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What you see is what you get: the impact of blockchain technology transparency on consumers

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Abstract
Blockchain technology (BT) represents a chance to bolster consumer responses toward retailers due to its ability to ensure transparency in each transaction within supply chain. Relying on signaling theory, we propose and test a theoretical model to examine BT effects. We test our theorizing in three experiments involving a total of 1995 participants. Our results suggest that retailer transparency elicited by BT fosters enhanced quality perceptions and retailer trust. As a result, consumers display higher future intentions toward the retailer. The findings illustrate that information quantity moderates the effects of transparency. Furthermore, the studies rule out interactivity and mental imagery as two possible alternative explanations of the effects of BT transparency. Our findings shed light on the importance of transparency in the supply chain in influencing consumer responses toward retailers and encourage retailers to consider in-store technologies such as BT that enable consumers to access such information.

Keywords Blockchain · Transparency · Signaling · Trust · Future intentions

1 Introduction

Consumers may face challenges when evaluating product quality, particularly for those products with unobservable quality features. Retailers play a pivotal role in conveying transparent information that can bridge the divide between manufacturers and consumers (Guan & Chen, 2015). One may wonder if adopting digital technologies that enhance retailer transparency can reduce the information asymmetry

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regarding product quality, thereby improving consumer attitudes and behavioral intentions toward the retailer. The current paper revolves around this question.

In doing so, we focus on Blockchain Technology (BT). While BT is predominantly recognized for its role in finance, it has found increasing applications in various sectors. In retailing, one notable use of BT is to ensure supply chain traceability (Iansiti & Lakhani, 2017). Platforms like Provenance or IBM Blockchain enable firms to use BT for tracing products. Thus, by leveraging these platforms, retailers now have the opportunity to provide consumers with transparent information about products' journeys (Gleim & Stevens, 2021).

Prior research has provided important insights into the role played by BT in supply chain management (Rejeb et al., 2021; Zheng et al., 2018). However, with few exceptions (e.g., Cozzio et al., 2023; Treiblmaier & Garaus, 2023), less is known about the impact of retailer transparency provided by BT on consumer responses. Still, consumers play a central role within the supply chain since they represent its final node. Research has suggested that BT has the potential to alter consumer perceptions due to its transparent transaction mechanism, which allows consumers to access the full set of transactions of supply chains (Gleim & Stevens, 2021). With the goal of understanding more about the role of retailer transparency elicited by BT in affecting consumer responses, we conducted three online experiments.

Our findings offer different contributions. First, we respond to the call for research on the effects of transparency in the supply chain on consumers (Gleim & Stevens, 2021). Second, we make an original contribution to the literature on quality signals by showing that transparency provided by BT traceability works as an effective quality signal. Third, we identify a boundary condition for the effects of retailer transparency (i.e., information quantity). Finally, our findings encourage retailers to leverage BT to trace supply chains more transparently.

2 Theoretical background

Transparency stands out as a way for companies to enhance practices throughout the supply chain (Fraser & van der Ven, 2022). It refers to the practice of making information about the supply chain accessible and understandable to relevant stakeholders, including consumers (Sodhi & Tang, 2019). Companies are increasingly encouraged by the law to be transparent about their products (e.g., The California Transparency in Supply Chains Act). However, while many companies pursue transparency by disclosing more information about their products, their efforts may fall short if consumers cannot verify the accuracy of the claims (Reynolds & Yuthas, 2008). A technology that should enhance supply chain transparency and, thus, may help companies positively influence consumers, is BT (Gleim & Stevens, 2021).

BT is a large distributed ledger that stores a continuously growing set of transaction bundles, called blocks, which are linked and secured cryptographically in a

peer-to-peer network (Alkhudary et al., 2023). BT has unique features—e.g., transparency and security—compared to other tracking technologies (e.g., labels, barcodes, RFID; Moretto & Macchion, 2022). In the area of supply chain traceability, however, the transparency of BT plays the most critical role (Gleim & Stevens, 2021). Through this technology, companies can provide consumers with verifiable information about the product's journey, from source to endpoint. BT decentralizes supply chain information, ensuring universal access instead of storing it in a single location. All transactions occurring along the chain are publicly accessible, and they cannot be altered without consensus.

While BT improves transparency at all stages of production and distribution (Saxena & Sarkar 2023), we are specifically interested in the transparency that BT elicits at the end of the supply chain, in the retailing stage, where the interaction with consumers takes place. In other words, we focus on retailer transparency.[1] We define it as the extent to which retailers are transparent, clear, and upfront in disclosing information about products (Bateman & Bonanni, 2019). Building on prior research on transparency and considering the unique features of BT, we advance that the higher transparency provided by BT is related to greater future intentions toward the retailer (i.e., patronage, WOM, and purchase intentions) compared to the lower transparency associated with other tracking technologies. Accordingly.

H1: Higher retailer transparency provided by BT traceability leads consumers to display greater future intentions toward the retailer.

Why may this happen? We suggest that the transparency provided by BT acts as a quality signal compensating for the information asymmetry between retailers and consumers about product quality (Spence, 1973). Prior studies have addressed the issue of information asymmetry by proposing cues that retailers can use as quality signals, such as price (Kirmani & Rao, 2000). The underlying principle is that consumers cannot observe a product quality directly, and must infer it from other signals. Nonetheless, the issue of information asymmetry may endure even when quality signals are present, as information can be readily forged or manipulated (Treiblmaier & Garaus, 2023). One way to overcome this problem may be for retailers to leverage their own verifiable transparency (Bolton, 2019).

Research started exploring the role of BT as a quality signal (Xu et al., 2022). For instance, in the context of supply chain finance, BT works better than conventional monitoring methods in signaling the firm's quality (Chod et al., 2020). Further, compared to company-owned labels, BT labels act as signals that increase consumers' quality perceptions of food products (Treiblmaier & Garaus, 2023). Consistent with existing theorizing, we advance that retailer higher transparency provided by BT conveys a stronger signal of product quality compared to the lower transparency associated with non-BT traceability.

[1] Hereafter, we use "transparency" to refer to "retailer transparency.".

Indeed, for a signal to be more credible, it should be costlier (e.g., in terms of money, time, risk; Kirmani & Rao, 2000). Retailers adopting BT instead of other tracking technologies incur in higher implementation costs (Moretto & Macchion, 2022). More importantly from the consumer perspective, using BT means that product information is fully verifiable. The cost of verifiable information is that it entails the risk of immediate identification of any misstep (Chaudhry & Wald 2022). Therefore, transparency enabled by BT should be a stronger signal of product quality than the one provided by non-BT tracking methods.

One condition that is necessary for relational exchanges between retailers and consumers is trust, particularly when the exchange is characterized by information asymmetry (Singh & Sirdeshmukh, 2000). We consider trust as consumers' confidence in the integrity and reliability of retailers (Inman and Nikolova 2017). A solid stream of literature shows that product quality is a significant antecedent of trust toward the retailer (e.g., Rubio et al., 2017). Hence, consumers exposed to a more transparent retailer may not only infer higher product quality, but also, as a consequence, place more trust in the retailer. Further, trusting a company drives consumers to be more loyal, more willing to re-purchase, and more inclined to spread positive WOM (Kang and Hustvedt 2014). Building on these findings, we suggest that higher transparency should affect future intentions as mediated by increased product quality and trust. Therefore.

H2: The effect of retailer transparency on future intentions is serially mediated by perceived product quality and trust toward the retailer.

If consumers perceive higher transparency as a signal of product quality, then its beneficial impact may disappear in the presence of other quality signals. Thus, if consumers already perceive product quality as high, tracing the supply chain by means of BT could be less beneficial for retailers. We focus on information quantity as an alternative quality signal (Chang & Wildt, 1994).

Quantity is one of the cues that make information diagnostic (Andrews, 2013). Literature on crowdfunding shows that when creators provide extensive information about their projects, they signal higher quality to funders as they are perceived as more prepared (Wessel et al., 2017). Indeed, offering a detailed description not only diminishes information asymmetry between parties, but also signals the costs invested by creators in terms of time and effort (Moradi & Badrinarayanan, 2021). Larger amounts of information offer a meaningful product quality cue even when the information provided is not highly informative, by serving a compensatory function (Keller & Staelin, 1987).

Accordingly, if retailers provide consumers with more information about the product's journey (i.e., more details about each step of the supply chain), the latter should infer higher product quality. Hence, we propose that, when product information quantity is high, consumers should already perceive product quality as high, mitigating the positive effect of BT traceability. Formally.

H3: Information quantity moderates the relationship between retailer transparency and perceived product quality: The effect of retailer transparency on perceived quality disappears when information quantity is high.

3 Experiments

To test the above hypotheses, we conducted three online experiments. Data and materials of the studies can be found here.

3.1 Study 1

Study 1 had two main goals. First, to test the main effect of BT transparency on future intentions (H1) and the sequential mediation by perceived quality and trust (H2). Second, to rule out alternative explanations: interactivity and mental imagery. We manipulate interactivity—i.e., the level of interactivity with which participants can access information about the product—to exclude the possibility that it is this technology feature, rather than the transparency elicited by it, to positively affect consumers (Fiore et al., 2005). Furthermore, consumers provided with more vivid product information may engage in higher mental imagery which could lead to positive outcomes (Babin & Burns, 1998). Thus, we include mental imagery as a parallel mediator in the model.

3.1.1 Method

We recruited a total of 400 UK participants on Prolific (71% female; $Median_{age} = 44$). Participants were randomly assigned to one of four experimental conditions resulting from a 2 (transparency: low vs. high) × 2 (interactivity: low vs. high) between-subjects design. First, we asked them to imagine themselves engaging in the purchase of a sweater from an apparel clothing store. All the participants saw the picture of a tag that simulated the label placed on the sweater. In the high transparency condition, the label explicitly reported that the product was tracked using BT. To make sure that participants understood what BT was, we provided them with a short definition of the technology (see Appendix A). In the low transparency condition, the label did not mention BT. In the low interactivity condition, the tag reported the list of steps that the product followed. In the high interactivity condition, the tag included a QR code that participants had to scan to obtain the same information on their phones. Examples of experimental stimuli used in Study 1 are displayed in Fig. 1 (see also Appendix A).

Next, we asked participants to evaluate the perceived information interactivity on three items ($\alpha = 0.61$), and retailer transparency on five items ($\alpha = 0.82$). Then, we presented them with a four-item mental imagery measure ($\alpha = 0.88$), a five-item

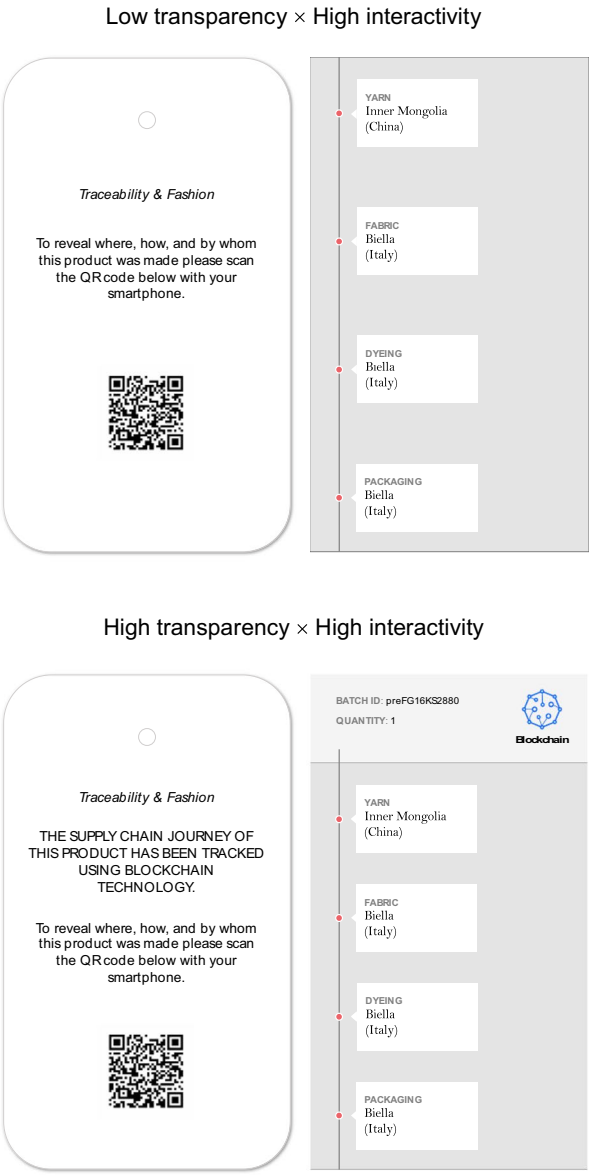

Fig. 1 Sample experimental stimuli (Study 1). Note. Left: Fictitious product label with the QR code participants had to scan to obtain traceability information. Right: Screenshot of what participants saw on their phones after scanning the QR code on the label

perceived quality measure ($\alpha = 0.90$), a two-item trust toward the retailer measure ($\alpha = 0.93$), and a three-item future intentions measure ($\alpha = 0.95$). Finally, we asked participants to rate their knowledge of BT, and to indicate their gender, age, and level of education (see Appendix B for scale items and sources).

3.1.2 Results

Manipulation checks A two-way MANCOVA with BT knowledge as a covariate[2] showed that participants perceived the retailer using BT as more transparent ($M_{HT}=5.13$, $SD=0.90$) than the retailer not using BT ($M_{LT}=4.33$, $SD=1.10$; $p<0.001$). Additionally, participants perceived the information accessible through the QR code as more interactive ($M_{HI}=4.66$, $SD=1.24$) than the information reported directly on the label ($M_{LI}=4.18$, $SD=1.12$; $p<0.001$). The interactions between the two manipulations on transparency and interactivity were non-significant.

Perceived quality, trust, and future intentions As predicted, a two-way MANCOVA with BT knowledge as a covariate showed a significant effect of transparency on perceived quality ($F(1, 395)=26.83$, $p<0.001$, $h_p^2=0.064$), trust ($F(1, 395)=34.64$, $p<0.001$, $h_p^2=0.081$), and future intentions ($F(1, 395)=27.02$, $p<0.001$, $h_p^2=0.064$), but a non-significant effect of interactivity, and a non-significant interaction between transparency and interactivity on perceived quality, trust, and future intentions. Given the non-significant interaction, we collapsed the high and low interactivity conditions. Participants in the high (vs. low) transparency condition perceived the product to be of higher quality ($M_{HT}=4.92$ vs. $M_{LT}=4.47$), showed a greater trust toward the retailer ($M_{HT}=5.14$ vs. $M_{LT}=4.54$), and displayed greater future intentions ($M_{HT}=4.97$ vs. $M_{LT}=4.44$).

Mediation analysis To test whether perceived quality and trust sequentially mediate the relationship between transparency and future intentions, we run a mediation analysis using PROCESS Model 6 (Hayes, 2017). As in Study 1, we included BT knowledge as a covariate. A 5000-sample bootstrap analysis found a 95% confidence interval that excluded zero, indicating a significant indirect effect of transparency on future intentions through perceived quality and trust (indirect effect = 0.26, $SE=0.12$, 95% CI = [0.04, 0.5]).

Next, we ran an additional (customized) mediation model with mental imagery as a parallel mediator. Results yielded a significant indirect effect of transparency on future intentions through mental imagery (indirect effect = 0.11, $SE=0.03$, 95% CI = [0.06, 0.17]). Nonetheless, the indirect effect through perceived quality and trust remained significant (indirect effect = 0.16, $SE=0.04$, 95% CI = [0.10, 0.23]). This finding rules out the possibility that mental imagery overshadows the signaling effect of transparency on future intentions.

[2] We conducted all the analyses of the studies with and without BT knowledge as a covariate. Results are consistent. The main text includes the findings related to the inclusion of the covariate, while additional results can be found in Appendix C.

3.2 Study 2

Study 2 replicated the findings of the previous study, and tested the moderation by information quantity (H3).

3.2.1 Method

A total of 400 UK participants were recruited on Prolific (76% female; $Median_{age} = 45$) participated in the study. No respondent has been excluded from the analyses. Participants were randomly assigned to one of four experimental conditions in a 2 (transparency: low vs. high) × 2 (amount of information: low vs. high) between-subjects design. We used the same scenarios and manipulation of transparency as in Study 1. Differently from Study 1, we maintained the same level of interactivity across all conditions—each label featured a QR code that all participants had to scan to read traceability information. Additionally, we manipulated information quantity by providing more or less detailed descriptions of the product's journey (see Appendix A).

To follow, we asked participants to evaluate the perceived information quantity on three items ($\alpha = 0.85$), and the set of scales from Study 1 (see Appendix B for items and internal consistencies).

3.2.2 Results

Manipulation checks We conducted a two-way MANCOVA with BT knowledge as a covariate and found that participants perceived the retailer using BT as more transparent ($M_{HT} = 5.25$, $SD = 1.09$) than the retailer not using BT ($M_{LT} = 4.56$, $SD = 1.09$; $p < 0.001$). Participants perceived the information to be in higher quantity in the high quantity condition ($M_{HQ} = 5.76$, $SD = 1.15$) compared to the low quantity condition ($M_{LQ} = 5.04$, $SD = 1.24$; $p < 0.001$). The interactions between the two manipulations on transparency and information quantity were non-significant.

Perceived quality, trust, and future intentions A two-way MANCOVA with BT knowledge as a covariate yielded a significant effect of transparency on perceived quality ($F(1, 395) = 15.10$, $p < 0.001$, $h_p^2 = 0.037$), trust ($F(1, 395) = 15.58$, $p < 0.001$, $h_p^2 = 0.038$), and future intentions ($F(1, 395) = 7.95$, $p = 0.005$, $h_p^2 = 0.020$). Similarly, we found a significant effect of information quantity on perceived quality ($F(1, 395) = 8.90$, $p = 0.003$, $h_p^2 = 0.022$), trust ($F(1, 395) = 5.58$, $p = 0.019$, $h_p^2 = 0.014$), but a non-significant effect on future intentions. Finally, we found a significant interaction between transparency and information quantity on perceived quality ($F(1, 395) = 4.57$, $p = 0.033$, $h_p^2 = 0.011$), consistent with H3 (Fig. 2). Participants in the low quantity condition perceived a higher product quality when the retailer was perceived as more transparent ($M_{HT} = 5.45$ vs. $M_{LT} = 4.91$, $p < 0.001$). However, for

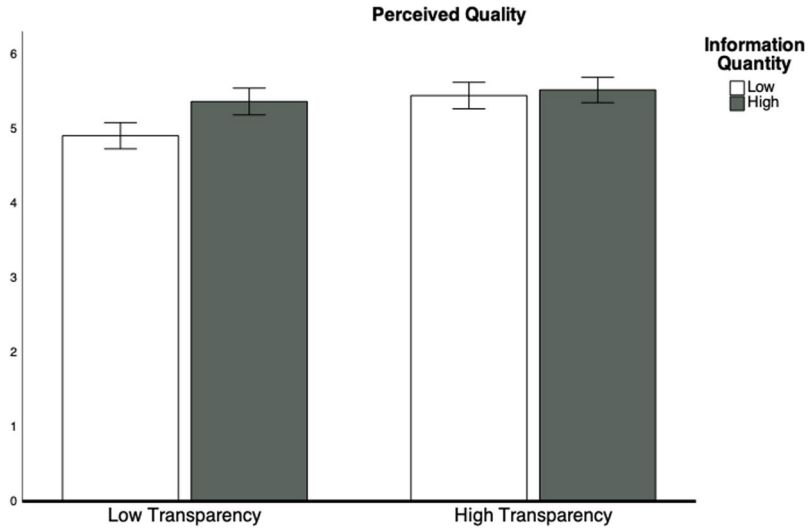

Fig. 2 Results (Study 2). Note. Error bars: 95% CI

participants in the high quantity condition, this difference disappeared ($M_{HT}=5.53$ vs. $M_{LT}=5.38$, $p=0.215$).

Moderated mediation analysis To test whether perceived quality and trust sequentially mediate the interaction effect of transparency and information quantity, we conducted a moderated mediation analysis using Model 83 of the PROCESS macro (Hayes, 2017). As in the previous studies, we included BT knowledge as a covariate. As expected, a 5000-sample bootstrap analysis found a 95% confidence interval that excluded zero, indicating a significant moderated mediation effect (index of moderated mediation $=-0.17$, $SE=0.08$, 95% CI $=[-0.33,-0.02]$). The overall model can be found in Fig. 3.

3.3 Study 3

Study 3 aims at addressing the following questions: Are the effects found in the previous studies attributable to the specific transparency provided by BT, or are they due to transparency in general? In other words, is there something special about BT-elicited transparency, or could we observe similar effects if the retailer used another approach to increase transparency? We posit that, given its unique features (e.g., security), it is BT-elicited transparency to drive the previously found effects rather than transparency more in general. To test this prediction, we manipulate both the type of traceability technology used by the retailer and the level of retailer transparency.

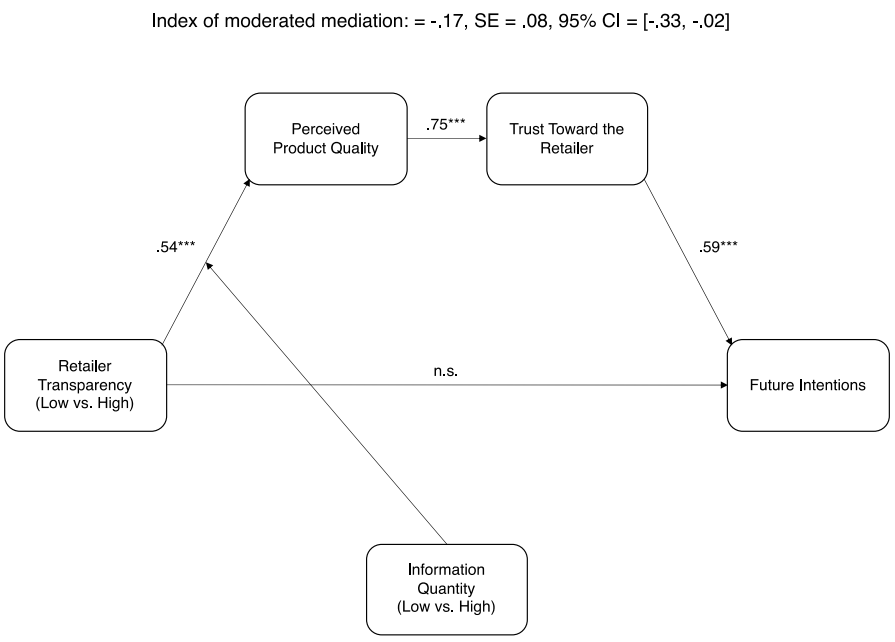

Fig. 3 Full model estimates (Study 2). Note. ***$p < 0.001$

3.3.1 Method

We gathered 395 UK participants on Prolific (58.1% female; $M_{age} = 46.17$, $SD = 14.03$). We excluded a total of 42 participants who failed an attention check.[3] Participants were randomly assigned to one of four experimental conditions resulting from a 2 (traceability technology: BT vs. company-owned) × 2 (transparency: low vs. high) between-subjects design. First, we asked them to state their level of knowledge of BT technology. Then, we explained them what product traceability is, and that such traceability can be provided by different technologies, including BT and company-owned technologies (COT). We provided them with a short definition of both technologies, following Cozzio et al., 2023 (see Appendix A). Next, we instructed participants to imagine themselves searching for a sweater online, and landing on the website of a fictitious clothing store called Envant, specifically in the product traceability section. We showed them the screenshot of this section.

To manipulate the traceability technology, the text on the fictious webpage reported that products were tracked using either BT or COT. In the high transparency condition, the website reported different transparency cues. In the low transparency condition, the website did not include any transparency cues (see Appendix A).

[3] Inclusion of these participants in the analyses does not change the results (details in Appendix D).

Then, we asked participants to evaluate the perceived security of traceability information as a check for the manipulation of type of technology ($\alpha = 0.96$), and the same retailer transparency, perceived quality, trust toward the retailer, and future intentions measures from Study 1. Finally, we asked participants to provide demographic information (see Appendix B).

3.3.2 Results

Manipulation checks A two-way MANCOVA with BT knowledge as a covariate showed that participants perceived traceability information as more secure when the retailer used BT ($M_{BT} = 5.15$, $SD = 1.19$) rather than COT ($M_{COT} = 4.50$, $SD = 1.23$; $p < 0.001$). Participants perceived the retailer reporting transparency cues on the website as more transparent ($M_{HT} = 4.90$, $SD = 1.34$) than the retailer not reporting transparency cues ($M_{LT} = 4.56$, $SD = 1.33$; $p = 0.011$). The interactions between the two manipulations on security and transparency were non-significant. However, participants perceived the retailer using BT as more transparent ($M_{BT} = 5.01$, $SD = 1.30$) than the retailer using COT ($M_{COT} = 4.38$, $SD = 1.33$; $p < 0.001$), in line with the findings from previous studies.

Perceived quality, trust, and future intentions We conducted a two-way MANCOVA with BT knowledge as a covariate and found a significant effect of traceability technology on perceived quality ($F(1, 348) = 9.29$, $p = 0.002$, $h_p^2 = 0.026$), trust ($F(1, 348) = 21.82$, $p < 0.001$, $h_p^2 = 0.059$), and future intentions ($F(1, 348) = 13.09$, $p < 0.001$, $h_p^2 = 0.036$), a significant effect of transparency on perceived quality ($F(1, 348) = 3.93$, $p = 0.048$, $h_p^2 = 0.011$), but a non-significant interaction between technology and transparency on the dependent variables. Thus, we collapsed the high and low transparency conditions. Participants in the BT (vs. COT) condition perceived the product to be of higher quality ($M_{BT} = 4.70$ vs. $M_{COT} = 4.38$), showed a greater trust toward the retailer ($M_{BT} = 4.95$ vs. $M_{COT} = 4.35$), and displayed greater future intentions ($M_{BT} = 4.71$ vs. $M_{COT} = 4.23$).

Mediation analysis We run a mediation analysis using PROCESS Model 6 with traceability technology as the independent variable, perceived quality and trust as sequential mediators, future intentions as the dependent variable, and BT knowledge as a covariate (Hayes, 2017). Consistently with the previous studies, we found a significant indirect effect of traceability technology on future intentions through perceived quality and trust (indirect effect = 0.19, $SE = 0.06$, 95% CI = [0.06, 0.32]).

4 Discussion

4.1 Theoretical and managerial implications

This research makes different theoretical contributions. First, we respond to the call for research on the effects of transparency in the supply chain on consumers (Gleim & Stevens, 2021). Our research provides evidence that BT can benefit retailers through greater transparency, adding also to the literature on in-store technologies. Such technologies have the potential to increase value perceptions (Pizzi and Scarpi 2020), but could also induce distrust (Darke et al., 2016). We found that consumers trust retailers more and display increased future intentions thanks to higher transparency enabled by BT. Second, we uncovered an underlying mechanism for these effects. We found that transparency provided by BT traceability works as a product quality signal that increases trust toward the retailer. Third, we identified a boundary condition of these effects—i.e., information quantity. Our findings suggest that transparency and information quantity may work as substitute quality signals.

Our research also has managerial implications. Our results encourage businesses to leverage BT in order to more transparently trace the supply chain. Since retailers play a pivotal role between manufacturers and consumers, our results prompt them to weigh the cost of investing in the technological infrastructure needed to provide consumers with BT traceability against the higher levels of future intentions expressed by consumers in response to such traceability. Our results are relevant for manufacturers as well, as sharing transparency data with retailers could become an excellent trade marketing tool. Complete disclosure of product information is a necessary condition for successful implementations of transparency strategies and alignments between supply chain businesses. BT-induced transparency may not only boost retailers' profits, but also generate backward advantages for all the suppliers involved with retailers.

4.2 Limitations and future research

Our research is not without limitations. First, drawing on existing literature and real-world evidence, we regarded BT as a fully secure technology, without questioning the assumption that the data recorded in the ledger could potentially be falsified or incorrect. However, wrong data may indeed be recorded by data providers, a misbehavior that could endanger consumer trust. This may represent a relevant avenue for future research.

Second, we assumed consumers view retailers as impartial verification agents (i.e., they adopt BT to solve an information asymmetry problem), but this may not always be the case. For example, what could happen if BT shows that the supply chain of the retailer's private label is inferior to that of brands available in store? Would the retailer be an impartial verification agent in that scenario too? Future research could consider this alternative view and investigate the effect of BT traceability on channel relationships (e.g., channel conflict).

Finally, while we focused on the signaling power of BT-induced transparency, we recognized that other quality signals (e.g., WOM) may be stronger. We examined information quantity as an alternative quality signal. Future research could explore other quality signals that may act as boundary conditions for the positive effects of BT.

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Data Availability The data that support the findings of this study are openly available in a project directory on the Open Science Framework at https://osf.io/dr5au/?view_only=59cb096ed2f44f8dbfd8a6c8f5e8726b.

Declarations

Informed consent All human participants consented to participate in the studies.

Conflict of interest The authors declare no competing interests.

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