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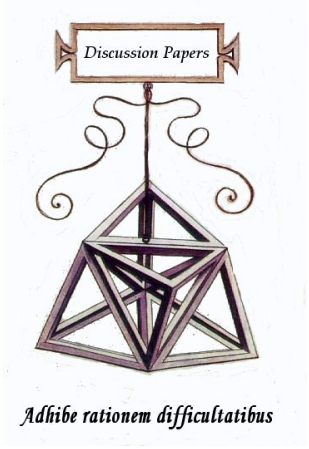

Matilde Banti, Tommaso Luzzati

Barriers to the Circular Transition: Insights from an Exploratory Study on Solid Cosmetics

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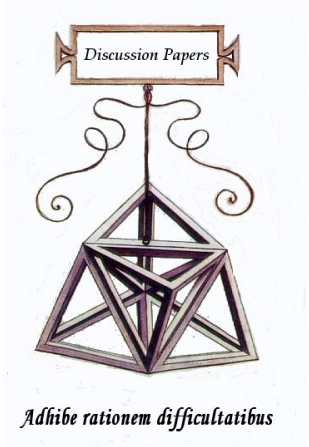

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The transition toward sustainability increasingly challenges the cosmetics industry to redesign its products and business models. Solid cosmetics - formulations without water and with minimal packaging - are positioned as eco-innovations that could reduce plastic waste and resource intensity. However, their market penetration remains limited. Existing research on the barriers to their diffusion is scarce and mainly focuses on consumer perspective. This paper first outlines the environmental benefits of solid cosmetics, then reviews the main barriers discussed in the literature. Given the near absence of studies addressing the business perspective, we conducted exploratory interviews to address this gap. Drawing on these interviews, we propose a preliminary interpretative framework to interpret the barriers hindering the diffusion of solid cosmetics and the systemic linkages shaping their market dynamics. The study offers implications for communication strategies and policy interventions supporting a transition toward more sustainable cosmetic practices.

Keywords: Barriers to diffusion; Sustainability transitions; Circular innovations; Plastic waste reduction; Material Efficiency

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Barriers to the Circular Transition: Insights from an Exploratory Study on Solid Cosmetics

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Abstract

The transition toward sustainability increasingly challenges the cosmetics industry to redesign its products and business models. Solid cosmetics - formulations without water and with minimal packaging - are positioned as eco-innovations that could reduce plastic waste and resource intensity. However, their market penetration remains limited. Existing research on the barriers to their diffusion is scarce and mainly focuses on consumer perspective. This paper first outlines the environmental benefits of solid cosmetics, then reviews the main barriers discussed in the literature. Given the near absence of studies addressing the business perspective, we conducted exploratory interviews to address this gap. Drawing on these interviews, we propose a preliminary interpretative framework to interpret the barriers hindering the diffusion of solid cosmetics and the systemic linkages shaping their market dynamics. The study offers implications for communication strategies and policy interventions supporting a transition toward more sustainable cosmetic practices.

Keywords: Barriers to diffusion; Sustainability transitions; Circular innovations; Plastic waste reduction; Material Efficiency.

Highlights:

1) Solid cosmetics offer ecological benefits but still face low market adoption.
2) Literature on solid cosmetics' diffusion focuses mostly on consumers.
3) Firms report barriers shaping solid cosmetics' market dynamics.
4) Interviews reveal systemic obstacles to wider use of solid cosmetics.
5) Communication and policy actions are needed to support greener cosmetics.

1 Introduction

The global cosmetics industry is undergoing continuous expansion, driven by innovation, marketing strategies, and an increasingly diverse consumer base (L'Oréal, 2024). This growth, however, is accompanied by a substantial environmental impact, including high levels of resource extraction, energy and water consumption, packaging waste, and greenhouse gas emissions (GHGs) from production and distribution processes. In response to these challenges, the concept of sustainable cosmetics has gained prominence. Sustainable cosmetics are developed with the dual objectives of safeguarding human health and preserving the planet's ecosystems (Davinson, 2023). They are formulated with safe, non-toxic ingredients while avoiding the overexploitation of natural resources. Moreover, producers commit to using environmentally responsible packaging, ensuring ethical labour conditions within manufacturing facilities, and maintaining transparency in their sustainability practices, thereby enabling consumers to make informed choices. As a holistic approach, sustainable cosmetics encompasses both environmental and social dimensions, which explains the lack of a single, universally accepted definition (Davinson, 2023).

Within the broader framework of sustainable cosmetics, the "Clean Beauty" movement has emerged, providing a structured perspective that aligns with the stages of a product's life cycle (Kalil et al., 2022). As Bom et al. (2019) explain, "Clean Beauty" is organized in five key phases, as every activity along the value chain must align with the concept of "clean". These five phases are: (i) **design and sourcing**, which focus on ethical selection of raw materials; (ii) **packaging**, involving the use of recycled materials and the minimisation of packaging-related impacts; (iii) **production**, aiming at reducing water and energy use during manufacturing; (iv) **distribution**, addressing fuel consumption and transport-related emissions; and (v) **consumer use**, which considers the water and energy footprint during product application. A further (vi) **post-consumer phase** can be added, addressing waste management and disposal practices (Bom et al., 2019; Feng, 2016). This life cycle perspective aligns with the Life Cycle Assessment

(LCA) methodology assessing environmental impacts across all stages of a product's life, from raw material extraction to end-of-life disposal.

A notable and increasingly popular category within sustainable cosmetics is solid (or waterless) cosmetics. These products are formulated and delivered in non-liquid physical forms - such as bars, sticks, tablets, or compressed powders - and contain little to no added water in their final formulation (Ogorzałek et al., 2024; Aguiar, 2022; Lukić & Krajišnik, 2024). When evaluated through the lens of the Life Cycle Assessment (LCA) methodology, solid cosmetics can be classified as sustainable, as they exhibit reduced environmental impacts across multiple life cycle stages (e.g. Aguiar et al.; 2022). The specific environmental advantages that make solid cosmetics more sustainable than their liquid counterparts will be analysed in detail throughout this article.

Despite their high potential for sustainability, solid cosmetics currently account only for a modest share of the global market. In 2024, the cosmetics industry was valued at approximately USD 290 billion (L'Oréal, 2024), whereas the solid or waterless cosmetics segment was estimated at USD 10.89 billion (Imarc Group, 2024), indicating limited penetration relative to the sector as a whole.

This situation raises a central question: why does their adoption remain limited? To answer it, a comprehensive understanding of both technological and socio-economic factors is needed. Yet, as a recent systematic review shows (Alviri et al., 2025), academic literature on sustainable cosmetics has expanded in recent years but remains dominated by hard science perspectives - such as chemistry and materials engineering - with comparatively few contributions from the social sciences. Studies explicitly focusing on solid cosmetics are even rarer. To the best of our knowledge, they include:

- Life cycle and sustainability assessment: Aguiar et al. (2022) provide a detailed LCA of waterless cosmetics, examining environmental impacts throughout the product life cycle.
- Market outlook: Webb (2021) analyses the commercial prospects and challenges of bringing solid cosmetics into the mainstream.
- Consumer expectations: Deguilhen et al. (2023) investigate consumer perceptions, highlighting usability and sensory experience as adoption drivers.

- Technological challenges: Lukić and Krajišnik (2024) review formulation and preservation issues specific to waterless formats, alongside possible technological solutions.
- Business models: Gatto (2022) examines sustainable cosmetics business models, including the development of solid formats.
- Cross-cultural perceptions: Rivera (2023) explores consumer attitudes towards solid shampoo in Europe and Mexico, focusing on cultural and behavioural determinants.

These studies suggest that, while technical and environmental aspects of solid cosmetics have been partially addressed, their market, cultural, and business dimensions remain underexplored. For this reason, the objective of the present article is threefold. First, it outlines the environmental potential of solid cosmetics. Second, it reviews the consumer-related barriers identified in the literature. Finally, it presents insights derived from interviews with four Italian managers in the cosmetic industry, offering perspectives that can inform further research, business practice, and policy considerations.

2 Background

2.1 The environmental impact of the cosmetics industry

The global cosmetics industry is experiencing sustained growth. In 2024, it recorded a 4.5% year-on-year increase (L'Oréal, 2024), and forecasts estimate a compound annual growth rate of 6.1% between 2024 and 2030 (Grand View Research, 2024). However, this rapid expansion places considerable pressure on the environment, raising urgent sustainability concerns across all stages of the product life cycle (Dube & Dube, 2023).

A primary area of concern is the industry's contribution to plastic pollution. Packaging alone accounts for approximately 70% of the total waste generated by the cosmetics sector (Borunda, 2019). In 2020, it was estimated that the industry produced around 120 billion units of packaging (British Beauty Council, 2020), much of which was neither recyclable nor biodegradable. For instance, according to the British Beauty

Council (2020) only 14% of plastic waste from beauty products is collected for recycling, and just 9% is effectively recycled. Consequently, the remaining waste often ends up in landfills or the oceans, exacerbating the global plastic pollution crisis. Moreover, the problem extends beyond packaging, as synthetic ingredients in formulations also contribute to microplastic contamination (Plastic Soup, 2022).

Water consumption represents another critical environmental burden. Water is the primary ingredient in most cosmetic formulations, accounting for between 60% to 95% of a product's content (Aguiar et al., 2022; Cosmetics Business, 2019). Because it is readily available and inexpensive compared to other ingredients, water has been used in the cosmetics industry as a product filler to increase product volume and profitability (Aguiar et al., 2022). The industry is regarded as one of the largest market contributors to both water use and wastewater generation (Clean Hub, 2024). In 2020, the cosmetics sector consumed approximately 10.4 million tonnes of water globally (Biceika, 2022), encompassing product manufacturing, sanitation processes, and consumer use.

The sector also plays a notable role in GHGs emissions. Quantis (2020) estimates that the cosmetics industry accounts for approximately 0.5% to 1.5% of global emissions, derived largely from consumer use (59%) and raw material sourcing (30%) (Foster & Retallack, 2023). Transportation and distribution further contribute to the industry's carbon footprint (around 5%) (Foster & Retallack, 2023), as conventional liquid formulations are significantly bulkier and heavier to transport than solid alternatives, requiring more energy and space for shipping.

Lastly, the widespread use of synthetic chemicals raises significant environmental and public health concerns. Among roughly 318,000 ingredients identified in beauty and personal care products, about one-third lack publicly available toxicological data. Moreover, approximately 45 chemicals categorized as *high hazard* remain in widespread use and are associated with chronic toxicity, environmental persistence, or bioaccumulation (The Guardian, 2024; ChemForeward, 2024). Less than 20% of the 12,000 industrial and synthetic chemicals commonly used in cosmetics are considered

safe (Dube & Dube, 2023; Bilal et al., 2020). Moreover, at least one-third of personal care products contain chemicals linked to cancer, while many others include hidden carcinogens (Girotto, 2013). Documented effects include allergic reactions, hormonal disruption, reproductive toxicity, and birth defects (Girotto, 2013; Halla et al., 2018). Notably, there is a proven correlation between the antimicrobial efficacy of preservatives and their toxicological risks (Halla et al., 2018).

2.2 Solid cosmetics: its contribution to reduce the environmental impact.

Solid cosmetics are waterless formulations, hence also called 'anhydrous' cosmetics. They include bars, sticks, powders, and tablets (compressed powders) (Lukić & Krajišnik, 2024), which are available for different types of products, as summarised in Table 1.

***Table 1**: Solid cosmetics, (adapted from Aguiar et al., 2022).*

Formula	Solid cosmetics
Solid bar	Face/body cream Bodywash Deodorant Shampoo Conditioner Sunscreen Intimate wash Shaving bar
Solid stick	Sunscreen Solid stick Body cream Deodorant Lipstick/lip balm Highlighter Perfume
Powder	Face/hair masks Dry shampoo/conditioner Body scrub Sunscreen Foundation/bronzing/blush powder
Tablet	Toothpaste Shampoo/shower tablet

Solid cosmetics have emerged as a promising alternative for reducing the environmental impact of the cosmetics sector. As highlighted by several studies (e.g., Aguiar 2022; Lukić & Krajišnik, 2024; Rivera, 2023; Sudati, 2021) there are multiple reasons why solid cosmetics are more sustainable than liquid ones. These include the following.

- **Reduction in water use.** Traditional cosmetic products can contain up to 95% water; solid cosmetics, by contrast, are anhydrous, meaning they do not require water as a solvent or base. This also influences ingredient selection: without water as a solvent,

many synthetic agents are unsuitable, prompting formulators to adopt natural, water-compatible alternatives such as plant-based hydrators, botanical extracts, and eco-friendly surfactants (Quinn, 2019; Garner, 2021). These not only maintain product efficacy but also enhance biodegradability and reduce environmental toxicity.

- **Reduction in plastic use**. The solid format allows for the use of biodegradable packaging materials such as cardboard and paperboard (Cosmetics Business, 2019). In this way, plastic waste would be avoided.
- **Reduction in consumption and waste**. Solid products are typically more concentrated in active ingredients than their liquid counterparts, containing fewer fillers and a higher proportion of functional components. This concentration enhances product efficacy, reduces the amount needed per use, and extends the product's lifespan, ultimately lowering consumption and waste (Garner, 2021).
- **Reduction in transport-related emissions**. Due to their higher density and solid state, these products occupy less volume and weigh less during transport. This leads to lower energy consumption in logistics, reduced fuel use, and decreased GHGs emissions throughout the supply chain (Aguiar, 2022).
- **Reduction in preservatives' use**. The absence of water makes microbial growth less of an issue, thereby reducing the need for chemical preservatives and allowing for milder, less irritating formulations (Sudati, 2021).

Collectively, these characteristics position solid cosmetics as a highly promising innovation within the broader sustainability agenda of the beauty industry. By minimizing water and plastic use, reducing waste, lowering transport-related emissions, and limiting the need for preservatives, solid formulations offer tangible environmental benefits across multiple life cycle stages. Nevertheless, despite their clear sustainability potential, market adoption remains limited, suggesting the presence of significant consumer, cultural, and business barriers that warrant further examination.

3 Barriers to the adoption of sustainable cosmetics

In addition to the environmental benefits, solid cosmetics may offer consumers several advantages, particularly in terms of portability. Their compact, lightweight format makes them ideal for travel, while their solid-state allows them to bypass liquid restrictions imposed by airline regulations. These features also facilitate handling and storage, enhancing their overall functional appeal (Cosmetics Business, 2019). However, these benefits are offset by significant barriers to adoption, as highlighted by the limited body of research examining the obstacles that hinder consumers' transitions towards more sustainable consumption. Understanding these barriers is crucial for identifying targeted strategies to foster adoption.

A widely used framework for understanding resistance to change is the Innovation Resistance Theory (IRT), originally proposed by Ram and Seth (1989) and later applied to the cosmetics sector by Sadiq (2021) and Szaban (2023). This perspective conceptualises sustainable personal care products as market innovations, and therefore interprets their adoption as a process that requires consumers to depart from their "status quo" - habitual preferences, established routines, and trusted brands. When a product necessitates behavioural adjustments, consumers may respond with resistance.

IRT distinguishes between two main categories of barriers: functional and psychological. The effects of these barriers are moderated by two variables - environmental concern and health concern – which can either amplify or mitigate their influence on purchase intentions. Functional barriers refer to tangible, practical obstacles that lead consumers to believe a product may not meet their need or expectations. Psychological barriers, on the other hand, encompass attitudinal, cultural, and knowledge-based factors that shape consumers' willingness to adopt sustainable products.

Within each of these categories, three subtypes are distinguished. The functional barriers are classified into usage, values, and risk barriers.

- **Usage.** The usage barrier arises when adoption is perceived as effort-intensive or disruptive to habitual behaviour. In the context of sustainable cosmetics, this may

involve limited product availability, reliance on specialised retail channels or online platforms, difficulties in accessing reliable sustainability information, and inconveniences related to packaging durability or usability.

- Value. The value barrier emerges when consumers perceive sustainable cosmetics as offering lower performance or benefits compared to conventional alternatives, especially when they priced higher, deliver less consistent quality, or fail to produce immediate, perceivable results.
- Risk. The risk barrier refers to consumers' uncertainty regarding product performance, safety, or authenticity. This uncertainty is often exacerbated by limited understanding of eco-labels and the prevalence of greenwashing, both of which erodes trust in sustainable cosmetics.

The psychological barriers are classified into tradition, image, and knowledge.

- Tradition. The tradition barrier stems from consumers' attachment to established routines and their reluctance to change familiar practices. In the cosmetics context, this may manifest as loyalty to specific brands, comfort with conventional product formats, or scepticism about the tangible impact of individual sustainable choices.
- Image. The image barrier reflects negative perceptions of sustainable cosmetics, often due to insufficient marketing communication, lack of performance proof, or unclear justification for higher prices. Poor communication can reinforce the belief that sustainable products are less effective or merely luxury items.
- Knowledge. The knowledge barrier, recently identified by Szaban (2023), refers to consumers' limited understanding of the environmental benefits of sustainable cosmetics, their difficulty in recognising genuinely green products, and their limited ability to interpret eco-friendly formulations or certification labels. This barrier may affect even regular purchasers, who may remain uncertain about ingredient lists or the true meaning of sustainability claims, thereby constraining informed decision-making.

Overall, resistance to the adoption of sustainable cosmetics is multi-layered, shaped by both tangible product-related factors and deeper perceptual or attitudinal dynamics. The persistence of certain barriers even among experienced users, indicates that adoption is not a one-off decision but an ongoing negotiation between consumer expectations, product performance, and perceived benefits. Although these insights derive from the broader sustainable cosmetics literature, they are highly relevant for

understanding the transition to solid cosmetics, where similar functional and psychological challenges are at play.

4 Some insights from business perspective

This section examines the extent to which solid cosmetics may be economically attractive for firms, which could potentially benefit from lower costs in packaging, storage, transportation, and distribution (Garner, 2021). To this purpose, we planned a series of open-ended interviews with firms operating in the sector. This section presents the first set of interviews conducted with four managers currently or formerly employed in cosmetics companies that differ in size, strategic orientation, and market positioning. The involved companies were as follows:

- Procter & Gamble (P&G), a major multinational company and one of the global leaders in the cosmetics industry.
- Iteritalia, a small company offering affordable solid cosmetics with a focus on reinterpreting the traditional soap bar as a high-quality, herbal-based product.
- Ethical Grace, a micro-enterprise positioned in the mid- to high-end market, whose identity is rooted in strong ethical values and artisanal production.
- Tea Natura, a small benefit corporation producing both solid and liquid cosmetics, allowing for direct comparison between these two formats.

The goal of the interviews was to explore businesses' perspectives on two key issues: why the adoption of solid cosmetics remains limited despite their potential, and whether solid cosmetics represent a viable business opportunity for firms. Data were collected using a semi-structured interview protocol, which ensured consistency across interviews while allowing flexibility to explore emerging topics (Gioia et al., 2013). The analysis of the interviews followed a qualitative research approach. Each interview was first analysed individually to identify recurring ideas and relevant insights. These were then coded using keywords, which were then grouped into broader thematic categories to facilitate data organisation and interpretation (Gioia et al., 2021). These categories formed the basis for a cross-case analysis (Eisenhardt, 1989; Linneberg & Korsgaard,

2019), which enabled the comparison of the experiences of the four companies, highlighting both common patterns and distinct approaches. This analytical process led to the development of an interpretive model built around four key forces that shape the dynamics of the solid cosmetics market. However, while the research process allows for the construction of abstract and conceptually grounded explanations, the findings remain based on a limited number of cases and should therefore be viewed as exploratory.

4.1 Results discussion

The outcome of the interviews is organised around the concept of **consumer's perceived value**, which reflects the subjective trade-off between expected benefits – both tangible and symbolic - and the price to be paid. The findings suggest that the perceived value in the market of solid cosmetics is shaped by four key forces, namely, environmental benefits, price, habits and functional/sensorial performance, and communication effort by firms. This section delves into each of these forces, while Figure 1 provides a visual summary of the results.

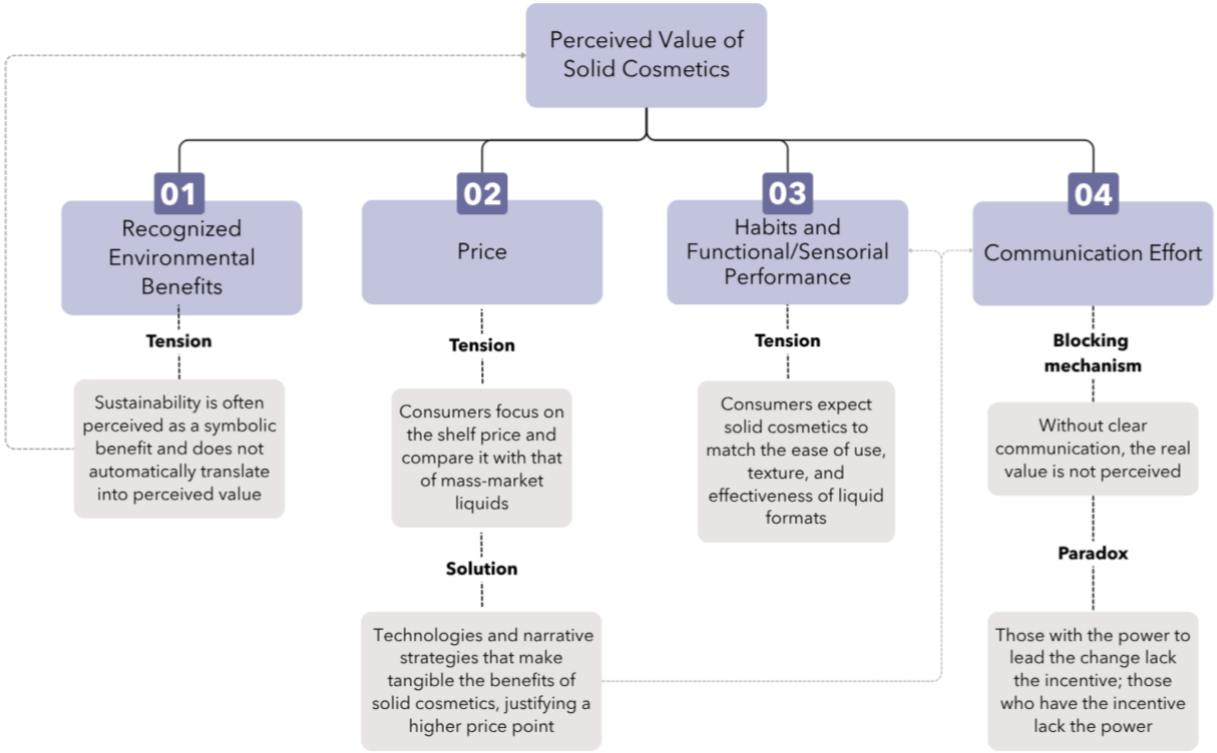

Figure 1: Interpretive model of sector dynamics: four forces of solid cosmetics.

4.1.1 Recognized Environmental Benefits

All the interviewed managers agreed that solid cosmetics offer clear advantages. Improved portability was considered as an undeniable functional benefit, although it is linked to specific usage contexts and therefore appeals only to a limited segment of consumers. The interviewed managers recognised that solid formats also provide significant environmental benefits but noted that these advantages are not fully perceived by consumers and remain largely symbolic. Moreover, in their view, most consumers are unwilling to pay a premium for sustainability. Overall, these considerations identify a first tension: sustainability alone does not trigger purchasing behaviour - it must be translated into tangible values to persuade the average consumer to shift toward solid formats.

4.1.2 Consumer Price (and Business Costs)

Price is a very tangible issue that plays a crucial role in shaping consumers' perceived value: while it can serve as a signal of quality, it also represents a financial sacrifice. A major obstacle lies in the difficulty of comparing the prices of liquid and solid cosmetics, as a single piece of solid product has a longer lifespan - more precisely, it provides more uses than liquid alternatives. Consumers receive little guidance from price tags, which typically omit information about the number of uses or the price per use. Consequently, as all interviewees emphasised, consumers tend to overlook potential savings over time and instead focus on the immediate, visible price. This becomes particularly problematic in mass markets, where price is a major driver of purchasing decisions. According to the former manager at the multinational company, one major challenge in lowering the prices of solid formats is that they are typically produced in limited quantities, preventing producers from exploiting economies of scale – unlike liquid cosmetics. Moreover, transitioning to solid cosmetics requires not only new technologies, specialised skills, and significant investment, but also involves the disruption of a well-established, liquid-based industrial system in order to achieve

scale efficiencies and recover the costs of the transition investments. For these reasons, achieving price competitiveness remains a considerable challenge.

For small businesses, the interviewed managers noted that the cost of producing solid cosmetics is roughly equivalent to that of liquid products, as higher ingredient costs are offset by cheaper packaging. Nonetheless, unit costs remain high compared to liquid industry standards due to limited scale and artisanal manufacturing processes. Whether solid or liquid, their products tend to be priced higher because they embody craftsmanship, high-quality ingredients, and a commitment to sustainability, while not benefitting from economies of scale. At the same time, as mentioned above, consumers often compare these products with mass-market alternatives, leading to a perceived lack of affordability. Consequently, a key challenge for small companies is to communicate that their pricing reflects a different economic and ethical rationale.

Overall, interviewees acknowledged the growth potential of solid cosmetics but emphasised that their low demand makes scalability difficult, thereby limiting the ability to reduce unit costs. A possible solution for small producers could be network cooperation, which would enable cost reduction through shared resources and access to joint services. Moreover, such networks can facilitate direct-to-consumer sales, allowing small businesses to avoid intermediaries, retain higher margins, and strengthen consumer relationships based on geographic proximity, transparency, and appreciation of artisanal craftsmanship. However, the managers reported that the industry in Italy currently shows limited openness to cooperation. In addition, without mass production, the logistical savings associated with compact formats remain modest. When asked about the possibility of reducing margins to lower prices, managers responded positively, noting that margins in the cosmetic industry are very high. Nonetheless, some argued that such a strategy could devalue the entire sector, as it risks undermining the perceived value of cosmetic products.

4.1.3 Consumer Habits and Functional/Sensory Performance

Another significant barrier to the adoption of solid cosmetics, as acknowledged by the interviewees, lies in consumer habits. The solid format requires changes in both usage and storage routines, challenging long-established consumer habits. However, there was a noticeable divergence in the interviewees' perspectives regarding the product's functional and sensory performance. The interviewed multinational manager argued that, at present, the technologies needed to deliver a solid product with performance and user experience comparable to liquid formats are not yet available. In contrast, small businesses claimed that their solid products provide sensory qualities and results that are equal to - or even superior to – those of liquid alternatives, particularly given their higher concentration in active ingredients. This suggests that the technology needed to overcome the ecological compromise" mindset is demonstrated by the experiences of small businesses, that, through artisanal methods, produce effective and high-quality solid products. However, this may not hold true for standardized industrial processes. If the technology is available, the remaining challenge lies in the narrative - that is developing a communication strategy that clearly and credibly conveys the value of solid cosmetics to consumers.

4.1.4 Communication Effort

Communication plays a pivotal role in shaping consumers' desire and in bridging the gap between real and perceived value. Managers from the small businesses identified two main obstacles: limited media exposure to explain product value and reputational damage from the spread of low-quality industrial solids and from cases of greenwashing. Building trust requires considerable communication efforts, which in turn entail financial resources that are often beyond the reach of small firms. The manager from the multinational company recognized the importance of communication but believed that firms have little interest in driving the necessary cultural shift. This reveals a blocking mechanism: without effective communication, the real value of solid

products remains invisible; yet effective communication requires not only strategic vision but also investment.

In conclusion, the solid cosmetics market appears to be trapped in a stagnant equilibrium. Demand has slowed and remains confined to a niche segment of committed consumers who are willing to pay a premium for sustainability. Small firms lack the systemic power to transform the market, while large corporations - with the necessary resources - show limited commitment, perhaps to avoid cannibalizing the more profitable liquid product lines. The stagnant dynamic can be explained by a paradox: those with the power to drive change lack the motivation, while those with motivation lack the power to influence the system.

5 Conclusion, limitations, and directions for future research

The general aim of this paper was to contribute to the discussion on solid cosmetics, a topic on which social science academic literature is very limited. After examining their environmental potential, the paper highlighted the consumer-related barriers reported in the literature, while research exploring the business perspective is virtually absent. To address this gap, we drew on the insights of four managers to develop a conceptual model framing the barriers to the adoption of solid cosmetics. This analysis provides a rather broad view of the dynamics currently shaping the solid cosmetics market. As all the interviewees acknowledged, solid cosmetics can significantly reduce the environmental impact of the industry. However, their widespread adoption continues to be hindered by a range of structural barriers, unresolved tensions, and blocking mechanisms.

Our proposed interpretive model highlights the tension between sustainability objectives and market logic, which has resulted in a stagnant equilibrium within the sector. After an initial period of curiosity, demand has gradually cooled, stabilising within a narrow segment of motivated consumers willing to pay a premium for environmentally friendly products. Small businesses, though driven by strong value commitments, lack the capacity to shift market dynamics on their own. Multinational

companies, which possess the resources to mainstream solid formats, appear constrained by strategic caution - likely due to concerns about cannibalizing their highly profitable liquid product lines. This creates a paradox that explains the sector's current stagnation: those with the power to instigate change lack the motivation, while those motivated to drive change lack the influence to transform the system. This paradox is particularly striking given one of our preliminary insights reveal – that the more sustainable solid cosmetics can offer comparable, or even superior, performance to the liquid alternatives. Moreover, it suggests that the business logic alone is not able to overcome this lock-in and that targeted policy interventions are requires. For instance, governments could discourage or restrict the use plastic packaging for cosmetics.

It is important to emphasise that our field analysis is limited to four company cases. We consider these cases relevant, as they present a coherent and largely uniform picture, with only minor differences among them – an observation that aligns with the limited literature on the subject. Nevertheless, we acknowledge that the sample is not exhaustive, and the interviews should be viewed primarily as a first interpretive framework rather than a set of generalisable conclusions. To validate its broader applicability, further research is needed, ideally involving a larger and more diverse sample of companies. Moreover, this study focuses on the perspective of businesses, aiming to understand their strategies, perceptions, and challenges in promoting sustainable solutions. A promising direction for future research would be to explore the consumer perspective, to complement the business viewpoint and examine more deeply the mechanisms of choice and resistance to adopting solid cosmetics. Combining these two perspectives would offer a more comprehensive understanding of the dynamics driving the evolution of this segment and contribute to the design of more effective transition strategies.

Authorship contribution statement

This manuscript is the result of an intense collaboration between the authors, who jointly discussed in detail all the analyses presented here. Nonetheless, sections 1, 2, and 4 can be attributed to Banti; sections 3, and 5 to Luzzati.

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