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Factors affecting the adoption of blockchain technology in innovative Italian companies: an extended TAM approach

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Mauro Sciarelli and Anna Prisco
Dipartimento di Economia, Management, Università degli Studi di Napoli Federico II, Napoli, Italy
Mohamed Hani Gheith
Department of Business Administration, Mansoura University, Mansoura, Egypt, and
Valerio Muto
Dipartimento di Economia, Management, Università degli Studi di Napoli Federico II, Napoli, Italy

Abstract

Purpose – The present research aims to identify the determinants for users' behavioral adoption of Blockchain, exploring the relationships among these variables and investigating whether the proposed model can provide a more comprehensive manner to understand the adoption of Blockchain technology.

Design/methodology/approach – This study adopts the Technology Acceptance Model (TAM) approach and extends it with external constructs: "reduced cost" and "efficiency and security". This paper used a quantitative and exploratory approach through the collection and analysis of data from a total of 108 Italian innovative SME. We have used the Partial Least Squares Structural Equation modeling (PLS-SEM) approach using SmartPLS for model evaluation.

Findings – The results show that "efficiency and security" is an important driver of firms' decision-making process to adopt Blockchain. Moreover, the results show that perceived usefulness is a strong predictor of the intention to use Blockchain in business processes.

Originality/value – This research advances the literature on technology adoption in business processes, focusing on a particular technology: Blockchain. The field has been strengthened by investigating the determinants of technology adoption, adding new perspectives; both reduced cost and efficiency, and security.

Keywords Blockchain, Technology acceptance model, PLS-SEM

Paper type Research paper

1. Introduction

In the last few years, Blockchain has been employed in a wide array of contexts such as open manufacturing (Li *et al.*, 2018), real estate (Veuger, 2018) and healthcare (Agbo *et al.*, 2019). Even if Blockchain is a recent innovation, it is already revolutionizing the digital world by bringing a new perspective to security, resilience and efficiency of the business processes. A Blockchain is a distributed ledger not governed by the central authority but maintained by many user organizations. The term Blockchain means that new transactions are enclosed in the data block

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with encryption techniques and added to the end of the existing Blockchain consisting of all the previous transactions (Nair *et al.*, 2020). This technology differs from traditional situations in which a central subject keeps track of all data and has the responsibility for it (Chowdhury *et al.*, 2018). This technology has redefined supply chain management, creating new challenges and new opportunities in terms of reduced cost, efficiency and security.

In 2019, Italian companies invested approximately EUR 30 million in Blockchain projects, a 100% increase compared to 2018. A recent has assessment placed Italy among the top 10 countries in the world for the number of Blockchain projects developed in 2019 (Blockchain and Distributed Ledger POLIMI Observatory, 2020). This growth implies the pressing need to improve our current understanding of the main factors that lead firms to adopt Blockchain technology. Indeed, despite its rapid evolution, Blockchain remains an immature technology with numerous applications yet to be discovered. The adoption of Blockchain in organizations is still in its infancy and the studies in this space are limited (Iansiti and Lakhani, 2017; Gammelgaard *et al.*, 2019). Moreover, there are very few studies conducted recently on Blockchain adoption (Kamble *et al.*, 2018; Queiroz and Wamba, 2019; Wamba *et al.*, 2020; Wong *et al.*, 2020). In addition, the Blockchain adoption literature that is specifically focused on the effect of perceived benefits on Blockchain adoption is scarce (Karamchandani *et al.*, 2020). Besides, it is fundamental to have an in-depth understanding of the behavior behind Blockchain technology adoption, considering the highly disruptive capacity of this technology (Wamba and Queiroz, 2020) and its unprecedented impacts on supply chains (Ivanov *et al.*, 2017; Dolgui *et al.*, 2019). To fill these gaps, this study aims to identify the key factors that can influence business adoption of the Blockchain.

Our paper focuses on Italian innovative companies. Italian law defines "Italian innovative companies" as not listed companies with at least two of these requirements: (1) incurred expenses in R&D and innovation equal to at least 3% of the higher value between turnover and cost of production; (2) part of the staff is a Ph.D. student, researcher or graduate; (3) is the owner, custodian or licensee of at least one patent or owner of a registered software). These companies have a greater propensity to integrate their business processes with new technologies.

This paper helps to understand the behavior of the entrepreneurs involved in the Blockchain adoption process.

The paper is structured as follows. In Section 2, we provide a literature review of Blockchain technology and Technology acceptance model (TAM). In Section 3, we develop our research hypotheses and the proposed model. Then, we describe the research methodology, followed by data analysis. The final section discusses the main findings and implications as well as limitations and suggestions for future research.

2. Literature review

2.1 Blockchain technology

Seebacher and Schüritz (2017, p. 15) define Blockchain as "*a distributed database, which is shared among and agreed upon as a peer-to-peer network. It consists of a linked sequence of blocks (a storage unit of the transaction), holding timestamped transactions that are secured by public-key cryptography (i.e. "hash") and verified by the network community. Once an element is appended to the Blockchain, it cannot be altered, turning a Blockchain into an immutable record of past activity.*" In other words, Blockchain can be considered as an ordered, incremental, solid and digital block of cryptographically linked data (Zheng *et al.*, 2018). The main difference between Blockchain and conventional digital technologies originates in its distributed Peer-to-Peer (P2P) nature. The peer-to-peer architecture of Blockchain allows all cryptocurrencies to be transferred worldwide, without the need for a central server.

Blockchain has potential benefits in different domains such as strategic, organizational, economic, informational and technological categories (Olnes *et al.*, 2017).

Blockchain provides adopters with advantages such as anonymity, immutability, transparency and fast transactions (Abubakar and Al-zyoud, 2021; Werner *et al.*, 2021). The immutability of the recorded data allows the creation of a new form of trust based on the transparency and traceability of the transactions (Panisi, 2017). Moreover, Blockchain offers benefits such as cost efficiency, better recordkeeping system and safe digital platforms (Andoni *et al.*, 2019; Puthal *et al.*, 2018). Regardless of the context of the sector in which it is applied, the Blockchain allows the reduction of several costs (such as transaction costs or administrative ones) (Casino *et al.*, 2019). Moreover, the decentralized structure allows eliminating intermediaries enabling the actors to interact more quickly and more efficiently.

2.2 Technology acceptance model

The Technology Acceptance Model (TAM) (Davis, 1989) has been developed as an evolution of the Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980). TRA focused on explaining the user's behavioral intention of a given technology (King and He, 2006). Since the first years, TAM has been found useful to reliably predict technology acceptance in a broad range of technologies and various types of context such as information systems (Hu *et al.*, 1999), software applications (Szajna, 1996; Gao, 2005) and e-commerce (Morris and Dillon, 1997; Koufaris, 2002).

As for the TRA, Davis (1989) identified the behavioral intention as a strong predictor of effectively performing the behavior (Ajzen and Fishbein, 1975; Davis *et al.*, 1989). In the TAM model, the Behavioral Intention could be determined by two responses to the technology features: first, the affective response and second, the cognitive response.

The affective response was linked to the user's attitude toward the specific behavior. It refers to individual positive or negative feelings about performing the target behavior (Ajzen and Fishbein, 1975). Davis identified two main factors to explain the attitude and the behavior intention to use a given technology and classified them as the cognitive response (Davis, 1985): Perceived Ease of Use and Perceived Usefulness. Davis and Bagozzi (1989) have suggested considering external variables in defining the drivers behind the cognitive and the affective response to the technical characteristics for a better adaptation of the TAM model to the specific context of the analysis. On the same page, several scholars have integrated TAM with external variables (Venkatesh, 2000; Kim and Woo, 2016; Melas *et al.*, 2011; Shih, 2004). The TAM model was used also to investigate blockchain adoption. Some scholars have adopted TAM to investigate determinants of Blockchain adoption extending models with external variables. For example, Lou and Li (2017) have extended TAM with compatibility or complexity, while Kamble (2021) have considered discomfort and insecurity.

3. Hypothesis development and research model

We developed a research model (Figure 1) based on TAM variables extended with perceived benefits, in turn, identified in terms of reduced cost (RC) and efficiency and security (ES). The model, therefore, consists of six latent variables, assuming that they may more significantly affect the behavioral intention to adopt Blockchain.

According to TAM, attitude (ATT) is a strong predictor of behavioral intention (BI) (Davis *et al.*, 1989). Lou and Li (2017) have shown that attitude is the most important predictor of intention to adopt Blockchain technology. The same result was confirmed by several other scholars (Kamble *et al.*, 2018; Albayati *et al.*, 2020; Jain *et al.*, 2020).

Accordingly, we propose the following hypothesis:

H1. Attitude positively influences the Behavioral Intention to adopt Blockchain technology.

TAM prescribes that BI is directly influenced by Perceived Usefulness (PU) as well (Davis, 1989). PU refers to "*the degree to which a person believes that using a particular system would enhance his or her job performance*" (Davis, 1989, p. 26). When people perceive a system as

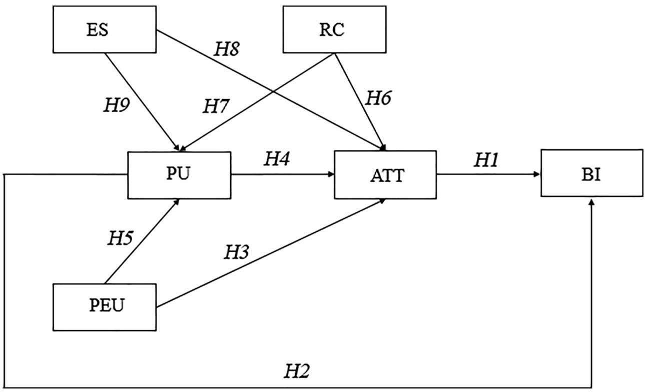

Figure 1.
Proposed model

useful, they connect to the system a positive use-performance and they are reinforced for good performance by getting advantages out of it (Pfeffer, 1982; Schein, 1980; Vroom, 1964). Several scholars (Folkinshteyn *et al.*, 2016; Jaoude *et al.*, 2017; Knauer *et al.*, 2019; Nuryyev *et al.*, 2020) have found that Perceived Usefulness positively influences the intention to adopt Blockchain technology. Accordingly, we propose the following hypothesis:

H2. Perceived usefulness positively influences the Behavioral Intention to adopt Blockchain technology.

In TAM, Davis (1985) defined that PU and Perceived Ease of Use (PEU) are the two main cognitive responses predicting ATT. Davis defined PEU as "*the degree to which a person believes that using a particular system would be free of effort*" (1989, p. 26). When users find technology easy to use and do not require much effort to learn, they will be more likely to adopt it (Tan and Ooi, 2018). Nuryyev *et al.* (2020) have highlighted that PEU positively influences ATT toward adopting Blockchain.

Accordingly, we propose the following hypothesis:

H3. Perceived ease of use positively influences the attitude to adopt Blockchain technology.

PU affects ATT as well (Davis, 1985). In terms of motivation theory (Cofer and Appley, 1964), it is also argued that if an individual perceives an activity to be beneficial to achieve the valued outcomes, he or she will be more likely to accept the new technology (Liao *et al.*, 2007). In the Blockchain context, several scholars (Kamble *et al.*, 2018; Nuryyev *et al.*, 2020; AlSuwaidan and Almegren, 2020) have shown that PU is a strong predictor of the ATT to adopt Blockchain technology. Accordingly, we propose the following hypothesis:

H4. Perceived usefulness positively influences the attitude to adopt Blockchain technology.

PEU can be considered as a relevant factor driving technology usage, and it has been proven that it reduces cognitive effort (Cho and Hong, 2011). The results from previous research have revealed the significant effect of PEU on PU (Davis *et al.*, 1989; Wang *et al.*, 2003; Kleijnen *et al.*, 2004). Indeed, PEU positively influences PU because technologies requiring fewer efforts can be perceived as more useful (Karahanna and Straub, 1999; Gangwar *et al.*, 2015). Also in the Blockchain context, several scholars (Kamble *et al.*, 2018; Kamble, 2021) have proven this relationship.

Accordingly, we propose the following hypothesis:

H5. Perceived ease of use positively influences perceived usefulness of Blockchain technology adoption.

Perceived benefits refer to the perception of the positive consequences that are caused by a specific action (Ray *et al.*, 2019). Moreover, Lee (2009) also found that perceived benefits positively influence the attitude to adopt online banking. On the same page Karamchandani *et al.* (2020) have shown that perceived benefits positively influence the PU of Blockchain. Therefore, it is reasonable to infer that perceived benefits positively influence PU and users' attitude and intention to adopt Blockchain technology. The main advantages of Blockchain are linked to the reduction of costs and the improvement of the efficiency and security of business processes. Hence we propose the following hypothesis:

H6. Reduced cost positively influences the attitude to adopt Blockchain technology.

H7. Reduced cost positively influences perceived usefulness to adopt Blockchain technology.

H8. Efficiency and security positively influences the attitude to adopt Blockchain technology.

H9. Efficiency and security positively influences the perceived usefulness to adopt Blockchain technology.

4. Methodology

4.1 Measurement

The data were collected using a survey questionnaire designed from previously validated scales adopted in the relevant literature and we used the translation and back-translation procedures (Saunders *et al.*, 2009) to produce the Italian version. TAM constructs were measured by 16 items (five items for ATT, three items for BI and four for each of PU and PEOU) adapted from previous literature (Davis, 1989; Kamble *et al.*, 2018). Perceived benefits refer to "reduced cost" (RC) and "efficiency and security" (ES), measured respectively by four and five items and adapted from Garg *et al.* (2021).

All the items were measured using a seven-point Likert scale (1 = "strongly disagree" and 7 = "strongly agree"). On the first page of the survey, we included two screening questions to ensure that the respondents know Blockchain technology. Finally, we include demographic information about Zone (North, Centre or South) and numbers of employees (<50; 51–250 or >251).

We have given to the firms instructions and note about the purpose of the study, data collection, assurance of the respondents' confidentiality and anonymity were mentioned (Chidlow *et al.*, 2015).

4.2 Data collection

The survey was pilot-tested with 30 respondents from the target segment to ensure face validity. Subsequently, we made some minor revisions to items' spelling before finalizing our questionnaire. We reached the Italian innovative companies through email and LinkedIn. The list of innovative companies was taken from the startup-registroimprese.it website and with a manual search, we found the emails of the companies. We conducted the survey from September 2020 to January 2021. The survey was hosted on a platform provided by the University of Naples Federico II, and it was shared on LinkedIn and through email. To reduce retrieval biases (Kline *et al.*, 2000; Podsakoff, 2003), we intermixed the items from different constructs in the various scale grids, while to reduce social desirability bias, we added guidelines to the survey to explain the scope of the survey, and to provide contacts for further information (Saunders *et al.*, 2009). Moreover, we analyzed the nonresponse bias between the four waves. To assess nonresponse bias, a MANOVA was performed and no statistical differences were found in the sample characteristics of the four waves (p-value is 0.6905). Therefore, we conclude that the nonresponse bias did not affect the model. Table 1 shows the characteristics of respondents in our sample (size, zone).

5. Data analysis procedure

Our goal is to understand the relationship between constructs instead of fitting a model (Hair *et al.*, 2011), for this reason, we used the PLS-SEM approach to test our model (Hair *et al.*, 2011), using SmartPLS (Ringle *et al.*, 2015). Several studies have used PLS-SEM in the context of Blockchain (Queiroz and Bamba, 2019, 2020; Wong *et al.*, 2020). The validity of the model is assessed in two stages (Hair *et al.*, 2016). The first is related to the quality of the measurement model and the second concerns the assessment of the predictive power of the structural model. For the quality of the measurement model, we have considered the indicator reliability, checking that the items' loadings on their latent are higher than 0.6 (Chin, 1998; Henseler *et al.*, 2009). Moreover, we have evaluated the reliability, verifying that each construct's Cronbach's alpha is higher than 0.7 (Hair *et al.*, 2011) and each construct's composite reliability (CR) index is higher than 0.7 (Hair *et al.*, 2011). Finally, we have studied the convergent validity assessment verifying that the average variance extracted (AVE) of each block is higher than 0.50 (Hair *et al.*, 2016) and discriminant validity with the Fornell–Larcker criterion verifying the square root of all constructs is higher than the correlations of these constructs with the other ones in the off-diagonal position and verifying that Heterotrait-Monotrait (HTMT) criterion are lower than the threshold of 0.90 (Hair *et al.*, 2019).

At the second stage, to evaluate model validity, we test the structural model looking at the constructs R2 to understand the ability of the model to predict their behavior intention.

5.1 Measurement model

The results of the measurement model are reported in Tables 2 and 3. All the indicators can be considered reliable, as none have a load factor of less than 0.6, except for PEU which has been removed. At the same time, from Table 2 we can see that both composite reliability (CR) and Cronbach's alpha (CR alpha) are greater than 0.7 for all the constructs, for this reason, the constructs can also be considered reliable. At the same time, from Table 2 we can see that both composite reliability (CR) and Cronbach's alpha (CR alpha) are greater than 0.7 for all constructs, for this reason, constructs can be also considered reliable. Moreover, the constructs have an AVE of less than 0.5 hence the model passes the convergent validity test. From Table 2 we can see that the constructs pass the discriminant validity which is measured

Characteristics	Types	Value	%
Size (n. employees)	<50	40	37%
	51–250	39	36%
	>251	29	26%
Zone	North	48	44%
	Centre	32	30%
	South	28	26%

Table 1.
Sample characteristics

Latent variable	Items	Indicator reliability	CR	CR alpha	AVE
Reduced Cost	RC1	0.908	0.943	0.919	0.805
	RC2	0.868			
	RC3	0.920			
	RC4	0.891			
Efficiency and Security	ES1	0.859	0.948	0.931	0.784
	ES2	0.901			
	ES3	0.902			
	ES4	0.871			
	ES5	0.892			
Perceived Usefulness	PU1	0.841	0.948	0.927	0.822
	PU2	0.891			
	PU3	0.959			
	PU4	0.931			
Perceived Ease of Use	PEU1	0.912	0.937	0.900	0.833
	PEU2	0.914			
	PEU4	0.912			
Attitude	ATT1	0.826	0.911	0.876	0.673
	ATT2	0.897			
	ATT3	0.862			
	ATT4	0.706			
	ATT5	0.797			
Behavioral Intention	BI1	0.913	0.930	0.888	0.816
	BI2	0.917			
	BI3	0.880			

Table 2. Measurement statistics of constructs

Fornell–Larcker Criterion/Heterotrait-Monotrait ratio (HTMT)	1	2	3	4	5	6
1. Reduced Cost	*0.90*	0.84	0.81	0.74	0.81	0.52
2. Efficiency and Security	0.78	*0.89*	0.82	0.61	0.88	0.50
3. Perceived Usefulness	0.75	0.77	*0.91*	0.82	0.84	0.60
4. Perceived Ease of Use	0.68	0.57	0.75	*0.91*	0.66	0.63
5. Attitude	0.73	0.79	0.76	0.59	*0.82*	0.59
6. Behavioral Intention	0.47	0.46	0.54	0.57	0.52	*0.90*

Note(s): The diagonal italic is the square root of average variance extracted (AVE). Above diagonal non-italic numbers represent the HTMT values

Table 3. Discriminant validity

by two criteria: the Fornell–Larcker criteria and the Heterotrait-Monotrait (HTMT) criteria. Using the first criteria, the results show that the square root of all the constructs is higher than the correlations of these constructs with the other ones in the off-diagonal position. Moreover, the HTMT criteria confirmed that all HTMT values are lower than the threshold of 0.90 (Hair *et al.*, 2019) concluding the discriminant validity of the constructs.

Finally, we tested the model for Common Method Bias (Podsakoff *et al.*, 2003) adopting the full-collinearity approach (Kock and Lynn, 2015); we found that the highest Internal VIF was 3.79, below the suggested limit of 5. It follows that the measurement model used in this document can be considered valid (Hair *et al.*, 2016).

5.2 Structural model and hypotheses testing

To examine the quality of the structural model, we assessed the coefficient of determinations (R^2), the predictive relevance (Q^2) and the magnitude and significance of path coefficients (Table 3).

As Table 3 indicates, the R^2 values for all dependent variables exceeded the 0.26 values suggested by Cohen (1988), indicating reliable predictive power of the model.

These findings are also supported by the Q^2 value of the predictive relevance which is greater than 0 for all the dependent variables, indicating that the structural model has a satisfactory predictive relevance for the dependent variables. We then use a bootstrap procedure with 5,000 resamplings (Hair *et al.*, 2016) for the file hypothesis testing (see Table 4). We found support for most of our hypotheses, except for H3. We found a significant influences on BI from ATT (0.269*) and PU (0.338*). Moreover, we found a significative influence on ATT from PU (0.288*) and ES (0.432***). Finally, we found significant influence on PU from PEU (0.414***) and from ES (0.429***) (See Figure 2).

Endogenous constructs	R^2	Q^2
Perceived Usefulness (PU)	0.741	0.552
Attitude	0.693	0.419
Behavioural Intention (BI)	0.324	0.236

Hypothesis and relation		Direct effect	*t*-value (bootstrap)	Percentile 95% CI	Support
H1	Attitude → Behavioral Intention	0.269*	1.984	[0.067;0.514]	Yes
H2	Perceived Usefulness → Behavioral Intention	0.338*	2.099	[0.043;0.572]	Yes
H3	Perceived Ease of Use → Attitude	0.013^ns	0.123	[−0.135;0.203]	No
H4	Perceived Usefulness → Attitude	0.288*	2.192	[0.77;0.509]	Yes
H5	Perceived Ease of Use → Perceived Usefulness	0.414***	4.195	[0.257;0.580]	Yes
H6	Reduced Cost → Attitude	0.170^ns	1.319	[−0.064;0.358]	No
H7	Reduced Cost → Perceived Usefulness	0.135^ns	1.251	[−0.039;0.317]	No
H8	Efficiency and Security → Attitude	0.432***	3.515	[0.228;0.636]	Yes
H9	Efficiency and Security → Perceived Usefulness	0.429***	4.959	[0.270;0.552]	Yes

Note(s): $*p < 0.05$; $***p < 0.001$; ns: not significant

Table 4.
Effect on endogenous constructs

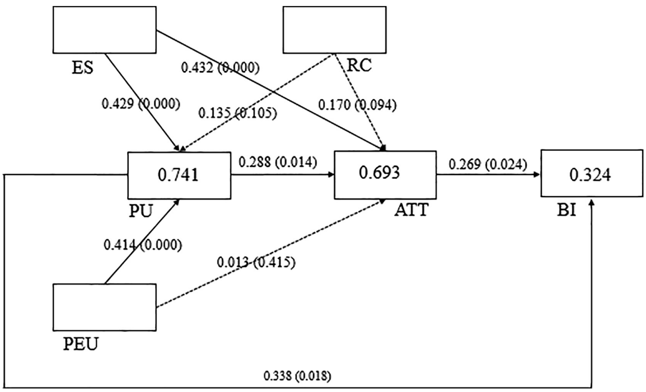

Figure 2.
Model after the testing

6. Discussion and implications

6.1 Theoretical implications

This paper is amongst the first attempts to explore factors influencing the adoption of Blockchain in the context of innovative Italian companies. We contribute to the extant literature on Blockchain adoption extending TAM with perceived benefits: RC and ES.

Our model shows several interesting results, both supporting and negating previous research. Regarding TAM constructs, our results support previous research on attitude as a predictor of BI (Kamble *et al.*, 2018; Albayati *et al.*, 2020; Jain *et al.*, 2020). At the same time, as shown by previous literature, we found a significant effect of PU both on BI (Nureyev *et al.*, 2020) and ATT (AlSuwaidan and Almegren, 2020). Finally, we found that PEU significantly influences PU (Kamble *et al.*, 2018; Kamble, 2021). Like Kamble *et al.* (2018) we found the insignificant influence of PEU on ATT. We enrich previous literature considering how reduced cost and efficiency and security influence blockchain adoption. Different from Garg *et al.* (2021) we integrate these constructs with TAM. We found a statistically significant effect of "efficiency and security" both on PU and ATT. On the contrary, we do not find any significant effect of RC on either ATT or PU.

Our focus on BI determinants is, to the best of our knowledge, one of the few attempts to factor in the effect of RC and ES on PU and ATT.

6.2 Practical implications

This article also presents interesting results for practitioners. Our results show that the effect of PEU on ATT is not significant, the findings reflect that respondents are not able to perceive the ease of use of the Blockchain compared to traditional technologies. This result could be linked to the fact that the respondent to the survey is the CEO and not the technical person who has the technical skills to use the Blockchain. Moreover, our data show that PU is the strongest predictor of BI, hence managers should define their services by leveraging the utility of Blockchain. PEU was found to significantly impact PU which means that users perceive Blockchain adoption as free of effort and this feature will help them to achieve the maximum benefit from using Blockchain technology in running their businesses. Finally, we found that ES has a significant effect on ATT and PU. These results show that managers perceived Blockchain as a tool to improve technical efficiency, able to improve the perception that Blockchain improves job performance. In reverse, the insignificant effect of RC on both ATT and PU shows that Italian managers of innovative companies do not perceive Blockchain's utility in terms of reduced cost. The insignificant effect of RC on ATT and PU could be due to the high cost of implementing a Blockchain technology as well as the substantial training costs necessary for a full understanding of the system. Even if Blockchain Technology improves efficiency firms' processes, blockchain adoption requires cost for the purchase of technology, for the implementation, for staff training. Hence in the first phase of adoption, it can reduce the perception of the capacity of blockchain to reduce cost. These results suggest managers where to focus their resources to improve the use of this Blockchain Technology, highlighting the need to leverage some characteristics of blockchain to increase the adoption by the firms (i.e. purchase and management costs of the blockchain technology).

7. Research limits and future research

This research is not without limits. First of all, we focused on a specific context: innovative Italian companies. At the same time, we did not focus on a specific business sector. The business sectors in which firms operate may influence the determinants of firms' behavioral intention to adopt Blockchain. Likewise, our research extends the TAM model with perceived benefits and does not consider other constructs that may influence Blockchain adoption (i.e. technological anxiety). Future research may use the following model and extend it with other constructs. In the same way, they could analyze other contexts or even analyze the existing differences between countries and sectors.

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Corresponding author
Anna Prisco can be contacted at: anna.prisco@unina.it