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Can blockchain technology strengthen consumer preferences for credence attributes?

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Abstract

Consumers' interest in product information, such as nutrition, environment, and social aspects, is increasing in the food market. Blockchain technology can enhance credibility of quality signals on labels through transparency and accountability in the supply chain. This study examines the impact of blockchain technology on reducing consumer uncertainty about credence attributes and facilitating informed choices. It is particularly relevant for food policies, as greater consumer awareness promotes proactive involvement in sustainability and public health. We conducted a choice experiment with 300 Italian consumers, focusing on craft beer and analysing how blockchain technology in strengthens organic and DOP certification. The results provide valuable insights for producers and policymakers to develop voluntary approaches that engage society in objectives that concern the collective well-being. They highlight the potential of blockchain technology in communicating credence attributes and empowering consumers. However, our study reveals that the impact of blockchain technology on choices is influenced by a different level of trust, likely due to the complexity of understanding its functioning.

Keywords: Consumer trust, Traceability, Organic certification, Personality traits, Hybrid choice models (HCM), Attitudes

Introduction

In the past few years, concerns about food safety and quality have led consumers to prefer foods that present greater guarantees about the information on the label conforming with the characteristics of the product (Moruzzo et al. 2020; Kaczorowska et al. 2021; Lewis and Grebitus 2016; Sadílek 2019). This trend is confirmed by the positive market results of foods with reliable quality signals (Profeta et al. 2008; Hobbs et al. 2005). On the other hand, while consumers are able to directly observe the search and experience attributes, they cannot verify the credence attributes.[1] For these attributes, they must refer to the indications provided by the producer or the retailer whose credibility depends on the trust that the consumer places in the overall food system, including the

[1] Credence attributes are product characteristics that cannot be readily observed or evaluated by consumers through examination or use. Examples of such attributes include the origin of the product or its environmental impact. As a result, credence attributes entail an issue of information asymmetry between consumers and producers, whereby consumers must rely on the producer's claims or third-party certifications to make informed purchasing decisions (Baron 2011).

authorities responsible for food safety and food labelling regulations (Meijer et al. 2021; Lassoued and Hobbs 2015; Fernqvist and Ekelund 2014).

Trust is a complex construct, influenced by the space–time distance between producer and consumer, by culture, the institutional environment, and the historical events that have affected the safety and quality of foods (Berg 2004). Currently, consumer trust in the food system is fragile, especially as far as transparency and authenticity are concerned (Edelman, 2019; Frewer 2017). Limits in trust reduce the effectiveness of certifications and, consequently, contribute to the fall of the potential demand for products with credence attributes, such as origin, the characteristics of the production process, and the health-giving properties of products. From the viewpoint of public interest, low trust negatively affects policies in favour of sustainable development and public health, which employ forms of traditional certification in order to inform the consumer of products' nutritional and ethical value (Kaiser and Algers 2017; Hobbs and Goddard 2015; Sapp et al. 2009; Kjærnes 2006; Kjærnes et al. 2005).

The studies that have analysed the constituent elements of trust show that it is grounded in cognitive beliefs (Macready et al. 2020). This finding stresses the importance that communication can assume in strengthening trust, inasmuch as cognitive beliefs are more reactive to information than affective beliefs (Macready et al. 2020). In particular, the authors point out the importance of communication capable of conveying relevant information. Among these, the transparency and accountability of the supply chains play a key role (Verbeke, 2011, 2005; Mazzocchi et al. 2008).

Blockchain technology (BCT) is an innovation that is potentially capable of providing greater transparency and accountability. Born in the area of the cryptocurrencies, BCT can be defined as "*a linked list of immutable tamper-proof blocks, which is stored at each participating node*" (Gupta and Sadoghi 2019, p. 1). Its architecture is such that it enables participants to share a ledger that is updated each time a transaction is made, so that each participant, who represents a node of the system, acts as both a publisher and a subscriber. The strength of the BCT is precisely its transparency, inasmuch that all of the actors of the chain acquire the information recorded at every stage but cannot modify any record. Once recorded, the information remains visible to all the actors of the chain, including the consumer (Zhao et al. 2019; Tian 2017).

In the past few years, BCT has been used in many sectors, which extend beyond those of its initial application (Tayeb and Lago 2018). The management of digital signature systems, tracking intellectual property rights, monitoring the health records of patients, and tracking products on supply chains are a few examples of its recent uses (Galvez et al. 2018).

In the food sector, with BCT all of the transactions between the actors of the chain are recorded as a guarantee of transparency and traceability of the products (Kamilaris et al. 2019). At each transaction, in addition to quantities and prices, farmers can report information concerning the agricultural phase, such as the geographical coordinates of the plots, the seeds, plant production products, fertilizers, farming techniques and animal welfare. The processors include information about the factory, such as the machinery, processes, and the lot numbers of products. The distributors also participate in updating the ledger with details about the travel route, such as transport time and conditions (i.e. temperature, humidity), information about expiry date, storage procedures and the

time products spend on shelves. Finally, consumers can use their smartphones to scan the QR code on the product labels in order to view all of the information recorded in the ledger, from the farm to the store shelf (Galvez et al. 2018). In addition to tracking the actions of various actors in the distribution chain, emerging applications of BCT offer new opportunities for the agri-food sector. One notable example is the use of BCT to identify inefficiencies and reduce the sector's carbon footprint. Moreover, the incorporation of smart contracts and sensors represents a significant advancement that extends beyond traceability in the supply chain. These cutting-edge technologies enable the integration of quality control and certification, establishing a direct link between environmental factors and the specific storage requirements of products (De Angelis et al. 2023; Pandey et al. 2022).

However, despite its potential, the current use of BCT in the food sector is mainly limited to supermarkets tracking their private-label products, such as meat, eggs, dairy, fruits, and vegetables. (see for example, Carrefour 2021; Coop 2021). Among the producers, one branch that presents several applications is that of breweries, which use this technology to guarantee authenticity associated with the place of production and the sustainability of the process (Blockchain 2021; Ireland Craft Beers 2021). Despite these first cases in the foods sector, BCT is still in its emerging stage, and its implementation represents a challenge for both businesses and institutions. On the level of businesses, the principal factors that can pose obstacles to implementing the BCT can be attributed to organizational capability, technical competence, energy requirements, and financial resources. On the institutional level, the implementation of BCT requires adequate digital infrastructures, legal and regulatory compliance (Dutta et al. 2020). Taking into account the investments necessary on the business and institutional levels to confront these challenges, it becomes important to know the impact on demand of using BCT to showcase food products. The results of the first studies on BCT show that consumers have a positive attitude towards foods tracked using this technology, and that the BCT positively affects consumers' purchasing decisions (Lin et al. 2022; Polenzani et al. 2020; Violino et al. 2019; Sander et al. 2018). Other authors, however, highlight that consumers place limited value in technology-specific information which certify that the food was traced by BCT (Shew et al. 2022).

Given these preliminary remarks, our study proposes to tackle the issue of the credence attributes in a context in which fragile trust in the food system can undermine the consumer's self-confidence in their capability to make informed choices. In particular, we propose to understand the role that the BCT can assume in communicating the credence attributes. Our thesis is that the BCT can strengthen the reliability of credence attributes.

To demonstrate our thesis, we have conducted a study on a representative sample of Italian consumers concerning behaviour with respect to craft beer, given that this product is already involved in several real applications of BCT. The study is made up of two parts. In the first part, we identified the determinants of craft beer consumption by means of applying a structural equation model (SEM), starting from a selection of personal traits that the literature indicates as related to the consumption of craft beer. In the second part of the study, the results of the SEM were used to design a choice experiment that aimed to analyse the role of BCT in shaping consumer

preferences for two important credence attributes: environmental sustainability of the production process and origin. These two attributes were chosen because they were found to be the fourth and fifth most important attributes for consumers in a study on craft beer conducted by Lerro et al. (2020), following taste, type of fermentation, and colour. To indicate these characteristics in the choice experiment, two well-established certifications in Europe, namely organic certification and PDO, were used on the label (Aertsens et al. 2011; Vecchio and Annunziata 2011; Smith and Paladino 2010; Pieniak et al. 2010).

In this framework, we tested the following hypothesis:

H1 The simultaneous presence of BCT and organic certification has a positive effect on consumer preferences for craft beer that is higher than that of organic certification taken singularly.

H2 The simultaneous presence of BCT and the protected denomination of origin (PDO) has a positive effect on consumer preferences for craft beer that is higher than that of PDO taken singularly.

H3 Tthe interaction between trust in the food system and BCT does not have a significant impact on consumers' preferences for craft beer.

Testing H1 and H2 would show that BCT acts on consumer preferences by increasing the effect of credence attributes, while testing the H3 would prove that the impact of BCT on preferences is independent from the consumer's trust in the food system, and therefore, low trust in the food system would not compromise the validity of H1 and H2.

Methods

Determinants of craft beer consumption and development of the Structural Equation Model

According to the literature review conducted by Nave et al. (2021), the number of publication on consumer behaviour with respect to craft beer is low. However, from the literature, it is possible to identify some personal traits that are correlated to the consumption of craft beer. In particular, the literature indicates that an important lever of drinking craft beer is the local nature of the breweries and their connection with the local environment (Fletchall A. 2016). In this regard, Fastigi et al. (2018) argue that the consumption of craft beer is linked to the interest in the relocalization of productions. The association between craft beer and the place of production is also pointed out by other authors (Carbone and Quici 2020; Skoglund and Sjölander-Lindqvis 2019) who find that craft beer consumption is related to the preference for local foods. Levitt et al. (2023) confirmed the importance of the local origin of craft beer in influencing consumer preferences. In a study conducted in the USA, the authors demonstrated that taste expectations were significantly higher for a locally produced craft beer as compared to a non-local one.

Therefore, we have included in the SEM the preference for local foods and the believes about regional foods as possible determinants of the consumption of craft beer, assuming

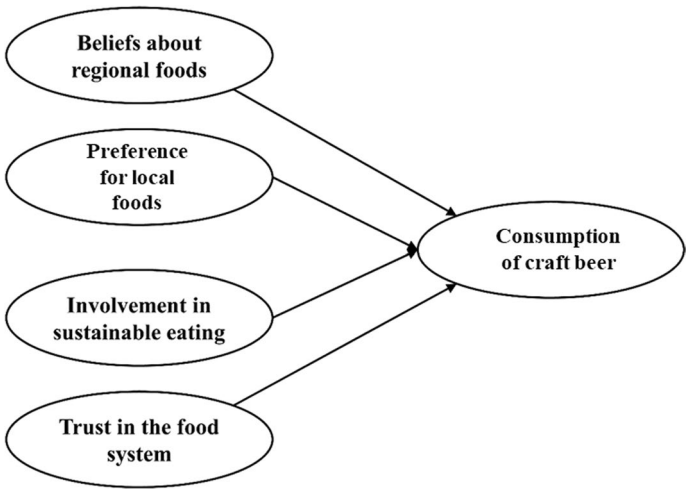

Fig. 1 Illustration of the structural equation model tested in our research

that a greater preference for local foods and more positive beliefs towards regional foods result in a greater consumption of craft beer.

Another factor that the literature shows to be a determinant of the consumption of craft beer is consumer attention towards the sustainability of the production process (Fastigi et al. 2018). Therefore, we have included in the structural model the involvement in sustainable eating, assuming that greater involvement can encourage the consumption of craft beer.

Finally, Foster et al. (2017) show that the most important issue from craft beer consumers is trust in the reliability, transparency, and integrity of breweries. This evidence could explain why the BCT is gaining ground precisely with craft beer and can be traced back to the fact that trust becomes more important when buying food produced by lesser-known brands (Benedicktus et al. 2010), as is the case with craft beer. Furthermore, literature shows that when it comes to artisanal foods compared to industrial food, trust in the food system can become relevant, because some consumers perceive artisanal foods as more at risk with regard to food safety (Cane 2018). Considering these findings, we have introduced into the model trust in the food system, assuming that greater trust is positively correlated with the consumption of craft beer. Figure 1 shows the model tested with the SEM.

Case study

Italian beer consumption has been on the rise, with a significant increase of 11.8% in 2020 compared to the previous year. This trend continued in 2021, with a growth of 1.8%. In 2021, beer production in Italy reached 17.6 million hectolitres, surpassing the levels achieved in 2019 (17.3 million hectolitres) (Assobirra 2021).

The significant growth in production has led to intense competition and new challenges for businesses. One of the major challenges is sustainability, as highlighted in Assobirra's latest report (2021). The report reveals that a growing number of Italians, approximately one-third of the population, are willing to pay a premium for sustainable products. For most Italians, sustainability is closely linked to local production and

Table 1 Sociodemographic characteristics of the sample ($n = 300$)

Variables	Sample (%)	Italian population[a] (%)
Age group		
18–34 years	24.00	21.89
35–54 years	39.67	41.05
Over 54 years	36.33	37.06
Gender		
Male	49.33	48.00
Female	50.67	52.00
Region of residence		
Northern Italy	48.33	46.00
Central Italy	20.67	20.00
Southern Italy and Islands	31.00	34.00

[a] The data concerning the Italian population was collected by the Italian National Institute of Statistics (ISTAT)

the commitment of producers to minimize their environmental impact. This includes efforts to minimize CO_2 emissions and energy waste, as well as the adoption of sustainable packaging practices. These findings underscore the importance of sustainable practices in the beer industry and emphasize the need for producers to prioritize sustainable production methods to meet the demands of an increasingly environmentally conscious consumer base.

Another significant challenge in the beer industry is product differentiation. Craft beer has obtained official recognition with Law 154 of July 28, 2016, which defines it based on its production process among various types of beer. This legal recognition provides craft brewers with a competitive edge, enabling them to distinguish themselves in the market and appeal to consumers seeking unique and high-quality beer. In particular, craft beer does not involve pasteurization and micro-filtration. Furthermore, it must be produced in independent breweries that must not surpass the production of 200,000 hectolitres. In Italy, there are 862 craft breweries and brewpubs that produce a total of 48,000 hectolitres of beer. These registered organizations employ 2800 individuals who produce beer for internal consumption, often in collaboration with the catering industry (Assobirra 2021).

Data collection and questionnaire

The study was conducted in Italy, with a sample of 300 craft beer consumers. The participants were recruited by a marketing research agency (Toluna Inc.) using quota-based sampling, as shown in Table 1. Invitations were sent to the respondents via email, and those who expressed willingness to participate were given access to the questionnaire through an online platform. The administration phase lasted for 15 days in October 2019. The data passed quality control based on response time, excluding all the questionnaires filled out in less than 5 min.

The questionnaire consisted of three parts. The first part concerned the choice experiment; the second recorded respondents' consumption of craft beer and their psychographic characteristics; the third part determined the sociodemographic characteristics.

 7 euro	 5,5 euro	Nessuna delle due opzioni
Opzione A	Opzione B	Opzione C

Fig. 2 Example of choice task

The choice experiment is a well-established stated preference method used in consumer behaviour analysis, marketing and agricultural economics (Piracci et al. 2022; Villas-Boas et al. 2021; Zemo and Termansen 2022). It enables the elicitation of individuals' preference for different products' attributes and attribute levels. Choice experiment is consistent with Lancaster's theory of consumer demand (Lancaster 1966) and Random Utility Theory (McFadden 1974). Participants are presented with multiple choice scenarios and asked to make buying decisions for their most preferred product between two or more alternatives described by different combinations of attributes, and attribute levels. By employing this method, researchers can observe participants' choice behaviour and investigate the factors influencing their decisions.

In this study, the choice experiment required respondents to choose between two 0.50 cl craft beers or to select the no-choice option. The two products differed from one another by the presence or absence of the three following attributes: organic certification, PDO certification, and BCT. Furthermore, the two alternatives differed by four price levels (€ 4; €5.5; € 7; € 8.5). An example of choice task is shown in Fig. 2. We decided not to provide any further information on the attributes included in the experiment in order to avoid creating a priming effect. Consequently, respondents' knowledge of the meaning of BCT corresponded to what they knew before being recruited. Given these preconditions, our study analyses the role BCT can play in determining consumer choices in the current scenario.

The set of choice tasks and the combination of attributes and levels in each task were identified with an orthogonal fractional design, which was specified in order to identify the main effects of the attributes and the interaction effects between the BCT attribute and the organic and PDO attributes. We obtained a design with twelve choice sets using Ngene software.

In the second part of the questionnaire, respondents were asked to declare how much they agreed with several statements. These included a subjective behavioural variable (which hereinafter we shall refer to as "Behaviour"), given by the frequency with which

Table 2 Description of the scales used to estimate the latent variables

Constructs and sources of adoption	Measuring items	Mean	Median	SD
Behaviour (Consumption frequency of craft beer)	Consumption frequency of filtered craft pale lager beer	3.45	3.00	0.80
	Consumption frequency of craft pale lager beer	3.17	3.00	0.88
	Consumption frequency of filtered craft red beer	2.89	3.00	0.94
	Consumption frequency of craft red beer	2.72	3.00	0.98
	Consumption frequency of filtered craft dark beer	2.85	3.00	0.94
	Consumption frequency of craft dark beer	2.72	3.00	1.00
Involvement in sustainable eating (Van Loo et al. 2017)	Sustainable eating is very important to me	5.22	5.00	1.45
	I care a lot about sustainable eating	5.06	5.00	1.45
	Sustainable eating means a lot to me	5.18	5.00	1.50
	I am very concerned about the sustainable-related consequences of what I eat	5.08	5.00	1.49
Beliefs about regional foods Adapted from (Van Ittersum et al. 2007)	Regional foods preserve a higher product quality	5.66	6.00	1.21
	Regional foods guarantee a constant product quality	5.62	6.00	1.24
	Regional foods reduce the likelihood of fraudulent copycat products	5.64	6.00	1.25
	PDO labels preserve product exclusivity	5.49	6.00	1.28
Trust in the food system (Adapted from Siegrist 2000)	How much do you trust the following components of the agri-food system: producers	5.10	5.00	1.31
	How much do you trust the following components of the agri-food system: retailers	4.67	5.00	1.39
	How much do you trust the following components of the agri-food system: National and European regulators	4.99	5.00	1.48
Preference for local foods Adapted from (Shimp and Sharma 1987)	It is always best to purchase local food products	5.35	6.00	1.45
	Italians should not buy foreign food products, because this hurts local business	4.76	5.00	1.70
	It may cost me in the long run but I prefer to support local food products	5.40	6.00	1.32

SD Standard deviation

they consumed craft beers (measured with a five-point scale ranging from "Never" to "Daily") and by the following psychographic constructs: (*i*) "Involvement in sustainable eating"; (*ii*) "Beliefs about regional foods"; (*iii*) "Trust in the food system"; and (*iv*) "Preference for local foods". The details on the scales employed to survey the constructs, with their related sources, are reported in Table 2. All of the items related to the psychographic constructs were measured by means of seven-point Likert scales.

Econometric approach

The methodology applied in this study is based on specifying a model via a two-step procedure in order to incorporate in the estimation the systematic heterogeneity due to psychographic traits (Yangui et al. 2016; Grebitus et al. 2013; Lin et al. 2019; Bazzani et al. 2017).

In the first step, we applied a structural equation model (SEM) to test the relationships between "Behaviour" and the previously described psychographic variables, namely "Involvement in sustainable eating", "Beliefs about regional foods", "Trust in the food system", and "Preference for local foods". The SEM consists of a set of linear equations that simultaneously estimate relationships between observed variables, i.e. the items, and the latent constructs measured by those items. One of the main practical advantages of using SEM for data analysis is its ability to identify relationships between latent variables that cannot be directly observed but can be inferred from observable variables. In the second step we included in a mixed logit model the predicted latent variables that proved significant with respect to "Behaviour" together with the beer attributes included in the choice experiment.

Therefore, our specification starts from the Random Utility Theory (McFadden 1974) where the utility that person n obtains from alternative beer j is specified as follows:

$$U_{nj} = \text{NOBUY} + \beta \text{X}_{nj} + \lambda \text{price}_{nj} + \varepsilon_{nj} \tag{1}$$

where NOBUY is an alternative-specific constant representing the no-buy option, X_j denotes the attribute vector (BCT, PDO and organic certification) coded as dummy variables for each alternative j, β is a vector of the utilities associated with each attribute, *price* is the price vector, and λ is the effect of price on utility. The ε_{nj} is the unobserved error term.

We develop Eq. 1 to allow for systematic heterogeneity in preferences incorporating the interaction terms between attributes of our choice models and the latent psychographic construct (for the sake of simplicity of notation we rely on a single latent variable):

$$U_{nj} = \text{NOBUY} + \beta \text{X}_{nj} + \lambda \text{price}_{nj} + \gamma \text{X}_{nj} \text{Z}_n + \varepsilon_{nj} \tag{2}$$

where Z_n is the vector of the latent psychographic characteristic of n-th respondent and γ is the effect of this characteristic on the utility function. The main underlying hypothesis is that the psychographic constructs can better explain the differences in preferences across respondents.

The estimation of the Z_n is performed using a measurement model. In fact, although the psychographic characteristics are not directly observed, a set of k responses to the psychographic questions are functions of the psychographic traits. Therefore, we can estimate a set of equations where the values of the I_{kn} indicators are dependent on the value of a psychographic factor:

$$I_{kn} = \delta_{Ik} + \zeta_{Ik} Z_n + \upsilon_{kn} \tag{3}$$

where δ_{Ik} is a constant for the k-th indicator, ζ_{Ik} is the estimated effect of the latent variable Z_n on this indicator, and υ_{kn} is a normally distributed disturbance.

As mentioned above**,** we incorporated only the Z_n of the latent variables that proved significant for the consumption of craft beer. Furthermore, in order to study the relations between BCT and the other certifications, in the final model we also inserted two interaction terms, i.e. between organic and BCT and the PDO BCT interaction. Consequently, Eq. 2 is rewritten as follows:

Table 3 Convergent and discriminant validity assessment

	Latent constructs	α[a]	AVE	Squared correlations among latent variables			
				1	2	3	4
1	Beliefs about regional foods	0.87	0.63	1			
2	Preference for local foods	0.79	0.58	0.36	1		
3	Involvement in sustainable eating	0.94	0.79	0.30	0.41	1	
4	Trust in the food system	0.74	0.53	0.30	0.17	0.22	1
5	Behaviour	0.85	0.51	0.04	0.06	0.12	0.11

[a] Cronbach's α; AVE Average variance extracted

$$U_{nj} = \text{NOBUY} + \beta X_{nj} + \lambda \text{price}_{nj} + \gamma X_j Z_n + \delta_1 (x_j^{\text{BCT}} * x_j^{\text{organic}}) + \delta_2 \left(x_j^{\text{BCT}} * x_j^{\text{PDO}} \right) + \varepsilon_{nj} \quad (4)$$

The significance and magnitude of γ-parameters indicate the shift in utility for each attribute for a respondent with an additional score that measures the psychographic construct. The $\delta_{1,}$ and δ_2 represent the shift in utility given by the presence of the BCT with organic and PDO certification, respectively. The model in Eq. (4) was estimated using a mixed logit model where the β-parameters are random and normally distributed**,** while the other parameters are instead assumed as fixed.

Results

Measurement and structural models

Preliminarily, we verified the internal consistency between the items of the constructs utilized by means of Cronbach's α. The scores vary from a minimum of 0.74 to a maximum of 0.94 (Table 3), so they are all over the limits of acceptability of 0.60 (Loewenthal 2004). Then, by means of a confirmatory factor analysis (CFA), the measurement model was estimated in order to test for the reliability, convergent and discriminant validity of the items that make up the constructs. The convergent validity was evaluated on the basis of two indicators: the factor loadings and the average variance extracted (AVE) values. The discriminant validity was measured comparing the AVE value of a latent construct with its squared correlation with any other latent construct in the model. If the AVE is always larger than the squared correlations, the discriminant validity is established. The previously described structural model was performed based on the measurement model. The measurement and structural models were estimated with a maximum likelihood with a Satorra–Bentler correction (Satorra and Bentler 1994), as the Mardia test rejected the null hypothesis of multivariate normality at 99%.

The factor loadings of the CFA are all higher than the minimum of the recommended level of 0.6 (Chin et al. 1997). Consequently, these items were not included in the successive analyses. The values of the AVE (Table 3), which range from 0.51 to 0.79, also exceed the recommended minimum values of 0.5 (Fornell and Larcker 1981). We can thus affirm that the items used have attained a satisfactory convergent validity in determining the latent constructs. Finally, we can observe that the AVE values are all above the squared correlation among the latent variables (Table 3), thereby assuring an adequate discriminant validity. The results of the model present excellent goodness-of-fit

Table 4 Standardized coefficients of model to predict behaviour

Variables	Coefficients	Std. Err.
Beliefs about regional foods	− 0.10	0.09
Preference for local foods	0.01	0.08
Involvement in sustainable eating	0.28***	0.08
Trust in the food system	0.26***	0.07

(***) significance at 1%; Std. Err.: Standard Errors

statistics: the ratio between the Satorra–Bentler scaled χ^2 and degree of freedom = 1.85; RMSEA = 0.053; CFI = 0.95; TLI = 0.94; SRMR = 0.052. The Satorra–Bentler scaled normalized Chi-square should indeed present a value of less than 3 (Schreiber et al. 2006), the CFI and TLI should prove greater than 0.90 (Hu and Bentler 1999), and the recommended cut-off value for the SRMR is less than 0.08 (Hu and Bentler 1999).

Table 4 shows the results of the structural model, whence emerges the existence of a relation between "Behaviour" and the constructs "Involvement in sustainable eating" and "Trust in the food system", both statistically significant at 99%. The first construct has a coefficient equal to 0.28, the second one has a coefficient of 0.26, indicating that these constructs present a positive impact in determining "Behaviour". "Beliefs about regional foods", and "Preference for local foods" instead do not have an impact significantly different from zero in predicting the consumption of craft beer. Overall, the constructs included in the model explain 16.75% of the variance of "Behaviour". The predicted scores relating to the constructs "Involvement in sustainable eating" and "Trust in the food system" were calculated and inserted in the econometric models.

Mixed logit model

The estimation results from the mixed logit model are reported in Table 5. The coefficient of price is negative and statistically significant, as well as the no-buy option. Estimated standard deviations for all attributes differ significantly from zero, indicating a heterogeneity in consumer preference for organic certification, PDO, and BCT.

The main effects of the attributes are all statistically significant with a positive sign indicating that consumer utility increases when beer is certified as organic, PDO, or BCT. The interaction term between organic certification and BCT is not significant. This means that the simultaneous presence of this two attributes has an additive effect on the utility function. On the other hand, the interaction term between PDO and BCT attributes is statistically significant with a negative sign. Therefore, the contemporaneous presence of both certifications does not have a completely additive effect on utility. However, the utility determined by their simultaneous presence proves greater than their utility generated singularly.

The effects of "Trust in the food system" and "Involvement in sustainable eating" on consumer preferences for the three attributes are gathered by interaction terms. Those with higher "Involvement in sustainable eating" show a greater preference for organic certification, while those with higher "Trust in the food system" also have a greater preference for beers certified PDO or that utilize BCT. The explanatory power of the model

Table 5 Mixed logit and mixed logit model with the interaction with psychographic terms

Variables	Mixed logit model		Mixed logit model with psychographic interaction terms	
	Coefficients	Std. Err.	Coefficients	Std. Err.
Random parameters				
Organic	1.21***	0.17	1.22***	0.17
PDO	1.13***	0.14	1.12***	0.14
Blockchain technology	1.05***	0.18	1.06***	0.18
Non-random parameters				
Price	− 0.41***	0.02	− 0.41***	0.02
No-buy	− 2.36***	0.15	− 2.35***	0.15
Organic*blockchain technology	− 0.15	0.22	− 0.17	0.22
PDO*blockchain technology	− 0.58***	0.22	− 0.58**	0.22
Organic*Involvement in sustainable eating			0.45***	0.11
PDO*Involvement in sustainable eating			− 0.10	0.07
Blockchain technology *Involvement in sustainable eating			0.07	0.07
Organic*Trust in the food system			0.10	0.13
PDO* Trust in the food system			0.21**	0.10
Blockchain technology * Trust in the food system			0.16*	0.09
Standard deviation				
Organic	1.92***	0.12	1.80***	0.12
PDO	1.15***	0.09	1.12***	0.09
Blockchain technology	1.01***	0.08	0.99***	0.08
Summary statistics				
Log-likelihood	− 2,748.51		− 2,726.25	
Number of observations	10,800		10,800	
Number of parameters	10		16	
Akaike's information criterion	5,517.02		5,484.50	
Bayesian information criterion	5,589.89		5,601.10	

(***) significance at 1%; (**) significance at 5% (*) significance at 10%; The number of Halton draws used for the simulation is 1,000. Std. Err.: Standard Errors

is improved since the latent factors included in the model proved to be significant in the choice of craft beer.

Discussion and conclusion

The study aimed to investigate whether BCT can enhance consumer preferences for credence attributes while overcoming trust issues in the food system. Specifically, we analysed consumer behaviour towards craft beer, identified the determinants of

consumption, and developed a mixed logit model that combines these factors with the results of a choice experiment. Our findings demonstrated the foresight of industry pioneers in utilizing BCT to effectively communicate the local and sustainable characteristics of their products, highlighting the potential of BCT as a valuable tool for addressing the new challenges facing the industry and meeting the growing demand for transparency and sustainability in consumer markets.

In addition, our study's results have broader implications for the food system and academic knowledge on effective communication of credence attributes in a credible manner, thereby promoting informed consumer choices. More specifically, the study verified that organic certification, PDO, and BCT have a positive impact on consumer preferences, which is consistent with previous research (Marchini et al. 2021; Polenzani et al. 2020; Violino et al. 2019; Sander et al. 2018; Asioli et al. 2017; Boncinelli et al. 2017). The effect of organic certification and PDO on preferences can be attributed to their established presence in the market and consumers' familiarity with them (Aertsens et al. 2011; Vecchio and Annunziata 2011; Smith and Paladino 2010; Pieniak et al. 2010). Similarly, the interest in BCT suggests that despite its recent diffusion, it has generated a positive attitude among consumers, as found in other studies (Violino et al. 2019). As for the interaction between the organic certification and BCT, our study shows that the simultaneous presence of organic certification and BCT has an additive effect on the preferences for craft beer. Therefore, we can confirm the hypothesis H1. Also with regard the association between PDO and BCT, we can confirm our hypothesis (H2) because our findings show that the effect of simultaneous presence of these attributes on consumer preferences for craft bee is higher than that of PDO taken singularly.

Taking a closer look at the relation between trust in the food system and certifications, high levels of trust positively affect the preferences for the PDO and the BCT, while they do not significantly modify those for organic certification. The interaction between trust and choice of foods with a PDO has already been established in the literature, which has pointed out that trust in the food system is essential in orienting preferences with respect to denominations of origin (Verbeke 2013).

On the other hand, the absence of a significant interaction between trust in the food system and preferences for organic certification can be explained by the fact that the preference for organic products is not correlated to trust in the overall food system, but is instead based on sharing values among the actors of the organic supply chain (Thorsøe, 2015). This trust consolidates through the consumer's satisfaction with respect to the perceived quality of products (Ladwein and Romero 2021) and identifies with the organic certification logo (Janssen and Hamm 2012).

The relation between the BCT and trust merits careful reflection on this technology's capability to convey a credible message. Our thesis is that the BCT succeeds in bypassing the problems associated with limited trust in the food system, inasmuch as BCT permits the consumer to become an integral part of the system and to directly follow the entire supply chain. In this case, by breaking through the barriers connected with trust, one could have expected a similar reaction in all consumers, independently of their level of trust in the food system. Therefore, the hypothesis that the interaction between "Trust in the food system" and BCT does not have a significant impact on consumers' preferences for craft beer (H3) is not confirmed. The results

of our study show that the impact of the BCT on choices is influenced by a different trust. This outcome could be tied to the complexity of the functioning of the BCT and the difficulty in understanding it. So, while it is true that consumers have developed a positive attitude towards the BCT, they may encounter difficulty in understanding its exact mechanism and, therefore, in understanding all of its properties. This incomplete knowledge has already been observed in previous research (Wang et al. 2019; Garrard et al. 2020) and could explain the reason for the continuation of different types of behaviour tied to the levels of trust in the food system.

In general, our results confirm that trust plays an important role in fully showcasing the quality signals. Therefore, successfully conveying messages that do not incur the mistrust and uncertainties of consumers about the reliability of the information that appears on foods is confirmed as a fundamental challenge to enable consumers to make completely informed choices, allow producers to create value, and permit the maximum effectiveness of public policies in terms of health and sustainable development. As far as policies are concerned, the capability to deliver credible messages is indeed essential to develop voluntary approaches based on the involvement of society in the goals of sustainability and public health. In fact, only effective information on the nutritional, environmental, and social value of productions can increase the consumer's awareness and invest them with an active role in the pursuit of objectives that concern the collective well-being (Jacobsen et al. 2021).

Our study underscores the potential of BCT as a valuable tool for enhancing trust in credence attributes and existing quality signals. However, it also highlights the challenge of effectively communicating the inner workings of BCT to consumers. It is vital for consumers to grasp how BCT ensures transparency and accountability, rather than perceiving it as a source of complexity in their decision-making process.

In conclusion, we acknowledge several limitations in our study. Firstly, we focused on a restricted set of credence attributes in our experimental design to ensure feasibility and prevent respondent fatigue. Nonetheless, future research should explore the impact of additional craft beer attributes, such as social sustainability certifications, free-from labels, or health claims, in conjunction with BCT. Additionally, although our sample might represent the Italian population, its relatively small size calls for further empirical evidence to strengthen the reliability of our findings.

The failure to confirm H3 suggests that the impact of BCT on choices is affected by the level of trust in the food system and raises concerns about consumers' comprehension of BCT. We did not evaluate respondents' knowledge of the BCT mechanism, underscoring the importance of future studies to investigate consumers' actual understanding of blockchain technology and consider educational approaches if needed. The outcomes of these studies would expand the informational framework in order to steer more effectively the communication campaigns on the capabilities of BCT to keep account of the supply chain of foods, strengthening the role of certifications, promoting informed choices of the consumer and stimulating their proactive role in the objectives of environmental and social sustainability and public health.

Abbreviations

AVE	Average variance extracted
BCT	Blockchain technology

CFA	Confirmatory factor analysis
ISTAT	Italian National Institute of Statistics
SD	Standard deviation
SEM	Structural Equation Model
STD. ERR.	Standard Errors

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Author contributions
CC involved in conceptualization, methodology, validation, investigation, data curation, and writing—original draft. FB involved in formal analysis, data curation, writing—original draft, and visualization. GP involved in writing—original draft, writing—review and editing, and investigation. GS involved in conceptualization, investigation, and writing—review and editing. LC involved in conceptualization, methodology, validation, investigation, data curation, supervision, and project administration. All authors read and approved the final manuscript.

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Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The research involved human participants. Informed consent was obtained and collected from all subjects involved in the study.

Competing interests
The authors declare no competing interests.

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