Sustainable Production and Consumption 57 (2025) 95–105

Contents lists available at ScienceDirect

Sustainable Production and Consumption

journal homepage: www.elsevier.com/locate/spc

Strategic shame management – Leveraging individual footprints to nudge sustainable development goal 12☆

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A R T I C L E I N F O

Keywords:
Sustainability reporting
Social sustainability
Responsible operations
Green consumer behaviour
Circular economy
System dynamics

A B S T R A C T

In the pursuit of United Nations Sustainable Development Goal 12 (SDG12) – 'Ensure sustainable consumption and production patterns' - a significant challenge persists: the misalignment between consumer demand for environmentally harmful products and the need for sustainable manufacturing practices. Through seven workshops with consumers, manufacturers, and academics, we explore innovative solutions using systems thinking. Our key finding reveals that calculating individual ecological footprints can catalyse change by triggering guilt in consumers and shame in manufacturers. We propose a three-stage model for policymakers to nudge gradual yet structural changes towards SDG12 by implementing rankings targeting the most polluting supply chains. This research offers theoretical insights into emotion-driven sustainability efforts and practical guidance for industry leaders to align consumer behaviour and manufacturing practices with global sustainability goals.

1. Introduction

There is no doubt about the unsustainability of current production and consumption practices; their detrimental effects on the environment, society, and future generations are well-supported by extensive research. The current economy remains tethered to linear models of production and consumption; this hinders the necessary transition 'in the way products are designed, produced, consumed, and disposed of' (Parker, 2023). In 2015, the United Nations introduced the Sustainable Development Goal (SDG) 12, 'Ensure sustainable consumption and production patterns'. To align with this goal, consumers should 'reduce their waste, be thoughtful about purchases and choose a sustainable option whenever possible,' and manufacturers must 'include sustainability at the core of business practices' (United Nations, 2015). However, both consumers and manufacturers often remain distant from achieving this goal, as their focus tends to be on growth – consumption and production, respectively – rather than on fostering meaningful and tangible progress towards a sustainable balance with nature (Raworth, 2017).

In this regard, many consumers implicitly contribute to the problems mentioned in SDG12 by driving demand for products that contribute to societal harm and environmental degradation. This is especially true for hedonic products linked to pleasure and enjoyment (like fast fashion), where the appeal of newness often precedes other purchasing criteria (Verhagen et al., 2010). Between 2019 and 2022, despite reducing the carbon impact of textiles by 12 %, the overall carbon reduction in the sector was reduced to just 2 % due to consumption growth (Wood, 2023). While Generation Z — those born between 1995 and 2010 – often say that sustainability and ethics are essential to them, that is not always reflected in their purchasing decisions. For example, Emily, 21, regularly buys from a well-known online fast-fashion retailer mainly due to its affordability, knowing she is not alone in this preference (Espiner and Acheson, 2025). Consumers may only experience embarrassment when they become aware of the hidden costs associated with their purchase. For example, a new pair of jeans costs our planet 2000 gal of water (Maiti, 2025). However, even if consumers are interested in how their purchases affect societies and the planet, this data is not easily accessible

☆ During the preparation of this work the authors used Grammarly in order to proof read the text. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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https://doi.org/10.1016/j.spc.2025.04.018
Received 8 July 2024; Received in revised form 22 April 2025; Accepted 26 April 2025
Available online 17 May 2025

outside of lengthy and intricate industrial reports. In other words, consumers cannot calculate their personal ecological impact (individual footprint) based on their buying preferences, and cannot choose a more sustainable option whenever possible. Together with social media trends and civil movements to consciously reduce purchases and avoid overconsumption ('underconsumption-core') (Conversation, 2023), behavioural scientists extensively study when and how message framing should be used to motivate sustainable consumer behaviour to support the alignment with SDG12; as such, appropriate framing of product information may change the *status quo* (Amatulli et al., 2019; White et al., 2019; Florence et al., 2022).

On a related note, governments and regulators around the world are mobilising against resource depletion. Environmental policy in the European Union, which has historically focused on sustainable waste management, is now shifting to address the issue from a manufacturing perspective (see Directive 2008/98/EC, which introduces eco-design principles). However, even when manufacturers are encouraged to integrate circularity principles into their design and production processes, these efforts are often misaligned with actual market demand, creating a noticeable disconnect (Ecodesign, 2009). Since there is no common agreement on how to address the threats imposed by resource depletion, governments have begun to provide numerous incentives for industry representatives to engage in creative problem-solving, rethink how consumer demand and manufacturing practices are connected, and bridge the theory-practice gap in alignment with SDG12.

Hence, we ask the following Research Question (RQ): How can policymakers nudge consumers and manufacturers towards more responsible practices, as outlined in SDG12?

This paper employs a backcasting methodology of strategic planning, which is well-suited for addressing complex issues related to long-term planning and change. This method focuses on developing scenarios of desirable futures and working backward to identify factors (and steps) that may contribute to realising those futures (Vergragt and Quist, 2011). While doing so, the methodology considers trends, uncertainties, drivers of change, and future goals for realising change. For this purpose, we engage industrial stakeholders and consumers through interactive systems-thinking workshops to explore the necessary industrial transformations for achieving SDG12 (Akkermans and Van Wassenhove, 2018; Akkermans et al., 2019). Experienced facilitators have used system dynamics to capture the envisioned impacts of supply chain transparency on consumers and manufacturers as causal loops (Sterman et al., 2015).

The novelty of this paper lies in addressing the interconnection between consumption and production to gradually accelerate the attainment of the SDG12 goal from both sides of the supply chain. Currently, consumers may manually calculate their footprints via online surveys (e.g., https://footprint.wwf.org.uk/) and see their score against the average in the country. Similarly, manufacturers cannot disclose accurate supply chain footprints in their annual reports. Neither calculation considers individual purchasing history/precise supply chain data. We found that calculating the individual footprints of consumers and manufacturers could serve as a novel catalyst for achieving SDG12, as it evokes a change impulse motivated by consumers' guilt and manufacturers' shame. By analysing the reinforcing and balancing effects of individual footprints, we identify that data-driven nudging will likely impact consumers' and manufacturers' intentions to reduce their environmental footprint and integrate SDG12 as a default priority. Through the lens of nudge theory (Thaler and Sunstein, 2008), we propose the three-stage 'strategic shame management' model as a new approach guiding supply chain redesign towards responsible sourcing (Elkington and Rowlands, 1999; Mejías et al., 2019).

The paper is organised as follows: first, we present a literature review. Second, we outline our methodology for constructing the system dynamics model. Third, we present and discuss our findings with existing literature. Lastly, we conclude by addressing limitations and proposing future research directions.

2. Literature review

2.1. Consumer side: guilt and shame in collective behaviour

Motives, and attitudes of consumers have become the target of marketing research to explore the intrinsic forces driving a consumer's purchasing decision. Among those latent aspects, the role of negative emotions has been examined. Guilt is known as '*the self*'s negative evaluation of specific behaviours' (Tangney, 1991, p. 599), and it has been increasingly the object of sustainability research. For example, Burnett and Lunsford (1994) investigate the post-purchase guilt of those opting for an environmentally harmful product or products that may cause guilt relating to social responsibility. This is believed to have a better impact on environmentally friendly decision-making than 'focusing on correcting or compensating for the transgression (i.e. guilt-repair)' (Arli et al., 2016, p. 11).

Similarly, the feeling of shame has also raised the interest of similar schools of thought regarding its potential impacts on sustainable purchasing decisions. Tangney (1991) highlighted the differences between guilt and shame in portraying the 'role of the self' differently and defined shame as 'the self's negative evaluation of the entire self' (Tangney, 1991, p. 599). Unlike guilt, shame may require an audience where one's actions are observed by others and perceived negatively. However, many sceptics contradict this viewpoint and believe shame can emerge without an audience (see Bero, 2020). On another note relating to shame, Ahmed et al. (2001) distinguished between 'shame as an emotion' and 'shaming as a regulatory practice'. The latter is associated with the publication of unethical practices by governmental agencies, such as the Department of Business and Trade's recent list naming and shaming over 200 UK employers for failing to pay the minimum wage to their lowest-paid staff (see GOV.UK, 2023). Damberg et al.'s (2022) study examines how shaming through negative news drives organisations to adopt sustainable management practices, finding that companies significantly increase efforts after facing negative publicity.

2.2. Manufacturing side: low-cost vs. sustainability dilemma

Cost efficiency has been the primary objective of most supply chains, which implies minimising expenses and maximising profit margins at every stage (Aslanertik, 2005). Such a strategy has been the backbone of supply chain management for decades, reflecting a business environment primarily driven by immediate financial gains. This has led, however, to various environmental degradations, including excessive resource consumption (i.e., Singhry, 2015; Hariyani et al., 2023), pollution and waste generation (i.e., Geng et al., 2017; Fu and Su, 2020), contributing to climate change (i.e., Nasir et al., 2017; Mohebalizadehgashti et al., 2020), habitat destruction (i.e., Foster and Brintrup, 2023; Zhu, 2023), and biodiversity loss (i.e., Lenzen et al., 2012; Salmi et al., 2023). While such deficiencies, in turn, have contributed to growing environmental concerns, increased social responsibility awareness, and consumer demand for responsible practices, they have altogether been the drivers of a significant shift towards more sustainable supply chains (Carter and Rogers, 2008).

Sustainability in supply chains typically refers to environmental aspects (Rajeev et al., 2017), such as reducing carbon footprints and optimising resource usage. On the other hand, the notion of responsibility (in the context of SDG 12) extends this further (Yawar and Seuring, 2017). Responsible supply chains encompass environmental commitment and labour practices such as fair trade and traceability in sourcing materials. As such, working towards more responsible consumption and production practices comprises a comprehensive and holistic approach for long-term success. Within this holistic approach, a company's responsibilities extend beyond its immediate surroundings to wider stakeholders (Rebs et al., 2018; Bello-Pintado et al., 2023). Reciprocally, the roles of those stakeholders increase to keep businesses sufficiently resilient and adaptable in a rapidly changing world (Bhuiyan et al., 2023). In other words, the mechanism of sustainable transition should be managed in both directions of the supply chains.

2.3. Policymaking: nudge theory view on production and consumption

The literature covers multiple examples of how nudging impacts business decisions from the consumer end of supply chains. Changes in purchase motives have resulted in businesses focusing on new, social responsibility-driven business models. For instance, Tao et al. (2022, p.6) investigate the impacts of customer behaviour on business model design, opting for brands that 'have contributed to society during the COVID-19 pandemic'. Such impact was also seen when customers' increased preference to purchase 'bio' products drove business model innovation (Arnold and Hockerts, 2011).

Nudge Theory influences decision-making processes by changing how options are presented to individuals while preserving their freedom of choice (Schmidt, 2017, p. 404; Thaler and Sunstein, 2008). For example, eco-labelling encourages preferences for sustainable alternatives, by informing consumers about a product's environmental impact (Gonçalves and Silva, 2021; Siraj et al., 2022); rearranging cafeteria layouts to place healthier options at eye level influences individuals towards better dietary choices (Wansink and Hanks, 2013; Hummel and Maedche, 2019). In the digital age, consumers receiving monthly feedback on their consumption are more likely to adopt sustainable behaviours (Schneider et al., 2017).

2.4. Digitalisation and data sharing practices

The rise of digital technologies has sparked increased discussion on the importance of supply chain transparency, aiming to foster circularity and sustainability (Friedman and Ormiston, 2022; Mejías et al., 2019). Since the early 2010s, digitalisation has emerged as a significant enabler of supply chain transparency 'from when an order is placed to outbound logistics' (Kagermann et al., 2013). Industry 4.0 was an attempt to address critical societal challenges such as the new societal attitudes towards consumption (e.g., higher demand for eco-transparency), environmental challenges (e.g., climate change and resource efficiency), and economic challenges (e.g., higher productivity and cost-reduction). Specifically, the Internet of Things (IoT) enables data generation from products in use (Kiel et al., 2017). It supports business models that convert hierarchical closed to hierarchical open firms (Leminen et al., 2018). These new business environments blur firm boundaries along the value chains (Kohtamäki et al., 2019; Mulligan et al., 2020; Westerlund et al., 2014) and distribution operations across many actors, creating manufacturing ecosystems (Kazantsev et al., 2023b; Pattinson et al., 2023).

Data sharing is emerging as a powerful tool for driving circular and sustainable models of production and consumption (Khan et al., 2016). Data sharing along the supply chain tiers improves situational awareness, which can be used both within supply tiers and by consumers (Overby et al., 2006). For example, consumer purchasing data can shape the supply chains to market demand (Rodríguez-Verjan and Montoya-Torres, 2009; Yang et al., 2022; Shockley et al., 2023). Likewise, consumers can also be informed via the data flow concerning the supply chain operations (i.e., Kraft et al., 2018). Considering the advancements in industrial digitalisation, these data flows can simultaneously work in collaboration. For example, Farmer Connect's solution can trace any physical product (focus on agricultural, food, and beverage products) from the origin to the end customer. It can also learn about farming communities supplying the products they purchase (see Farmer Connect, 2023a). End consumers can donate to help local projects and communities grow (see Farmer Connect, 2023b) to show their support. CENTRIQ™ app helps customers engage in environmentally friendly practices regarding durable goods (MyCentriq, 2023; DeNisco Rayome, 2020). By scanning the product label, customers can access manuals, guides, how-to videos, warranty and manufacturer contact information.

2.5. The research model: negative emotion-driven sustainability efforts

Designing a systemic shift towards an ideal sustainable world represents a new approach to sustainability (Ellen MacArthur Foundation, 2019), recognizing the emergent, contextual, and perspective-dependent nature of systems. Many researchers have investigated factors influencing the disconnect between green intentions and actions (e.g., Syed et al., 2024), with the consensus that the products featuring positive environmental messages do not increase sales, e.g. in energy-efficient household appliances (Deutsch, 2010), disclosing 'food miles' (Coley et al., 2011), and last-mile delivery preferences (Ignat and Chankov, 2020). The price tag still looks highly attractive to the customer and, in return, creates a cost-efficient supply chain when the order-winning criteria are met. However, this also triggers our hypothesis that negative information should be communicated to have a more pronounced impact (Amatulli et al., 2019; Borin et al., 2011). Florence et al. (2022) identified *emotions* as one of the key mediators of change in consumers' behaviour towards sustainability via message framing. The variety of data accessed and the increased communication channels enable *guilt and shame nudges*. For example, marketers can increase customers' guilt by developing messages that 'nudge consumers' evaluation of their behaviour' (Antonetti and Baines, 2015). Such guilt can affect consumers' ethical perceptions (Shin et al., 2024) and social comparison (DiCosola III and Neff, 2022). Shame, conversely, can catalyse the change in businesses to create new business models due to changing consumer behaviours (Damberg et al., 2022). Public ranking of sustainability performance acts as 'shame-nudges', incentivising improvements through reputational pressure (Bergquist et al., 2019). For example, Coca-Cola started to invest in technologies to manufacture packaging made of recycled marine litter, responding to a Greenpeace report and adverse publicity that identified the company's products among the most frequently found brands during global coastline clean-up initiatives (Arthur, 2019). Therefore, developing a regulatory practice around shame management could reshape production and consumption practices to align more closely with SDG12, Fig. 1.

3. Methods

Addressing complex, multifaceted challenges demands the application of innovative and forward-thinking approaches. This paper is part of a foresight study of digitally enabled manufacturing ecosystems in the UK by 2040. Foresight studies aim to identify desirable future scenarios and the factors that may facilitate or inhibit supporting those future visions. They are particularly suited to addressing complex, long-term problems involving multiple stakeholders, evolving interrelationships, and emerging concepts and factors (Puglieri et al., 2022; Iden et al., 2017; Chermack, 2007). As the background of this work, researchers addressed the InterAct network (https://interact-hub.org/) that brings together UK manufacturers, economic and social scientists, policymakers, and technology providers to reflect on the future scenario of sustainability attached to SDG12.

We employ a backcasting methodology, which is well-suited for addressing complex, long-term issues related to strategic planning. This method focuses on developing scenarios of desirable futures and working backwards to identify factors (and steps) that may contribute to realising those futures (Vergragt and Quist, 2011; Sutherland and Woodroof, 2009; Voros, 2001). We used a backcasting method to identify enabling factors (variable) and develop system thinking models to realize the sustainability scenario by using the impacts of supply chain transparency. While doing so, the methodology considers trends, uncertainties, drivers of change, and future goals for realising the change. For data collection, we invited industrial stakeholders and consumers through seven interactive workshops to explore the necessary industrial transformations for achieving SDG12 (United Nations, 2015; Voss et al., 2015). Participants discussed the role of the individual footprint using systems thinking with system dynamics (Akkermans and Van

Fig. 1. A research model of the consumer and producer mindset shift driven by individual footprints.

Wassenhove, 2018; Akkermans et al., 2019), Table 1.

Systems thinking, with its causal loop diagramming technique, helps elicit complex relationships among those factors and identify critical factors in realising the future (Aboah et al., 2024). The main goal was to sketch and analyse interrelations among the enabling or inhibiting factors (or variables) and provide insights for policy-making (Akkermans and Van Wassenhove, 2018; Sterman et al., 2015), where stakeholders are actively involved in the model development process, enhancing its relevance and acceptance.

Workshop participants reflected on the supply chain transparency calculated on the individual level that supports SDG12 to delineate key variables and their interaction in the system. Based on that, we constructed causal loop models to emphasise key enabling themes, elucidating cause-and-effect relationships among factors contributing to the shared theme and demonstrating the effects of individual footprints on consumption, production, and their interconnection. This is how we integrated the model with stakeholder feedback. Researchers openly questioned each link to ensure it worked for various industries in real-world applications.

The first author of this paper finalised the causal loop models of variables and their interconnections (Sterman, 2001), as shown in Fig. 2.

Lastly, to complete validation, we followed the best practices outlined by Sterman et al. (2015), e.g., the *structure assessment tests*, which ensure that the model structure is consistent with the supply chain models, and parameter assessment when we evaluated the relevance of the suggested variables based on the literature. An earlier version of this paper was presented at the European Operations Management Conference (Kazantsev et al., 2023a).

4. Results

4.1. Consumers' guilt: individual footprints and their private rankings

As consumers often lack information about the impacts of product production and use, we emphasise that collecting and making consumption data visible is the starting point for driving changes. Many products already have sensors that can measure the incurred impacts of the product in use. Alternative data sources to assess the individual footprint are industrial reports.

Reinforcing loop 1: Compiling consumption and product utilisation data together is of the utmost importance, as it makes consumers aware of the extent to which each purchase (and the product utilisation) adversely affects SDG12. Our respondents agreed that if consumers are informed about production practices in use for sourcing components, making and delivering the product, each purchase indirectly represents consumers' approval. This can be measured by a holistic individual metric: `consumers' footprint`. In contrast to the national carbon emissions per capita, this is an individual metric built on personal

Table 1
Description of workshops with consumers, academics, and manufacturers.

N	Location	Date	Recruitment approach	Stakeholders involved
Phase 1 – Pilot study				
1	Liverpool, UK	17.11.2022	InterAct contacted academic and industrial attendees at the annual Digital Manufacturing Week.	10 UK-based mid-level academics; CEO of the manufacturing firm.
Phase 2 - Main study				
2	Loughborough UK	14.02.2023	InterAct network personally promoted the event via MakeUK, HVMC, MTC, and Midlands Engine.	23 participants, inc. FMCG, automotive, fashion, technology - hardware/software, property, consultancy (Two C-level, four senior, four mid-level and two junior-level managers, and eleven consumers)
Phase 3 – Validation (multi-sector)				
3	Cambridge, UK	10.11.2023	A researcher directly interacted with participants at the academic event.	3 consumers (engineers)
4	Cambridge, UK	26.01.2024	A researcher directly interacted with participants at the weekly interdisciplinary research colloquium in Clare Hall College.	30 consumers (academics).
Phase 4 – Validation (sector-specific)				
5	Cinnamon Grand, Sri Lanka	16.11.2023	InterAct network personally promoted the workshop and interacted with representatives from the apparel industry during a global mission.	30 apparel and textile participants, inc. mid and top-level executives of 6 trade associations.
6	Cambridge, UK	01.12.2023	A researcher directly interacted with participants at an InterAct workshop to investigate the role of supply chain transparency in enabling informed consumer choices.	30 participants, inc. 23 consumers, four consultants, one top-level manager (telecom), one engineer, one representative of a UK Food association and an international organisation.
7	Coventry, UK	27.03.2024	InterAct network personally promoted the event 'Future of Digital Manufacturing Ecosystems for MedTech' via MakeUK, HVMC, MTC, and Midlands Engine.	16 participants, inc. three academics, four mid-level consultants, and nine mid-level industrial managers from MedTech.

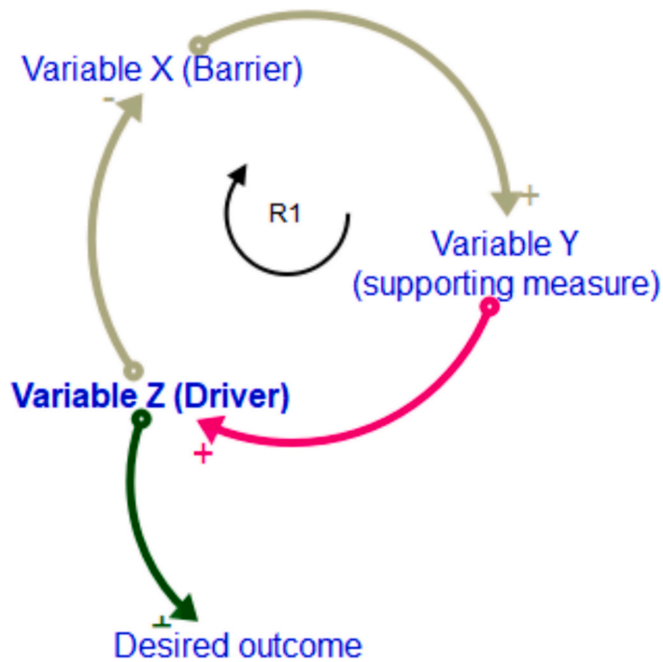

Fig. 2. The system dynamics metamodel. Grey arrows represent the connections between the variables; the pink arrow represents the key drivers; the green arrow points to the primary outcome of the model. R1 shows the iterative reinforcing relationship between the variables.

consumption data. For example, products with excessive CO_2 emissions will drastically raise their footprint, while using green production and reusing products will affect their footprint more slowly and incrementally. The more products are purchased, the faster the individual footprint will grow, reflecting one's contribution to the climate crisis. The data sources for this footprint include the existing industrial reports on production, along with products' supply chains, including CO_2 calculations, raw material sourcing, and labour utilisation, are added to the footprint. Moreover, further data points appear as the new products already have embedded sensors that generate and share production data. This footprint will be supplemented with what workshop participants called consumption data, including product utilisation, component replacement, recycling, and reuse data. While the footprint will gradually increase over product utilisation, each new purchase will increase the footprint abruptly. This will be an essential difference to illustrate, as using for longer is preferred for SDG12, in contrast to constant new purchases. Individuals would be nudged to rethink their consumption patterns based on their footprints, leading to a consumer mindset shift towards SDG12, Fig. 3a.

Reinforcing loops R2 and R3: Based on R1, the next step for the consumers' footprint is to inform consumers about their incremental impact over time. There was a consensus that increasing awareness about the individual's adverse contribution to sustainability reinforces the consumer mindset to change due to the emerging feeling of guilt. The quote below illustrates the identified link:

> Many consumers may feel guilt when informed about unsustainable practices associated with a product they buy. This emotional response [of guilt] can arise from a sense of personal responsibility or a conflict with their values, especially among those who are environmentally conscious (IM1)

The more individuals know about the actual impacts of their consumption, the easier it will be for a society (as a collection of individuals) to mobilise and facilitate the change towards sustainable consumption and production. When consent is granted for sharing consumption data, compiling consumer rankings for a household, municipality, town, region, or country, and comparing with others, is supported by the emerging feeling of guilt. That will facilitate a consumer mindset shift. When sharing consumption data is not allowed, consumers can be informed about the boundaries of consumer groups, compiled by the average footprints, that range from top polluters to top green leaders. Allocating themselves into the category can also initiate the feeling of guilt, (Fig. 3b).

Balancing loops B4 and B5: Consumer awareness regarding the implications of individual purchases and the resulting sense of guilt can influence green consumer behaviour, as real-world action, bringing activism, voicing concerns, and the attitude of using products for longer. The quote below confirms the general link between changes in consumer behaviour leading to reduced consumption over time:

> The feeling of guilt or discomfort can lead to a change in consumer behaviour. Some examples can be [...] look[-ing] for more sustainable alternatives, [and] reducing consumption [as] some may opt to use less of the unsustainable product (IM2)

The practice of recycling is paramount for this model. This approach may alleviate consumer guilt associated with contributing to waste creation, thus reducing the adverse individual impact. Products can be diverted from waste and utilised as valuable inputs in subsequent manufacturing processes:

> when you record data about recycling, [you may keep track of how these recycled materials are reused, which] creates something more valuable as consumers go to buy a product, they feel good about buying that product as opposed to buying [an ordinary product] (SL4)

An increased readiness to engage in material recycling (e.g., packaging, product accessories, components, batteries, and filaments) opens another real-world action — another loop of the model, which reduces Consumption volume (Fig. 3c).

4.2. Manufacturers' shame: individual footprints and their public rankings

Reinforcing loop B1: The conventional manufacturing strategy appropriates value by selling more products. Cost pressures may compel upstream supply chain firms to create social vulnerabilities, increasing manufacturers' footprint. Workshop participants agreed that data collection and sharing from consumption is a key data point to inform business model innovation on the new sources of value for consumers, such as prolonging the use. For instance, firms may adopt payment models based on usage, availability, or performance outcomes. This will increase the utility of their products on the market. Besides, public campaigns are critical in raising awareness about production conditions and supporting the manufacturers' mindset shift towards

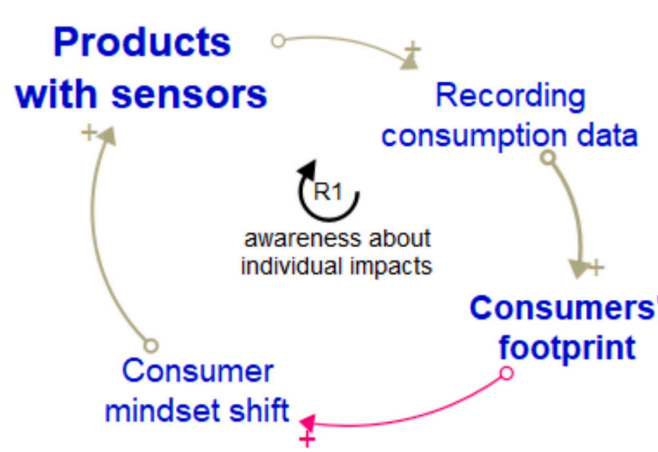

Fig. 3a. Generating data along the smart product lifecycle leads to a consumer mindset shift.

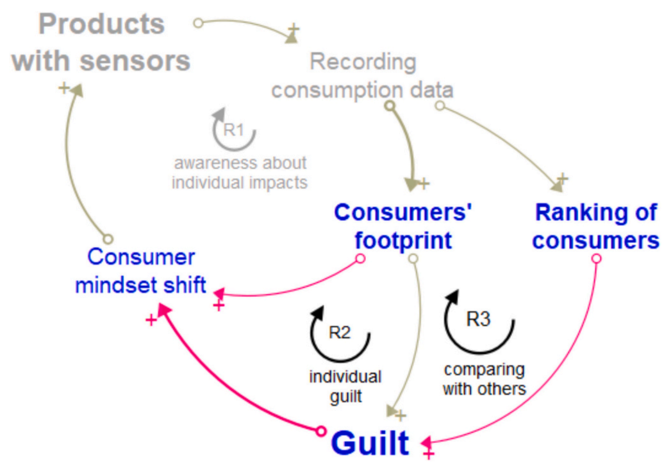

Fig. 3b. Comparing individual footprint with others drives reinforces consumer mindset shift.

SDG12. If individual footprint data becomes available, non-governmental organisations and charities would be best suited for campaigning. As such, manufacturers are expected to comply with real-world actions, such as fair pay to workers (fair trade) and improve their readiness to extend the product lifecycle (Fig. 4a).

Balancing loop B2: Similar to the consumer aspect of the model, the effect of public campaigns using actual production footprint provides additional data points for a more accurate ranking of manufacturers. Organisations such as Greenpeace or World Wide Fund for Nature disseminate such data. However, as per a quote below, there is a need to standardise rankings, similar to various sports competitions, to increase its adoption and popularity:

> it is very interesting the way we like to think of standardisation typically; we see it from a historical perspective as [measuring results] in athletics, [the same] way [measuring emissions] needs standardisation (IM4)

Ranking at the bottom of this list is anticipated to evoke shame for manufacturers, potentially prompting a manufacturer's mindset shift and subsequent actions, such as compliance with SDG12 values. A study participant, SL5, suggested that the impact would be more significant for manufacturing firms with recognisable brands, as the brand communicates specific values to consumers and would fail to stay in business otherwise. Hence, if consumers change their values, brands (the related manufacturers and supply chains) would change accordingly (Fig. 4b).

Balancing loops B3: Data on consumption volumes and consumer preferences informs the manufacturing sector about necessary production volumes to avoid overproduction. While the growth of production volume typically increases cost pressure in supply chains, in the model, the improved readiness of manufacturers to fair trade does not allow worker abuse to happen. Reducing production volumes to balance production and consumption (Raworth, 2017) not only results in reduced CO_2 emissions but also necessitates extending the lifecycle of existing products and developing additional services for them (see Fig. 4c).

4.3. Governmental nudging to achieve SDG12

Supply chain transparency is key in the model, providing reciprocal data flows from the upstream supply chain to consumers and back. This leads to better awareness of demand signals, thus avoiding overproduction and keeping the balance within the boundaries suggested by SDG12. Fig. 5 shows the entire system dynamics model.

The model suggests that individual footprints can be utilised by government nudging initiatives towards SDG12, and removing unsustainable business practices, and excessive carbon emissions. Policymakers offer suggestions to enhance material recycling, reduce CO_2 emissions and promote energy efficiency. The new legislation may

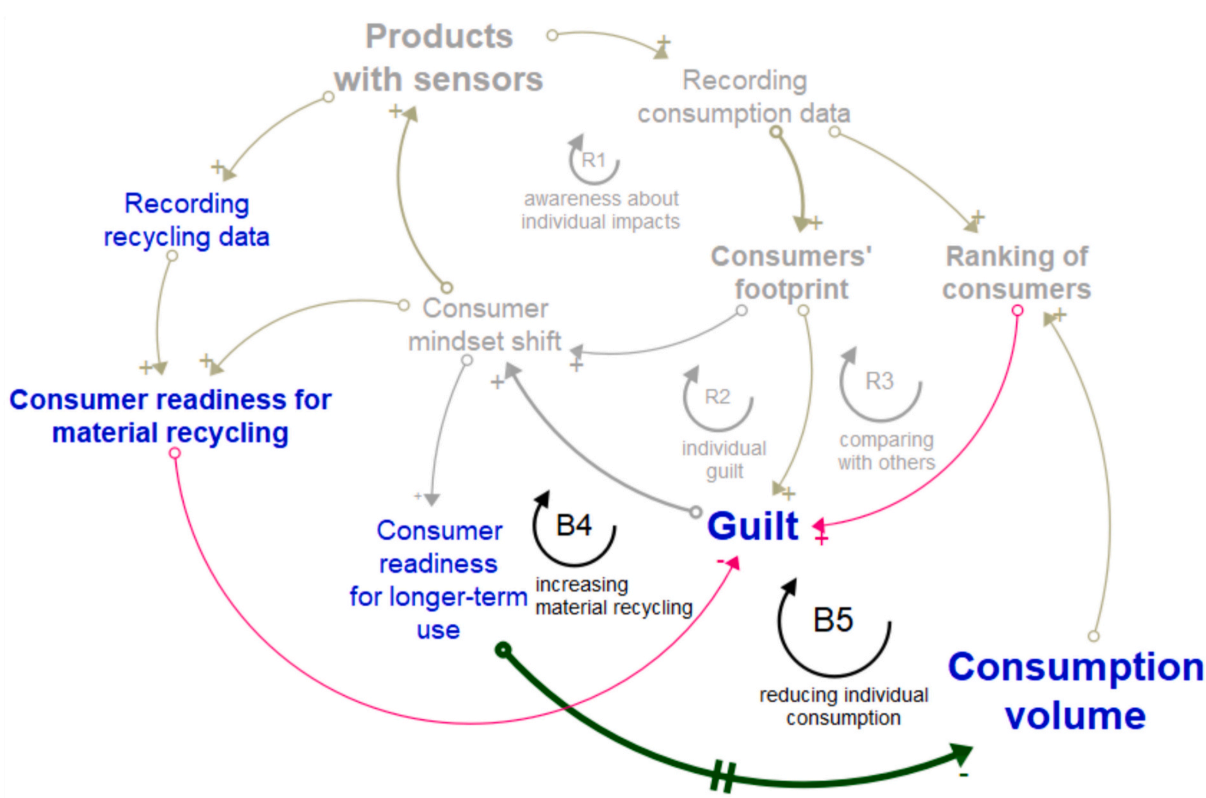

Fig. 3c. Intensifying material recycling and consumer readiness for longer-term use decreases consumption volume

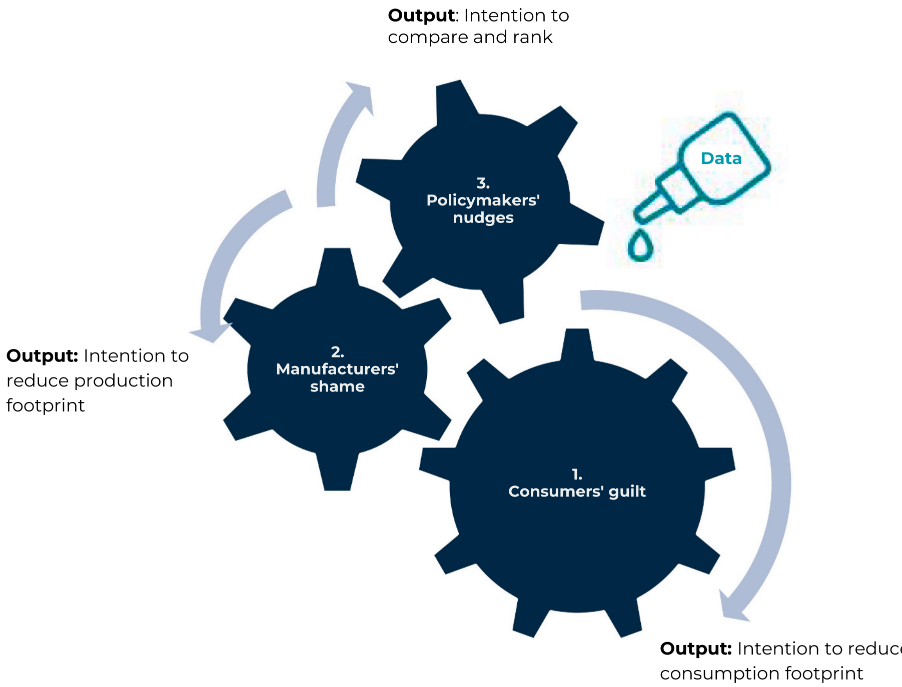

Fig. 4a. Public campaigns bring manufacturer mindset shifts.

include extra taxes or `penalties` for overlooking sustainability-related concerns. For example, participants suggested balancing the relationship to regulation, i.e., when the level of emissions is reduced to fit the goals, as confirmed by the quote below:

> Regulation can also drive some behaviour within an organisation, and what type, what form of regulation, what type of regulation, whether imposed by the government or self-regulation of some sort (SL1)

Companies will likely notice these shifts earlier and alter their practices to retain their customer base, mainly supported by the openly available information about their footprint.

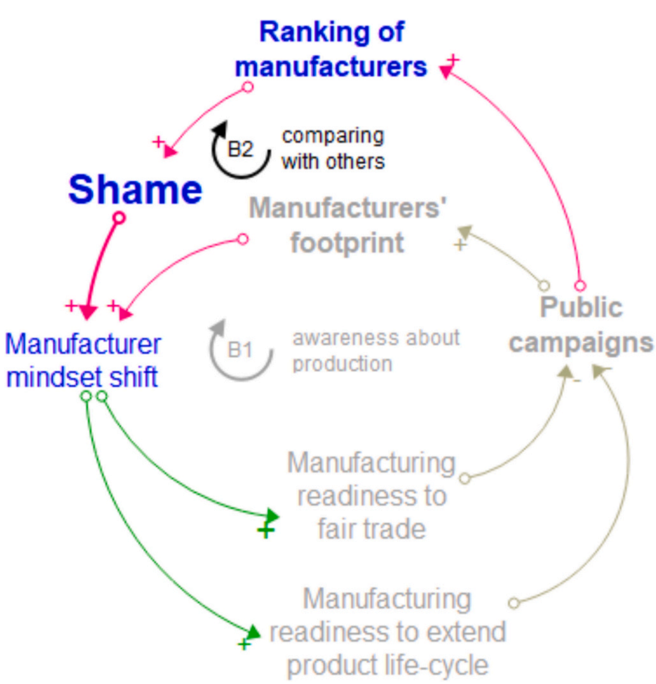

Fig. 4b. Comparing with others: Opening the negative consequences of producing low-utilisation products.

5. Discussion

5.1. Theoretical contribution

This study's key contribution is its systemic approach to bridging the consumer intention-action gap towards reaching this balance in alignment with SDG12 (Essiz et al., 2023; Raworth, 2023). We identified how calculating individual footprints could catalyse behavioural and structural changes in consumer behaviour and manufacturing practices. Unlike conventional green marketing approaches that assume rational consumer decision-making, our model acknowledges the emotional and social dimensions of sustainability choices. The findings illustrate how guilt and shame-based nudges can operate at a systemic level to influence entire supply chains, via the lens of nudge theory (Thaler and Sunstein, 2008).

Combining guilt nudges (downstream) and shame nudges (upstream) can extend the application of negative emotions beyond individual decision-making to collective supply chain dynamics, and help align market forces to drive consumer and manufacturer behaviour towards SDG12. Strategically managing the shame would support consumers to act according to their pro-environmental values (Syed et al., 2024). Moreover, strategic shame management could amplify these values by connecting personal underconsumption choices to measurable upstream impacts (e.g., reduced factory emissions per purchase avoided). Public sustainability rankings compel companies to adopt greener production practices due to public accountability and can motivate behavioural change (DiCosola III and Neff, 2022).

Based on our findings, we derived a three-stage model to address the research objectives of nudging consumers and manufacturers towards responsible practices, bridging the gap identified in the introduction between consumer intentions and real-world actions in alignment with SDG12, and offering a structured pathway for market-driven sustainability transformation (Fig. 6).

5.1.1. Consumers' guilt based on the individual footprints

Prior studies have explored how guilt affects post-purchase regret

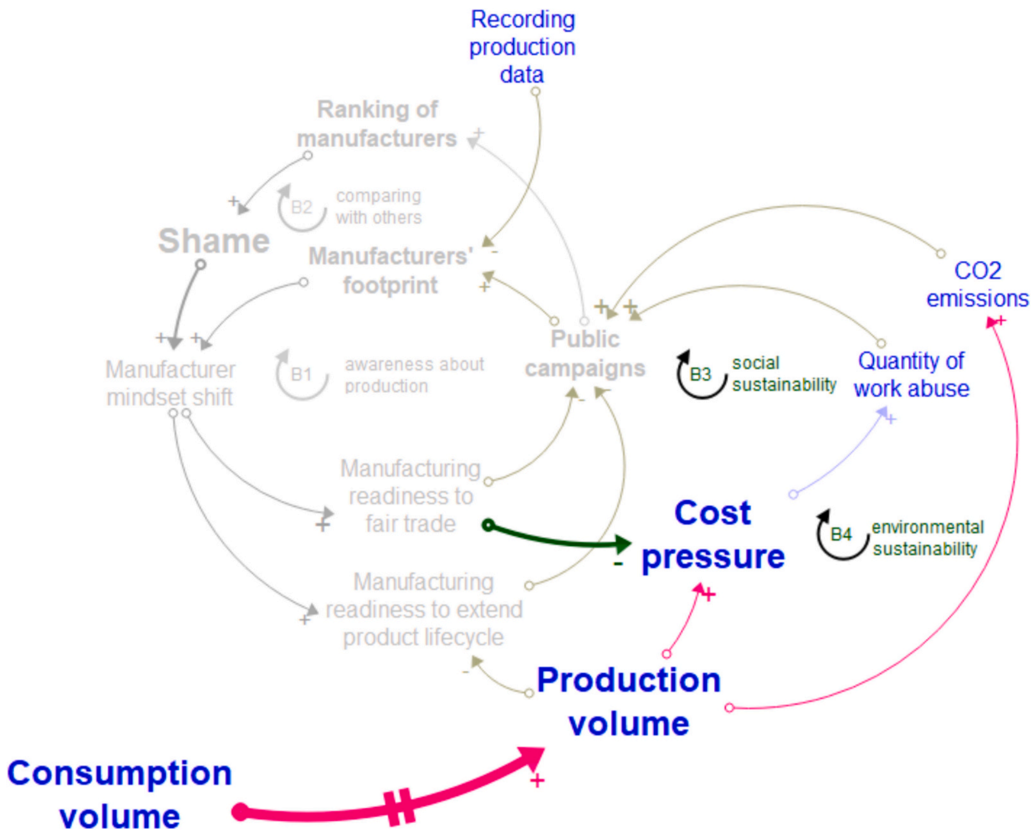

Fig. 4c. Nudging future manufacturing change.

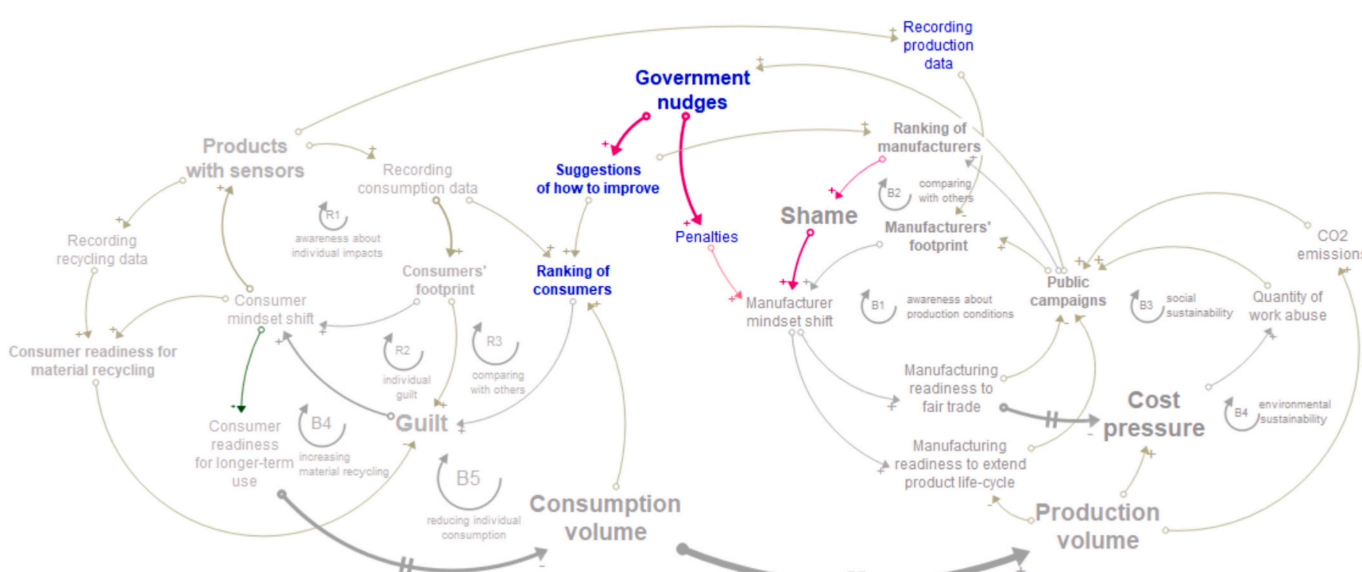

Fig. 5. Consumer mindset change drives the changes in future manufacturing.

(Burnett and Lunsford, 1994) and the effectiveness of guilt appeals in sustainable marketing (Amatulli et al., 2019). Our findings expand upon these ideas by demonstrating how data-driven guilt—arising from an awareness of individual footprints—can serve as an intervention to shape purchasing behaviours before decisions are made. Showing that individual footprints can alter consumer behaviour, supports previous research demonstrating that guilt arises when individuals perceive their actions as conflicting with moral or social norms (Tangney, 1991). Considering that consumers have prior environmental knowledge before purchasing-related decisions (Schwepker and Cornwell, 1991), our model extends their *locus of control* of an individual consumer. Early examples have already tried to compile company rankings based on sustainability metrics (Lyon and Shimshack, 2015), conversely highlighting firms persisting in unsustainable production practices. To the best of our knowledge, this is the first work that explores consumer guilt at the individual level and shame at the firm level to develop more sustainable consumption and production patterns.

Prior research has shown that consumers are more likely to engage in green behaviour when their actions are visible to others (White et al., 2019). This mechanism explains why public ranking of individual

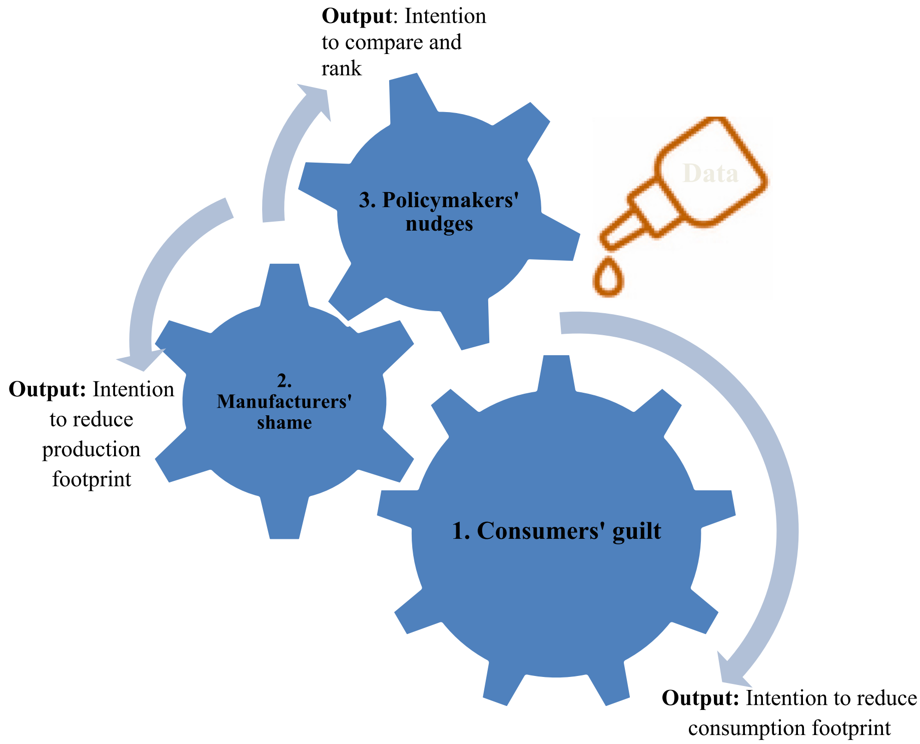

Fig. 6. Data enables the strategic shame model to function.

footprints may be particularly effective in motivating sustainable purchasing and prolonged product use. The social comparison theory (DiCosola III and Neff, 2022) argues that individuals adjust their behaviour when they realize their score is low in comparison with that of their peers. Our work suggests that opening consumers' environmental impact enhances the effectiveness nudging based only on guilt. Previous studies have also warned that excessive guilt may lead to psychological reactance, where individuals disengage or feel helpless (Arli et al., 2016). To counteract this, guilt nudging should be framed positively, emphasizing solutions such as repairing, recycling, or reusing instead of merely inducing guilt for unsustainable actions.

Proposition 1. Consumers' guilt drives downstream supply chain changes towards more responsible buying.

5.1.2. Manufacturers' shame based on public rankings

Contrary to some works that labeled shame as counterproductive due to antisocial behaviours (Arli et al., 2016), we found the place of shame in a regulatory practice. The study demonstrates how shame-based nudging can be a powerful mechanism for triggering sustainable production. Our findings add to the literature on shame as a regulatory practice and its impact on corporate social responsibility (CSR) disclosures (Lyon and Shimshack, 2015). We show that public sustainability rankings and media-driven shaming can influence manufacturers to improve their sustainability efforts (Damberg et al., 2022). However, shame-based nudging should be combined with communicating best practices of how others did to avoid short-term ‘greenwashing’ (Bero, 2020; Yu et al., 2020).

Proposition 2. Manufacturers' shame drives upstream supply chain changes towards more sustainable production.

5.1.3. Governmental nudging: interventions to support achieving SDG12

Prior research has emphasised that transparent supply chain data can influence consumer purchasing behaviour (Gonçalves and Silva, 2021), yet the effectiveness of product sustainability labels remains mixed (Borin et al., 2011; Coley et al., 2011). Complementary to traditional supply chain data sharing, such as reporting used for conventional products (i.e., apparel, food), a new generation of products will be embedded with sensors that generate and exchange data, thus drastically increasing the number of data points. These products will facilitate supply chain transparency due to interconnection from product development, production, usage, and end-of-life, i.e. following the entire lifecycle of Industry 4.0 products (Kagermann et al., 2013). The new regulations mandating the supply chain footprint disclosure in the annual reports can be further supported by economic incentives (e.g., tax breaks and co-funding initiatives) for sustainable practices. Exploring individual footprints will enhance coordination between consumers and producers and redirect demand away from cheaper, non-transparently produced alternatives (Tabi, 2013; Tortorella et al., 2017).

Proposition 3. Supply chain transparency amplifies the feelings of consumers' guilt and manufacturers' shame.

5.2. Managerial, policy, and ethical implications

Our findings aim to support civil movements that consciously reduce purchases and avoid overconsumption (e.g., ‘underconsumption-core’) (Conversation, 2023), circular manufacturing business models, and the alignment of consumption and production with SDG12. We argue for systemic support in calculating the individual footprints of consumers and manufacturers to assess personal responsibility for deviation from SDG12. As our paper suggests, policymakers can institutionalise organic behavioural shifts by structurally linking underconsumption values to supply chain accountability. Footprint metrics can be integrated into social media platforms (e.g., TikTok, Instagram). Adding ‘sustainability scores’ on fashion haul videos could contextualise personal choices within global supply chain impacts, transforming lifestyle trends into measurable SDG12 progress.

However, individual footprints can be interpreted differently depending on individual ethics. Mass production and consumption appeared relatively recently in human history, and hence, their impacts are not fully reflected in an “ethical codex” worldwide. Once compliance with SDG12 becomes one of the *core implicitly desired* societal values, and the individual footprint illustrates the adverse impact, consumers will prioritise sustainable alternatives over fast-consumption habits to offset the personal adverse impact on SDG12 attainment.

5.3. Limitations

First, strategic shame management requires supply chain actors to share data. Privacy concerns regarding consumption data present a barrier. Developing policies supporting supply chain transparency is a critical connection between the consumer and manufacturer components of the proposed model in guilt-nudging downstream and shame-nudging in upstream supply chains. Second, we assume consumers have prior environmental knowledge before engaging in purchasing-related decision-making (Schwepker and Cornwell, 1991). Based on consumer segmentation, individual strategies for sustainable consumption can be adjusted to reveal the differences between the consumer groups with distinct strategies for 'greening' lifestyles, which arguably would require different 'shaming mechanisms'. Future research should address cognitive biases and production-related data complexities to guide effective policy decisions and enhance sustainable practices. Marketing research can explore consumers' green segmentation details regarding their sustainability values in emerging generations. Finally, due to the complexities in production-related data and its interpretation, policymakers need further research to determine how to leverage this information to induce positive change.

6. Conclusions

As a key finding, this study presents a systematic framework that promotes structural changes in consumption and production in alignment with SDG12. We recommend that policymakers engage consumers in the loop for sustainable manufacturing and provide nudges based on individual footprints. Future work requires developing incentives for aligning with SDG12 and fostering more responsible purchasing and manufacturing decisions. Further, compiling public sustainability rankings will create reputational pressure on manufacturers and urge them to shift to greener production practices.

CRediT authorship contribution statement

Nikolai Kazantsev: Writing – original draft, Visualization, Software, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Ahmet Onur Agca:** Writing – original draft, Investigation, Formal analysis, Conceptualization. **Orsolya-Anna Mate:** Writing – original draft, Investigation. **Kamran Chatha:** Validation, Supervision. **Jan Godsell:** Validation, Supervision, Resources, Funding acquisition, Conceptualization.

Declaration of competing interest

No conflict of interest is noticed in this submission.

Acknowledgements

This work was supported by the UKRI Made Smarter Innovation Challenge and the Economic and Social Research Council via InterAct [Grant Reference ES/W007231/1]. The first author acknowledges the role of the Clare Hall College community, particularly Dr. Kevin Edwards, in organising the interdisciplinary research colloquium on the role of informed consumers in reshaping unethical practices in chocolate production. We also thank Dr. Kyle Alves, Dr. Valeria Ramirez, and Ms. Alice Mumford for the friendly review and comments that helped improve the manuscript's quality, as well as the two blind reviewers for several rounds of exciting revisions.

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