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"Putting your money where your mouth is": An empirical study on buyers' preferences and willingness to pay for blockchain-enabled sustainable supply chain transparency

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ABSTRACT

This paper investigates how buyers assess the importance of various attributes of supply chain sustainability disclosed by suppliers. These include different types of disclosure (i.e., product, process, and sourcing network), self- and third-party verified disclosure, partial and full disclosure, as well as the attributes associated with information disclosure using blockchain technology: immutability and update frequency. Building on concepts in signalling theory and inter-organisational trust, our research uses a choice-based conjoint experimental design to elicit responses from 234 managers with decision-making roles in procurement. Using this design, we calculate the relative importance of attributes, part-worth utility, and marginal willingness to pay, and test hypotheses about buyer preferences and willingness to pay. Our research reveals that buyers prefer suppliers with sustainability signals that span across different types of disclosure and methods of disclosure. It emphasises the importance of how sustainability information is disclosed, highlighting buyer trust in self-disclosure and a preference for comprehensive, regularly updated information. However, we find mixed results for buyers' willingness to pay. For instance, buyers prefer third-party verified supply chain transparency, but we do not find a significantly higher willingness to pay for such information compared to self-disclosure. The implications suggest a competitive advantage for suppliers adopting voluntary disclosure, prioritising disclosure based on buyer preferences, and recognising the limited direct impact of blockchain technology. Our research contributes to advancing our understanding of information disclosure in supply chain transparency and presents new avenues of inquiry into the value of blockchain-enabled platforms in supply chain sustainability reporting.

1. Introduction

Research shows when selecting new suppliers, buyers often look beyond purely financial concerns such as price, to include a variety of non-financial criteria such as the environmental and social performance of their suppliers (Bai et al., 2019; Sarkis and Dhavale, 2015; Sauer and Seuring, 2018). This is in part due to the reputational risk to the buyer from having suppliers with unsustainable practices in their supply chain. For example, the public outcry and scrutiny of firms in the fast fashion industry after the collapse of the Rana Plaza factory in Bangladesh, in the Thai seafood industry after the emergence of reports of slave labour, or the reports of deforestation in Malaysia and Indonesia that triggered scrutiny of firms that source ingredients such as palm oil from this region (Bateman and Bonanni, 2019). But a central question in sustainability reporting remains – To what extent are buyers willing to pay a premium price for detailed and reliable information about their suppliers' sustainability footprint?

In line with increasing stakeholder awareness and demands for sustainable supply chain transparency, there have been two significant developments of interest in sustainability reporting (Longoni and Cagliano, 2018). First, several new cost-effective technology-enabled reporting solutions that use blockchains have emerged in the past decade. These offer buyers as well as data brokers (e.g., Respect-code and Provenance) the ability to track suppliers' sustainability data (Babich and Hilary, 2020). Second, not wanting to be left behind, suppliers in various industries such as apparel, food, and electronics, are now voluntarily disclosing their sustainability-related information such as certifications, social commitment, and environmental responsibility

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statements (Wognum et al., 2011). These types of disclosures not only address the transparency expectations of stakeholders, but it is also useful for suppliers to be more competitive: differentiate themselves and attract prospective buyers (Kshetri, 2018). For example, the Princes Group – an international food and drink business that manufactures, imports and distributes its own brand, as well as customers' brand products, uses blockchain technology to voluntarily disclose sustainability information about its canned tuna supply chain: from the point of harvest to packaging – thus offering retailers and buyers a reliable 'ethical sourcing journey' of their produce (Agi and Jha, 2022).

In this context, our research is driven by two fundamental inquiries. Firstly, while it is expected that buyers prefer suppliers that claim to be more sustainable, the extent to which buyers are willing pay a premium price to source from suppliers who make different sustainability disclosures remains unclear. Specifically, we seek to understand what sustainability disclosures within the supply chain hold greater value in the eyes of buyers. To address this set of questions, we employ signalling theory (Spence, 1974) as our guiding framework. This theory provides valuable insights into decision-making processes, particularly in scenarios marked by information asymmetry. Here, the buyer does not possess perfect information about the suppliers' practices, but relies on signals, such as a sustainability claim, emanating from the supplier to inform their choices.

The second line of inquiry centre on the utilisation of blockchain technology in the realm of sustainability reporting. Notably, signalling theory posits that the value of a signal is heightened when the signal is deemed more credible. In this regard, we explore whether the incorporation of blockchain-enabled reporting that offers characteristics such as update frequency and immutability, enhances the buyer's perception of value and, as a result, their willingness to pay a premium price. To delve into these questions, we draw upon insights from the inter-organisational trust literature (Schnackenberg and Tomlinson, 2016; Vanneste and Gulati, 2022), in conjunction with signalling theory, to gain a comprehensive understanding of the dynamics at play.

We empirically evaluate the theoretical predictions regarding how buyers are expected to respond to suppliers' sustainability signals, using a meticulously designed Choice-Based Conjoint (CBC) experiment that has been validated by industry experts and data that was collected from a sample of 234 managers with decision-making roles in procurement. In contrast to conventional survey approaches, the CBC methodology offers several advantages. Most notably, it immerses decision-makers in a dynamic decision-making environment where they must make choices akin to real-world scenarios, thus affording us the opportunity to gauge the precise value that respondents attribute to various supplier attributes. Specifically, this research aims to advance our understanding of how buyers assess the importance of various attributes of supply chain information voluntarily disclosed by suppliers. These include product, process, and sourcing network disclosure as well as the attributes associated with digital technologies: update frequency and immutability of the disclosed information. Our research contributes to two related research streams: sustainable supplier selection and supply chain transparency research.

2. Literature review

2.1. Overview of sustainable supply chain transparency

We expand upon the framework established by Sodhi and Tang (2019) for supply chain transparency and define sustainable supply chain transparency as the public disclosure of sustainability-related information pertaining to a company's products and its upstream operations. This disclosure can take the form of either mandatory or voluntary initiatives (Okongwu et al., 2013). Despite the proliferation of global laws and regulations mandating such disclosures, as exemplified by the U.S. Dodd-Frank Wall Street Reform and Consumer Protection Act, which compels suppliers to reveal the presence of conflict minerals in their products, a significant proportion of transparency practices remain voluntary (Bateman and Bonanni, 2019; Marshall et al., 2016). Our specific focus centres on the latter category: voluntary disclosures made by suppliers who bear responsibility for the performance of their supply chains (Hartmann and Moeller, 2014; Yawar and Seuring, 2017).

Within this context, sustainable supply chain transparency practices encompass a range of activities. These may involve, among other things, the engagement of third-party auditors to evaluate the firm's products, the inclusion of supplier information and compliance records in annual reports, and the publication of detailed production processes on their corporate websites (Jiang et al., 2019; Zerbini, 2017). Notably, several of these practices have gained substantial traction in industries such as apparel, food, and electronics (Wognum et al., 2011).

We find that the categorisation of disclosure practices in existing literature lacks uniformity and consistency. For instance, Marshall et al. (2016) propose a classification comprising four categories: supply chain membership, provenance, social information, and environmental information, while Egels-Zandén et al. (2015) suggest three distinct types: traceability, information, and the buyer's own purchasing practices. In our research, we build upon this body of literature and organise these practices into three overarching categories, guided by three pivotal questions: What do we produce? (referred to as product disclosure), How do we produce it? (referred to as process disclosure), and whom do we source from? (referred to as sourcing network disclosure). We have detailed these three types of disclosure, along with their definitions and illustrative examples, together with references to existing literature, in Table 1. It is worth noting that these categories are not mutually exclusive, and many firms choose to disclose multiple types of information in an integrated manner.

2.2. Sustainable supply chain transparency and supplier competitiveness

Going beyond the obligatory sustainability disclosures that are regulatory mandates, a pivotal inquiry arises: Does the voluntary disclosure

Table 1
Three types of disclosure, definitions, and examples.

Type of disclosed information	Definition	Example
1. Product disclosure (What do we produce?)	This type of disclosure includes information related to the product itself, product components, and sustainable product information.	● Disclosure of particular raw materials (e.g., Marshall et al., 2016) ● Disclosure of percentage of recycled materials used (e.g., Okongwu et al., 2013)
2. Process disclosure (How do we produce?)	This type of disclosure includes information related to sustainable operations, practices, code of conduct, and production standards	● Disclosure of labour policies such as work hours, wages and benefits, workplace safety compliance (e.g., Egels-Zandén et al., 2015; Sodhi and Tang, 2019) ● Disclosure of human rights such as child labour, immigrant workers (Marshall et al., 2016; e.g., Okongwu et al., 2013)
3.Sourcing network disclosure (Who do we source from?)	This type of disclosure includes information related to supplier lists (both direct and indirect suppliers)	● Disclosure of Tier-1 suppliers' identity and location (e.g., Chen et al., 2019; Kalkanci and Plambeck, 2020) ● Disclosure of suppliers involved in the production processes at all tiers (Bateman and Bonanni, 2019; Egels-Zandén et al., 2015)

of supply chain sustainability exert an influence on a supplier's competitive position? To delve into this question, we draw insights from two distinct strands of research.

Firstly, the literature on sustainable supplier selection offers valuable perspectives. This body of work contends that buyers, in their supplier evaluation process, often transcend financial considerations by incorporating sustainability performance as a crucial selection criterion (e.g., Bai et al., 2019; Sarkis and Dhavale, 2015; Sauer and Seuring, 2018). However, a comprehensive review by Zhan et al. (2021) revealed that much of the research in this domain has remained theoretical, primarily focusing on the development of mathematical models or analytical frameworks, rather than presenting empirical real-world data. Furthermore, a significant portion of these studies tends to regard sustainability performance from the perspective of buyers' perceptions, often overlooking the role of information disclosed by the suppliers themselves (Davis-Sramek et al., 2018, 2020; Thomas et al., 2013, 2016; Zhan et al., 2021). For instance, in a study by Davis-Sramek et al. (2020), a scenario highlighting high sustainability is presented, but the way sustainability information is acquired or disclosed, particularly the potential role of digital technologies, remains unexplored.

The second line of research, centred on supply chain transparency, underscores the potential benefits of divulging sustainability-related information in terms of cultivating consumer trust and enhancing consumers' willingness to pay. For instance, findings from a study by Kraft et al. (2018) suggest that disclosing process-related details, such as labour costs, could augment consumers' willingness to pay by a substantial margin, ranging from 2% to 10%. Voluntary disclosure of product-related sustainability information, such as greenhouse gas (GHG) emissions and conflict mineral usage, has been shown to bolster a supplier's reputation and market share (Kalkanci et al., 2016). However, much of the prior research has predominantly concentrated on the impact of product and process disclosures, often side-lining the exploration of sourcing network disclosure and the synergistic effects of combining various types of disclosure (e.g., Chen et al., 2019). Furthermore, considering the multidimensional nature of transparency (Schnackenberg and Tomlinson, 2016), it is plausible that buyers have distinct preferences for each form of disclosure and may need to make trade-offs when navigating supplier selection decisions. Consequently, the realm of sourcing network disclosure and its interplay with other forms of disclosure remains relatively under-researched.

2.3. Blockchain-enabled sustainable supply chain reporting

Firms employ various methods to communicate their sustainability information. Traditional approaches encompass the dissemination of information through official documents like annual reports and sustainability reports, marketing collateral such as brochures and product labels, and digital platforms including their own websites and social media channels (Gualandris et al., 2015; Zerbini, 2017).

In recent times, the landscape of sustainability disclosure has evolved with the emergence of digital technologies such as RFID, cloud computing, and blockchain. These technologies have become increasingly cost-effective, playing a pivotal role in elevating supply chain transparency (Babich and Hilary, 2020; Rogerson and Parry, 2020). Real-world instances highlight how firms, spanning various industries, have harnessed these digital tools to facilitate the disclosure of supply chain information. These technologies not only provide access to critical data but also offer insights into certifications, social commitments, and environmental responsibility (Kshetri, 2018).

Despite a growing chorus of researchers extolling the virtues of blockchain utilisation, empirical evidence regarding the impact of blockchain-enabled information disclosure remains somewhat limited (Montecchi et al., 2021). A noteworthy exception comes from a study by Treiblmaier and Garaus (2022), which illuminates the positive effect of blockchain adoption in disclosing supply chain information within the food industry. Their research reveals that blockchain deployment enhances customers' perception of product quality, subsequently bolstering their intent to make purchases.

2.4. Voluntary disclosure as a signal

Information asymmetry is an inherent aspect of any buyer-supplier relationship, compelling buyers to seek an extensive understanding of various facets concerning a supplier. For instance, if a buyer is concerned about the long-term viability of a supplier, they would naturally desire insights into the supplier's financial health. Likewise, when sustainability within the supply chain is a focal point, buyers aim to acquire comprehensive information about the supplier's sustainability practices.

However, the acquisition of detailed information can often be prohibitively expensive, impractical, or even unattainable. Consequently, buyers frequently rely on signals that serve as proxies for the specific attributes of concern (Spence, 1974). This practice gains even greater relevance when buyers lack prior experience with a particular supplier, such as when they are exploring new supplier relationships. In such instances, buyers must place their trust in signals they perceive as credible to bridge the information gap.

Concurrently, suppliers have a vested interest in generating and transmitting these signals, all while ensuring they are regarded as credible by the discerning buyer. For example, if a supplier wanted to convey a signal of quality, they could show the results of their own tests and claim the superior quality of their products or they could promote a third-party quality certification like ISO 9000 to convey a quality signal to potential buyers (Connelly et al., 2011). In this scenario, a new buyer, unfamiliar with the supplier's actual product quality, is more inclined to view the ISO certification as a credible signal compared to the supplier's self-proclamation. The credibility of such a signal hinges on the buyer's trust in the belief that the supplier could not have obtained the ISO certification unless their products genuinely met high-quality standards.

In a similar vein, our objective is to assess whether a supplier's voluntary disclosure of sustainability-related information is likely to be considered a credible signal for sustainability. Depending on the nature of the disclosures within a sustainable supply chain, suppliers have various avenues through which they can signal their commitment to sustainability. In the subsequent sections, we will delve into the diverse attributes of sustainability-related information that suppliers disclose, considering additional factors related to digital technologies. From this exploration, we aim to formulate testable hypotheses concerning the influence of these attributes on buyers' supplier selection decisions.

3. Hypotheses development

3.1. Value of voluntary disclosure over non-disclosure

Our research focuses on voluntary disclosure, a scenario in which suppliers possess the discretion to decide whether to reveal their sustainability-related information. The body of evidence substantiates the widely held belief that suppliers are more inclined to disclose information that casts them in a favourable light, and those who do disclose information tend to appear more legitimate, trustworthy, and reputable than their non-disclosing counterparts (Holder-Webb et al., 2009; Kim et al., 2020). When a supplier voluntarily shares specific sustainability information with the public, buyers are inclined to interpret this as a strong commitment to, or at the very least, accountability for their sustainability practices (Doorey, 2011; Villena and Dhanorkar, 2020). In fact, there exists a disincentive for unsustainable suppliers to abstain from disclosure or to provide false information since such actions could backfire if unsustainable practices are uncovered by vigilant entities such as watchdog groups, non-governmental organisations (NGOs), or the general public (Reimsbach and Hahn, 2015). Consequently, voluntary disclosure is likely to be perceived by buyers as a credible signal of a supplier's high level of sustainability commitment, and, by extension, suppliers that lack any sustainability-related

disclosures are likely to be viewed as less trustworthy.

Drawing upon the principles of signalling theory within the supply chain context, we recognise that signals must possess three essential attributes: they must be visible, meaningful, and trustworthy (Banerjee et al., 2020). In the realm of sustainable supply chain transparency, these signals are visibly accessible as suppliers typically make such information readily available to the public through avenues such as annual reports and company websites (Zerbini, 2017). Furthermore, these signals hold substantive meaning as they directly pertain to the sustainability of the business (Sarkis and Dhavale, 2015). Trustworthiness, a paramount consideration in this context, is often associated with elevated signalling costs (Connelly et al., 2011). The process of procuring sustainability-related information for disclosure entails a significant investment of time, effort, and direct expenses in acquiring the signal. Additionally, there are potential penalties if the information is found to be inaccurate or misleading. Consequently, we anticipate observing a strong inclination among buyers to prefer and express a willingness to pay a premium price for suppliers who engage in sustainability information disclosure.

H1(a). Buyers prefer suppliers that voluntarily disclose information over suppliers with non-disclosure.

H1(b). Buyers would be willing to pay a premium price for suppliers that voluntarily disclose information over suppliers with non-disclosure.

3.2. Relative worth of different types of voluntary disclosure

As previously mentioned, sustainable supply chain transparency encompasses three primary forms of disclosure: product, process, and sourcing network disclosure. Given the multifaceted nature of transparency (Schnackenberg and Tomlinson, 2016), buyers are likely to ascribe varying levels of importance to each type of disclosure when making supplier selections. Among these three categories, we anticipate that product disclosure will hold the highest significance for buyers. This is because product-related information aligns most closely with the buyer's central concern, as they ultimately procure the product from a supplier (Şen et al., 2008). In the context of signalling theory, product-related information, viewed as a signal, tends to be more visible than other aspects, such as the production process and its upstream supply chain (Gilley et al., 2000).

We expect process disclosure to occupy a crucial intermediary position in the hierarchy of relative importance. Previous research shows that buyers pay attention not only to product disclosure; process disclosure is also important as it offers valuable insight into the journey of how products are created, recognising its role in assessing sustainability and ethical considerations (Kraft et al., 2018). Despite its being less visible and may not align closely with buyers' immediate concerns compared to product-related information, process disclosure carries substantial weight in shaping buyer attitudes toward a supplier's overall sustainability practices. Thus, we anticipate that buyers will recognise the importance of process disclosure as second only to product disclosure in their evaluation criteria.

Conversely, we expect that sourcing network disclosure will receive the least emphasis from buyers, as it is relatively distanced from their immediate supply chain. As Bateman and Bonanni (2019) have noted, only a limited number of buyers possess a comprehensive understanding of their entire supply network. Additionally, sourcing network disclosure is comparatively novel and less prevalent than the other two forms of disclosure (Chen et al., 2019). Consequently, we anticipate that buyers will attribute the highest importance to product disclosure, followed by process disclosure, and place sourcing network disclosure at the bottom of their priority list.

This nuanced assessment of the relative worth of different types of voluntary disclosure aligns with the proposed hierarchy, where product disclosure is deemed most critical, followed by process disclosure, and sourcing network disclosure is considered less pivotal. This fundamental distribution is foundational to our hypotheses, H2(a) and H2(b), anticipating buyers' prioritisation and willingness to pay premiums based on the perceived importance of each type of disclosure.

H2(a). Among the three types of disclosure, buyers assign greatest importance to product disclosure, followed by process, and sourcing network disclosure.

H2(b). Buyers would be willing to pay a premium price for product disclosure over process disclosure as well as for process disclosure over sourcing network disclosure.

3.3. Value of third-party verification in product and process disclosures

In the realm of product and process disclosures, two prevalent practices are self-disclosure and third-party verification. Self-disclosure entails suppliers voluntarily revealing information that has been internally assessed through their own processes, often involving audits. For instance, as part of process disclosure, certain suppliers may provide details about their workforce composition, including the percentage of female and migrant employees, as well as the average age of their workforce. On the other hand, third-party verification entails having this information independently confirmed by an external third party, typically an auditor, with the resulting certificate being disclosed. As an example, within the scope of product disclosure, suppliers may display certificates from third-party entities like the Organic Content Standard, a certification applicable to non-food products composed of 95–100% organic material. Chen and Lee (2017) have highlighted that in these contexts, buyers often harbour concerns regarding the accuracy of disclosed information, and they may not fully trust suppliers if certain details are not validated by a third party.

Drawing insights from signalling theory, a pivotal distinction between self-disclosure and third-party verification lies in the signalling cost. The certification process is not only time-consuming but also financially burdensome, rendering cheating or engaging in false signalling significantly more challenging. Consequently, third-party verification is associated with a higher signalling cost and is often perceived as offering a higher degree of transparency compared to self-disclosure. In a similar vein, the expenditure involved in acquiring a third-party signal enhances its value. Therefore, we not only anticipate that buyers will exhibit a preference for suppliers with third-party verification over those relying solely on self-disclosure but also that buyers will be willing to pay a premium price for suppliers who have obtained third-party verification, recognising its elevated credibility and transparency.

H3(a). Buyers prefer suppliers with third-party verification over suppliers with self-disclosure only.

H3(b). Buyers would be willing to pay a premium price for suppliers with third-party verification over suppliers with self-disclosure only.

3.4. Value of full disclosure of sourcing network

Regarding sourcing network disclosure, suppliers commonly adopt either a partial disclosure or a full disclosure approach to reveal information about their sourcing network. A prevalent practice for partial disclosure involves divulging the location and names of their tier-1 suppliers (Chen et al., 2019; Kalkanci and Plambeck, 2020). As an illustration, Nike follows this approach by sharing its manufacturing map, which includes the names of tier-1 suppliers along with their factory addresses. Conversely, for full disclosure, suppliers opt to reveal the entire network of firms involved in the upstream supply chain (Bateman and Bonanni, 2019; Gong et al., 2018). As an example, Dawn Denim takes this route by disclosing all the suppliers engaged in every aspect of the upstream supply chain for its jeans, spanning from processing to confection and packing.

In alignment with our earlier argument contrasting self-disclosure and third-party verification, it's essential to recognise that full

disclosure imposes a higher signalling cost and is generally perceived as offering greater transparency. Consequently, we anticipate that buyers will not only express a preference for suppliers engaging in full disclosure compared to those opting for partial disclosure, but they will also demonstrate a willingness to pay a premium price for suppliers who provide a more comprehensive level of disclosure. This preference aligns with the notion that increased transparency, even at a higher signalling cost, holds greater value for buyers in making informed supplier selection decisions.

H4(a). Buyers prefer suppliers with full disclosure over suppliers with partial disclosure.

H4(b). Buyers would be willing to pay a price premium for suppliers with full disclosure over suppliers with partial disclosure of sourcing networks.

3.5. Value of blockchain-enabled reporting: update frequency and immutability

Recent research underscores the significant value of blockchain technology in facilitating information disclosure and enhancing supply chain transparency (Abeyratne and Monfared, 2016; Bai and Sarkis, 2020; Chen et al., 2019). In contrast to traditional methods, the utilisation of blockchain for information disclosure introduces signals related to update frequency and the immutability of disclosed information, thereby amplifying the cost associated with the signal and heightening its value (Bai and Sarkis, 2020; Sundtoft and Kinra, 2019; Xu et al., 2021).

Regarding update frequency, digital technologies empower suppliers to refresh their disclosed information in a more real-time fashion. When combined with technologies like RFID and sensors, this capability allows relevant stakeholders to track and instantly disclose either a portion or the entire journey of a product, along with its associated data (Garcia-Torres et al., 2019). It is important to note that while update frequency is not an exclusive feature of blockchain technology, it is a characteristic shared by digital technologies in general. According to signalling theory, a signal is essentially a static snapshot of a supplier or its supply chain and diminishes in strength over time (Davila et al., 2003). Therefore, transmitting signals at higher frequencies enhances their effectiveness (Park and Mezias, 2005). While previous research has often concentrated on the frequency of signals involving the use of various signals to convey the same message (Balboa and Martí, 2007; Janney and Folta, 2003), our research narrows its focus to the frequency of signal updates: information update frequency. From the perspective of buyers, signals with more frequent updates are likely to be perceived as more credible. Thus, we posit that buyers will exhibit a preference and willingness to pay a premium price for suppliers who disclose information more frequently.

H5(a). Buyers prefer suppliers that disclose information more frequently.

H5(b). Buyers would be willing to pay a premium price for suppliers that disclose information more frequently.

Regarding information immutability, the distinctive feature of blockchain technology lies in its decentralised consensus and cryptography system. Once data is recorded in the blockchain, it becomes eternally fixed, irrevocable, and impervious to alteration (Xu et al., 2021). This attribute represents a relatively novel dimension that has yet to be thoroughly explored in the realm of signalling literature. The closest analogous concept is signalling consistency, which pertains to the harmony among various signals emanating from the same source to convey a congruent message (Connelly et al., 2011). High signalling consistency minimises miscommunication and reinforces the effectiveness of signalling. However, blockchain technology does not guarantee consistency across different signals but unequivocally establishes the permanence of each individual recorded piece of information.

In essence, the immutability of information, as facilitated by blockchain technology, serves to augment supply chain transparency by heightening suppliers' responsibility for their disclosed information and rendering it more trustworthy (Fosso Wamba et al., 2020; Kshetri, 2018). Consequently, we anticipate that buyers will exhibit a preference and willingness to pay a premium price for suppliers who employ blockchain technology to disclose information that possesses this immutable quality.

H6(a). Buyers prefer suppliers that disclose immutable information.

H6(b). Buyers would be willing to pay a price premium for suppliers that disclose immutable information.

4. Methodology

4.1. Choice-based conjoint (CBC) experimental design

We use an experimental design to test the hypotheses (Field and Hole, 2002) as it can eliminate other extraneous noise by creating a controlled decision-making environment (Siemsen, 2011). A choice-based conjoint (CBC) experimental setup is an appropriate design to test our hypotheses for three reasons. First, it covers several attributes and their combinations to varying levels of interest. Second, it depicts contributing attributes by ranking them in order of importance. Third, compared to typical survey-type experiments with one-off decisions, it requires participants to incorporate trade-offs in decision-making to maximise their utility. Therefore, a CBC design represents real-world choices and reduces social desirability bias because participants reflect what happens in real-world decision-making (Husted et al., 2014).

We designed the CBC following the guidance from Orme (2010). The initial design was based on similar conditions from previous studies (Banerjee et al., 2021; Davis-Sramek et al., 2020; Hartmann and Moeller, 2014; Petersen et al., 2005). It was then validated by 17 leading scholars and industry experts in areas of supply chain transparency and blockchain. Five attributes, i.e., the three types of disclosure - product, process, and sourcing network, and two factors associated with blockchain - immutability and update frequency, were identified initially. We decided to add price as the sixth attribute for three reasons and the levels were ascertained based on expert feedback. First, the price remains one of the key decision criteria in supplier selection (Bai et al., 2019; Sarkis and Dhavale, 2015). Second, it is required for a more nuanced willingness to pay estimation (Orme, 2010). Third, a trade-off between different types of disclosure and price is expected (Matos et al., 2020). The proposed theoretical constructs and the final set of attributes and levels are shown in Table 2.

Our chosen context is that of a buyer seeking a supplier of customised T-shirts. This is because the apparel industry is a front-runner in the voluntary disclosure of sustainability-related information and offers an adequate level of complexity (Wognum et al., 2011). Such a context is often used in experimental designs (Hartmann and Moeller, 2014). Participants were informed that "Firm A is currently paying £10,000 per lot for its corporate T-shirts. Recently, due to quality issues with the current supplier, Firm A has decided to look for an alternative supplier for a long-term partnership. Please note that the following suppliers have all passed the quality assessment based on the samples provided." In addition, we utilise a projective technique that further reduces social desirability bias (Fisher, 1993): "As you answer each question, predict how Firm A would act in their supplier selection. Please do not base your answers on how you think they should approach the situation, but rather on how they would actually approach the situation.".

We use Sawtooth software to generate eight orthogonal choice sets for each participant with three suppliers and a 'none option' per choice set. An example of a single choice set from the CBC is shown in Fig. 1. Apart from the CBC questions, the experiment consists of a consent check, a three-and-a-half-minute introductory video about sustainable

Table 2
List of attributes and levels for the Choice-Based-Conjoint experimental design.

Attributes	Price	Product Disclosure	Process Disclosure	Sourcing Network Disclosure	Immutability of Information	Information update frequency
Level 1	10,000	No disclosure	No disclosure	No disclosure	No disclosure on immutability	No disclosure on update frequency
Level 2	10,500	Self-disclosure of corporate policy to contain only sustainable materials	Self-disclosure of corporate governance policy following industry-standard labour rights	Partial disclosure of direct suppliers only	Information immutable due to blockchain	Annual update
Level 3	11,000	Third-party verification of "contain only sustainable materials"	Third-party verification of "corporate governance policy on labour rights"	Full disclosure of entire supply chain		Monthly update
Level 4	11,500					Daily update
Level 5	12,000					

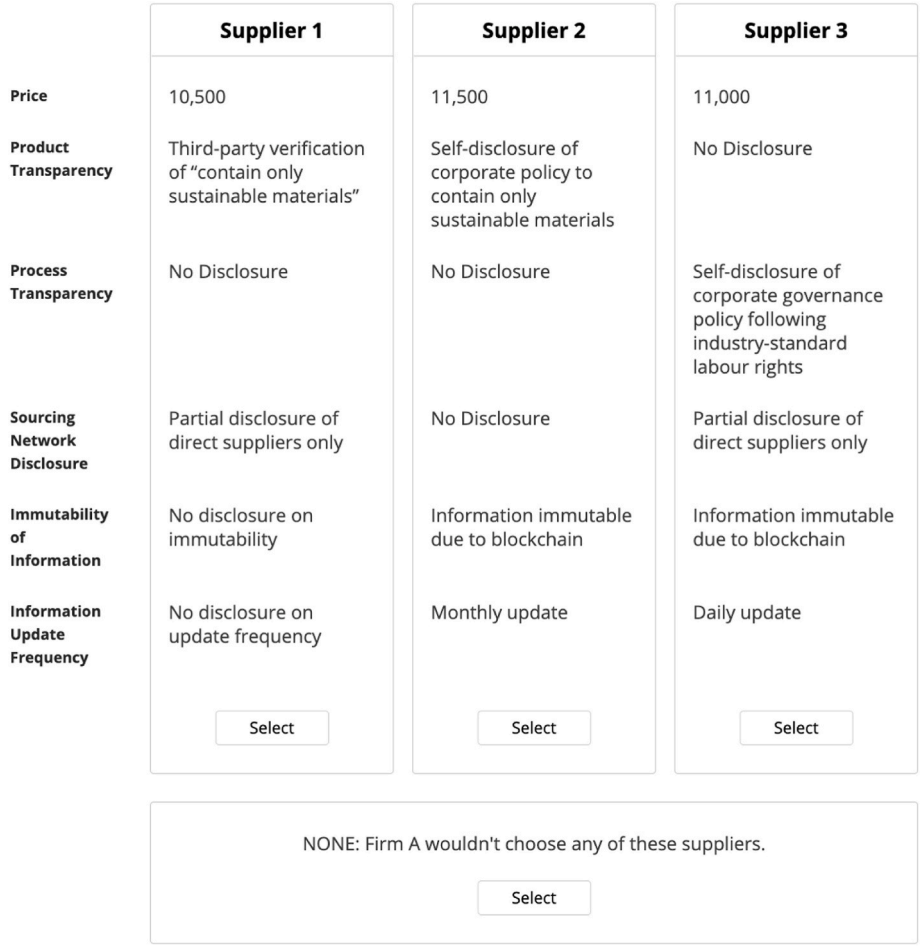

Fig. 1. Example of a single choice set from the CBC.

supply chain transparency and the use of blockchain technology for information disclosure, three attention check questions, three open-ended questions regarding selection criteria, and 11 participant demographic questions.

4.2. Participants

According to the guideline by Orme (2010), the minimum sample size (N) can be calculated using the following formula: $N \geq (500*C)/(T*A)$; where N represents the minimum sample size, C represents the highest number of levels among all attributes, T represents the number of tasks, and A represents the number of alternatives per task (excluding the none alternative). In our research, we have the highest number of levels, which is five, and we have included eight tasks with three alternatives per task. Therefore, the minimum sample size should be at least 105 participants.

To recruit participants, we used the online panel provider platform, Prolific. This platform can recruit reliable participants and has been used in previous purchasing and supply chain literature such as a study by Banerjee et al. (2020). Following the similar procedures of this study, we used the platform's pre-selection criteria to pre-screen participants with previous experience in decision-making responsibilities in procurement. Every participant was paid £1.75 to complete the survey. 258 participants gave consent and completed the survey. From these, 24 participants (9%) failed at least one of the three attention checks, so they were removed from the analysis, resulting in the final sample of 234 participants. The demographic characteristics, utilised as control variables in the regression analyses, are presented in Table 3. Regarding the

Table 3
Demographic characteristics of the participants (N = 234).

	Counts (N = 234)	Percentage (%)
Age		
20–29 years	79	34%
30–39 years	85	36%
40–49 years	47	20%
50–59 years	17	7%
More than 60 years	6	3%
Gender		
Male	135	58%
Female	99	42%
Education		
Up to high school	30	13%
Undergraduate (Bachelor's degree)	122	52%
Postgraduate (Master's degree)	58	25%
PhD degree	5	2%
Other professional qualification or certification	17	7%
Prefer not to say	2	1%
Years of experience		
Less than 1 year	5	2%
1–5 years	69	29%
6–10 years	48	21%
More than 10 years	111	47%
Prefer not to say	1	0%
Primary functional experience		
Sales	44	19%
Marketing	14	6%
Procurement	33	14%
Operations	67	29%
Finance	20	9%
Human Resources	5	2%
IT	19	8%
Others	28	12%
Prefer not to say	4	2%

experience of our participants, the breakdown based on the number of years is as follows: Less than 1 year, accounting for 2% of the total; 1–5 years, representing 29% of the total; 6–10 years, making up 21% of the total; and more than 10 years, constituting 47% of the total. Overall, the demographic characteristics are appropriately distributed among the sample size.

5. Results

5.1. Relative importance of attributes and part-worth utility analyses

The results of the average importance of attributes and the part-worth utility analysis (Table 4) show how buyers interpret signals. From the average importance of attributes, we observe that while price is an important attribute with the highest score of 24.14% (SE 0.96), it is not the only major influencers. It is only marginally higher than the second most important attribute – Product disclosure with a score of 21.39% (SE 0.51). These are followed by two other types of disclosure: process disclosure (18.09%, SE 0.33) and sourcing network disclosure (14.87%, SE 0.34). This supports our second hypothesis H2(a) that buyers value product disclosure the most, and value sourcing network disclosure the least. The two attributes related to blockchain-driven disclosure: information update frequency and information immutability yield the second least and the least scores of 13.11% (SE 0.31) and 8.40% (SE 0.50), respectively.

The part-worth utility analysis indicates how much each level influenced the buyer's decision compared to other levels in the same attribute. The results are largely as expected. Buyers prefer lower prices, with the price of £10,000 having the highest utility (46.51%, SE 4.44) and the price of £12,000 having the lowest utility (−67.48%, SE 3.40). For all three types of disclosure, higher levels have higher utility, indicating that buyers tend to value supply chain transparency. Buyers

Table 4
Average importance of attributes and part-worth utility analysis for each level.

Attributes and levels	Average importance of each attribute	Part-worth utility of each level in each attribute	Lower 95% CI	Upper 95% CI
Price	24.14 (SE 0.96)		22.26	26.02
1 10,000		46.51	37.80	55.22
2 10,500		36.53	32.40	40.65
3 11,000		5.71	3.04	8.39
4 11,500		−21.28	−26.15	−16.41
5 12,000		−67.48	−74.15	−60.80
Product disclosure	21.39 (SE 0.51)		20.38	22.40
1 No Disclosure		−76.95	−81.04	−72.85
2 Self-disclosure		35.63	32.97	38.28
3 Third-party verification		41.32	38.30	44.34
Process disclosure	18.09 (SE 0.33)		17.45	18.74
1 No Disclosure		−65.48	−68.12	−62.83
2 Self-disclosure		27.20	25.11	29.28
3 Third-party verification		38.28	36.36	40.20
Sourcing network disclosure	14.87 (SE 0.34)		14.20	15.54
1 No Disclosure		−46.16	−49.37	−42.95
2 Only direct suppliers		8.82	6.42	11.22
3 Entire supply chain		37.34	35.13	39.55
Information immutability	8.40 (SE 0.50)		7.80	9.00
1 No Disclosure		−23.04	−25.26	−20.81
2 Information immutable due to blockchain		23.04	20.81	25.26
Information update frequency	13.11 (SE 0.31)		12.13	14.09
1 No disclosure		−37.25	−40.04	−34.46
2 Annual update		−6.97	−10.60	−3.34
3 Monthly update		21.07	18.97	23.16
4 Daily update		23.15	18.42	27.88

prefer third-party verification (41.32%, SE 1.54, in product disclosure; 38.28%, SE 1.06, in process disclosure) to self-disclosure (35.63%, SE 1.36, in product disclosure; 27.20%, SE 1.06 in process disclosure). Moreover, buyers prefer full disclosure (37.34%, SE 1.13) to partial disclosure (8.82%, SE 1.23) in sourcing network disclosure. Regarding blockchain-driven disclosures, the results show that buyers value the disclosure of information immutability (23.04%, SE 1.13), and information update frequency, specifically daily update (23.15%, SE 2.41), and monthly update (21.07%, SE 1.07).

5.2. Regression analyses

We conduct regression analysis to estimate the likelihood of buyers selecting a supplier over the base option. The base option is a supplier offering £10,000 per lot with no disclosure related to the product, process, sourcing network, information immutability, and information update frequency. The logistic regression results with the dependent variable 'buyers selecting a supplier over the base option' are shown in Table 5. Model 1 presents the odds ratios of the logistic regression model with six demographic characteristics as control variables, including age, gender, education, years of experience, primary functional experience, and deal size. Model 2 presents the odds ratios of the logistic regression model with the main attributes: price, product disclosure, process disclosure, sourcing network disclosure, information immutability, and information update frequency. Model 3 is a combination of Model 1 and Model 2, incorporating both the control variables and the main attributes.

Table 5
Logistic regression results of selecting a supplier over the base option.

Independent Variables	Model 1		Model 2		Model 3	
	Odds Ratio	Standard Error	Odds Ratio	Standard Error	Odds Ratio	Standard Error
Price (base 10,000)						
£10,500			0.79***	(0.04)	0.78***	(0.05)
£11,000			0.47***	(0.05)	0.45***	(0.05)
£11,500			0.29***	(0.04)	0.27***	(0.04)
£12,000			0.14***	(0.02)	0.13***	(0.02)
Product disclosure (base No disclosure)						
Self-disclosure			6.22***	(0.50)	6.84***	(0.58)
Third-party verification			6.67***	(0.57)	7.37***	(0.67)
Process disclosure (base No disclosure)						
Self-disclosure			4.91***	(0.35)	5.34***	(0.39)
Third-party verification			5.62***	(0.40)	6.15***	(0.45)
Sourcing network disclosure (base No disclosure)						
Only direct suppliers			2.54***	(0.17)	2.66***	(0.18)
Entire supply chain			3.73***	(0.27)	4.00***	(0.30)
Information immutability (base No disclosure)						
Information immutable due to blockchain			2.26***	(0.11)	2.36***	(0.12)
Information update frequency (base No disclosure)						
Annual update			1.72***	(0.06)	1.77***	(0.06)
Monthly update			2.62***	(0.12)	2.76***	(0.13)
Daily update			2.70***	(0.16)	2.85***	(0.18)
Age (base 20–29 years)						
30–39 years	0.80	(0.17)			0.72	(0.22)
40–49 years	0.86	(0.21)			0.79	(0.29)
50–59 years	0.65	(0.22)			0.53	(0.26)
More than 60 years	0.66	(0.23)			0.54	(0.28)
Gender (base Male)						
Female	1.00	(0.13)			1.00	(0.19)
Education (base Up to high school)						
Undergraduate (Bachelor's degree)	1.12	(0.20)			1.18	(0.32)
Postgraduate (Master's degree)	1.16	(0.23)			1.26	(0.37)
PhD degree	1.69	(0.74)			2.19	(1.45)
Other professional qualification or certification	1.16	(0.32)			1.25	(0.52)
Prefer not to say	1.24	(0.62)			1.38	(1.03)
Years of experience (base Less than 1 year)						
1–5 years	0.71	(0.24)			0.60	(0.30)
6–10 years	0.74	(0.28)			0.64	(0.37)
More than 10 years	0.77	(0.30)			0.67	(0.40)
Prefer not to say	0.02***	(0.01)			0.01***	(0.01)
Primary functional experience (base Sales)						
Marketing	1.53	(0.43)			1.90	(0.80)
Procurement	1.25	(0.29)			1.40	(0.49)
Operations	1.44*	(0.28)			1.73*	(0.50)
Finance	1.37	(0.34)			1.61	(0.60)
Human Resources	4.12***	(1.13)			8.39***	(3.36)
IT	1.09	(0.29)			1.14	(0.45)
Others	1.03	(0.25)			1.05	(0.37)
Prefer not to say	0.74	(0.25)			0.64	(0.32)
Deal size (Less than £10,000)						
Between £10,001 and £50,000	1.28	(0.49)			1.45	(0.82)
Between £50,001 and £250,000	1.17	(0.46)			1.27	(0.74)
Between £250,001 and £500,000	1.13	(0.46)			1.20	(0.73)
Above £500,000	1.47	(0.71)			1.80	(1.30)
No prior experience	0.55	(0.27)			0.42	(0.30)
Prefer not to say	0.76	(0.32)			0.66	(0.42)
Constant	0.04***	(0.01)	0.04***	(0.01)	0.03***	(0.02)
Pseudo R2	0.02		0.26		0.29	
Respondents	234		234		234	

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

5.3. Marginal willingness to pay (MWTP) analyses

We also conducted marginal willingness to pay (MWTP) analyses to further explore the monetary impact of sustainable supply chain transparency. MWTP is the approximate price buyers are willing to pay for an upgrade in a certain attribute (e.g., an additional cost associated with a disclosure of particular information). Both algebraic and Sampling of Scenarios (SOS) methods were performed following instructions by Orme (2021). The former is the most commonly used simple calculation to interpret utility disparities between other attribute levels into monetary values by taking the price slope to divide the total utility differences between two distinct attribute values at the individual levels. This method does not take into consideration the impact of competition in the market (e.g., when another supplier has a higher-level attribute with a lower price), thus, the MWTP is sometimes higher than the actual situation (Miller et al., 2011). This concern is addressed by the Sampling of Scenarios (SOS) method. The share of preference simulation function pre-installed in the Sawtooth software is used to simulate different scenarios and then calculate the MWTP across those scenarios (Hinnen et al., 2017). In this method, the market competition is considered and the estimated MWTP is expected to be more accurate (Orme, 2021). The results of MWTP estimations by both algebraic and SOS methods are

shown in Table 6.

5.4. Test of hypotheses

5.4.1. Value of voluntary disclosure

From Table 5, we observe a positive association between information disclosure and the probability of selecting a supplier that is also consistent with the part-worth utility analysis (Table 4) and supports our first hypothesis H1(a). When keeping everything else equal, buyers prefer suppliers with information disclosure over those with non-disclosure regardless of disclosure types. From the MWTP analysis (Table 6), using the algebraic method, we estimate that buyers are willing to pay for an upgrade from no disclosure to the first level disclosure: £1887.00 for product disclosure, £1552.95 for process disclosure, and £922.18 for sourcing network disclosure. Similarly, the MWTP estimations by the SOS method are £1663.09 for product disclosure, £1406.25 for process disclosure, and £861.33 for sourcing network disclosure. All of these are significantly different from the base value of non-disclosure. This provides strong empirical support for H1 (b).

5.4.2. Relative worth of different types of voluntary disclosure

As seen in Table 4, we have support for H2(a). A t-test shows that the difference in average importance of product disclosure (21.39, SE 0.51) and process disclosure (18.09, SE 0.33) is statistically significant (t-value 5.43, SE 0.61, $p < 0.001$) and the difference is average importance of process disclosure with sourcing network disclosure (14.87, SE 0.34) is also statistically significant (t-value 6.80, SE 0.47, $p < 0.001$). This lends further support for H2(a).

From MWTP estimations (Table 6 - SOS Method) we find that buyers are willing to pay a premium for a buyer's self-discourse of products £1663.09 (SE 210.31), compared to process (£1406.25, SE 187.28) and sourcing network (£861.33, SE 170.16). However, the t-test shows that the difference is MWTP between product and process self-disclosure (t-value 0.91, SE 281.61, p 0.362) and between process and sourcing network self-disclosure (t-value 2.15, SE 253.04, p 0.032) are only partially significant. Therefore, we find partial support for H2(b).

5.4.3. Value of third-party verification

We find that buyers are more likely to select suppliers with third-party verification over those with self-disclosure. From Table 5 (Model 3), when compared to the base cases with no disclosure, self-disclosure and third-party verification of product disclosure yield odds ratios of 6.84 (SE 0.58) and 7.37 (SE 0.67), respectively. Similarly, self-disclosure and third-party verification of process disclosure yield odds ratios of 5.34 (SE 0.39) and 6.15 (SE 0.45), respectively. In line with results from part-worth utility analysis, this provides support for hypothesis H3(a). We also find that even though third-party verification is preferred by the buyers, there are only minor differences between self-disclosure and third-party verification for product disclosures. This is more clearly seen in the MWTP analyses (Table 6 – SOS Method) that show the MWTP increases for third-party verification from self-disclosure, the difference that is not statistically significant in a t-test for both case of product disclosure (t-value 0.00, SE 285.49, p 0.997) and process disclosure (t-value 0.47, SE 269.67, p 0.641). This shows we do not have empirical support for H3(b).

Table 6
Marginal willingness to pay (MWTP) estimations by algebraic and Sampling of Scenarios (SOS) methods.

Attribute	Algebraic method		Sampling of Scenarios (SOS) method	
	Marginal WTP	Standard Error	Marginal WTP	Standard Error
Product disclosure (base No disclosure)				
Self-disclosure	£1887.00	(53.34)	£1663.09	(210.31)
Third-party verification	£1982.24	(57.31)	£1664.06	(193.07)
Process disclosure (base No disclosure)				
Self-disclosure	£1552.95	(37.29)	£1406.25	(187.28)
Third-party verification	£1738.66	(35.32)	£1532.23	(194.03)
Sourcing network disclosure (base No disclosure)				
Only direct suppliers	£922.18	(44.80)	£861.33	(170.16)
Entire supply chain	£1399.57	(42.56)	£1308.59	(170.17)
Information immutability (base No disclosure)				
Information immutable due to blockchain	£772.47	(38.09)	£770.60	(121.59)
Information update frequency (base No disclosure)				
Annual update	£507.16	(28.76)	£515.14	(77.54)
Monthly update	£976.98	(36.40)	£992.19	(140.90)
Daily update	£1011.33	(59.97)	£1054.69	(163.67)

5.4.4. Value of full disclosure

For sourcing network disclosure, we find that buyers are more likely to select a supplier if that supplier provides full disclosure rather than partial disclosure. Specifically, Model 3 in Table 5 demonstrates a significant difference in the odds of buyers' supplier selection, with odds ratios of 4.00 (SE 0.30) for full disclosure and 2.66 (SE 0.18) for partial disclosure, when compared to the base case of no disclosure. This is consistent with the results from the part-worth utility analysis, thus hypothesis H4(a) is supported. We find the same pattern in the MWTP analyses of Table 6 - SOS Method, which shows buyers are willing to pay £1308.59 (SE 170.17) for full disclosure and £861.33 (SE 170.16) for partial disclosure, when compared to no disclosure. A t-test analysis (t-value 1.86, SE 240.65, p 0.064) provides weak support for H4 (b).

5.4.5. Value of blockchain-enabled reporting

We incorporate two features of blockchain-driven information disclosure: update frequency and the immutability of the disclosed information. Both features provide a significant and positive effect on the likelihood of selecting a supplier. Our data shows the more frequently the information is updated, the higher the likelihood of supplier selection by buyers. However, as per Model 3 in Table 5, we observe that the transition from an annual update (odds ratio 1.77, SE 0.06) to a monthly update (odds ratio 2.76, SE 0.13) has a greater impact on buyers' likelihood of selecting a supplier than the transition from a monthly update to a daily update (odds ratio 2.85, SE 0.18). Additionally, we find that buyers are more inclined to select a supplier if that supplier discloses immutable information. The impact of blockchain-driven information immutability on buyers' supplier selection is represented by an odds ratio of 2.36 (SE 0.12) when compared to the base case of no disclosure. These findings are consistent with the results from the part-worth utility analysis, thus the hypotheses H5(a) and H6(a) are supported.

From MWTP estimations (Table 6 - SOS Method) we find that buyers are willing to pay to see a supplier's disclosure of information update frequency: £515.14 (SE 77.54) for annual updates and £992.19 (SE 140.9) for monthly and £1054.69 (SE 163.67) for daily updates. A t-test shows that while the difference between the annual and monthly is significant (t-value 2.97, SE 160.83, p 0.003), the difference in MWTP for monthly and daily updates is not significant (t-value 0.29, SE 215.97, p 0.772). This indicates a greater willingness to pay for update frequency: from annually to monthly – but not daily and so only partially support H5(b). For information immutability, we find there is great WTP compared to the base scenario (£772.47, SE 38.09). This supports H6(b).

5.5. Text analysis of key decision criteria

Participants were asked to write about key decision criteria and explain what influenced their choices. The results of the text analysis are shown in Table 7. 50% of participants mentioned 'Price' as a central attribute. This finding is consistent with the results from the average importance of attributes that the price is the most important attribute in

Table 7
Results from text analyses.

Decision Criteria	Counts	Percentage	Examples of quotes
Price	116	50%	"Most firms, from my experience, only care about the price." - P14 "Mainly the price, as an employee of a large company I have a duty to maximise the profit for the shareholders, spending more than is needed would be wrong." - P99 "The first criteria, and I assume that this goes for most companies, was cost. Every company prioritizes profit, and with this, every cost should be reduced." - P228
Overall transparency	98	42%	"I have chosen the options with the most coherent criteria in terms of sustainable supply chain transparency" - P37 "A company that provides more information is probably more professional and trustworthy." - P123 "The transparency and the amount of information that the company was willing to disclose were important to me." - P185
Product disclosure	48	21%	"Sustainability of materials because it's important to ensure that the materials required are readily available" - P4 "Product Disclosure because as the business we able to see the products we going to use how are they sustainable" - P63 "I considered product transparency to be the most important … " - P218
Process disclosure	32	14%	"Labor rights transparency which ensures that people are not taken advantage of." - P4 "My decisions were aimed at choosing a company that discloses as much data as possible about the method of production … " - P94 "I think labor rights is the farthest a cooperation usually goes for when taking profit into account." - P151
Sourcing network disclosure	20	9%	"Sourcing disclosure provides insight if the company receives its products from reliable supplies." - P172 "I really needed to know where they sourced the items … " - P196 " if this doesn't include the whole supply chain it's pretty useless." - P245
Information immutability	24	10%	"Disclosure on immutability to ensure that information is true and correct and cannot be adjusted … " - P4 "Blockchain, it is not corruptible and the companies can not go back and change what they disclosed." - P89 "I chose immutable information by blockchain because we can actually have a look at the blockchain and see evidence of what's going on." - P254
Information update frequency	48	21%	"I was influenced by how often they did the disclosure, tending to choose daily or weekly disclosure." - P51 "I preferred those who divulged the information more and more, even those who did it monthly or daily. " - P100 " If information is updated frequently it can be trusted. The more frequently it is updated the more accurate the information." - P232
Self-disclosure	14	6%	"My main criterion was almost always to choose self-disclosure, I think that if anyone knows our product, it's us." - P44 "(The decision was based on) how many self disclosure requirements were provide." - P251 "self-regulation … these are factors that are considered necessary in a transparent company" - P260
Third-party verification	28	12%	" … third party certifications. I gave very little weight to self-disclosures, especially when not involving immutability of very sparse updates." - P55 "I also preferred a third-party approval over a self-disclosure because it seems more reliable, and can be more difficult to get approval from a third party." - P185 "I looked for the one that made the most 3rd party disclosures, as I would trust that information to be accurate and impartial." - P197

the supplier selection decisions. The second most frequently mentioned attribute is overall transparency, mentioned by 42% of participants - but it does not specify a specific type of disclosure. We find that many participants consider the trade-off between these two key factors: price and overall transparency. For example, Participant 57 mentioned, "I… weighed up what was a good balance with my preferred disclosures and price.". Similarly, Participant 140 made decisions based on "a balance of price and the amount of disclosure that they choose to reveal".

Among the three types of product, process, and sourcing network disclosures, we find that buyers prefer product disclosure the most, and sourcing network disclosure the least. Participants mentioned product disclosure the most (21%), followed by process disclosure (14%), and sourcing network disclosure (9%). This is consistent with the results from the average importance of attributes, in ascending orders of product disclosure, process disclosure, and sourcing network disclosure.

The information update frequency and information immutability are mentioned by 21% and 10% of the participants. We find that information update frequency is mentioned even more than process disclosure and sourcing network disclosure.

6. Discussion

Research indicates that despite a growing commitment among numerous companies to enhance the sustainability of their supply chains, the precise methods for achieving this goal in a cost-effective manner still lack clarity (Villena and Gioia, 2020). One commonly employed approach by buyers is to actively seek out suppliers with a stronger sustainability track record. However, our understanding of how buyers evaluate the authenticity of sustainability claims made by their suppliers and, more importantly, whether they are willing to invest in obtaining more reliable information about these claims at an additional cost remains limited. In this section, we delve into our research findings within the context of how buyers perceive the value of self-reported, third-party verified, and blockchain-enabled information, as well as the associated price premium for sustainable supply chain transparency.

6.1. Importance of 'how' sustainability information is disclosed

Our research reveals that a substantial portion of sustainability information relies heavily on self-reporting, necessitating buyers to embark on the challenging task of assessing supplier credibility and establishing trust in the information provided (Belhadi et al., 2021). The latter aspect becomes particularly critical in light of instances of supplier greenwashing, where unverified sustainability claims are presented with the intention to deceive, thereby posing risks to buyers, even if the fault ultimately lies with the supplier (Pizzetti et al., 2021). As a result, buyers increasingly encounter the imperative to validate supplier information, especially when dealing with lesser-known suppliers. This demand has given rise to two distinct options for buyers: seeking third-party verification and exploring blockchain-enabled reporting.

A credible third-party verification, while incurring costs, bestows essential credibility upon claims made by relatively unknown suppliers, especially in the eyes of discerning buyers. Similarly, a blockchain platform, founded on distributed ledger technology, offers a robust system for recording transactions, delivering a host of advantages such as operational efficiencies, traceability, and the immutability of records in the intricate landscape of supply chain management (e.g., Vinayavekhin et al., 2023). Notably, data on a blockchain platform undergoes real-time verification through a peer-to-peer network, setting it apart from most third-party certifications, which tend to be non-real-time and primarily awarded to suppliers rather than individual transactions. Therefore, adopting a blockchain platform for reporting sustainability information equips buyers with an additional layer of detailed and reliable insights into suppliers' data, albeit at an associated cost (Saurabh and Dey, 2021)

Our data suggests that buyers exhibit a preference for sustainability claims to be substantiated through third-party verification and reported on a blockchain-enabled digital platform. While this preference contrasts with the absence of disclosure, it is worth noting that the margin over self-disclosure, sans third-party validation, was only marginally higher, particularly in the case of product disclosures. Buyers' MWTP exhibited a mere premium (5%, calculated by the Algebraic method; 0.1%, calculated by the SOS method) for self-reported versus third-party-verified product disclosures. Although the differences lack statistical significance, this MWTP increased notably (12%, calculated by the Algebraic method; 9%, calculated by the SOS method) for process disclosures. Similarly, buyers on average demonstrated a greater MWTP for information sourced from a blockchain platform, with an approximate 8% premium for immutable information and an approximate 10% premium for information updated daily, when compared to no disclosure. These findings underscore the importance buyers place on the way sustainability disclosures are presented and authenticated.

6.2. Value of signalling and buyer-supplier trust

In the context of procurement, the decision by buyers to shift toward a more sustainable supply chain is poised to reshape the dynamics of the buyer-supplier relationship. This transformation hinges on whether buyers opt for acquiring more in-depth information, albeit at an added expense, or rely on the veracity of their suppliers' claims (Busse et al., 2017; Cole and Aitken, 2020). To elucidate this phenomenon, we draw upon signalling theory, which posits that buyers place a premium on suppliers that have greater transparency in their sustainable supply chain practices. This preference stems from the understanding that transparency entails higher signalling costs, thus signifying a supplier's commitment to sustainability in a more credible manner.

While the disparities in the perceived importance of the three types of disclosure were not consistently statistically significant, it is intriguing to note that buyers did not attribute significant additional value to third-party-verified sustainability disclosures when compared to self-disclosures. This finding underscores a substantial level of implicit trust that buyers place in the sustainability signals emanating directly from their suppliers. This trend aligns with empirical observations that the immutability of information ranks as a relatively less pivotal concern (See Table 4), marking it as the least important attribute in buyers' assessments. On the contrary, buyers appear to place a premium on comprehensive information, as evidenced by the relatively high utility assigned to sourcing network disclosure encompassing the entire supply chain, as well as the frequency of updates, be it on a monthly or daily basis. These observations suggest that buyers are more inclined to trust sustainability information when it is both detailed and regularly updated. This insight contributes significantly to the body of research on buyer-supplier trust within sustainable supply chains (Gualandris and Kalchschmidt, 2016).

6.3. Understanding the transparency-price premium

Our research contributes to the emerging research area of supply chain transparency (Sodhi and Tang, 2019). While previous research has typically studied only one type of disclosure our research entails multidimensional and nuanced perspectives of supply chain transparency: three types of disclosure, self-disclosure vs third-party verification, partial vs full disclosures, and blockchain vs non-blockchain. Furthermore, our CBC experiment design can reveal buyers' trade-off behaviours and willingness to pay a price premium when selecting a supplier based on such a multidimensional perspective.

We also build on previous research that shows buyers do not completely trust suppliers if the particular information is not verified by a third party (Chen and Lee, 2017). Third-party audited information is perceived as more accurate and reliable (Schnackenberg and Tomlinson, 2016). According to our qualitative results (Table 7), 12% of participants mentioned third-party verification while 6% of them mentioned self-disclosure as a key decision-making criterion. They prefer third-party verification over self-disclosure due to the reliability of the disclosed information. For instance, Participant 185 noted that "I also preferred a third-party approval over a self-disclosure because it seems more reliable and can be more difficult to get approval from a third party". However, when we consider buyers' willingness to pay for the third-party verification, our research finds that buyers do not perceive a significant additional utility when suppliers have their disclosures verified by a third party, compared to self-disclosures. As we analysed the MWTP increases for third-party verification, the difference is statistically not significant in a t-test; thus, we do not have empirical support for H3(b). This indicates that while third-party verification is more trustworthy compared to self-disclosure – the difference in the price premium is small.

In addition, we develop a more nuanced understanding of the buyer's trade-off between the need for transparency and willingness to pay (Matos et al., 2020). We show buyers care more about product transparency over process or sourcing network transparency. This indicates that buyers are acutely aware of the additional price for transparency and therefore prioritise what is more important to them. Similarly, buyers care about the frequency with which the sustainability information is updated and show a significant increase in willingness to pay for monthly updates compared to annual updates.

6.4. Impact of blockchain adoption in supply chain literature

Our research is in line with previous studies that show the suppliers' usage of digital technology, in this case - blockchain technology, in disclosure processes matters for the buyers (Treiblmaier and Garaus, 2022). However, it should be noted that this is not the main concern for the buyers as the immutability of information is rated as the least important attribute. We argue that suppliers' blockchain usage might increase buyers' purchase intention, but the disclosed information and its update frequency are far more important regardless of the underlying technology used.

This research builds on two constructs related to blockchain-driven

sustainable supply chain transparency: update frequency and immutability. These two constructs have not been fully developed in the signalling literature (Balboa and Martí, 2007; Connelly et al., 2011; Janney and Folta, 2003). Insights from our discussion of the results show that buyers value both update frequency and the immutability of the signals. We define the former as 'the frequency with which the signal is updated' and the latter as 'the characteristic of a signal that is tamper-proof due to the decentralised consensus and cryptography system of blockchain technology'. This calls for further development in the signalling theory for the digital era in which the signals are impacted by the characteristics of the digital medium.

6.5. *Implications for practitioners*

We show that suppliers can adopt voluntary disclosure of sustainability information as a strategy to gain a competitive advantage over their competitors. Our data reveals that buyers value various types of voluntary disclosure with different important levels, but most importantly they value suppliers with transparency over not having any transparency. Given limited resources, suppliers should attempt to disclose information which they find the easiest to acquire.

Suppliers should prioritise what to disclose according to the order of buyers' preference (Johnsen et al., 2018). Our data shows suppliers should give priority to product, process, and sourcing network disclosures, respectively. In addition, instead of pursuing only one type of information disclosure and spending more resources to get third-party verification, suppliers are likely to benefit more by self-disclosing more types of disclosure.

Suppliers may use blockchain to assist the disclosure processes, but they should not expect the direct benefits from the technology itself. From our findings, buyers value the disclosed information and its update frequency regardless of the underlying technology used. Thus, suppliers should not overlook the disclosed information (i.e., three types of disclosures) to maximise the full potential of blockchain usage.

7. Limitations and further research

While our research presents novel insights about the impacts of sustainable supply chain transparency concerning the use of blockchains, it has some limitations that provide the foundation for further research. First, even though conjoint experimental designs provide a robust basis to understand trade-offs – it is not a replacement for revealed preferences in the real world. Second, our scope is limited to voluntary disclosure where information disclosure is not mandatory (Reimsbach and Hahn, 2015). Other dimensions of transparency including clarity and accuracy of information could be further explored (Schnackenberg and Tomlinson, 2016). Third, the disclosed information is considered an intentional signal (Banerjee et al., 2020) and therefore it is consistent and positive in our experiment design. Further research could incorporate unintentional signals, inconsistent disclosure, and negative information (Sodhi and Tang, 2019). Last, we specifically explored the usage of blockchain in the context of information disclosure. Our research did not find a significant value in blockchain implementation perceived by buyers, however, different usage of blockchain in other contexts such as supply chain financing (Jia et al., 2020) and product traceability (Garcia-Torres et al., 2019) should be studied.

CRediT authorship contribution statement

Sukrit Vinayavekhin: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Aneesh Banerjee:** Conceptualization, Data curation, Funding acquisition, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. **Feng Li:** Funding acquisition, Supervision, Validation, Writing – review & editing.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT and Google's Bard to check for grammatical errors and improve sentence construction. After using these tools/services, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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