Twin Transition in the European cosmetics industry: an investigation of the current level of implementation

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Abstract: This paper presents the research developed within the ACTT4Cosmetics European project framework, aiming to carry out advancements in industrial engineering with a focus on elevating production management practices and integrating new operational technologies. The focus is on leveraging the Twin Transition concept to foster sustainability in the cosmetics industry. This initiative marks a significant shift towards sustainable practices as manufacturers adopt innovative strategies to meet environmental goals. Through the Twin Transition, which emphasizes digitalization together with sustainability, European cosmetic manufacturers are now utilizing advanced technologies to refine production processes and reduce their environmental impact. This approach not only facilitates real-time monitoring of resources and waste management but also promotes eco-friendlier operations. Furthermore, the Twin Transition encourages stakeholder collaboration and knowledge exchange, paving the way for best practices and joint ventures that aim at shared sustainability objectives. The research is based on the collaboration with cosmetic industry associations and clusters at European level and present the result of a survey distributed to European companies of the cosmetic sectors. It investigates necessities, barriers, and drivers of European cosmetics enterprises with respect to the Twin Transition topic, as well as their current level of awareness and readiness to the transition. The research results are useful to shape the future of the cosmetic with respect to twin transition and net zero European goals.

Keywords: Cosmetic Industry, Twin Transition, Sustainability, Digitalization

1. Introduction

The synergetic occurrence of Green Transition (GT) and Digital Transition (DT) is currently re-shaping the European industrial sector. For this reason, the joint exploitation of the two trends is called Twin Transition (TT) (Montresor and Vezzani 2022; Ortega-Gras et al. 2021).

TT is conceived as the leveraging of digital technologies and tools to improve the environmental sustainability of products and manufacturing processes (Rehman et al. 2023). Industry 4.0 technologies can have beneficial impacts in terms of energy consumption and management, materials consumption, waste minimization and circularity fostering (Perossa et al. 2023b). Nonetheless, it is acknowledged how companies often meet relevant hurdles and difficulties when implementing TT, moreover in the case of small and medium enterprises (SMEs) (Horváth and Szabó 2019; Stentoft et al. 2019). This difficulty is due to the lack of human resources, economic capital, and technical know-how that SMEs typically suffer compared to large enterprises (LEs).

Such barriers prevent companies from fully exploiting the TT implementation benefits, creating a gap between the technological state of the art and what is actually implemented. In the European cosmetics industry (CI) SMEs are the backbone of the industry, moreover for what concerns the manufacturing phase (Cosmetics Europe, 2022). It is crucial offering SMEs external support to performing TT, to ensure their long-term competitiveness (Rocca et al. 2021; Schumacher et al. 2019; Perossa et al. 2023b). To this consideration, it is important to add that CI has significant economic and social relevance in the European economy. According to Cosmetics Europe, the CI brings at least €29 billion of added value annually to the European economy. It employed in 2022 254.259 people directly and 2.778.674 people indirectly (Cosmetics Europe, 2022). Furthermore, the sector has been presenting clear signals of a growing relevance of sustainability aspects related to industrial activities, even more than in other industries, due mainly to a higher sensitiveness of the consumers (Acerbi et al. 2023; Bom et al. 2019; Rocca et al. 2022). Other signals involve the rise of the organic and natural products sub-market, which was valued US$ 24,2 billion worth in 2022, with projections soaring to US$52.2 billion by 2030 (Researchandmarkets.com, 2023). Additionally, the global biodegradable cosmetic packaging sector is expected to increase, with estimates surpassing US$10 billion by 2029 (Data Bridge Market Research, 2022). Concerning ingredients, natural alternatives are progressively substituting chemical-based ingredients. A noteworthy instance is the substitution of the commonly used anti-aging ingredient, Retinol, with the natural-based Bakuchiol, with an anticipated Compound Annual Growth of 6,5% between 2021 and 2028 (Data Intelo, 2022). Furthermore, the global essential oil market, valued at US$ 9,02 billion worth in 2020, is expected to demonstrate a CAGR of 9,57% between 2021 and 2028 (PXR, 2022). The main environmental sustainability targets identifiable in the Literature as characterising CI according to (Rocca et al., 2022) are: (i) preserving biodiversity, (ii) reduction of Green House Gases emissions, (iii) reduction of waste, (iv) reduction of water consumption, and (v) reduction of plastics consumption.

ACTT4Cosmetics project, co-funded by the European Commission under the HORIZON-2022-EIE programme, aims at fostering diffusion of TT in the European cosmetics value chain. In the context of this project, a survey to investigate the current state of the art of the level of implementation of TT solutions, as well as companies awareness about the topic, has been conducted. It aimed to assessing the current situation of European CI, in order also to understand what are the main weaknesses of CI in implementing TT, and thus what kind of support may be needed.

To fulfil this research objective, the following research question, at the base the survey conducted in the project, was defined: what is the current state of the art of the practical implementation of TT of European cosmetics companies?

The reminder of the paper is organized as follows: in section two the adopted methodology is described in detail. In section three main results are described, while in section four they are discussed. Finally, in section five main conclusions are drawn.

2. Methodology

A specific questionnaire has been developed. It aimed at covering all the relevant points to be investigated without being too long. It counted for six generic introductory questions, investigating mainly company size and covered value chain stage. Further 10 questions, specific for the TT interventions performed by the answerer, were prepared, relating mainly to: (i) Familiarity with concepts of TT, GT, and DT; (ii) Level of engagement with TT activities; (iii) Typology of specific interventions eventually performed to implement TT.

It was followed the research protocol proposed by (Glasow, 2005), divided in five steps. As a first step of the protocol, it was defined the objective of investigating the current level of implementation of the TT in the European CI. Following the protocol second step about survey design, as a medium was selected online, moreover e-mails and LinkedIn, to reach a larger number of companies. As a timeframe were chosen three months, to be compliant with ACTT4Cosmetics deadlines. Regarding the sample, a non-probabilistic sample was chosen, as the probability of choosing a specific member could not be calculated, as the entire number of European cosmetics companies is not known. As a language, it was chosen to translate the survey into the languages spoken in the countries where it was distributed (i.e., French, Italian, Portuguese, Romanian, Polish, and Ukrainian). Moving to the third protocol step, about the survey-instrument development, it was chosen to prefer split the questionnaire into generic questions, about companies and respondents information, and specific questions, about TT interventions. Multiple-choice questions were preferred, to decrease the effort to be undertaken by the respondents. For the fourth protocol step, concerning the survey execution, the validation was conducted by showing the questionnaire to the quality manager of an Italian cosmetics producer. She confirmed the relevance of the questions and suggested some minor adjustments. As a fifth and last step of the protocol, a quantitative data analysis has been conducted, whose main results are shown in the next paragraphs.

After the distribution of the survey, phone calls were used to remind companies to reply the survey sent via e-mail. Finally, also in a webinar opened to CI actors held in March 2024 in the context of ACTT4Cosmetics, it was suggested the participants to answer the survey, sharing with them the link to it. A total of 26 replies was collected. Of course, this is not a number of companies comparable to the entirety of the European cosmetics enterprises. Nonetheless, it is sufficient to be considered as a useful statistical sample to understand the current state of European CI. In many cases the answering companies stated to be covering more stages of the value chain.

The questionnaire presented questions adopting a Likert scale (from 1, "I am very much familiar" or "strongly agree" to 5 "I am not familiar at all" or "strongly disagree"), a "yes" or "no" question related to the TT projects actively pursued in the last year, and a question related to the level of automation of the production process presenting three options: (i) fully automated, (ii) partially automated, and (iii) not automated at all. Two further questions aimed at investigating the most implemented GT strategies and the most implemented DT strategies. For each of them, a series of possible answers to choose from was provided. This meant to select a bunch of possible strategies to be included among the answers, trying to be as comprehensive as possible. The selected possible answers were as follows for the GT:

- Sustainable sourcing of raw materials: practices of sustainable procurement are particularly relevant for CI (Bom et al. 2019). The concerned aspects include: (i) sustainable agriculture, (ii) raw materials extraction and related impacts, (iii) impacts on human health and environment of used chemicals, (iv) responsible and ethical sourcing, (v) fair trade, and (vi) economic development, also for the territories where ingredients are sourced (Bom et al. 2019). Digital technologies can be used for supporting sustainable procurement in the CI. As an example, traceability technologies can certify the source of the materials (Santacruz et al. 2022).
- Energy efficient production processes: energy efficiency is one of the most important and discussed aspects of industrial environmental sustainability, and is often associated with reduction in operational costs (Johansson and Thollander 2018)(Cagno et al. 2013). CI is no

exception, as it involves manufacturing processes that are particularly energy intensive, such as turboemulsion (Bom et al. 2019; Su et al. 2014). Digital technologies can offer important contributions to energy efficiency improvements in manufacturing processes (Perossa et al., 2023a)(Vijayaraghavan and Dornfeld 2010)(Salonitis and Ball 2013)(Leiden et al. 2021).

- Eco-friendly packaging: In CI the packaging is crucial for what concerns environmental sustainability performance. Indeed, typically, emphasis is put on issues related to cosmetics packaging. Among the materials composing packaging of cosmetics products, plastics have traditionally been widely used. Crucial features include usage of alternative materials (Rocca et al. 2022) and emissions and water usage minimization during packaging production (Bom et al. 2019, 2020).

- Waste reduction and recycling initiatives: moreover for packaging, recyclability and waste management actions, both product- and process-related, play a key role (Kaestner et al. 2023). That is why this kind of solutions are given a particular relevance in the questionnaire. Indeed, recycling, reuse, and reduction of cosmetics packaging waste are solutions widely accepted as key for making the industry more sustainable (Jordan Gatt and Refalo 2021)(Cosmetics Europe, 2023).

- Waste-water reduction: CI is typically water-intensive. For hygienic reasons, manufacturing equipment needs to be washed often. This produces big amounts of wastewater, polluted with chemical substances, that needs to be treated and possibly reused or reduced (Abidemi et al. 2018; Guerra-Rodríguez et al. 2020).

For the DT strategies, the selected possible answers were the following:

- Production process simulation: simulation is a powerful tool for identifying and analyzing optimal scenarios and process configurations, minimizing energy consumption (Roemer 2016) and maximizing eco-efficiency (Sproedt et al. 2015).

- Predictive maintenance using data analytics: benefits of predictive maintenance using big data and data analytics tools have been widely discussed, in terms of optimization of productivity and maintenance-related costs minimization (Zonta et al. 2020). Nonetheless, optimized maintenance processes and procedures have as indirect benefits the reduction of energy leakages that is often connected to malfunctioning.

- IoT integration for real-time monitoring: optimization of processes and of their scheduling in order to monitor and minimize energy consumption, water consumption, or materials consumption, can be enabled by the usage of IoT (Shrouf and Miragliotta 2015; Jadhav et al. 2018; Beier et al. 2018).

- Traceability technologies: Distributed ledger technologies, data spaces, and blockchain offer the possibility of monitoring along the supply chain the ordered materials, proving in this way their sustainable procurement. Specific studies related to CI have been conducted on this topic (Santacruz et al. 2022).

- 3D printing for prototyping and parts: in CI, additive manufacturing can be used for the production of goods composed of biomaterials (de León et al. 2023).

- Robotics in assembly and packaging: CI presents vast opportunities for processes automation, in phases of assembly (e.g., of mascara products), filling, and packaging (Hajghasem and Reza 2022). This presents opportunities for robotics implementation as well. A further possibility is related to customization of packaging, as proved by KIKOiD.

3 Results

The respondents to the survey were asked their role in the company as well. Nonetheless, only in 16 cases out of 26 an answer was provided. Answers included three quality managers, general managers, CEO, or president of the board of directors, four managers of the marketing department, one technical manager, one CFO, and one corporate development manager. In terms of size of the company, the sample presented: (i) Five micro enterprises (1-10 employees); (ii) Twelve small enterprises (11-50 employees); (iii) Six medium enterprises (51-500 employees); (iv) Three large enterprises (more than 500 employees). This result is representative of the context of the European CI, where most of the companies are SMEs (about 8500 cosmetics SMEs operating in Europe (Cosmetics Europe, 2023)), with few big enterprises representing moreover the final stages of the value chain, (Rossi and Hoffman 2007). In terms of covered value chain stages, the following distribution was met: (i) Raw materials supplier: 2; (ii) Machinery production: 3; (iii) Primary packaging production: 7; (iv) Final product manufacturing: 11; (v) Testing: 3; (vi) Packaging and/or Packaging design: 9; (vii) Services: 10; (viii) Distribution: 2; (ix) Other: 3. The resulting sample was representative of the entire value chain. The discrepancy between the total number of answering companies (26) and the sum of the answers listed above (50) is due to the fact that several companies covered more stages of the value chain. In the first question, companies were asked their degree of familiarity with the concepts of DT, GT, and TT. Most of them showed to have at least a certain degree of familiarity, as can be seen in Figure 1.

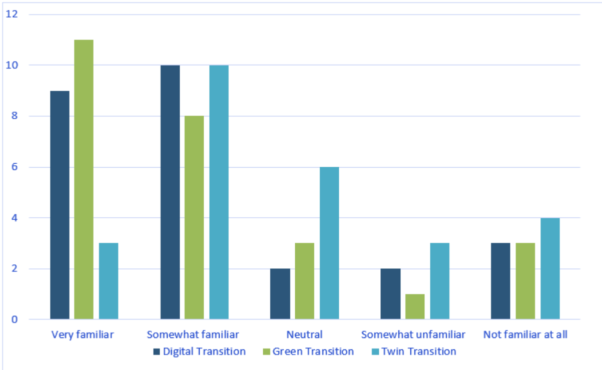

Fig. 1 - Distribution in the sample of the degree of familiarity with DT, GT, and TT

On the one hand, this is a confirmation of the relevance of these macro-trends in the CI. On the other hand, it is important to keep in mind while reading the results that in survey, answerers tend to be biased in selecting an answer that would provide a better image of themselves, even when (like in this case) they are ensured that the results will be disseminated in an anonymous and aggregated manner. This phenomenon is typically called Social Desirability Bias (Nederhof 1985). The overall picture seems suggesting that CI is indeed sensitive to these trends, which is not surprising considering its traditional attitude towards innovation (Cosmetica Italia, 2019). Nonetheless, from this sample, it appears that the idea of leveraging digitalization to improve environmental sustainability is less spread in the industry compared to GT alone and DT alone.

When asked if they had performed a TT intervention in the last 12 months, six companies (i.e., about 23% of the sample) answered affirmatively. On the one hand, it is clear that the stated amount of performed interventions in the last 12 months only is not insignificant (about 23% if we consider all companies that answered yes, about 11,5% if we only consider those that provided an intervention description consistent with the concept of TT). On the other hand, it is also clear that the vast majority of companies did not perform significant TT interventions along a quite long amount of time. This does not necessarily means that they are not engaged in TT, but it surely means that they are not involved in a continuative path of improvement. Furthermore, it appears that the likelihood that a company has performed a TT intervention in the last 12 months increases as its size increases too. Most notably, no Micro-enterprise has undergone a single intervention in the last year, as can be seen in Figure 2.

This is a confirmation of the fact that SMEs meet averagely higher barriers than LEs, for the motivations already presented in the introduction paragraph.

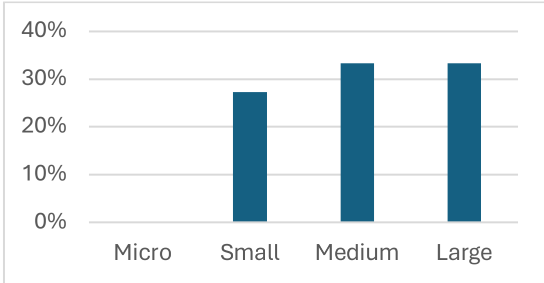

Fig. 2 - Percentage of companies in the sample that performed TT interventions in the last year arranged by size

Awareness of the importance of TT for CI was confirmed by the answers of the sample about the agreement of the respondents with the sentence "TT is an opportunity for innovation and industrial efficiency". Answers were distributed as follows: (i) Strongly agree: 7 companies; (ii) Agree: 12 companies; (iii) Neutral: 6 companies; (iv) Disagree: 0 companies; (v) Strongly disagree: 0 companies.

Considering most implemented strategies to improve environmental sustainability, results can be seen in Figure 3.

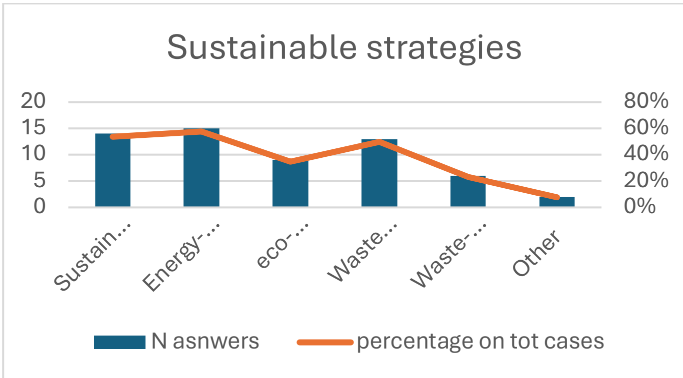

Fig. 3 - Distribution of answers related to sustainability strategies performed by the sample

Energy efficiency, sustainable raw materials sourcing, and waste management emerged as the most pursued strategies. Eco-friendly packaging was selected by nine companies (35%) of the answers. Nonetheless, calculating the percentage over the number of companies that sated to being involved in packaging production and/or design (10), it emerges that 90% of packaging companies in the sample are pursuing strategies to make their products more eco-friendly.

Answers related to the most implemented strategies for digitalization can be seen in Figure 4.

Internet of Things (IoT) and predictive maintenance resulted as the most utilised technologies.

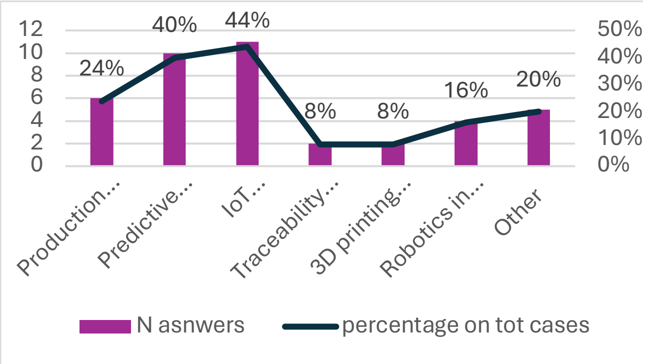

Fig. 4 - Frequency of strategies adopted for environmental sustainability commitment in the sample

Concerning the level of automation of the production process, it emerged that most of the interviewed companies have implemented it at least at a certain degree. The results presented (i) fully automated process for 16% of companies, (ii) partially automated process for 76% of companies, and (iii) no automation at all for 8% of companies.

4 Discussion

From the survey, did not emerge, on the contrary of what could have been expected, a particularly strong trend related to the size of the companies. Micro- and small. enterprises appear, from the obtained results, as interested and aware about TT as Medium- and Large ones. It is possible to infer that this is a consequence of the traditional attitude of the sector towards innovation, characterizing SMEs as well (Cosmetica Italia, 2019).

Some trends emerged nonetheless. Considering the stage of the value chain covered by companies, it emerged that companies operating in the distribution phase of the value chain have a lack of confidence with the GT concept. This is surprising, as distribution and shipping is typically considered as a sector strategic for the net zero transition (e.g., (McKinsey, 2024)). Nonetheless, the low number of companies present in the sample and belonging to that stage of the cosmetics value chain (only two) does not allow to generalize on this finding.

It also emerged that traceability technologies are scarcely implemented. This kind of technology may play a key role in witnessing the sustainability of sourced materials, and in the question related to most considered sustainability strategy, raw materials sustainability had emerged as relevant to sampled companies. From this can be inferred that enterprises may be averagely unaware about this chance or unable of implementing it.

Another surprising result was related to the implementation of interventions related to water management. Indeed, wastewater generation and water consumption is one of the most environmentally impacting aspects of the CI (Aguiar et al. 2022). Nonetheless, from the survey, it emerged as scarcely considered in the environmental sustainability improvement actions typically undertaken by companies, as can be seen in Figure 3.

Concerning the implemented strategies for DT, it was possible to notice that small enterprises are those that appear as focusing almost exclusively on IoT solutions (7 times) and Predictive maintenance (6 times), while micro-, medium-, and LEs appeared as focusing in a more variegated way on all the technologies. A likely cause may be that IoT and Predictive maintenance are more well-known solutions compared to the others, as well as their benefits are, and small enterprises are thus more driven towards their implementation.

Considering the level of automation of the production process, unsurprisingly, the companies not automated at all were exclusively micro- (two out six respondents) and small enterprises (one out of eleven respondents). Likewise unsurprisingly, LEs presented the highest rate of full automation (33%), even though by there being only 3 LEs in the sample, this information cannot be generalized. Notably, all medium companies (out of six) had only a partial automation.

Finally, an important consideration should be made around the emerged comprehension of the TT concept by CI companies. Indeed, as observable in Figure 1, there is a good comprehension of the relevance of TT, and as emerged from the question about the implemented interventions of the last 12 months, TT is actively pursued. Nonetheless, when specifying the nature of the implemented interventions, it emerged that:

- In one case the intervention was related to digitalization of internal information sharing and smart working enabling, not impacting on environmental sustainability performance.
- In another case the intervention was related to the digitalization of the manufacturing process, but no mentioning was made about environmental sustainability performance.
- In a further case, it was not specified what kind of TT interventions were performed in the company.

This uncovers a certain confusion of the companies around the concept of TT. This appears to be in contrast with the declared degree of familiarity stated by companies themselves in the previous questions. Therefore, it is immediate to infer that while companies are clearly aware about the existence of GT, DT and TT trends, they do not have a clear comprehension of the three and of the differences among them, probably moreover for TT.

5 Conclusions

The survey provided a sample representing the current situation of the European CI in the field of GT, DT, and TT. It has clearly emerged a strong interest of the sector towards these trends, and a first comprehension of its relevance in the sector is understood. Nonetheless, as mentioned in the previous paragraphs, there is still confusion around the concept of TT. This translates into a need of support for the CI to better and more deeply comprehend the meaning of TT, and then its potentials and benefits. This is a first fundamental step towards its implementation and exploitation.

A slight difference in implementation level has been spotted between SMEs and LEs, probably due to the barriers and difficulties SMEs meet in implementing GT, DT, and TT, as discussed in the Introduction paragraph. Nonetheless, such difference did not appear as big as it may be expected in other industries.

It emerged an overall comprehension of the relevance of GT, DT, and TT among CI enterprises. Nonetheless, a certain degree of confusion around the concept of TT seemed to be present, as well as a lack of comprehension of the possible benefits of digital traceability technologies for sustainable sourcing. Thus, for future studies, it can be important supporting practitioners of the CI in better understanding TT and related concepts, as well as benefits coming from its implementations. Instruments supporting their decision-making will have a concrete positive impact in the future innovation of the sector.

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