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Blockchain adoption in Italian winemaking: insights from a PLS-SEM study

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Abstract

Purpose – This empirical study aims to expand the literature on the application of blockchain by analysing the factors that influence Italian winemakers.

Design/methodology/approach – An online questionnaire was used to collect data from 114 Italian wine producers. The factors influencing the adoption of blockchain technology were based on an extended Unified Theory of Acceptance and Use of Technology (UTAUT). Partial Least Squares Structural Equation Modelling (PLS-SEM) was used to analyse the data using the SmartPLS computer program.

Findings – The PLS-SEM results show that two dimensions of the extended UTAUT, including performance expectancy and trust, positively influence blockchain technology adoption. At the same time, effort expectancy, social influence and facilitating conditions are found to have no significant influence on the intention to adopt blockchain technology. The intention to adopt blockchain is therefore linked to the expectation of improving the winery's production efficiency, on the one hand, and the greater transparency that this brings, and the benefit that this can bring to consumers, on the other.

Originality/value – The empirical results of this study fill a gap in the existing literature regarding the factors influencing the adoption of blockchain by Italian winemakers. This study found that, out of five factors, only two have an impact on behaviour, thus providing insight into this issue that has not been clearly examined in previous studies.

Keywords Wine, Producers, Blockchain, UTAUT, PLS-SEM, Trust

Paper type Research paper

1. Introduction

Wine is one of the most distinctive products of Italian culture (Gregori *et al.*, 2017), and the Italian wine industry is a major player in the international wine market. Italy, together with Spain and France, accounts for more than half of the world wine production (OIV, 2024). In 2023, it was also the largest exporter with roughly 21 million of hectolitres, accounting for 20% of the global exports, with the main markets being USA, Germany and the UK (OIV, 2024). Having such a major role on the global market might be jeopardised by issues like fraud, affecting the

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connection and trust-building between supply chain stakeholders (Romano *et al.*, 2021). If we consider the structure of the Italian wine entrepreneurial tissue, this aspect becomes much more serious. Because of the long history of some family enterprises, family-owned businesses are common in the Italian wine industry (Cuel and Cangelosi, 2020). Indeed, wine represents a set of family beliefs, symbols and traditions rooted in the family's region, and this is especially true if the family has a strong market reputation (Vrontis *et al.*, 2016). This setting has a strong influence on the creation of the trust among supply chain participants. In today's wine system, trust at various levels is maintained through personal connections, reputation, integrity, partnership and mutually shared beliefs (Brookbanks and Parry, 2022). Supply chain participants, such as processors, retailers and even consumers, have long recognised the importance of trust building in long-term, close and sustainable business relationships (Brookbanks and Parry, 2022; Robinson *et al.*, 2020; Fischer, 2013). As such traditional configuration is rapidly evolving, wine would be one of the sectors that would benefit considerably from the adoption of digital technologies, as it is characterised by the production of high-value products, dynamicity, tradition and long-term history but also complex relationships and strong competition (Agostinelli *et al.*, 2023; Silvestri *et al.*, 2023). The introduction of digital solutions will support the maintenance of trust and will improve productivity, sustainability, efficiency, economic performance and competitiveness (Bartoli *et al.*, 2024; Cui and van Esch, 2024; Popović *et al.*, 2022; Dicuonzo *et al.*, 2021; Zilberman *et al.*, 2019; Cui, 2018). Among the different technologies, a suite of tools is available to improve land and vine management through a more-informed decision-making process. These include remote and proximal sensing technologies, GPS, GIS, geostatistics, artificial intelligence and decision support systems. They are generally referred as Precision Viticulture technologies (Sapaev *et al.*, 2023; Tardaguila *et al.*, 2021). For the traceability of the supply chain, a disruptive innovator in the wine system could be blockchain technology (BCT) (Zarbà *et al.*, 2024). BCT could integrate its intrinsic characteristics, namely autonomy, decentralisation, immutability, transparency and security, to promote a trustworthy traceable supply chain without compromising data privacy (Adamashvili *et al.*, 2024; Chiaraluce *et al.*, 2024; Bastard and Chaillet, 2023; Malisic *et al.*, 2023; Compagnucci *et al.*, 2022; Popović *et al.*, 2022; Galati *et al.*, 2021). The real cases of the three Italian wineries "Placido Volpone", "Ricci Cubastro" and "Torrevento" show what BCT could bring to a winery (Silvestri *et al.*, 2023, 2024; Galati *et al.*, 2021). All three Italian companies experienced an enhanced brand visibility after BCT implementation, especially in foreign markets, indicating that the brand image and consumer trust were strengthened. Moreover, "Placido Volpone" and "Torrevento" saw increased efficiency and improved relations with suppliers. However, although BCT seems to bring significant and positive improvements to wine supply chains, a few challenges need to be addressed. From a technical point of view, scalability, performance issues, digital equipment required and costs may pose severe hurdles to a practical application, especially in small and medium enterprises (Bastard and Chaillet, 2023; Malisic *et al.*, 2023). In these settings, even the lack of knowledge, personal skills, supply chain integration and understanding may invalidate efforts in investing and adopting such technology (Adamashvili *et al.*, 2024; Sabbagh *et al.*, 2024; Popović *et al.*, 2022; Dicuonzo *et al.*, 2021). In addition, acceptance of a system based on decentralisation and equity among participants also requires a strong collaborative approach, where a consistent amount of information and data must be shared. While this approach should enhance transparency and trust building, privacy and confidentiality of data and information are primary concerns that need to be addressed when promoting BCT (Cordeiro and Olsen, 2021; Krumpholz *et al.*, 2021; Cuel and Cangelosi, 2020). Indeed, despite the important advantages that this technology seems to bring, winemakers are still hesitant to adopt it (Bastard and Chaillet, 2023; Malisic *et al.*, 2023; Vu *et al.*, 2023; Kumar *et al.*, 2022; Luzzani *et al.*, 2021; Sadhya and Sadhya, 2018).

Considering the findings from the literature on BCT, this paper aims to address the research question: what are the factors that influence the adoption of BCT by Italian winemakers?

To answer this question, we based our research model on the well-established Unified Theory of Acceptance and Use of Technology (UTAUT) in the version applied by Queiroz *et al.*

(2021) and Queiroz and Wamba (2019), which also includes trust. Since most of the research on BCT adoption has been conducted especially in developing economies and there is only a little share of research in the context of the Italian wine sector, the novelty of the present study is to attempt to empirically examine the factors affecting BCT adoption in the Italian context, characterised by small-medium wine producers. This study brings a valuable contribution to advancing knowledge about BCT adoption in the agri-food sector, with a focus on the wine supply chain, to foster its adoption and make such a traditional system more resilient, transparent and innovative. Our findings could provide light on the technical and practical factors to consider when implementing BCT in a small- to medium-sized business setting.

The paper is structured as follows. Following the introduction, Section 2 presents the theoretical background and the research hypotheses. Section 3 explains the employed methodology. Sections 4 and 5 present and discuss the main results. Finally, Section 6 concludes, presenting some theoretical and practical implications of the study along with its limitations and future research directions.

2. Research model and hypothesis development

In the literature, analysing user acceptance of technology is a key topic, and its discussion is still ongoing. This interest has led to the use of a wide range of exploratory techniques that examine many different systems and technologies in countless contexts (Williams *et al.*, 2015). One of the most widespread and applied methodologies is the UTAUT (Oguntegbe *et al.*, 2022; Venkatesh *et al.*, 2003, 2012). In the specific case of BCT technology, UTAUT has been widely applied in different sectors to analyse the factors that influence its adoption (Almekhlafi and Al-Shaibany, 2021). As mentioned above, there are only a few studies that provide consistent results on the factors that influence the adoption of BCT technology in the agri-food supply chain.

These studies use the UTAUT, or part of it, to identify the factors influencing the use of BCT in different agri-food sectors. According to Adaryani *et al.* (2024), the intention to adopt BCT in the Iranian poultry supply chain is influenced by effort and performance expectancies, social influence and objective knowledge of the technology. This means that there is a higher probability of adopting BCT when stakeholders perceive ease of use and job performance improvement, and also when a trustworthy third party suggests its application. In their study, trust worked as a moderator of the behavioural intention to adopt BCT. Similar results were found by Toader *et al.* (2024), confirming the significant influence of performance expectancy, effort expectancy and trust in European agri-food companies, and by Sharma *et al.* (2023), where social influence, facilitating conditions and interfirm transparency were also found to have a significant impact on the behavioural intention to adopt BCT in the Indian agri-food supply chain. Even the analysis by Shih and Chiu (2023) shows a significant positive influence of performance expectancy, effort expectancy, facilitating conditions and social influence on the intention to adopt BCT. In addition, they extended the UTAUT model by adding perceived value, government support and information security, discovering that the latter two factors influence the intention to adopt BCT in Taiwan.

Nayal *et al.*'s (2023) study investigates the potential mediating role of BCT to improve the sustainability of the Indian agriculture supply chain. Apart from the performance expectancy derived from the original UTAUT model, the authors found other factors influencing BCT adoption, including green and lean practices, supply chain integration and risk, internal and external environmental conditions, regulatory and top management support, innovation capability, and the costs needed to implement the technology. Ullah (2021) found a substantial impact of all UTAUT items on the behavioural intention to adopt BCT in Pakistani agriculture firms, except for social influence. Therefore, in this case, BCT adoption seems to be more influenced from technical and performance aspects rather that the behaviour and opinion of other people. Conversely, Kramer *et al.* (2021) utilised the instrumental stakeholder theory to study the behavioural intention to adopt BCT in the coffee supply chain. They suggest that, with a normative management approach, the adoption and use of the technology could be positively impacted when the creation of qualified jobs, better education and increased job security are expected. Concerning the wine supply chain, similar results can be highlighted. Cordeiro and Olsen (2021) applied the UTAUT model in a qualitative framework to study the Chinese importation of Bordeaux wine. They found high expectations that a BCT-based traceability system will be quite effective (performance expectancy), with a certain degree of uncertainty in terms of cost-efficiency (effort expectancy). In addition, regional policies would work as a facilitator to incentivise the adoption of a BCT-based system (facilitating conditions). Conversely, Saurabh and Dey (2021) identified disintermediation, traceability, price and trust as the factors that could influence the behavioural intention to adopt BCT in the wine industry.

The original version of UTAUT argues that behavioural intention (BINT) and use behaviour are influenced mainly by the factors: performance expectancy, effort expectancy, social influence and facilitating conditions. Evidence confirms that not all primary assumptions proposed under UTAUT hold true in different contexts (Adaryani *et al.*, 2024). For this reason, Venkatesh *et al.* (2016) suggest that conceptualising their proposed UTAUT model in various contexts can lead to its expansion and improvement. Therefore, following the work of Queiroz *et al.* (2021) and Queiroz and Wamba (2019), we added the factor of trust as a predictor of behavioural intention.

2.1 Performance expectancy

Performance expectancy (PEXP) is defined by Venkatesh *et al.* (2003) as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance." In our context, PEXP refers to the extent to which using BCT benefits winemakers in production operations and sales.

Based on a review of the literature, this factor is widely recognised as one of the main positive predictors of intention to adopt BCT. In particular, Adaryani *et al.* (2024) indicate that the poultry supply chain contains processes and stages that are completely interlinked, where achieving optimal performance is somewhat difficult due to the interdependence of operations. Therefore, the actors of the supply chain will be more likely to adopt BCT if they perceive that the benefits of this technology can improve their work performance. The study by Toader *et al.* (2024) yielded comparable findings in a study conducted using an international sample of expert in use of BCT in agri-food supply chain. This positive influence was also found in the studies by Sharma *et al.* (2023) conducted in the North Indian state of Punjab, Shih and Chiu (2023) conducted on Taiwan farmers and Ullah (2021) conducted in Pakistan agricultural supply chain system. Based on the literature review, we have established the following hypothesis:

H1. Performance expectancy positively influences BCT adoption.

2.2 Effort expectancy

Effort expectancy (EEXP) is defined as "the degree of ease associated with the use of the system" (Venkatesh *et al.*, 2003). In our context, it represents the difficulty that winemakers have in applying BCT. From previous research in the agri-food sector, EEXP emerges as the second strong predictor of behavioural intention towards BCT adoption. According to Adayani *et al.* (2024), in a cognitive trade-off process, supply chain actors will adopt BCT if the expected benefits outweigh the effort required to use it. The same results were found in the study by Toader *et al.* (2024), who added that due to the positive impact of this factor, it is imperative for organisations to pay attention to optimising the user-friendliness of BCT-based agri-food supply chain platforms. Lastly, this positive influence was also found in the studies of Sharma *et al.* (2023) and Shih and Chiu (2023). Hence, we posit the following hypothesis:

H2. Effort expectancy positively influences BCT adoption.

2.3 Social influence

Social influence (SINF) represents the "degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh *et al.*, 2003). It is the influence that the social sphere of the winemakers has on their attitude towards applying BCT. This factor does not always seem to have an impact on the intention to adopt BCT. In fact, in Ullah's (2021) paper, this variable was found to be not significant for the agricultural supply chain system in Pakistan. However, in other contexts, it emerges as a positive predictor of the intention to adopt BCT (Sharma *et al.*, 2023; Shih and Chiu, 2023). According to Adayani *et al.* (2024), this could happen in a context where BCT is an emerging technology. In fact, farmers who have little practical experience with this technology could wait for the decision or advice of another perceived important person to decide whether to accept/reject such a technology. Given the limited diffusion of BCT among Italian winemakers, the following hypothesis was formulated:

H3. Social influence positively influences BCT adoption.

2.4 Facilitating conditions

The last factor indicated by the UTAUT is facilitating conditions (FCON). This factor is defined as "the degree to which an individual believes that an organisational and technical infrastructure exists to support use of the system" (Venkatesh *et al.*, 2003). In this work, it is understood as the perception that winemakers have of the technological level of their farm and their predisposition to adopt BCT. The actual influence of this factor on behavioural intention towards BCT is debated in the literature. According to Adayani *et al.* (2024), FCON predominantly predict actual behaviour rather than behavioural intention to use the technology. Particularly in developing countries, where businesses suffer from lack of digital infrastructure and Internet speed, FCON are irrelevant in predicting behavioural intention to use BCT. However, these findings contrast with those of Sharma *et al.* (2023), Shih and Chiu (2023) and Ullah (2021) where it is stated that FCON in developing countries is a key factor in behavioural intention to adopt BCT. Sharma *et al.* (2023) also state that when there is sufficient technological, organisational, network and human support for BCT, users are more likely to engage with the technology. Hence, we posit the following hypothesis:

H4. Facilitating conditions positively influence BCT adoption.

2.5 Trust

The last predictor considered in the analysis was Trust (TRUST), understood as "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" (Queiroz *et al.*, 2021). In the case under analysis, trust is not intended in the technology, but in the other stakeholders along the supply chain with whom the tracked information is shared. Supply chains are characterised by multiple relationships and a certain level of complexity, and as a result, cooperation within the network becomes an essential variable for most organisations, which implies that such entities need to develop coordination tools to support this interaction (Grandori and Soda, 1995). In an agrifood supply chain context, relationships between organisations are fundamental to their operations and trust becomes a fundamental aspect. Prior research has investigated the correlation between trust and the inclination to adopt BCT in the context of agri-food supply chains. The study by Queiroz and Wamba (2019) presents a comparative analysis of questionnaires collected in India and the USA, indicating that in both contexts, trust does not exert a significant influence on the intention to adopt BCT. The study suggests that this may be attributed to the hesitancy of supply chain professionals in India and the USA to share data with members of their supply chain. However, subsequent empirical studies conducted by Quiroz *et al.* (2021), Ullah (2021), Sharma *et al.* (2023) and Toader *et al.* (2024) yielded opposing results, demonstrating the significant influence of individuals' trust in diverse stakeholders on their behavioural intention to adopt BCT. As Toader *et al*. (2024) observe, this is particularly relevant for those who are less familiar with or inexperienced in using BCT. Their initial level of confidence significantly influences their decision to adopt this pioneering technology. In consideration of the findings presented in the existing literature, a hypothesis has been formulated as follows:

H5. Trust positively influences BCT adoption.

3. Methods

3.1 Data collection and survey

To comprehensively investigate Italian wine producers' intention to adopt BCT, we developed a questionnaire based on the theoretical framework proposed by Queiroz *et al*. (2021) and Queiroz and Wamba (2019). As previously mentioned, Queiroz and colleagues proposed a modified version of the UTAUT (Venkatesh *et al*., 2003, 2012), incorporating the role of trust into the model.

An online questionnaire was carried out in 2023 on a targeted sample of Italian wine producers. In order to obtain a comprehensive sample of wineries, a database was constructed containing the contact details of wineries by Italian region, collected online from the websites of one of the most important Italian wine producers' associations, namely "Assovini" (Assovini (2025). After a pre-test with experts and producers, the questionnaire was sent by e-mail to the companies included in the database. A total of 128 responses were collected, of which 114 were considered valid.

The questionnaire was divided into two sections. In the first section, after providing respondents with a definition of BCT, items generating the latent variables used in the analysis were included. Overall, 24 items were defined and measured using a five-point Likert scale that ranged from 1 ("strongly disagree") to 5 ("strongly agree"). The decision to use a five-point Likert scale, unlike Queiroz and Wamba (2019, 2021), who used a seven-point scale, was based on two key factors. First, it reduces respondent fatigue, as wine producers have demanding schedules, and a shorter scale minimises cognitive load, enhancing engagement and response quality. Second, empirical evidence from Dawes (2008) shows that five-, seven- and ten-point scales yield comparable results in terms of standard deviation, skewness, kurtosis and analytical validity. Additionally, data from a five-point scale can be adjusted to a seven-point equivalent without affecting results, and while longer scales may slightly lower average scores, they do not impact reliability. This approach respected both methodological rigor and respondents' needs. Moreover, to ensure the retention of the original meaning of each construct, all items were translated into Italian by a professional translator. The translated items were then back-translated into English and carefully reviewed by a native English speaker. The items used are reported in Table 1.

In the second section, items concerning the technical-economic characteristics of the respondent winery and the socio-demographic characteristics of the respondents were included, such as age, gender and level of education.

3.2 Data analysis

Conducting research on the adoption of BCT in the wine supply chain involves navigating obstacles and identifying potential opportunities within the industry. Gathering data from a subset of 114 wine producers poses a difficulty due to the specialised nature of the field and varying levels of technological preparedness. In this context, PLS-SEM emerges as a fitting analytical method for several reasons (Hair *et al*., 2019). Firstly, PLS-SEM caters to smaller sample sizes, making it viable for scrutinising intentions and influential factors of adoption with a restricted number of participants. This is crucial for rigorous statistical examination despite constrained data collection from wine producers. Secondly, PLS-SEM's competence in addressing non-normal data distributions harmonises well with the multifaceted

Table 1. Measurement item used in the structural model

Construct	Measurement item	Item
BINT	I intend to use blockchain in the future	*BINT1*
	I predict I would use blockchain in the future	*BINT2*
	I plan to use blockchain in the future	*BINTE3*
EEXP	Learning how to use blockchain is easy for me	*EEXP1*
	My interaction with blockchain is clear and understandable	*EEXP2*
	I find blockchain easy to use	*EEXP3*
	It is easy for me to become skilful in using blockchain	*EEXP4*
FCON	I have the necessary resources to use blockchain	*FCON1*
	I have the knowledge necessary to use blockchain	*FCON2*
	Blockchain is compatible with other technologies I use	*FCON3*
	I can get help from others when I have difficulties in using blockchain	*FCON4*
PEXP	I find blockchain useful in my daily life	*PEXP1*
	Using blockchain increases my chances of achieving tasks that are important to me	*PEXP2*
	Using blockchain helps me to accomplish tasks more quickly	*PEXP3*
	Using blockchain increases my productivity	*PEXP4*
	I would find blockchain useful in my job	*PEXP5*
SINF	People who are important to me think that I should use blockchain	*SINF1*
	People who influence my behaviour think that I should use blockchain	*SINF2*
	People whose opinions I value prefer that I use blockchain	*SINF3*
TRUS	I believe that blockchain is trustworthy	*TRUS1*
	I trust blockchain	*TRUS2*
	I have no doubt on blockchain's reliability	*TRUS3*
	I feel assured that legal and technological structures adequately protect me from blockchain-related problems	*TRUS4*
	Blockchain has the ability to fulfil its task	*TRUS5*

Source(s): Queiroz *et al.* (2021) and Queiroz and Wamba (2019)

backgrounds and operational variances in the viticulture industry. BCT adoption involves interconnected factors such as perceived advantages, organisational preparedness and external influences, which can be effectively represented through PLS-SEM modelling.

Lastly, PLS-SEM allows for the incorporation of formative constructs, which is beneficial when analysing nascent technologies like BCT in fields where theoretical frameworks may still be evolving.

4. Results

4.1 Descriptive statistics of the sample

The characteristics of the sampled companies and wine producers are consistent with the average characteristics observed in the Italian wine sector. In particular, most of the Italian wine production is concentrated in the northern regions of the country. Most companies are classified as small, and the majority of producers are male (Nomisma, 2024).

The characteristics of the farms and the sample are presented in Table 2.

In alignment with the aforementioned characteristics, the majority of participants were male (71%) and within the 40–59 age range (58%). Of the 114 individuals who were interviewed, 50 (44%) had obtained a university degree, while 12 (11%) had pursued higher education. The wineries represented by the participants were predominantly located in Northern Italy (52%), with the majority engaged in the production and processing of the product (83%) and following an organic production system (46%). The wineries analysed are predominantly micro-enterprises (59%). The only characteristic of the sample that differs from the national average is the frequency of companies that use organic methods, which in Italy is 21% (Sinab, 2023). However, the high presence of organic producers indicates a high presence

Table 2. Respondents and wineries characteristics

Respondent (owners)			Wineries		
Gender	Male	71%	Location	North	52%
	Female	27%		Centre	25%
	nd	2%		South and Islands	24%
Age	18–35	22%	Turnover	<500,000	59%
	36–50	39%		>500,000	41%
	51–75	39%	Activity	Producer	10%
Education level	Middle school	4%		Transformer	7%
	High school	42%		Producer and transformer	83%
	Graduate	44%	Farming	Conventional	34%
	Postgraduate	11%		Organic	46%
				Integrated	20%

Source(s): Authors' own work

in the sample of producers attentive to quality production. Finally, 65% of the interviewees stated that they had already heard of BCT.

4.2 Descriptive statistic of the latent constructs and model fit

The validity of the latent constructs was analysed through the descriptive analysis of their value and through the estimation of Cronbach's alpha (Table 3).

Looking at Cronbach's alpha, indicating the reliability of each scale, observe high internal consistency across all measures. Therefore, the items composing each construct were averaged into a single score (Table 3). Given the midpoint of 3, from a descriptive point of view the average scores for each construct reveal that users perceive BCT as relatively easy to use (FCON and EEXP) and trustworthy (TRUST). However, the scores for SINF and PEXP are comparatively lower, indicating that users do not feel significant social pressure to adopt BCT and are not entirely convinced of its utility in their daily lives or jobs. Overall, users exhibit a moderate intention to use BCT in the future (BINT), reflecting a cautious but open attitude towards adopting this emerging technology.

Once the validity of the latent constructs was established, the BINT prediction model was estimated.

The structural model results, including standardised path coefficients and their significance levels, are summarised in Table 4 and Figure 1. The model explains 78.36% (adjusted R-squared = 0.7836) of the variance in the behavioural intention to adopt BCT.

PEXP ($\beta = 0.738$, $p < 0.001$) and TRUST ($\beta = 0.1405$, $p < 0.05$) were found to have a significant positive influence on the intention to adopt BCT. Therefore, hypotheses H1 and H5 are supported. Other constructs, including EEXP, FCON and SINF, did not show a statistically significant effect on the intention to adopt BCT. Consequently, hypotheses H2, H3 and H4 are rejected.

The average variance extracted (AVE) for all constructs exceeded the threshold value of 0.5, indicating adequate convergent validity (AVE ranged from 0.632 to 0.883). Additionally, the composite factor reliability (CF) for each construct was higher than the conventional cutoff of 0.70. The standardised root mean square residual (SRMR) value was 0.07, which generally considered a good fit, and the relative goodness-of-fit (GoF) value was 0.98271, suggesting an excellent fit of the model to the data.

Discriminant validity was assessed using the Fornell–Larcker criterion, which compares the squared interfactor correlations with the AVE values. All constructs demonstrated adequate discriminant validity, as the AVE values for each construct were higher than the corresponding squared interfactor correlations. The AVE values and squared interfactor correlations are presented in Table 5.

Table 3. Latent constructs descriptive statistics and Cronbach's alpha

Measure	Items	Mean (SD)	α	Averaged score
BINT	I intend to use blockchain in the future	3.07 (1.24)	0.933	2.94 (1.20)
	I predict I would use blockchain in the future	3.04 (1.30)		
	I plan to use blockchain in the future	2.70 (1.30)		
EEXP	Learning how to use blockchain is easy for me	3.17 (1.07)	0.887	3.00 (0.95
	My interaction with blockchain is clear and understandable	2.87 (1.12)		
	I find blockchain easy to use	2.89 (1.08)		
	It is easy for me to become skilful in using blockchain	3.08 (1.15)		
FCON	I have the necessary resources to use blockchain	3.00 (1.14)	0.805	3.06 (0.94)
	I have the knowledge necessary to use blockchain	2.93 (1.25)		
	Blockchain is compatible with other technologies I use	3.36 (1.10)		
	I can get help from others when I have difficulties in using blockchain	2.96 (1.23)		
PEXP	I find blockchain useful in my daily life	2.71 (1.19)	0.903	2.74 (0.98)
	Using blockchain increases my chances of achieving tasks that are important to me	2.93 (1.19)		
	Using blockchain helps me to accomplish tasks more quickly	2.72 (1.12)		
	Using blockchain increases my productivity	2.32 (1.12)		
	I find blockchain useful in my job	3.03 (1.17)		
SINF	People who are important to me think that I should use blockchain	2.26 (1.18)	0.896	2.22 (1.02)
	People who influence my behaviour think that I should use blockchain	2.15 (1.10)		
	People whose opinions I value prefer that I use blockchain	2.24 (1.08)		
TRUST	I believe that blockchain is trustworthy	3.39 (1.08)	0.878	3.18 (0.95)
	I trust blockchain	3.26 (1.14)		
	I have no doubt on blockchain's reliability	3.11 (1.24)		
	I feel assured that legal and technological structures adequately protect me from blockchain-related problems	2.74 (1.11)		
	Blockchain has the ability to fulfil its task	3.43 (1.20)		

Note(s): BINT = Behavioural intention to adopt; EEXP = Effort expectancy; FCON = Facilitating conditions; PEXP = Performance expectancy; SINF = Social influence; TRUST = Trust. The range of values is 1–5 for all variables. Standard deviation is in parentheses
Source(s): Authors' own work

Table 4. Structural model – standardised path coefficients

Variable	Intention	*p*-Value
EEXP	0.061	0.4108
FCON	0.015	0.855
PEXP	0.738	0.000
SINF	0.012	0.831
TRUST	0.140	0.020
Adjusted R-squared	*0.7836*	

Note(s): EEXP = Effort expectancy; FCON = Facilitating conditions; PEXP = Performance expectancy; SINF = Social influence; TRUST = Trust
Source(s): Authors' own work

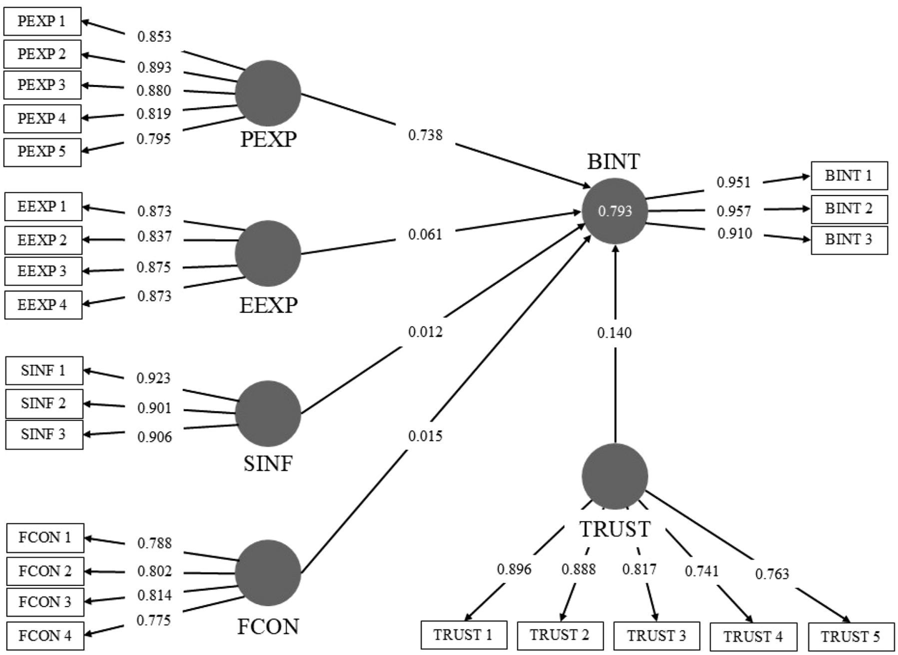

Figure 1. Structural model – standardised path coefficients (Source: Authors' own work)

Table 5. Discriminant validity – squared interfactor correlation vs average variance extracted (AVE)

	BINT	EEXP	FCON	PEXP	SINF	TRUST
BINT	1.000					
EEXP	0.354	1.000				
FCON	0.432	0.636	1.000			
PEXP	0.774	0.354	0.464	1.000		
SINF	0.329	0.190	0.246	0.409	1.000	
TRUST	0.421	0.306	0.370	0.391	0.156	1.000
AVE	*0.883*	*0.747*	*0.632*	*0.720*	*0.828*	*0.679*

Note(s): BINT = Behavioural intention to adopt; EEXP = Effort expectancy; FCON = Facilitating conditions; PEXP = Performance expectancy; SINF = Social influence; TRUST = Trust
Source(s): Authors' own work

5. Discussion

Results demonstrated the pivotal role of PEXP and TRUST as important latent constructs affecting the Italian winemakers' intention to adopt BCT. PEXP (β = 0.738, p < 0.001) emerged as the main significant factor impacting intention, aligning with the Technology Acceptance Model, which posits perceived usefulness as a key motivator for technology adoption (Davis, 1989). Although this finding contrasts with Queiroz *et al.* (2021), who highlighted a negative impact on operations and supply chain management, it is broadly consistent with previous studies in the agri-food sector (Adaryani *et al.*, 2024; Toader *et al.*, 2024; Sharma *et al.*, 2023; Shih and Chiu, 2023; Ullah, 2021). This supports H1, highlighting the context-dependent nature of the UTAUT model. Distinctly, in the Italian context, wine producers appear particularly driven by the expected benefits of BCT, such improving production efficiency and ensuring product authenticity. BCT's decentralised and immutable characteristics resonate strongly with the wine industry's need for transparency and traceability (Malisic *et al.*, 2023), crucial in combating fraud, a persistent issue in the Italian wine sector (Romano *et al.*, 2021). Unlike larger, industrialised wine-producing regions, Italian wineries often emphasise tradition, quality, and appellation control, making transparency and authenticity paramount (Cricelli *et al.*, 2024). Our findings suggest that, in Italy, the perceived benefits of BCT extend beyond efficiency gains to preserving the integrity of wine heritage and enhancing market competitiveness.

When stakeholders recognise a technology's capacity to optimise production processes and guarantee product authenticity, their adoption intent increases (Adaryani *et al.*, 2024). These findings underscore the importance of clearly communicating the tangible advantages and added value that BCT can bring, potentially through marketing strategies or educational initiatives demonstrating how productivity could improve with BCT implementation (Dwiwedi *et al.*, 2019). Similarly, TRUST significantly influenced the intention to adopt BCT ($\beta = 0.1405$, $p < 0.05$), confirming H5.

Trust, a key factor in technology adoption (Adaryani *et al.*, 2024; Toader *et al.*, 2024; Sharma *et al.*, 2023; Queiroz *et al.*, 2021; Ullah, 2021; Gefen *et al.*, 2003; McKnight *et al.*, 2002), was intended as confidence in supply chain stakeholders rather than the technology itself, considering it as a booster for cooperation and coordination (Grandori and Soda, 1995). Despite Queiroz *et al*. (2019) finding no significant impact of trust on BCT adoption in India and the USA, our findings confirm that trust in stakeholders strongly influences winemakers' BCT adoption, similar to other studies (Queiroz *et al.*, 2021; Ullah, 2021; Sharma *et al.*, 2023; Toader *et al.*, 2024), where its importance was particularly highlighted for less experienced users. In the Italian context, where wine production is deeply embedded in local networks and traditions, trust plays an even more central role. Italian wineries, particularly smaller ones, rely on long-standing relationships within the supply chain, making trust in data-sharing and stakeholder integrity essential for BCT adoption (Cricelli *et al.*, 2024). The sector's fragmented nature, with a high prevalence of small and family-run enterprises, may explain why trust exerts a stronger influence on adoption than in more consolidated wine industries. Therefore, greater confidence in data-sharing across stakeholders correlates with higher adoption willingness, emphasising trust-building as key to industry uptake.

Conversely, EEXP, FCON, and SINF did not significantly affect the intention to adopt BCT in the Italian wine production context, leading to the rejection of H2, H3 and H4. This aligns with other studies (Adaryani *et al.*, 2024; Ullah, 2021).

The lack of effect from these latent constructs may stem from limited familiarity with BCT among Italian wineries. Previous studies (e.g. Luzzani *et al.*, 2021; Malisic *et al.*, 2023) have noted that awareness and expertise regarding BCT are generally low in the sector, with informed companies being the exception. Additionally, Malisic *et al*. (2023) highlighted that small-scale wineries often face challenges in adopting digital technologies due to high costs, insufficient infrastructure and a lack of standardisation. In Italy, where artisanal wine production remains dominant, digital transformation efforts are often met with scepticism, further limiting the impact of external facilitating conditions. This lack of familiarity may result in difficulty assessing the technology's potential benefits, contributing to low adoption rates (Cricelli *et al.*, 2024). Efforts to mitigate this gap should focus on increasing awareness and providing accessible resources to navigate the complexity of BCT adoption decisions (Kamble *et al.*, 2019; Kim *et al.*, 2008; Agarwal and Prasad, 1999).

6. Conclusions, implication and limitations

This study advances the theoretical understanding of BCT adoption by verifying an expanded UTAUT model in the Italian wine industry. The results highlight the significant roles of PEXP and TRUST in driving the intention to adopt BCT among wine producers. While factors such as EEXP, FCON and SINF were not significant, the findings emphasise the importance of perceived benefits and trust in the adoption decision. These insights can guide stakeholders in the wine industry, BCT solution providers and policymakers in developing strategies to enhance adoption rates and leverage the benefits of BCT. By focusing on communicating the tangible benefits and building trust, it is possible to drive higher adoption rates and facilitate the integration of BCT into the wine production sector.

6.1 Theoretical, practical and policy implications

The implications of these findings are substantial. From a theoretical point of view, this study is the first to use the extended UTAUT to analyse factors influencing Italian winemakers' propensity to adopt BCT. Our findings broaden the UTAUT model's applicability in the wine supply chain by demonstrating that EEXP, SINF and FCON have no meaningful impact, underlining the necessity for sector-specific theoretical frameworks. The strong impact of PEXP suggests that efforts to promote BCT in the wine industry should focus on its productivity and efficiency benefits. This has important practical implications. In fact, educational campaigns and workshops could emphasise how BCT enhances operational performance and product traceability. Moreover, policymakers should consider actions to reduce the barriers to BCT adoption among small businesses. The creation of proprietary BCT, in fact, is often costly and not feasible for small or medium-sized enterprises. This leads companies to do without the technology or to rely on third-party companies, resulting in the loss of control over the published data. Policymakers could therefore consider introducing subsidies and technical support for the adoption of BCT, for small and medium enterprises that rely on this technology. Furthermore, the creation of a national public BCT accessible to all companies for the traceability of Italian wine could be considered.

The addition of trust as a crucial element BCT adoption strengthens its place in supply chain technology adoption theories, prompting further study to look at trust dynamics in decentralised systems. The significant role of TRUST underscores the necessity for producers adopting BCT to build and maintain trust through robust and transparent networks. Trust in the network is crucial for the large-scale adoption of BCT.

6.2 Limitations and future research

This study has some limitations. Firstly, the sample size was relatively small and restricted to a specific geographic region, which may limit the generalisability of the findings. Secondly, the data collected through the online questionnaire is self-reported, which may introduce biases such as social desirability bias or recall bias. Additionally, this study focused on the intention to adopt BCT rather than actual adoption behaviour. Longitudinal studies that examine the transition from intention to actual adoption would provide a more comprehensive understanding of the adoption process ad its dynamics.

The cross-sectional design of the study captures data at a single point in time, which limits the ability to assess changes in attitudes or behaviours over time. This is particularly relevant for technology adoption processes that may evolve. As respondents' understanding and familiarity with BCT may vary significantly over time, this variance could influence their responses, especially regarding EEXP and PEXP. Future research should consider longitudinal approaches to monitor changes in attitudes and behaviours towards BCT adoption over time, offering insights into the long-term impacts of the technology. Furthermore, the cross-sectional nature of this study limits the ability to draw causal inferences. Employing experimental or longitudinal designs in future research could help establish causality more robustly.

While this study incorporated key variables from the UTAUT model and included trust as an additional predictor, other potentially influential factors such as cost, regulatory support or competitive pressure were not considered. Future research could benefit from a more comprehensive set of variables, including exploring the actual willingness to pay for a BCT service, which might be a significant hurdle in incentivising BCT adoption.

Lastly, complementing quantitative findings with qualitative research could provide deeper insights into the reasons behind winemakers' attitudes and decisions regarding BCT adoption. Qualitative methods such as interviews or focus groups could reveal nuanced understandings of the barriers and motivators influencing the adoption of BCT. In this regard, research is extremely beneficial in a complex system like the agri-food, as it promotes technological adaptation and helps overcome multiple technical and cultural barriers.

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