoins. Tan and Low (2017), however, concluded that no new accounting treatment is required for financial reporting of Bitcoin, and suggested instead an authoritative interpretation through IFRS interpretation committees.

Table 7 presents information on the regulation framework and its parameters.

**Table 7**  
**Regulation Framework and Its Parameters**

<b>Author(s)</b>	<b>Objectives</b>	<b>Methodology</b>	<b>Identified Parameters</b>
Ram et al. (2016)	To determine a conceptual approach for accounting for Bitcoin	Uses an interpretative mixed-method approach and semi-structured interviews	Accounting framework
Hendrickson & Luther (2017)	To examine the extent to which a government can ban an alternative currency; namely, Bitcoin	Uses a monetary model with endogenous search and random consumption preferences	Regulation and policy
Tan & Low (2017)	To contribute to a standard setter's conceptualization of approaches to digital currency	Applies accounting principles to a practical issue to contribute to the standard setter's approach to digital currency	Accounting framework
Bryans (2014)	To examine application of federal and state anti-money-laundering regulations to Bitcoin	Identifies challenges tasked with regulating money-laundering and look for the best option	Regulation and policy
Luther & Salter (2017)	To explore the effect of increased downloads of Bitcoin apps on specific countries	Collects rank data on all 15 Bitcoin apps and estimates the index of downloads for each country	Impact
Sotiropoulou & Guégan (2017)	To analyze the risks associated with the use of Bitcoins because of the absence of financial regulation	Conceptually highlights regulations in the Bitcoin ecosystem, including Bitcoin protocol, uses, and members	Regulation and policy
Weber (2016)	To examine governance of Bitcoin system and its legitimacy as a payment and monetary system	Focuses on Bitcoin's potential to create input and output legitimacy as a payment and a monetary system	Regulation and policy

*--Continued*

**Table 7** (Cont'd)

Author(s)	Objectives	Methodology	Identified Parameters
Dwyer (2015)	To explain the use of the technologies and limitation of quantity produced that creates an equilibrium	Uses data from Mt. Gox from 2010 to 2013 and on U.S. dollar trades from 2010 to 2014 and examines the daily volatility of Bitcoin prices	Impact
Hendrickson et al. (2016)	To identify conditions under which government transactions policy might deter the use of Bitcoin	Uses a model with endogenous matching and random consumption preferences	Regulation and policy
Gross et al. (2017)	To explore tax issues related to transaction in the lack of authoritative guidance	Uses example of Winklevoss twins' purchase of tickets on Virgin Galactic's Spaceship Two using Bitcoins	Taxation

#### **4.2.5. Future Scope**

Fiat and peer-to-peer cryptocurrency are relatively new technologies. Pavlovski (2015) presented a reference architecture for banking that illustrates the key technical components and security controls required to support these new financial technologies. Luther (2016) concluded that Bitcoin technology and that of other cryptocurrencies will be widely adopted to process digital payments.

Kleineberg and Helbing (2016) discussed the multidimensional currency system that represents the social-digital capital; i.e., social Bitcoin. The system could be generated by the individuals who perform search and navigation in the digital world, which would sustain digital diversity by reducing control by powerful monopolies and creating new business opportunities.

Harwick (2016) evaluated schemes to stabilize purchasing power by adjusting the quantity of coins. He concluded that the future progress of cryptocurrency depends on the financial intermediaries whose cryptocurrency-dominated liabilities circulate as media of exchange.

Table 8 presents information on the future of Bitcoin and its parameters.

**Table 8**  
**Future of Bitcoins and Its Parameters**

<b>Author(s)</b>	<b>Objectives</b>	<b>Methodology</b>	<b>Identified Parameters</b>
Kleineberg & Helbing (2016)	To discuss how social Bitcoins can sustain digital diversity and create business opportunities	Discusses how one dimension of a multi-dimensional currency system could represent socio-digital capital (social Bitcoins)	Future scope
Luther (2016)	To explore the factors that facilitate exchange in the Bitcoin market	Analyzes the obstacles to Bitcoin from incumbent monies and Altcoins	Future scope
Elbahrawy et al. (2017)	To shed light on properties of the cryptocurrency market and establish a first formal link between ecological modeling and the study of this system	Considers history and analyzes 1,469 cryptocurrencies from 2013 to 2017	Research and development
Pavlovski (2015)	To propose a reference architecture for adopting such a form of financial asset in a central banking scenario; i.e., fiat-based cryptocurrency	Provides insights on trends in cryptocurrency and proposes an IT solution to accommodate centrally issued electronic currency	Research and development
Cocco et al. (2017)	To review an agent-based artificial cryptocurrency market in which heterogeneous agents buy or sell cryptocurrencies, in particular Bitcoins	Studies two types of typologies – random traders and chartists -- and proposes a model to produce real-time statistical properties of Bitcoin market	Research and development
Henwood (2014)	To examine the future of Bitcoins, with respect to various considerations	Discusses controversies relating to cryptocurrency's correlation with bankruptcies and thefts and political views of libertarians and socialists	Future scope

## **5. CONCLUSION AND RESEARCH AGENDA**

This paper presents a systematic review of research studies on Bitcoin and other cryptocurrencies. Based on our analysis of the papers selected from Web of Science and ScienceDirect, we found that the thematic framework of research about Bitcoin and other cryptocurrencies can be constructed around the introduction of concepts, price return and volatility behavior, relationship with other financial indicators and instruments, determinants of Bitcoin, degree of use and value, regulations and accounting framework, and the future scope of Bitcoin and other cryptocurrencies.

Based on our systematic review of the papers selected for this study, we identified five important research gaps, as stated earlier in this paper:

1. There is need to conduct research on the use of Bitcoin and cryptocurrency in developing countries and across countries as well.
2. Research methods adopting a mixed-method approach are rare; hence, there is a need for this kind of work, including case studies and user surveys.
3. More research is needed on legal regulations and the accounting framework of Bitcoin, as well as its usability from a developer's perspective; for example, the difficulty of using Bitcoin has not been addressed. There is also a need for studies focusing on the correlation of Bitcoin with other financial market indicators. There is likewise a need for more innovation and research on, for example, latency, size, bandwidth and development of advanced applications to ensure greater security and scalability.
4. There is a need also for research that performs a comparative analysis and mixed-method approach with respect to other cryptocurrencies and Bitcoin, which will reveal and produce better models and transactions in both areas.
5. To better understand this subject, especially from its inception, there is a need for studies focusing on a longer period of analysis.

Future research efforts may focus on the five research gaps identified above or on the three research questions set forth in section 2 of this paper. Table 9 presents the five research gaps in relation to the research questions.

**Table 9**  
**Research Gaps Attached to Research Questions**

Gap <sub>1</sub> – There is a need to conduct research about use of Bitcoin and cryptocurrency in developing countries, including across the countries as well	RQ <sub>1</sub> – To conduct a comparative analysis of Bitcoin as an investment instrument in developing economies and across boundaries
Gap <sub>2</sub> – Research methods adopting a mixed method approach are rare and so there is a need for the same, including case studies and user surveys	
Gap <sub>3</sub> – More research is required on the legal regulations and accounting framework, and usability from developer’s perspective, e.g. difficulty of using Bitcoin is not been tackled. Additionally, the studies focusing on the correlation of Bitcoin with other financial market indicators seem a necessity. There is also a need for more innovation and research on e.g. latency, size, bandwidth and development of advanced applications to ensure a more security and scalability	RQ <sub>2</sub> – To implement a mixed methods approach, additionally with case studies and user surveys and preferably a longer assessment period, to produce better models and evaluation techniques to study price returns, volatility and payment gateways
Gap <sub>4</sub> – Studies performing a comparative analysis and a mixed method approach with respect to other cryptocurrencies and Bitcoin is called for, which shall reveal and produce better models and transactions in other cryptocurrencies as well	RQ <sub>3</sub> – To conduct future research directed towards legal and accounting regulations, usability, security and scalability of Bitcoin environment as well as focused on the correlation between different cryptocurrencies and other financial market instruments
Gap <sub>5</sub> – To better understand this subject, especially from its inception, the studies focusing on longer period of analysis are relevant and needful.	

The literature review in the current study is limited to Web of Science and ScienceDirect databases, excluding purely law and technology-based papers. It is up to future researchers, therefore, to include other databases, journals, and references, as well as purely law and technology-based papers, in order to gain a better insight into and understanding of Bitcoin and other cryptocurrencies.

Our evaluation of each of the papers selected for systematic review was based on subjective interpretation of the literature. There is a need, therefore, for additional discussion in future research.

This systematic review of the literature provides an overview and summary of existing studies relating to cryptocurrencies and offers a starting point for future research in this area.

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