An Empirical Study of Blockchain Technology, Innovation, Service Quality and Firm Performance in the Banking Industry

A. G. Rekha and A. G. Resmi

Abstract Despite the potential promises that blockchain technology (BT) offers to the financial services sector, its large-scale implementations are still in a nascent stage. There is no consensus on what benefits BT may bring, and there is always a possibility of difference between expected benefits and experienced real-world impact. Since the actual impact can be assessed only after large-scale implementations by financial institutions, there is little empirical evidence available in the literature. In this context, this research seeks to explore the potential impact of BT by developing and empirically testing a model. For this purpose, we have identified four dimensions of BT, namely, Decentralization, Transparency, Trustlessness, and Security. The impact of BT on innovation, service quality, and firm performance is assessed based on the extent to which these dimensions are present in the organization. The linkages of the latent constructs are estimated by analyzing the primary data collected from senior managers of various banks in India. The findings of this study provide several important considerations regarding the implementation of BT.

Keywords Blockchain · Bank · Financial service · Innovation · Service quality · Performance

1 Introduction

Blockchain technology (BT) is identified as a disruptive innovation of the Internet era. This technology promises to bring revolutionary transformations in the way we transact over the internet, with prospective applications in various domains (Swan 2015; Huckle et al. 2016; Tapscott and Tapscott 2016; Beck et al. 2017). A

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blockchain is a distributed, decentralized, and immutable database, consisting of a growing sequence of blocks containing timestamped transactions, which is shared among a peer-to-peer network by a consensus mechanism. BT has got promising application prospects in the banking and financial services industry, especially in payment clearing and settlement systems, bank credit information systems, trade finance, etc. (Guo and Liang 2016; Peters and Panayi 2016; Treleaven et al. 2017). By way of decreasing transaction costs and by improving operating efficiency, BT offers the potential to be the core, underlying technology of the future financial services sector.

Despite the potential promises that this technology offers, large-scale BT implementations in the banking sector are still in the nascent stage. There is always a possibility of difference between expectations and experienced real-world impact of BT since the actual impact can only be assessed after large-scale implementations by financial institutions. While there are several initiatives offering blockchain solutions, especially by financial service providers and FinTechs, so far, no application has achieved large-scale recognition. It is necessary to be aware of the potential impacts resulting from the use of blockchain technology to real-world applications to foster the adoption of this technology at a larger scale. But there is no consensus on what benefits BT may really bring (Halaburda 2018).

Numerous conceptual studies are published focusing on BT. However, only a limited number of studies are available in literature, which is analytical and empirical in nature. Further, the focus of most of the research available on BT deals with technical, computational, and engineering aspects of blockchain. BT has not yet been thoroughly investigated from a strategic and managerial perspective by both academicians and practitioners. This gap has created exciting research avenues, especially from the perspective of managerial challenges and implications. A set of characteristics of BT are identified for this study, considering the above into account. Further, these characteristics are grouped into four dimensions of BT. Using these dimensions, we explore blockchain and related technologies from different perspectives, including strategic as well as managerial. A theoretical model is developed and empirically tested to explain the potential impact of BT on innovation, service quality, and firm performance in the context of the banking industry.

The rest of the paper is organized as follows: The research model and hypotheses are presented in sect. 2. This is followed by a discussion on the data and methodology in sect. 3. Section 4 presents the analysis and findings. Finally, the concluding remarks are given in sect. 5.

2 Research Model and Hypotheses

In order to understand the underlying concept of BT and to derive a distinct set of characteristics, a rigorous literature review is performed. One of the significant reasons for the interest in BT is its characteristics that provide security, anonymity, and data integrity without the need for any third party in control of the transactions (Yli-Huumo et al. 2016). BT can be leveraged to overcome the drawbacks that are associated with trusting a central authority by enabling reliable transactions on the blockchain without knowing or trusting the peer dealt with. Some authors have pointed out that BT enables a secure trust-free transaction system (Beck et al. 2016). Shared and distributed storage of information is mentioned as another characteristic of BT which enhances the transparency of the blockchain system (Garman et al. 2014; Cai and Zhu 2016). Seebacher and Schüritz (2017), in their work, identified trust and decentralization as the key characteristics of BT. Transaction security and immutability in the blockchain network achieved through public-key cryptography and peer verification process are also discussed in the literature (Cucurull and Puiggalí 2016; Weber et al. 2016; Zhao et al. 2016). An in-depth review and synthesis of these literature have revealed a set of characteristics that facilitate implementation of BT in an organization. From these four principal characteristics are identified for BT, namely, Decentralization, Transparency, Trustlessness, and Security. Using these dimensions, we explore BT from a strategic as well as managerial perspective. Further, we examine the potential impact of BT on innovation, service quality, and firm performance in the context of banking industry.

Innovation is generally considered as an essential component for organizations to obtain competitive advantage and superior performance (Cooper and Kleinschmidt 1987; Mone et al. 1998; Gunday et al. 2011). As per the definition given in the OECD Oslo manual 2005, product innovation can be viewed as the introduction of a new or significantly improved good or service. Process innovation is the implementation of a new or significantly improved production or delivery method. Organizational innovation is the implementation of a new organizational method in the firm's business practices, and it is strongly related to administrative efforts (OECD 2005). Product and process innovations are closely related to technological developments (Gunday et al. 2011). Further, considerable research has been conducted on the relationship between innovation and service quality (Verhees and Meulenberg 2004; Parasuraman 2010) and also on service quality and firm performance (Roth and Jackson III 1995; Kaynak 2003; Yee et al. 2010).

While there are many conceptual studies that suggest that BT will have a positive impact on the firm's performance, there is no empirical evidence published so far. Similarly, there are only a limited number of studies focusing on BT and service quality, and again there is no empirical evidence in the literature. In the context of the banking industry, BT is expected to decrease transaction costs and improve operating efficiency. In this study, we aim to explore the impact of the dimensions of BT on firm performance through innovation by examining the product, process, and administrative innovations, as well as through service quality in the context of the banking industry. Figure 1 represents the conceptual framework of the study.

A structural model is developed for testing the following hypothesis:

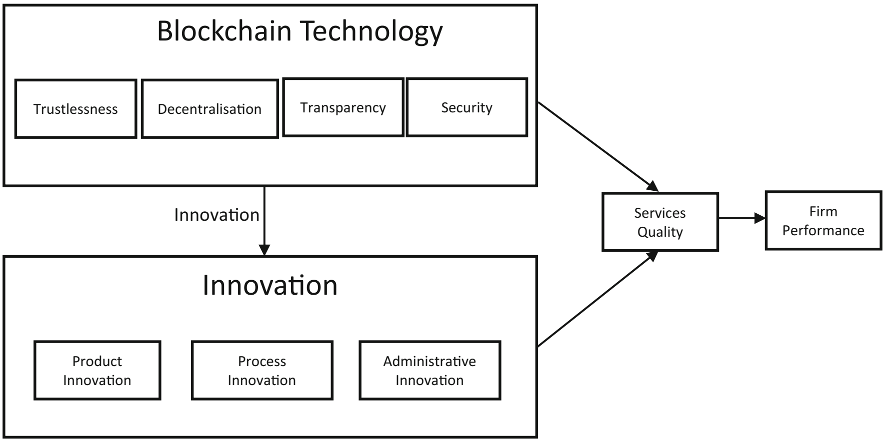

Fig. 1 Conceptual framework of the study. Source: author's own study

H1: *The four dimensions of blockchain technology (i) trustlessness, (ii) decentralization, (iii) transparency, and (iv) security are positively related with the three dimensions of innovation, (a) product innovation, (b) process innovation, and (c) administrative innovation*

H2: *The four dimensions of blockchain technology (i) trustlessness, (ii) decentralization, (iii) transparency, and (iv) security are positively related with service quality*

H3: *The three dimensions of innovation (a) product innovation, (b) process innovation, and (c) administrative innovation are positively related with service quality*

H4: *Service quality is positively related with firm performance*

3 Data and Methodology

The linkages of the latent constructs are estimated by analyzing the primary data collected from senior managers of various banks in India by applying Structural Equation Modeling (SEM). A scale for BT is developed for this study with Trustlessness, Decentralization, Transparency, and Security as multidimensional constructs. Measures of innovation (Jiménez-Jiménez and Sanz-Valle 2011), service quality (Parasuraman et al. 1988), and firm performance (Jiménez-Jiménez and Sanz-Valle 2011) are adapted from previous literature. All these constructs are measured using a five-point Likert scale, measured from strongly disagree to strongly agree. A draft questionnaire is pre-tested to check the content validity and hence modified accordingly. Questionnaires containing items measuring BT, innovation, service quality, and firm performance were distributed to 200 senior managers of various banks in India. A total of 167 responses were obtained, out of which

Table 1 Descriptive statistics of latent constructs

Variable	Items	Item Code	Mean	Std. Dev
Trustlessness	Level of anonymity of transactions in the organization is high	TRL1	3.12	1.246
	Degree of Automation in my organization is high	TRL2	3.15	1.269
	Need for a central authority for exchange of information within my organization is low	TRL3	3.12	1.320
	Need for a central authority (like RBI) for exchange of information within the industry among peer network comprising competitors, vendors, etc. is low	TRL4	3.15	1.279
Decentralization	Extent of collaborative storage of information within my organization by various functional areas is high	DEC1	3.17	1.319
	Extent of collaborative storage of information within my industry by peer network comprising competitors, vendors, etc. is high	DEC2	3.13	1.258
	Extent of distributed sharing of information within my organization by various functional areas is high	DEC3	3.18	1.332
	Extent of information updating within my organization by various functional areas is high	DEC4	3.12	1.275
	Extent of information updating within the industry by peer network comprising competitors, vendors, etc. is high	DEC5	3.10	1.187
Transparency	Extent of consensus needed for modifying shared information by various functional areas within the organization is less	TRN1	2.90	1.170
	Extent of consensus needed for modifying shared information by peer network comprising competitors, vendors, etc. is less	TRN2	2.87	1.175
	Degree of auditability in the organization is high	TRN3	2.85	1.259
	Degree of traceability of transactions in the organization is high	TRN4	2.92	1.200
Security	In my organization updating of shared information is possible only with authorization	SEC1	3.08	1.210
	Risk of tampering of history of transactions is very low in my organization	SEC2	3.08	1.210
	Information access is possible with authorization in my organization	SEC3	3.08	1.210
	There is a high level of accountability about transactions in my organization	SEC4	3.08	1.210
Product Innovation	The frequency of new products/services introduced in my organization is high	PDI1	3.28	1.274
	My organization has pioneer disposition to introduce new products/services	PDI2	3.30	1.252
	My organization invests high efforts to develop new products/services in terms of hours/person, teams, and training	PDI3	3.27	1.322

(continued)

Table 1 (continued)

Variable	Items	Item Code	Mean	Std. Dev
Process Innovation	The frequency of introduction of changes in processes is high in my organization	PCI1	3.06	1.195
	My organization has pioneer disposition to introduce new processes	PCI2	3.10	1.224
	My organization provides clever response to new processes introduced by other companies in the same sector	PCI3	3.10	1.179
Administrative Innovation	My organization has high novelty of administrative systems	ADI1	3.10	1.413
	There is a high degree of search for new administrative systems by managers in my organization	ADI2	3.10	1.296
	My organization has pioneer disposition to introduce new administrative systems	ADI3	3.10	1.383
Service Quality	My organization is able to provide services as promised	SQL1	3.19	1.255
	My organization is prompt in providing services to the customers	SQL2	3.18	1.332
	My organization can instill confidence in the customers	SQL3	3.12	1.297
	My organization provides services that best suits to the customers	SQL4	3.15	1.325
	My organization is technologically up-to-date	SQL5	3.12	1.285
Firm Performance	Quality of product/services of my organization is high	FPR1	3.15	1.296
	There is high internal process coordination in my organization	FPR2	3.15	1.296
	The image of my organization and its products is high	FPR3	3.15	1.296

Source: Based on primary data

11 responses were with missing values and those were excluded from the final sample.

4 Analysis and findings

The data revealed that all the constructs are having high item communalities, hence the concern of sample size adequacy is satisfied. Descriptive statistics of indicators of all the latent constructs are shown in Table 1.

Individual confirmatory factor analysis (CFA) is performed by considering each latent construct one by one, and the results are explained in Table 2. All the nine constructs are having statistically significant ($p < 0.001$) factor loadings (≥ 0.5), and the value of Average Variance Extracted (AVE) exceeds the recommended

Table 2 Convergent validity of latent constructs

Variables	Item Code	Convergent Validity				
		Factor Loading	Convergent Validity	Internal Reliability	Construct Reliability	R^2
		Standardized Regression Weight (> 0.5)	Average Variance Extracted (≥ 0.5)	Cronbach's Alpha (≥ 0.7)	Composite Reliability (≥ 0.7)	Squared Multiple Correlations (>0.5)
Trustlessness	TRL1	0.925	0.864	0.962	0.962	0.856
	TRL2	0.925				0.855
	TRL3	0.941				0.886
	TRL4	0.925				0.855
Decentralization	DEC1	0.927	0.846	0.965	0.965	0.859
	DEC2	0.905				0.819
	DEC3	0.947				0.897
	DEC4	0.930				0.866
	DEC5	0.895				0.801
Transparency	TRN1	0.927	0.842	0.955	0.955	0.860
	TRN2	0.920				0.847
	TRN3	0.922				0.850
	TRN4	0.902				0.813
Security	SEC1	0.927	0.859	0.961	0.961	0.860
	SEC2	0.927				0.860
	SEC3	0.929				0.862
	SEC4	0.926				0.858
Product Innovation	PDI1	0.934	0.852	0.945	0.945	0.872
	PDI2	0.923				0.852
	PDI3	0.914				0.835
Process Innovation	PCI1	0.913	0.828	0.935	0.935	0.833
	PCI2	0.905				0.818

(continued)

Table 2 (continued)

Variables	Item Code	Convergent Validity				
		Factor Loading	Convergent Validity	Internal Reliability	Construct Reliability	R^2
		Standardized Regression Weight (> 0.5)	Average Variance Extracted (≥ 0.5)	Cronbach's Alpha (≥ 0.7)	Composite Reliability (≥ 0.7)	Squared Multiple Correlations (>0.5)
	PCI3	0.913				0.834
Administrative Innovation	ADI1	0.946	0.876	0.954	0.955	0.895
	ADI2	0.927				0.859
	ADI3	0.935				0.875
Service Quality	SQL1	0.930	0.859	0.968	0.968	0.864
	SQL2	0.946				0.894
	SQL3	0.907				0.822
	SQL4	0.917				0.841
	SQL5	0.921				0.848
Firm Performance	FPR1	0.936	0.878	0.955	0.956	0.877
	FPR2	0.937				0.879
	FPR3	0.937				0.878

Source: Based on primary data

Table 3 Intercorrelation, AVE, and Squared Intercorrelation values

Constructs	Intercorrelation				AVE	Square of Intercorrelation			
	Trustlessness	Decentralization	Transparency	Security		Trustlessness	Decentralization	Transparency	Security
Trustlessness	–				0.864	–			
Decentralization	0.527	–			0.846	0.278	–		
Transparency	−0.606	−0.671	–		0.842	0.367	0.450	–	
Security	0.582	0.576	−0.342	–	0.859	0.339	0.332	0.117	–

Source: Based on primary data

Table 4 Fitness indexes of latent constructs

Variable	CMIN/DF (< 5.0)	χ^2 ($p > 0.05$)	NFI (>0.9)	IFI (>0.9)	TLI (>0.9)	CFI (>0.9)
Trustlessness	0.590	1.180	0.998	1.001	1.003	1.000
Decentralization	0.788	3.941	0.996	1.001	1.002	1.000
Transparency	2.187	4.374	0.993	0.996	0.989	0.996
Security	0.000	0.000	1.000	1.003	1.008	1.000
Product Innovation	0.850	0.850	0.998	1.000	1.001	1.000
Process Innovation	0.111	0.111	1.000	1.002	1.007	1.000
Administrative Innovation	7.566	7.566	0.985	0.987	0.960	0.987
Service Quality	7.802	1.560	0.992	0.997	0.994	0.997
Firm Performance	0.000	0.000	1.000	1.002	1.006	1.000

Source: Primary data

minimum value of 0.50. Again, Cronbach's alpha and composite reliability of all the constructs are greater than the recommended threshold of 0.70 (Hair et al. 2011; Fornell and Larcker 1981), and R^2 values above 0.5 (Easterby-Smith, 1991), indicates evidence for convergent validity.

The results from Table 3 confirm that the intercorrelation values of the exogenous variables are well below 0.85 and AVE values are greater than squared intercorrelation values, and hence indication for discriminant validity (Hair et al. 2011; Fornell and Larcker 1981).

Table 4 shows that the values for NFI, IFI, TLI, and CFI are well above the recommended threshold of 0.90 (Hu and Bentler 1999; Hair et al. 2011; Hooper et al. 2008). Hence unidimensionality of all the latent constructs are verified. Therefore, it is evident that there are no cross loadings, or the indicators are reflecting only the corresponding construct.

The VIF values for all the four predictor variables are less than 5, with tolerance levels greater than 0.2, indicating the fact that there is no multicollinearity issue in the data set. Figure 2 represents the structural model used in this study. According to the results summarized in Table 5 the overall fit of the structural model is good, with a $\chi 2$ value of 1153.695 and CMIN/DF value of 2.303, which is well below 5.0 (Marsh and Hocevar 1985). NFI, IFI, TLI, and CFI are above 0.90 (Hair et al. 2011; Hu and Bentler 1999; Hooper et al. 2008). All these results suggest that the overall fit of the structural model is good.

Table 6 shows the results of hypothesis testing. The first hypothesis (H1) is developed for testing the relationship between four dimensions of BT and three dimensions of innovation. H2 tests the relationship between BT and service quality. Further, H3 tests the relationship between innovation and service quality. Finally, H4 tests the relationship between service quality and firm performance.

The results of the study generally support theoretical predictions, and some interesting findings also emerged. The results reveal that there is a significant positive relationship between trustlessness and process innovation, trustlessness and administrative innovation, decentralization and product innovation,

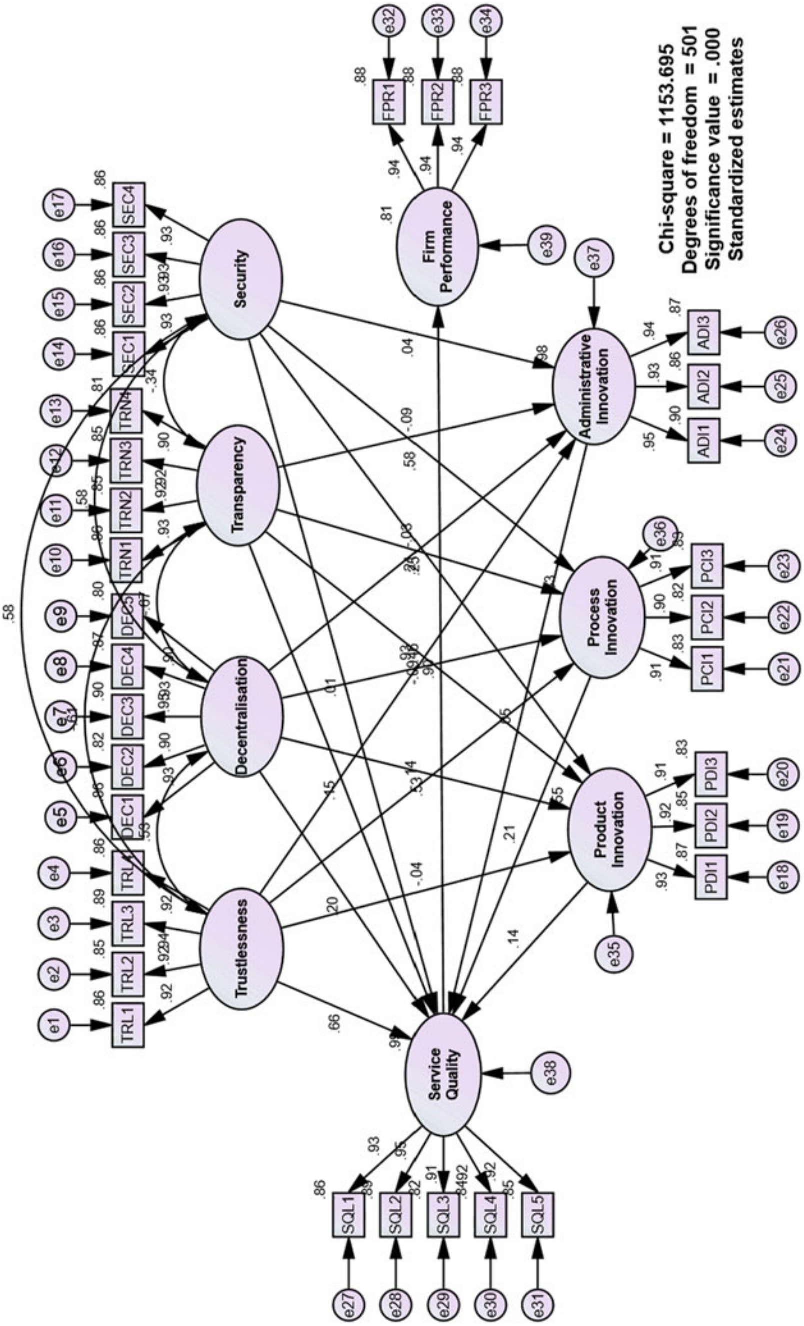

Fig. 2 Structural Model. Source: Primary data

Table 5 Model fit summary

CMIN/DF (< 5.0)	χ^2	NFI (> 0.9)	IFI (> 0.9)	TLI (> 0.9)	CFI (> 0.9)
2.303	1153.695	0.9	0.9	0.909	0.919

Source: Based on primary data

decentralization and process innovation, transparency and process innovation, security and product innovation, and security and process innovation. However, trustlessness was found to have an insignificant relationship with product innovation. Banking, being a service industry, this result has important implications. From the three dimensions of innovation, both product and process innovation are positively and significantly related to service quality. Further, consistent with the findings of existing literature, the relationship between service quality and firm performance was found to be positive.

Another significant finding and consequent implication of this study is that except security, all other dimensions of BT are positively and significantly related to service quality. Contrary to the proposed benefits on service quality aspects expected from BT's heavy reliance on cryptographic security mechanisms (Dubovitskaya et al. 2017; Schlegel et al. 2018), our results indicate that the security dimension is having an insignificant relationship with service quality. Since processing speed plays a significant role in achieving superior service quality and faster banking transactions is one of the key advantages expected from BT, this result should be read along with some of the previous studies investigating the security-speed trade-offs in blockchain protocols when it comes to tackling scalability (Kiayias and Panagiotakos 2015). Research on this area is still immature. Extensive research on different aspects of BT, primarily related to security, speed, and scalability in delivering financial services, is required to overcome the challenges hindering its large-scale adoption. Importantly, the significance of the results lies in the fact that it reveals that an in-depth understanding of security aspects of blockchain systems will be needed when considering large-scale implementations in the banking sector.

5 Conclusions

In this work, we have attempted to foster a general understanding of the impact of blockchain technology from a managerial perspective. A theoretical model is developed and empirically tested to explain the potential impact of BT on innovation, service quality, and firm performance in the context of banking industry. This study makes several significant contributions to theory and practice. It is the first of its kind to shed light on the various dimensions of blockchain technology and its impact on innovation, service quality, and firm performance. The findings of this study provide several important considerations to the decision makers regarding implementation of BT in their organizations. The results provide a better understanding of why banking

Table 6 Hypotheses testing

	Relationships			Standardized path coefficient	S.E.	t Value	
Hypothesis	Structural Paths			Standardized Regression Weight		C.R.	Comments
H1a	Product_Innovation	←	Trustlessness	−0.038	0.093	−0.428	Not Supported
H1b	Process_Innovation	←	Trustlessness	0.142	0.059	2.249*	Supported
H1c	Administrative_Innovation	←	Trustlessness	0.929	0.060	17.262***	Supported
H1d	Product_Innovation	←	Decentralization	0.529	0.098	5.355***	Supported
H1e	Process_Innovation	←	Decentralization	0.455	0.063	6.412***	Supported
H1f	Administrative_Innovation	←	Decentralization	−0.032	0.045	−0.768	Not Supported
H1g	Product_Innovation	←	Transparency	−0.090	0.106	−0.944	Not Supported
H1h	Process_Innovation	←	Transparency	0.210	0.068	3.070*	Supported
H1i	Administrative_Innovation	←	Transparency	−0.091	0.050	−2.146*	Supported
H1j	Product_Innovation	←	Security	0.253	0.092	2.950**	Supported
H1k	Process_Innovation	←	Security	0.582	0.063	8.903***	Supported
H1l	Administrative_Innovation	←	Security	0.037	0.043	0.978	Not Supported
H2a	Service_Quality	←	Trustlessness	0.662	0.330	2.063*	Supported
H2b	Service_Quality	←	Decentralization	0.203	0.047	4.234***	Supported
H2c	Service_Quality	←	Transparency	0.155	0.049	3.438***	Supported
H2d	Service_Quality	←	Security	0.015	0.050	0.312	Not Supported
H3a	Service_Quality	←	Product_Innovation	0.137	0.030	4.427***	Supported
H3b	Service_Quality	←	Process_Innovation	0.212	0.064	3.623***	Supported
H3c	Service_Quality	←	Administrative_Innovation	0.052	0.308	0.156	Not Supported
H4	Firm_Performance	←	Service_Quality	0.902	0.056	16.409***	Supported

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

industry might want to invest in using blockchain-based technologies. Further, this study corroborates prior research relating service quality and performance. Finally, given the little empirical research on blockchain technology, future research across various other industries would help determine if the findings are more generalizable.

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