# Antecedents and Consequences of Blockchain Innovations

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*Emergent Research Forum (ERF)*

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## Abstract

Blockchain technology is playing an increasingly important role in modern business. We aim to study the impact of blockchain innovations on firm performance and how firms respond strategically to the threat of disruption from the blockchain. Based on disruptive innovation theory and resource-based view, we propose that peer firms' blockchain innovations could stimulate the focal firm's blockchain innovations as the blockchain innovations improve firm performance. We empirically examine one antecedent and possible outcomes of blockchain innovations with blockchain-related technology patents data from 2001 to 2020. Results from a fixed effect panel analysis and textual analysis offer theoretical insights into the role of blockchain as a new disruptive innovation and provide firms with suggestions on blockchain innovations.

**Keywords**

Blockchain innovation, blockchain technology, patents, disruptive, LDA model.

## Introduction

Blockchain technology is most simply defined as a decentralized, distributed ledger that records the provenance of a digital asset. Due to the advantages of blockchain to increase trust, security, transparency, and data traceability, it is widely used in various industries. The global blockchain market size is expected to grow from USD 4.9 billion in 2021 to USD 67.4 billion by 2026 (Markets&Markets, 2021).

The rapid development of blockchain technology has also triggered academic research to investigate its business value. So far, most studies rely on cases studies and literature review to propose and examine the impact of blockchain innovations on firm performance with the exception of a few studies (Chen et al., 2019)

Disruptive innovation frequently employs new technologies or business models to replace old business practices, resulting in new needs, rivals, and business models (Suseno, 2018). There is very little empirical evidence on how disruptive blockchain innovation affects firms' performance and IT strategies (Gupta et al., 2018). It is thus of high importance to empirically understand the antecedents and consequences of Blockchain Innovations. The following research questions guide this study:

*RQ1. How do firms respond to disruptive blockchain innovations by peer firms in terms of their own blockchain innovations?*

*RQ2. To what extent do blockchain innovations improve firms' performance?*

To understand how blockchain technology innovations influence firms' performance and IT strategies, we make use of the blockchain patents data from 2001 to 2020 and the corresponding financial data. LDA topic modeling is used to identify blockchain technology innovation types. Through fixed-effects panel data analysis, we find out how firms in different industries respond strategically to the blockchain innovations of peer firms. Theoretically, we provide insights in understanding blockchains' role as a new disruptive innovation. Practically, we provide firms with suggestions on blockchain adoption.

# Theoretical Background

Prior studies have empirically demonstrated herding behaviors in business decisions (Bikhchandani et al., 1998). Under the framework of herding models, the competitive rivalry-based theories argue that firms imitate each other to maintain their relative competitive advantages and mitigate uncertainties and risks (Deephouse, 1999). Blockchain technology, which records the provenance of a digital asset using decentralized technology, is still insufficiently investigated by most firms (Xu et al., 2021). Investment in blockchain innovation could be considered risky by these firms. Therefore, blockchain patent behaviors of peer companies provide low-risk and accessible instructions for firms observing the actions. Thus, we assume that

*H1: Peer firms' disruptive blockchain innovations will increase the likelihood of focal firm's blockchain innovations.*

Blockchain as an emerging and potentially disruptive technology has attracted business scholars' attention (Frizzo-Barker et al., 2020). We assume a positive impact of blockchain innovation on firm performance, since blockchain is one of the most valuable types of innovation for financial industry (Hald & Kinra, 2019), and FinTech innovations yield substantial value to innovators with blockchain being particularly valuable (Chen et al., 2019).

*H2: Blockchain innovations improve firm performance.*

There has been a lot of research on the difference between the impact of blockchain technology on startups and non-startups (Sáez, 2020). Scholars invoke disruptive innovation to describe new technologies or startups that aim to shake up an industry and alter its competitive patterns (Christensen et al., 2018). Incumbents can use their own innovation to protect themselves from outside (Aghion et al., 2005). Market leaders can avoid negative value effects by investing in innovation (Hald & Kinra, 2019). Therefore, we assume that,

*H3a: The impact of blockchain innovations on firms' performance is higher for startups firms than for non-startups.*

Blockchain innovation could be related to different aspects of its core technologies, such as distributed ledgers and smart contracts. Based on disruptive theory, we link disruption levels with innovation types, then identify how it moderates the impact of blockchain innovations on firms' performance.

*H3b: The impact of blockchain innovations on firms' performance is moderated by innovation types.*

The resource-based view of IT suggests that environmental conditions influence the value of capabilities (Nevo & Wade, 2010). Environmental volatility is the frequency and extent of change in critical market variables (Dess & Beard, 1984). We define environmental volatility as the competition of blockchain technology innovations, namely the number of blockchain patents applied every year in different industries.

*H3c: The impact of blockchain innovations on firms' performance is stronger for industries with higher environmental volatility.*
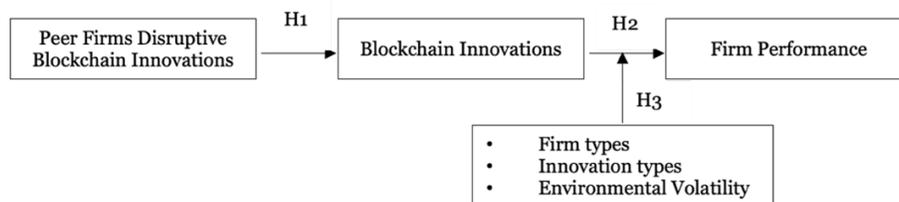


**Figure 1. Research Model**

# Methodology

## *Data and Variables*

The technological trend of blockchain innovation can be explored through blockchain patent (Bhatt et al., 2020). We use blockchain related patents to measure innovations. Our empirical analysis uses archival data from several sources. The United States Patent Tradeoff Office (USPTO) is used to get blockchain-related patents, and Compustat is used to collect financial data of these firms. We search the patents by the keywords related to blockchain features between January 1, 2001 and December 31, 2020, and retrieve fields of patents, such as PatentNo, Title, Abstract, Applicant name, International Patent Class, and so on.

We focus on firms rather than individuals for the "applicant name" attribute. This sample covers 1136 unique patents possessed by 301 firms and 83 individuals. There are 167 public firms and 134 private firms after the aggregation of firm names due to name inconsistency. We also combined the subsidiaries, i.e., Bell Helicopter Textron Inc. and Textron Innovations Inc. into the parent company Textron, since there aren't financial records for the subsidiaries. Among the public firms, 87 have financial data in Compustat North America database anytime between 2001 and 2020. We then use the LDA model to examine the topic of these patents' details. Attributes for LDA modeling include title and abstract of patents. Then we get the blockchain innovation types for testing hypothesis 3. Table 1 shows the definitions of our main variables.

| Variables | Definitions |
|---|---|
| **Dependent variables** | |
| Firm Disruptive Blockchain Innovations | The number of blockchain patents possessed by the firm. |
| Firm performance | Tobin's Q is a measure of firm performance that provides a good indicator of shareholder value (Anderson et al., 2004). |
| **Main explanatory variables** | |
| Peer firms blockchain innovations | The number of blockchain patents possessed by peer firms in the same industry in year t. |
| Firm types | Startups vs. non-startups. |
| Innovation types | The focus of the patent. It is derived from Topic Modeling. |
| Environmental Volatility | The competition of blockchain technology innovations, namely the number of blockchain patents applied every year in different industries. |
| **Control variables** | |
| Firm size | Total number of employees (Chung et al., 2019). |
| Industries | 3_digit Naics code. |
| Year | Year dummies for the sample years from 2001 to 2020 were included in our model to control for year-specific effects. |

**Table 1. Definitions of variables**

## *Model Estimation*

$$log(\frac{p_{it}}{1 - p_{it}}) = \alpha_i + \beta_1 * \sum_{j=0}^{n} Innovation_{jt-1} + \emptyset * Controls_{it} + \varepsilon_{it}$$

Where $p_{it}$ is the likelihood of innovation for firm i in year t. $Innovation_{jt-1}$ denotes whether this is an innovation for company j that is in the same industry as company i in year t-1.

$$log(\frac{f_{it}}{1 - f_{it}}) = \alpha_i + \beta_1 * Innovation_{it-1} + \beta_2 * Public_i + \beta_3 * Disruptive_{it-1} + \beta_4 * Volatility_{it-1} + \emptyset * Controls_{it} + \varepsilon_{it}$$

Where $f_{it}$ is the performance for firm i in year t. $Innovation_{it-1}$ denotes how many innovations there are for company i in year t-1. $Public_i$ denotes whether company i is a public company. $Disruptive_{it-1}$ denotes whether the innovation for company i is disruptive in year t-1. $Volatility_{it-1}$ denotes the environment volatility for company i is disruptive in year t-1.

# Findings

Figure 2 presents blockchain patent applications change by all firm applicants during the sample period. It shows the number of blockchain patents has been increasing with a sharp growth rate in the past four years.
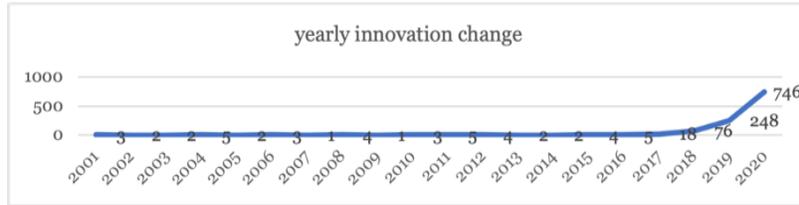
**Figure 2. Yearly Blockchain Patents**

Figure 3 shows the patent applications change over the last four years of top 10 firms with most patents, as well as the patents of the public top 10 firms in North America. We can see that Alibaba with the most patents applied blockchain patents from 2020 with 153 patents in total came in at the first place. And IBM, Bank of America, Accenture, and Dell occupied the next four places.
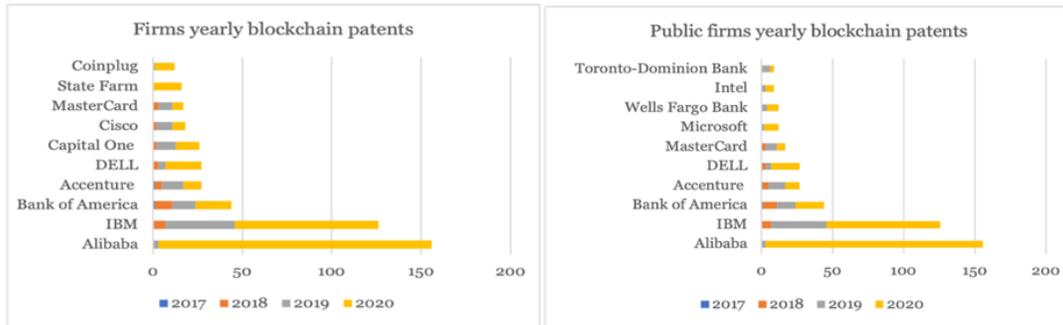


**Figure 3. Firms blockchain patents application over time**

To identify blockchain innovation types, we conducted a text analysis of patent details. We use the LDA model to examine topics of patents' title and abstract. The LDA model helps identify 10 topics as the optimal number of topics and the top keywords of each topic. Through these top keywords, we can summary the main technology term in every topic and identify key technology categories as blockchain innovation types.

|   | **Topic description** | **Keywords** |
|---|---|---|
| 1 | networking and communication | communication, ledger, distribute, security, use, item, network, client, embodiment, secure |
| 2 | records management | access, control, entity, include, base, distribute, network, block, ledger, associate |
| 3 | verification of records | node, storage, base, network, authentication, include, associate, verification, provide, apparatus |
| 4 | encryption | private, public, include, digital, account, transaction, cryptographic, base, use, generate |
| 5 | asset usage tracking | asset, identity, digital, signature, certificate, source, use, unit, group, party |
| 6 | distribute ledger | ledger, distribute, service, record, vehicle, transaction, provider, mobile, application |
| 7 | smart contracts | contract, smart, target, base, include, transaction, execute, receive, privacy, store |
| 8 | data analytics | transaction, network, message, token, service, distribute, include, use, provide, database |
| 9 | product-based tracking | resource, product, associate, medium, virtual, profile, base, include, interaction, platform |
| 10 | user authentication | hash, value, transaction, include, document, receive, generate, store, use, identifier |

**Table 2. Top keywords of the topics**

# Conclusion and future study

We empirically examine an antecedent and possible outcome of blockchain adoptions. We aim to provide theoretical insights in understanding blockchains' role as a new disruptive innovation. Practically, we provide firms with suggestions on blockchain adoption. Future work will be focused on the panel data analysis to find out how firms in different industries respond strategically to the blockchain innovations.

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