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Tools based on immersive technologies for supporting decision making to achieve sustainability and resilience in Small and Medium Enterprises

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Abstract

Environmental and social sustainability (ESS) is becoming a growing concern for organisations and an important part of corporate strategy. Although the environmental and social footprint of individual small and medium-sized enterprises (SMEs) may be limited, their collective impact is significant. The first main objective of this study is to explore and present the factors and drivers that influence the successful adoption of sustainable environmental and social practices in these SMEs.

The new technological paradigm is laying the foundations for the development of immersive technologies as a tool to support various activities in different areas of business. However, it is large organisations that have the greatest availability of these technologies. The second main objective of this study is to analyse the use of immersive technologies in SMEs in the context of the three dimensions of sustainability (economic, social and environmental).

The study is based on a mixed methods approach, which includes a comprehensive literature review and an analysis of empirical case studies. The literature review highlighted factors associated with the adoption of sustainable practices and immersive technologies in SMEs, as well as current trends. The empirical component included detailed case studies illustrating best practices of European SMEs in relation to sustainable practices and the use of immersive technologies. These case studies provided a practical insight into the challenges of adoption and highlighted best practices that could potentially guide SMEs towards greater sustainability and resilience.

The findings suggest that while SMEs face significant barriers such as a lack of resources, insufficient knowledge and technological challenges, there are significant opportunities for the use of immersive technologies in the area of sustainability, not only social and environmental, but also economic.
These technologies, in fact, not only help to overcome some of the traditional barriers to sustainability, but also provide innovative ways for SMEs to improve their operational efficiency, stakeholder engagement and strategic implementation of sustainable practices.
Based on this comprehensive study, a step-by-step guide for SMEs to adopt immersive technologies and use them as tools for sustainable results has been developed. The aim of the guide is to comprehensively address those SMEs that are potentially interested in adopting AR or VR in their business and provide them with a path to follow for their successful implementation.

In conclusion, the thesis highlights the potential of immersive technologies to transform SMEs by aligning their business models with sustainability goals. It offers a guideline for the adoption of such technologies, advocating a strategic approach that integrates technological innovation with sustainability principles to foster a resilient and competitive business environment in the SME sector.

Table of Contents

1. Introduction

1.1 Motivation

Environmental and social sustainability (ESS) is becoming a growing concern for organisations and an important part of corporate strategy. However, large companies often dominate the implementation of sustainable initiatives due to their greater resources. The influence of large companies in this area is fundamental, but while the environmental and social impact of individual small and medium-sized enterprises (SMEs) may be limited, their collective impact is significant. It is therefore important to understand the dynamics that can help these organisations adapt to today's evolving business landscape, as well as those that can hinder them, in order to identify opportunities for improvement.

At the same time, the scarce resources of SMEs put them at a disadvantage in terms of technological development. Among the various new technologies that have been growing in recent years, immersive technologies are emerging as interesting tools in the business context. They can be implemented in many contexts, giving life to a long list of use cases and applications that could be used as a reference point by SMEs to create a competitive advantage. In addition, their use could have an impact on sustainability, both from an environmental and social perspective. In this case, too, it is important to show how these technologies could improve the efficiency and performance of SMEs.

1.2 Scope

This study will deal with SMEs operating within the European Union, and this study follows the definition provided by the European Commission, which embraces companies with fewer than 250 employees. The geographical area includes companies operating in any industry within the EU. In this study, one focuses mainly on current data; thus, the main materials are journal articles published in the past 10 years, with most articles being published within the past 5-6 years up to the current year. In addition, most of the material used was in English, with some minor findings in Spanish and Italian.

Demographic considerations such as ownership structure, age of the company, or regional location in Europe are not considered in the current study, so the study can be viewed as very broad and highly inclusive in regard to SMEs and their involvement in sustainability practices and immersive technologies.

1.3 Objectives

The first objective of this study is to explore the factors, drivers, and barriers that influence the successful adoption of sustainable environmental and social practices in SMEs. This research aims to

explore the mechanisms and influences that can lead SMEs to implement sustainable practices in their business. It also aims to provide a starting point for effective implementation by providing examples of some best practice through some real case studies.

The second objective of this study is to focus on the use of immersive technologies in SMEs, in parallel with the study of sustainability in SMEs. This entails outlining an overview of the factors that could potentially drive the acquisition of these technologies, reinforcing it with examples of real case studies.

Finally, a critical objective of this study is to correlate the use of immersive technologies within SMEs with the three dimensions of sustainability: economic, social, and environmental. Through this analysis, this research aims to find potential synergies between immersive technologies and sustainable outcomes and provide insights into how SMEs can embrace technological advancements while promoting sustainability.

1.4 Methodology

The entire study was conducted using a mixed methods approach, with different phases addressing different objectives.

The first phase consisted of a literature review divided into two parts. The first part focuses on the synthesis of the existing knowledge on the factors, drivers and barriers for the adoption of sustainable practices in SMEs. The following keywords were used to select the research papers: 'SMEs', 'sustainable practices', 'drivers', 'barriers', 'green practices' and 'sustainable development'. The second part focuses on the use of immersive technologies in SMEs, using the keywords 'immersive technologies', 'XR', 'ER', 'metaverse', 'SMEs', 'barriers', 'drivers' and 'benefits'. Databases such as Scopus, ScienceDirect, ResearchGate, Emerald Insights, Wiley and Google Scholar were used in addition to grey literature, after ensuring its reliability.

Having first identified the influences on SMEs' engagement with sustainable practices and immersive technologies, the study then examines, through surveys and articles, the current position of SMEs with regard to Corporate Social Responsibility (CSR) and immersive technologies in Europe. In this respect, the study presents real SMEs in order to gain insight into the factors necessary for adoption, either of sustainable practices or immersive technologies. Heterogeneous purposive sampling is used to showcase companies from different sectors - manufacturing, retail, hospitality, technology and services - allowing for the exploration of practices in different contexts.

The contribution and analysis section of the study is divided into two parts, based on the material previously presented. The first part focuses on the intersection of immersive technologies and potential outcomes for sustainability, while the second part presents practical guidelines for SMEs wishing to adopt these practices.

Despite the challenges of data availability and accessibility, particularly in an emerging area of immersive technologies in the SME context, the study uses a range of sources and methodologies to fill the gaps.

The significance of this research lies in its potential to empower SMEs to innovate their business practices and enhance sustainability performance. By providing insights, examples, and guidelines, this study aims to support SMEs in embracing technological advancements while promoting sustainability.

2. Literature review

2.1 Sustainability in Small and Medium Enterprises

2.1.1 Definition of sustainable, environmental, social and economic practices

"Sustainability is the ability to continue economic, social, cultural, and environmental aspects of human society and the nonhuman environment.

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

(Porta M. , 2014)

Specific definitions of the term *Sustainability* have been discussed along the years, but in the broadest sense, a process or an action can be said *sustainable* if it can be maintained or supported continuously over time.

In the latest years and in everyday use, the term is often connected to the environment, as to indicate the avoidance of the depletion of natural resources to maintain the ecological balance. However, this is just one of the three aspects that the sustainable approach considers: more than focusing only on the environmental impacts of processes and actions, it also considers the social and economic sides of those.
These 3 ESG pillars (Economic, Social, Governance) were introduced with the publication of the Brundtland Report ("Our Common Future") in 1987 and have laid the foundation for the concept of sustainable development as it is generally understood today.

Environmental sustainability is the ability to protect and preserve the natural environment through appropriate practices focused on the treatment of pollution, climate change and biodiversity. "Environmentally sustainable organizations take steps to enhance efficiencies, reduce resource consumption and waste, and measure and monitor carbon emissions" (Environmental sustainability: A commitment to a better future).

Social sustainability, on the other hand, is about the balance of the impacts of actions and processes on the lives of human beings; it promotes equity, human rights and well beings, enhancing good practices in the fields of work, education, and health, such as fair labour boosting and inclusion initiatives.

Finally, economic sustainability refers to the approach that aims to achieve long-term economic growth and profits, balancing them with resource efficiency and social equity. It offers the challenge of expanding economic activities, while reducing their impact on the planet and on the humanity as part of it.

ESG pillars are strongly intertwined between each other's: while analysing practices in this framework may be useful in the individuation of the best choices in different fields, it is important to understand the relationships between each area to exploit efficiency and avoid unwanted effects.
To illustrate and highlight this connection it is possible to use an example extrapolated from *The Brundtland report*, which states that poverty causes environmental problems, and that poverty also results from them; so, addressing environmental problems requires understanding the factors behind world poverty (economic aspect) and inequality (social aspect).

Nowadays, the comprehension of these interactions and their importance is especially fundamental for businesses and organizations, which must include in their strategic planning sustainable considerations more and more often to meet the expectations of a variety of stakeholders. It is in fact an era in which technological change and environmental mindfulness push in the direction of sustainability for all the actors in creating value, from big to small enterprises. Companies are sensitive to a change in consumption patterns that reflects concerns about the climate emergency and the respect for human rights. Moreover, other recent factors, such as the increase in energy prices or supply chain interruptions, have opened a space for reflection on the location of value chains and the availability of local alternatives to cover those needs.

However, the nature of sustainability for organizations can be ambiguous and, above all, challenging to implement in substance; the triple bottom line (TBL) concept was proposed by Elkington in 1994, to support and operationalize sustainable development implementation. The TBL is in fact a business concept that redesignates the 3 pillars of sustainability around the sole context of businesses, stating that, rather than focusing only on generating profits, companies and organizations should use the same level of commitment for measuring their social and environmental impact. (Gimenez, 2012).

Later in 2015, continuing with the aim to put the sustainability essence into practice, the United Nations (UN) General Assembly launched the 2030 Agenda for Sustainable Development as a shared outline to address the TBL of sustainability with specific and clear objectives, trying to design an action plan to achieve prosperity that is respectful for the planet and its inhabitants. This Agenda

introduces 17 sustainable development goals (SDGs) and calls upon all governments and private businesses to support the achievement of the specified SDGs, which are listed in figure 1.

Figure 1: retrieved from (United Nations (Department of Economic and Social Affairs), 2024)

The SDGs goals represented a big step forward in the direction of sustainability implementation in being precise in the representation of which are the objectives to chase but leaving the necessary generalization to adapt to each kind of business.

Another useful concept when discussing about businesses and sustainability is that of *Circular Economy* (CE), defined by an article of the European Parliament as "a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible" (Circular economy: definition, importance and benefits, 2023). In a summary, businesses wanting to be part of a circular economy, should create supply chains that reduce waste to the minimum and transform in further value the one that cannot be eliminated.

The clarification of the aforementioned concepts is a necessary starting point to frame businesses in the sustainability scenario. Nevertheless, the concretisation of such guidelines is a challenge for several reasons, the most important of which is the impossibility of standardising concrete actions for all actors involved. In fact, it is important to highlight that each organization and its strategy varies on a multitude of variables, such as sector, dimensions, processes, and resources, making it impossible

to adopt universal practices equals for all the cases. This is even more evident in the case of Small and Medium Enterprises (SMEs), in which the smaller scale of the supply chain is based on very particular and precise actions that aim to sustain the business itself and reach especially internal goals. However, the importance of adopting sustainable practices must be recognized especially by these last ones, since, even if their impact can be limited if considered individually, it is substantial if considered in an aggregate way. In fact, SMEs play a key role in the economies of all the world: in the EU, as an example, they represent 99% of the total of businesses and provide around three-quarters of all jobs (European Investment Bank - SMEs overview 2022).

This data can provide us the magnitude of the impact that SMEs can have in pursuing the unifying principle behind sustainability of rejecting wasteful short-term processes and embracing the planet's long-term well-being. To drive in this direction, it is then fundamental to analyse the context of relationships between SMEs and sustainability application, from the barriers that obstacles the acquisition of sustainable practices, to the incentives that aim to the same goal.

2.1.2 Factors influencing the adoption of sustainable practices in SMEs

Having analysed all the barriers to the adoption of sustainable practices by small and medium-sized enterprises, it is important to highlight all the factors that, instead, encourage their implementation.

The literature on the subject is largely consistent in stating that "both internal and external factors play a crucial role in this transition" (Troise, Santoro, Jones, & Bresciani, 2023) - referring to the transition to sustainable business models (SBMs). Internal factors can be related to specific characteristics of the organisation itself, "such as owner-manager attitudes, environmental awareness, perceived benefits and concern for employees" (Satchapappichit, 2020). External ones, on the other hand, refers to the pressure exerted by all the possible external stakeholders that have an impact on a company's environmental strategy, such as customers and suppliers, governments and regulators, and other supporting organisations.

As the analysis of barriers to the adoption of green practices has shown, external support is essential to overcome the limitations that Small and Medium Enterprises might face.

The research article "*The collaborative roles of stakeholders in supporting the adoption of sustainability in SMEs"* (Journeault, Perron, & Vallieres , 2021) individuated five different and complementary roles that a range of stakeholders can play to support sustainability practices within SMEs. The peculiarity of this article with respect to the rest of the related literature is that it does not specifically aim to find the drivers and actors that influence the implementation of sustainability in SMEs. On the other hand, it focuses on what are the support functions that can encourage a small or medium-sized organisation to implement a sustainable development strategy. These functions are that of *trainer*, *analyst*, *coordinator*, *specialist* and *financier*. These findings demonstrate that one keyway for governments to improve the sustainability performance of SMEs may be to facilitate and shape the development of stakeholder networks capable of performing these five critical roles as part of efforts to promote sustainability adoption within firms. (Journeault, Perron, & Vallieres , 2021).
It was discovered that the *trainer* position helped SMEs overcome two obstacles: lack of time and resources to dedicate to sustainability, and a poor understanding of the advantages of sustainability. This role could be carried out through focused seminars and conferences that educate managers about the benefits of sustainability for their company. According to the study's findings, the trainer's job helped managers see their organizations from new angles, and this was crucial in helping the company begin an internal reflection process on sustainable development.
Some managers were aware of the potential benefits of adopting sustainable practices but lacked the ability to identify specific opportunities related to their business, often due to a rigid view on the

operational side of their activities. The *analyst*, being detached from the internal dynamics of the firm, could offer different perspectives, through strategic assessments and tailored recommendations. This role was fundamental in identifying key action points for each organisation to reduce waste and improve resource efficiency within their operations.

The *coordinator* acted to connect SMEs with other important stakeholders for realizing sustainable development projects and to oversee project implementation. Facilitating communication and providing guidance, it helped the organisations overcoming the lack of resources dedicated to green practices adoption.

Similar to the analyst, the *specialist*'s role was designed to overcome a lack of knowledge and expertise. However, their ultimate objective was to execute a specific practice rather than to evaluate opportunities in general, which distinguishes them from the analyst. By focusing on providing technical expertise, they could help SMEs to implement specific techniques.

Finally, the role of the *financier* was crucial, as SMEs generally lack financial resources, as discussed in chapter 2.1.2. By providing funding, programmes or loans on favourable terms, the finance provider enabled the organisation to invest in energy efficient systems that would have been unlikely without external funding.

The approach used in the aforementioned article offers structured insights into the factors that should be considered to overcome the fundamental shortcomings of SMEs. By examining the five key areas highlighted, each SME can conduct a self-assessment of its own weaknesses and prioritise efforts to address them. At the same time, from a government perspective, this approach highlights those areas that need improvement and where efforts should be focused.

The literature that will be followingly discussed examinates the various actors and dynamics influencing the transition to sustainable development in more detail and with a more concrete approach.

Drivers

Customers

Customers are one of the primary external stakeholders that has a great impact on the environmental strategy of an organisation. According to (Arsawan & al., 2021), one way to encourage SMEs to invest money in green innovation is through the desire of the customers to pay more attention to green innovative products.

Customer participation enhances green product innovation in SMEs by facilitating the recognition and exploitation of opportunities (Chena & Liu, 2020). On the other hand, the impact is minor when the practices are related to production processes. Results suggest that customers have more influence

on the extent to which SMEs engage in green products and services than on SMEs' involvement in greening processes (Hoogendoorn, Guerra, & Zwan, 2014).

Regarding the market served, it was found that SMEs serving consumers are more likely to engage in greening their products and services than SMEs serving other enterprises. Such a difference is not found for what concerns greening processes. However, as the environmental qualities of goods and services frequently depend on how they are made, it is also possible to hypothesise that there may be an indirect impact also on greening processes.

Despite the limitations identified in the section 2.1.2 (Cheapness as a dominant paradigm in society and fast-moving trends), there is a growing preference for products with ESG-related claims, especially in consumer packaged goods (CPG).

A study from McKinsey and NielsenIQ demonstrated that products making ESG-related claims averaged 28 percent cumulative growth over the past five-year period, versus 20 percent for products that made no such claims. As for the Compound Annual Growth Rate (CAGR), products with ESG-related claims boasted a 1.7 percentage-point advantage—a significant amount in the context of a mature and modestly growing industry—over products without them (Figure 2). (Frey, Am, & Noble, 2023).

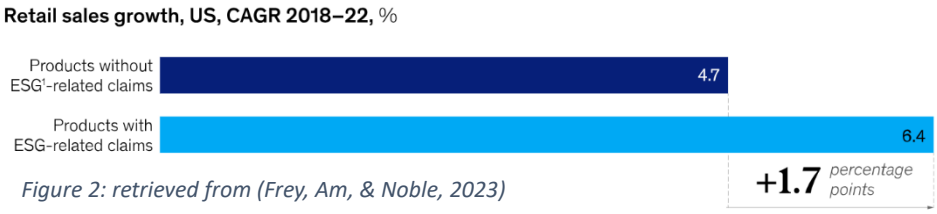


Figure 2: retrieved from (Frey, Am, & Noble, 2023)

Some other interesting insights about the consumers' behaviour can be gleaned from the same study, which shows which characteristics drive growth the most.

Firstly, products with multiple claims across different ESG classification themes sold better than other products, showing that visibility of sustainability can be good for business; specifically, products making multiple types of claims grew about twice as fast as products that made only one (Frey, Am, & Noble, 2023).

Second, people who lived in urban and suburban areas, had children and had higher incomes were more likely to buy products with one or more ESG claims.

Third, out of all the product categories evaluated, 59% saw disproportionate growth for the smallest brands that made such claims. However, medium-sized companies underperformed, probably because they lack the marketing and distribution scale of large companies and the reputation of small ones.

With these factors in mind, we can conclude that, given the significant increase in consumer awareness of sustainability issues, consumer influence is significant and needs to be considered by

SMEs in their long-term strategic planning. The influence is particularly relevant for companies that sell directly to consumers and offer products rather than services, and very relevant for CPG. In addition, we can expect consumer preferences to have a greater impact on smaller companies than on medium sized ones, especially if they incorporate high-impact ESG-related claims across multiple categories and products.

Value chain

Having discussed the driving force of customers, the analysis now shifts to examine the other side, the driving force of suppliers. Their importance can be significant as their commitments influence and set the standards for sustainable behaviour within the supply chain.

Initiatives for sustainable development in supply chains have been most probably initiated by pioneering organizations (not necessarily concentrating enterprises), and they are expanded into the remaining cells of the supply chain. For example, an organization acting more proactive in the given supply chain starts initiatives towards its sustainable development, and carries out even more tempered practices, which will be later exported to other parts of the supply chain (Kot, 2018). In addition, there has been a growing body of research into sustainable supply chain management in recent years, showing how decisions made at one stage can affect downstream and upstream partners. According to sustainable supply chain management, every business is a component of a larger social-natural system, which itself is a part of a larger system, comprehending nature and society. An empirical study (Wu, 2017) provides evidence for this theory by demonstrating a strong and positive correlation between suppliers' socially conscious business practices and SMEs' sustainability-focused innovations.

More specifically, the factors through which suppliers and the wider supply chain can influence SMEs to adopt sustainable practices are, first and foremost, collaboration and partnership. Increased cooperation could help to overcome the lack of knowledge and facilitate access to resources. The literature also shows that, if companies want to produce without harming the environment, then co-operation and interdependency between corporations is necessary (De Marchi, 2012).

However, as noted in chapter 2.1.2, there is still a lack of cooperation between companies, especially small and medium-sized ones, and transparency of information along the supply chain is still not achieved. It is important to understand the importance of overcoming this barrier, as collaborating can not only help SMEs reduce their negative environmental impact, but also open up new economic prospects, boost their competitiveness and promote a more sustainable future for all concerned.

In addition to the collaborative approach, (Vachon & Klassen, 2006) identified another approach: monitoring and control. This involves checking the environmental performance of value chain partners and collecting information about it. This is related to the fact that large companies are

increasingly signing up to climate change initiatives and corporate social responsibility commitments and need to ensure that their value chains are aligned with these objectives. As a result, it is reasonable to expect that larger companies will prefer to do business with SMEs that demonstrate sustainability performance and transparency in their operations. To maximise their business opportunities in B2B relationships, SMEs should therefore proactively prepare to meet high sustainability standards.

Organization

"These external factors explain only a part of decision making, since facilities often behave differently in different situations based on similar external factors". (Satchapappichit, 2020).
Internal drivers based on moral and ethical values play a crucial role in the engagement in sustainability of SMEs. These include the attitude of the manager/owner and of the workforce, the corporate culture, reputation and brand image.

Research has shown that one driver of sustainability initiatives in SMEs is the awareness and commitment of the manager, who in the reality of SMEs is often also the owner. (Williams & al, 2013) found that personal values and beliefs are key motivators for environmentally proactive managers, while (Reyes-Rodriguez, 2016) highlighted the role of strategic intent in driving the adoption of environmental initiatives. The manager's involvement, in fact, can be highly dependent on the perceived benefits, among which brand reputation stands out. Moreover, as the manager's interest allows him to take advantage of external opportunities that can help overcome structural deficiencies, his engagement is crucial.

On the other hand, employees can also be influential in driving sustainability initiatives.
(Wolf, 2013) highlights the potential for employees to lead change in this area, specifically highlighting the positive impact of employee engagement on business performance. In fact, increasing the involvement of employees in the business has the effect of encouraging them to come up with innovative solutions, including sustainable ideas, from both an environmental and social perspective. This is linked to the influence of corporate culture: (Wang, 2022) found that a flexible corporate culture has a positive impact on innovation capability, which in turn promotes sustainable performance. Corporate social responsibility is a key driver of sustainable innovation, suggesting that a culture of social responsibility can have a significant impact on sustainability initiatives linked to the adoption of sustainability marketing strategies.

Enablers

Government and other institutions

Regulations and legislations are probably the most crucial external factor in encouraging SMEs to adopt green practices.

Tight rules and regulations regarding environmental protection and their proper enforcement increase the rate of green innovation adoption in SMEs (Wen & al, 2019). As can be seen from this and other findings in the literature, what turns legislation from a barrier to a driving factor in the sustainable development of SMEs is the power of its pressure. For example, (Wasiq & al., 2023) found that the SMEs analysed were forced to adopt green innovations as a result of regulatory pressure, and that stringent regulations, as well as their appropriate application, improved the rate of adoption of green innovations in SMEs. In this scope, government figures as an indispensable external driver that can strongly influence the strategic planning of a firm and improvement in the government legislation can significantly influence the success of sustainable implementation within the supply chain (Ghadge & al, 2017).

Until recently, sustainability legislation was mainly aimed at large companies. Recently, however, there has been a growing recognition of the need to extend these regulations to companies of all sizes, including SMEs.

In the European Union, for example, the Corporate Sustainability Reporting Directive (CSRD), adopted in 2022, replaced the Non-Financial Reporting Directive (NFRD) as part of a package of measures designed to drive financial and resource flows towards more sustainable activities. Under the NFRD, only large companies with more than 500 employees were required to publish annual non-financial reports on their sustainable performance. However, the CSRD extends this requirement to large companies with more than 250 employees first and to SMEs from 2026.

Regulations are also being pushed by national governments, such as the Danish government, which has introduced a so-called corporate carbon tax. This will be introduced in 2022 and will impose a tax of 1,125 Danish crowns per tonne of carbon dioxide emitted on all companies, including SMEs.

In this way, companies will have a strong incentive to calculate and reduce their carbon emissions in order to minimise the associated tax burden. It is reasonable to expect that this type of regulation will increase in the future, as corporate reporting that integrates social, environmental and economic performance becomes increasingly important.

In addition to mandatory legislation, voluntary regulations and standards, such as ISO 14000 (a family of environmental management standards) and ecolabelling, promote sustainable practices and performance assessment. As a benefit to businesses, they can enhance market differentiation and reputation, and help companies prepare for future regulatory changes (Rajapakshe & al., 2020).

Nevertheless, the role of governments and intergovernmental organisations is not only legislative, but also supportive, both from an economic and a non-economic point of view.

Governments can support SMEs' access to sustainable finance by crowding in private sector financing through credit guarantees for green or sustainability-linked lending, and by supporting the provision of equity finance for innovative green ventures through intermediaries and partnerships. (OECD, 2022). The first type of support from governments, the EU and international organisations is therefore in the form of mobilising private sector financing. To a lesser extent, however, they are also providing support through direct funding programmes, subsidies and incentives aimed at further widening access to capital.

The results of the OECD 2023 survey of financial institutions are interesting for understanding the level of financial support provided to SMEs. Of the financial institutions surveyed (private and public, not only regulators and policy makers, but also ESG intermediaries and financial providers such as banks and insurance companies), 73% indicated that they provide green/sustainable finance to SMEs. To understand the type of financial products they use, the graph in figure 3 shows the responses to the question:

"*Does your institution provide any financing/investment products classified as:"*

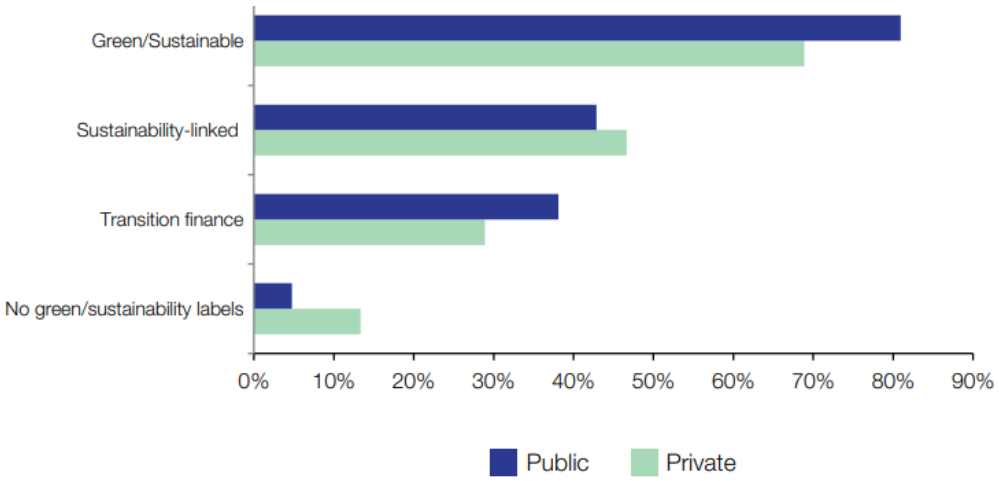


Figure 3 retrieved from (Frey, Am, & Noble, 2023)

The same survey also highlights the non-financial types of support that are being offered to address the knowledge, awareness and capacity gaps that SMEs face in relation to sustainable investment and the transition to net zero. They can also help SMEs build their capacity to meet future reporting requirements and tap into the growing pool of sustainable finance (OECD, 2022). The survey reveals a classification of the types of helps offered through the answers to the question:

"What type of non-financial support does your institution offer to SMEs to build their capacity to measure, report and take action on climate-change and net-zero?"

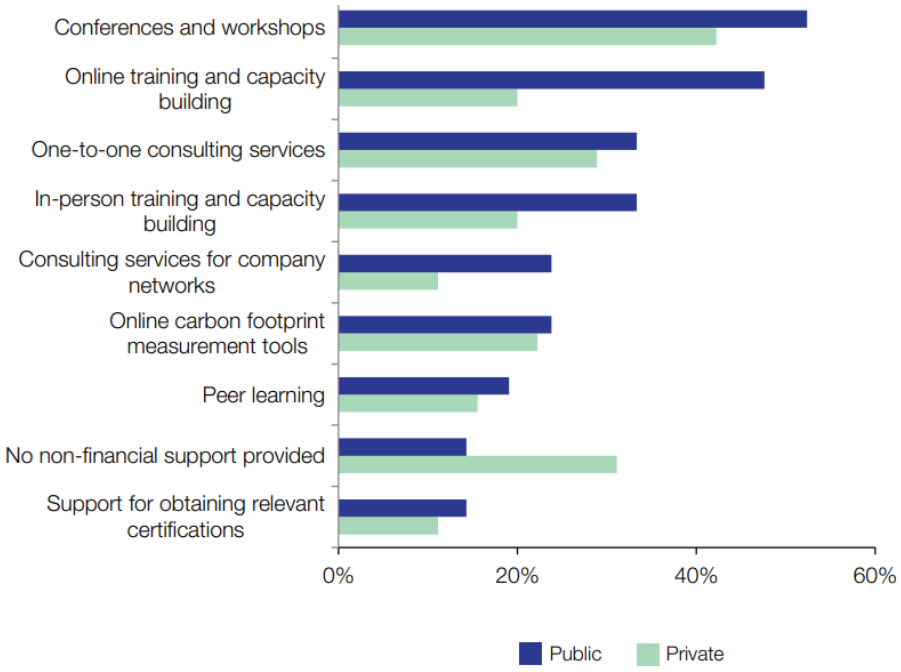


Figure 4 retrieved from (Frey, Am, & Noble, 2023)

In summary, a wide range of external and internal factors influence the adoption of sustainable practices by SMEs, but the main actors able to influence these factors are customers, value chain partners, government and other institutions.

In order to be competitive and satisfy market expectations, SMEs are encouraged to incorporate sustainability into their operations by the growing demand from customers for socially and ecologically conscious goods and services. By working together with distributors and suppliers, among other value chain participants, SMEs can have access to information, resources, and assistance for integrating sustainable practices all the way down the supply chain. Furthermore, financial incentives, knowledge gaps, and raising SMEs' awareness of sustainability challenges are all made possible by government laws, rules, and support initiatives. SMEs may successfully contribute to sustainable development by identifying and responding to these external impacts.

Table 1: Influencing factors

Factor	Impact on SMEs' Adoption of Sustainable Practices
Regulatory Compliance	• Legal requirement: Ensures SMEs meet environmental standards to avoid penalties. • Governance influence: Promotes the integration of sustainability in corporate governance to align with regulatory expectations.

Market Demand	• Consumer preference: Drives SMEs to offer eco-friendly products and services. • Competitive advantage: Encourages differentiation in the market, attracting customers who value sustainability.
Cost Savings	• Operational efficiency: Reduces costs through more efficient use of resources like energy and materials. • Long-term profitability: Lowers long-term operational costs, improving financial sustainability.
Technological Advancements	• Accessibility: Easier implementation of sustainable technologies. • Innovation opportunity: Opens new business models and processes that are environmentally friendly.
Brand Reputation	• Customer loyalty: Builds trust and loyalty among environmentally conscious consumers. • Market positioning: Enhances brand image and market position as a leader in sustainability.

2.1.3 Barriers to adoption of sustainable practices for SMEs

To have a chance in the sustainability challenge, SMEs should have a more equitable access to the resources and better aligned regulations. Especially after 2020, SMEs have been living a very uncertain period, that has caused difficulty in medium-long term planning and, consequently, in the adoption of transformative tools, which require investments, technical knowledge, human resources and a change-friendly environment (Castiñeira, 2023). Due to the limited and slow capacity proper of most of the SMEs, their primary goal is their survival, particularly after the pandemic of Covid-19.

The latest report (Castiñeira, 2023) by the SDG Observatory, promoted by the Centre of Leadership and Sustainability of Esade and "la Caixa" Foundation, collected through discussion sessions with 43 Spanish SMEs from various sectors committed to sustainable development, gives important clues about what are the principal barriers that SMEs meet in approximating to the sustainability matter. Thanks to the just mentioned report and the article "Barriers to a circular economy in small- and medium-sized enterprises and their integration in a sustainable strategic management framework" (Fabian Takacs, 2022), it has been possible to structure the different types of difficulties that SMEs can meet, categorizing them in five macro-areas: economical, market related, operational, technological, legislative.

Economic and company internal barriers

The economic aspect is a key matter in the acquisition of sustainable applications for SMEs. Very often, the decision of being sustainable increases the costs of operations, requires substantial initial investments and forces organizations to take less rentable decisions. SMEs frequently face difficulties obtaining funding from conventional sources like banks: since they have a less established track record and require less collateral, financial institutions may view them as higher risk. Because of this, it is difficult for SMEs to obtain credit or loans on acceptable terms. It is then clear that the scarcity of financial resources of SMEs is an important barrier in the race to sustainability: in a 2023 survey, 55% of SMEs identified a lack of funding as a key obstacle to climate action; nearly 70% stated that they need additional funds to take climate action or accelerate their progress on emissions reductions (SME Climate Hub Survey, 2023). This last percentage of respondents indicated different impacts of the possibility of receiving more funds: 14% stated they would not be able to take a step towards net-zero without more funding, 32% said they would be limited, and 55% claimed they would make faster progress with more funding. The difficulty of obtaining credit, the lack of sustainable financing methods and the long and uncertain payback period lead to the fact that some businesses choose to postpone the fulfilment of sustainability obligations as long as possible, nurturing the characteristic

risk aversion of SMEs. In the concrete, “Managers assess business risk associated with a CE implementation higher than the environmental risk (e.g., resource scarcity) of not implementing a CE” (Fabian Takacs, 2022).

However, the lack in resources of SMEs is not only of a financial type. In fact, the top reason preventing them from acting on ESG criteria integration, basing on the *SME Climate Hub Survey 2023*, is the low level of skills and knowledge. The company size and the fact that the company itself often does not perceive its potential impact in the macro-scenario guides the inertia in developping said learning on the concrete implementation options for CE. For example, the company does not learn more than is necessary about the various stages of the value chain., (e.g., the origin of raw materials) or about how to manage the returns. This lack of knowledge reinforces the economically dominated thinking, that sees economic value creation as an end itself.

The third type of resource constraint, identified by SMEs themselves in the SME Climate Hub Survey 2023, is time. Implementing a CE and maximising the use of resources is time-consuming, which complicates the decision-making process that, moreover, needs to be accompanied by a long-term strategy. The expected returns from circular investments are seen as too distant from the present and are therefore not prioritised. In addition, time is needed to fill knowledge gaps, to implement the necessary organisational changes associated with radical innovation and, above all, to learn a new business paradigm. Then, especially in a period of rapid change such as the present, the adoption of sustainable practices becomes less attractive to SMEs also because of the time required to implement them.

The interaction between all the above internal barriers can be a powerful disincentive for SMEs to adopt the ESG pillars. Overcoming these limitations requires a degree of risk-taking and failure tolerance, as well as a critical examination of one's own business model, breaking out of familiar thinking patterns to broaden management horizons and take a long-term view. Closely linked to this is the need for managers to see their value creation as correlated to society and the environment, and to move away from the economically dominated thinking.

However, it is important to recognise that a company and its internal barriers are embedded in a larger picture, which is strongly influenced by external factors. These factors will be discussed in the following paragraphs.

Market and consumer barriers

Lack of transparency in different forms in the market prevents CE implementation. Firstly, transparency plays a crucial role for SMEs to see and absorb successful methods from other

businesses in their sector. It is challenging for smaller organizations to comprehend and imitate the successful tactics if there is a lack of role models to follow. Other than in the processes, transparency can be missed also in the products themselves. Not knowing about ingredients or materials of products hinders the recognition of real quality, as well as unfair practices do. In fact, hand in hand with the importance of the sustainability matter, has developed the practice of *Greenwashing.* This is defined by the Cambridge Dictionary as "behaviour or activities that make people believe that a company is doing more to protect the environment than it really is". It represents a problem for SMEs wanting to approach a CE because the competition from big organizations can attract costumers superficially environmentalists with lower prices. Eco-labelling should provide a remedy to the absence of openness, offering proven certification that a product and its making meet specific environmental performance criteria. However, the different types of eco-labels existing and the complicated associated processes to receive them, often constitute another hurdle for SMEs, that generally prefer to avoid complexity. An example from the article *Barriers to a circular economy* (Fabian Takacs, 2022) may be useful to illustrate the problem: much of the coffee in Brazil "is not certified organic" - even though most Brazilian coffee growers are smallholders that carry out the production naturally - "because the hurdles with all the effort are immense for a small business".

Unequal market power is another market barrier for SMEs, which can be visible already in some of the concepts mentioned above, such as *greenwashing*. However, the inequality respect to large companies can be seen in many more aspects; these last ones, for example, are able to charge lower prices thanks to economies of scale, e-commerce business or because they have the resources to finance less profitable products. Moreover, SMEs can suffer from price pressure also due to the convenience of imported products respect to domestic ones. As a result, the bargaining power of buyers is quite high, contributing to the pressure on SMEs.

On the other side, the bargaining power of suppliers stresses SMEs position as well. In fact, sustainable materials and processes are generally more expensive than ordinary ones; prices of recycled materials are often higher than the ones of virgin materials (e.g., cotton), fossil energy is usually more convenient than renewable options and domestic labour is more expensive compared to manufacturing abroad. In order to offer competitive prices, cheaper non-environmental practices are often chosen by SMEs.

Saving costs is especially necessary for SMEs to survive, considering some characteristics of nowadays' society. Even though the concerns about sustainability are spreading, the dominant paradigm in society, when it comes to buying goods, is still cheapness, and price sensitivity plays a key role in strategic decisions. In addition, society's attitude towards consumption is based on fast-

moving trends and a substantial willingness to consume. People have strong preferences on prices, but also on functions and appearance and they are reluctant to change them. For example, a non-environmentalist customer, would not appreciate the decision of using a reduced amount of packaging. The report (SME Climate Hub Survey, 2023) offers an interesting data in assessing the awareness of consumers on this matter: only 23% of small and medium businesses have been asked to reduce emissions by their customers.

Operational and supply chain barriers

The position of small and medium enterprises in the value chain can also represent a source of barrier in the application of sustainable operations.

Firstly, as their negotiating power is generally weaker than the one of their suppliers, SMEs have limited ability in communicating with larger companies and international clients and suppliers, as well as little capacity of influencing them. This communication gap hinders the integration of sustainable measures principally for two reasons: limited offer of sustainable products and difficulty to source small amounts. It can be difficult to find suppliers that are committed in the CE and provide sustainable options, for instance reusable containers. Instead, in the case in which they offer eco-friendly choices, they often can furnish only bulk quantities, so that SMEs are constrained to demand, for example, more packaging than they need. A statement of *Luis Guillen,* owner of *Trendsplant*, from the report by the SDG Observatory (Castiñeira, 2023), expresses this issue first-hand:

"Sometimes, it is difficult to find suppliers who are in this boat. It's complicated, because some of those who could, thanks to their scale of production, are not interested in it, and with others who are aligned with our green production goal, we can't, because of the large production minimums or the higher cost price."

Operational barriers can also result from a lack of horizontal cooperation between SMEs themselves. Networking could help small organisations to overcome some of the resource-related barriers by providing the opportunity to benefit from economies of scale and cross-organisational learning. An example of horizontal cooperation could be the purchase of shared machinery to create a common waste avoidance system. However, the collaboration between SMEs is still very limited.

For small and medium-sized enterprises, integrating sustainability throughout the value chain can be a difficult undertaking. To overcome these challenges, SMEs need to look for opportunities to work not only with larger partners, but also with organisations at their level.

Technological and talent barriers

Technological barriers are characterised by the existence of requirements for which the company does not have suitable eco-friendly answers. This can be due to a lack of adaptation of the product design to suitable business models or due to the inexistence of a fitting solution.

The first issue highlights the discrepancy between the strategic goals of the business in terms of sustainability and the design of its products (e.g., adding components to pure materials in manufacturing can induce impurities that hinder a CE (Fabian Takacs, 2022).

Certain technical solutions for a CE are not yet sufficiently useful for functional use, are not available in a form that can be sold or have not been sufficiently tested. For instance, biodegradable packaging is not practical for moist products; the infrastructures that facilitate transportation through electric vehicles are still in an introduction phase. Specific properties of the product, required for its functionality, quality or design inhibit circular economies. Besides the immaturity of technological solutions, the potential for circularity is sometimes constrained by the practices required to create a product, such as physical and chemical interactions that are necessary for safety or hygienic reasons. When a product or material is removed from its natural environment, it inevitably "reduces its usefulness for CE per the rules of thermodynamics (e.g., degradation or dispersion)" (Fabian Takacs, 2022).

The debate has focused on lack of knowledge and technology constraints as significant barriers to sustainable development in small and medium-sized enterprises. Concomitant with these difficulties is the challenge of attracting talent, which is a hurdle to advancement. In fact, SMEs offer fewer opportunities than large companies for what regards professional growth and benefits. However, companies highlight the growing interest around professional activities that are strongly committed to social or environmental impact. Always more committed companies are applying new practices in people management that put employees at the centre, recognising their value and wellbeing.

This situation is directly expressed by Manuel Tejedor, owner of *MAS Business*, in a comment taken from the SDG Observatory report 2023 (Castiñeira, 2023):

"The smaller companies are, the more difficult it is for them to attract and retain talent. There is no doubt in my mind that the driving force of organisations are people and their well-being is important for them to be able to give their full value. If sustainability is incorporated with conviction and have a model that puts employees at the centre at the centre, human resource management improves significantly."

Legislative barriers

Adopting sustainable practices by SMEs is frequently hampered by legislative impediments, which are characterized by complex regulatory frameworks and custom duties, covering a wide range of issues.

Firstly, general legislation can hinder the use of a CE because of its restrictive rules, such as those on hygiene and food safety. For example, plastic containers cannot be washed and re-used, so the only option is to throw them away after use. Another case is that of intellectual property laws, that may limit the ability of businesses to repair or repurpose products, preventing the full realization of CE potential. However, given the importance of both sustainability and the law, analysing their relationship is a difficult task. To create solutions that serve both goals, all stakeholders must carefully cooperate to find a balance between the need to promote sustainability goals and legal compliance.

On the other hand, specific sustainability norms and standards have been developed without taking into account the constraining circumstances of SMEs compared to larger companies. In fact, although economic instruments and mechanisms have been made available to businesses, the access to those remains a challenge for SMEs. The main issues are excessive bureaucracy (i.e., legal requirements for receiving subsidies and certifications processes), lack of adaptation to the reality of small organizations and slowness in actually obtaining funding: all reasons why companies may be forced to refuse support due to the extra effort involved. Uncertainty is also fuelled by rapidly changing regulations and the lack of a clear vision for sustainable change. Legislation, often price-driven, does not take sufficient account of sustainability or is ambiguous, causing confusion, especially for SMEs that cannot rely on dedicated departments to keep up with evolving regulations. It is then essential to simplify sustainability standards to clearly show the direction in which transformations should go.

Lack of standardization and institutionalized systems should also be mentioned between legislative barriers. A significant problem is the absence of well-established mechanisms for reverse logistics and collection, like the ones needed for the mobility industry to fuel gas or electricity. Establishing effective systems for the recovery and reuse of materials is challenging for SMEs since they frequently lack the size and resources to internally internalize such activities. Furthermore, the absence of uniformity among various entities makes things much more difficult, especially when it comes to packaging and shipment. In this context, collaboration between the various stakeholders is essential to integrate sustainable practices across different sectors and companies.

The aim of the summary table below is to summarise all the barriers discussed in the previous paragraphs.

Table 2: SMEs barriers

Scope of the barrier	Barriers
Economical and internal	• Limited economic resources. ➢ Difficulty in receiving funds. • Low level of knowledge and skills. • Lack of time.

Market and consumers	• Lack of transparency.
	• Unequal market power.
	  ➢ High bargaining power of consumers.
	  ➢ High bargaining power of suppliers.
	• Cheapness as dominant paradigm in society.
	• Fast moving trends.

Operational and supply chain	• Limited ability of communication along the supply chain.
	  ➢ Scarce offer of sustainable suppliers.
	  ➢ Large orders required.
	• Lack of horizontal cooperation with other SMEs

Technological and talent	• Proper characteristics of the product that inhibit eco-friendly solutions.
	  ➢ Unavailability of a solution.
	  ➢ Immaturity of the solution.
	• Difficulty in attracting talent.

Legislative	• Restrictive legislation. • Rapidly changing and not clear sustainability related norms. • Lack of standardization.

2.2 Immersive technologies in SMEs

2.2.1 Definitions and importance

The term *immersive technologies* refers to technologies designed to immerse the user in an artificial environment in order to create realistic sensations (Suh & Prophet, 2018). With the use of these technologies, users may add virtual information—in the form of data and images—to the real environment. This allows them to assess the effects of their decisions before they are put into action, saving money and guaranteeing everyone's safety (Dincelli & Yayla, 2022).

The family of immersive technologies include *augmented reality* (AR), *virtual reality* (VR) and *mixed reality* (MR) to achieve this immersion. The term *Extended reality* (ER) encompasses all three kind of immersive technology.

AR enables users to engage with virtual information superimposed on the physical world. This mediated immersion places digital resources throughout the real world, augmenting users' experiences, and interactions (Suh & Prophet, 2018). AR technology is often experienced through smartphones, tablets or glasses, which allow the user to see the digital overlays, but not to interact with them.

VR, on the other hand, hides the real world and immerses the user completely in a digital experience designed to simulate a real-life experience. Users are required to wear a headset with sight and sound in order to interact with the generated environment.

Finally, MR blends AR and VR, bringing together an environment in which physical and digital object coexist and can interact in real time. MR technology integrates virtual objects into the user's physical environment in a way that they can interact with and manipulate.

Figure 5, sourced from an *ARreverie* article (Prabhu, 2017), can help visualise the above definitions.

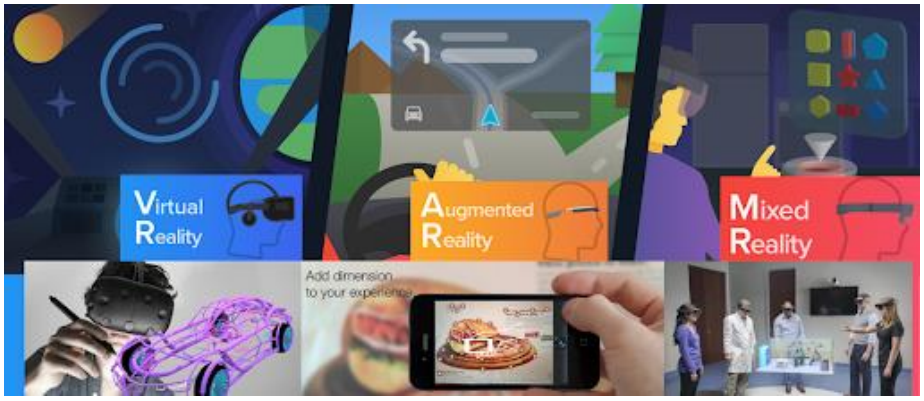


Figure 5 retrieved from (Prabhu, 2017)

The importance of immersive technologies is growing across a wide range of businesses and industries, who are using them to gain competitive advantage in a variety of ways. The implementation of the metaverse presents endless opportunities for logistics, manufacturing, enterprises, and other industries (Ooi & al, 2023).
With ER, companies can revolutionise customer engagement, training techniques, process visualisation, product design and more, increasing productivity and efficiency. However, even though the potential of immersive technologies could be exploited in many industries, it is the large organisations that have the greatest availability of these technologies, as they have the financial resources and the knowledge, leaving SMEs at the tail end of the competitive advantages derived from these technologies (Bilous, 2022). SMEs, in fact, often start by digitising administrative and advertising tasks, or by using electronic invoices similar to large companies. However, the differences are exacerbated when it comes to more complex technologies, such as ER, due to the barriers that have already been explored in the chapter 2.1.2**.**

Economic benefits have been the predominant driver for the application of immersive technologies in business. However, while there is a growing body of literature on the use of ER technology for environmental sustainability (Cosio & al., 2023), its potential has not yet been exploited on the social and environmental dimensions (Dabbous & al., 2023). In fact, immersive technology can help SMEs not only to mitigate rising operating costs, but also to reduce emissions and improving business environments by streamlining innovation processes (Abulrub & Al, 2012). For example, immersive technologies can help minimise the need for physical travel and infrastructure and, more generally, resource consumption by simulating scenarios without the need to physically build them, thereby reducing a company's carbon footprint. At the same time, they could promote inclusivity and remote collaboration with employees and customers, thereby contributing to social sustainability.

2.2.2 Factors influencing the adoption of Immersive Technologies

Drivers

Immersive technologies could offer a wide range of benefits to SMEs, depending on the sector or core activity of the organisation, that can drive their acquisition. They could improve various aspects of their operations, resulting in a significant competitive advantage in today's dynamic business landscape. Despite the challenges faced by SMEs, this section will explore the main potential benefits and drivers found in the literature that can be achieved through the successful implementation of AR and/or VR in day-to-day operations.

(Amuso & al., 2021) makes a first-level distinction of the benefits of XR for SMEs, stating that its role could contribute to improving either the efficiency or the quality of working relationships. This categorisation serves as a useful framework for identifying the basic generic areas of benefit for immersive technologies. However, the most common applications are analysed below in order to identify the diversification of these benefits depending on the type of activity.

Product design and development is the most common use case identified in the literature review. A major advantage over traditional product development is the ability to visualise the finished product and assess its problems before production, saving time, money and reducing risk. By gaining efficiency in this process, organisations could easily accelerate the product development task, with the benefit of getting to market in less time (Brettschuh & al, 2022). Moreover, this allows for a more effective buyer-supplier communication by intervening on production processes and identifying preferences during the virtual development (Ecorys, 2017). From a sustainable perspective, avoiding physical prototypes, could help reduce waste significantly. In addition, freeing teams from the expensive and time-consuming physical design process gives them more freedom to think differently, test new ideas and innovate (Five Benefits of Immersive Technology for Business), empowering them and fostering a culture of creativity. Immersive technologies could also improve relationships between employees in a remote working context, potentially connecting people from distinct parts of the world and clarifying the vision of the new product.

In a similar way to product development, planning and optimising the layout of facilities can be an advantage for SMEs. As before, it helps to save costs and time, but on a larger scale. In fact, virtual design does not interfere with ongoing production, allows different views (first person, top view...) and allows the simulation of different machine placements that would otherwise require a lot of effort. Safety planning and solving complex problems become easier and faster tasks, increasing the productivity of employees (Brettschuh & al, 2022). This is especially true when XR technologies are combined with predictive analytics, IoT and customisation that allow for the most realistic

simulations of day-to-day factory operations. For example, a logistics team could identify potential delays and bottlenecks and map alternatives using a virtual view of the plant (Ooi & al, 2023).

Another quite common mentioned driver was related to work-related training. First, training with immersive technologies can help speed up the learning process and increase knowledge retention (Five Benefits of Immersive Technology for Business). Indeed, (Cotrino & al., 2020) mention that VR-based training methods have a fast-learning curve, which helps new users to catch up with experienced users more quickly. In addition, XR in training could improve safety in the workplace by adequately training personnel in a safer virtual learning environment before they perform riskier tasks (Amuso & al., 2021), allowing users to become familiar with the environment and their tasks without taking any hazard. Finally, because this training style is accessible from virtually anywhere, it may save some expenses if the training often involves travel.

From a customer perspective, marketing activities using XR can create a competitive advantage and provide a powerful boost to SMEs. AR, can rely on smartphones to offer various degrees of simulation, allowing for a personalisation of the product experience; for example, a piece of furniture can be viewed in one's own home, or clothes can be tried on (Amuso & al., 2021). In this way, the process of connecting with the customer, even though through virtual technologies, is enhanced almost physically, maximising brand engagement. In fact, it is important to emphasise that personalisation, which can be enabled using immersive technologies, is a fundamental aspect of the customer experience. Such 'simple' things as allowing the user to change colours/sounds during the experience can help make it unique (Amuso & al., 2021). Finally, another advantage mentioned by (Brettschuh & al, 2022) is that large products can be showcased at exhibitions, for example through virtual tours, thus improving the company's image through the use of new technologies.

Strategically, SMEs that adopt XR could also attract talent. By demonstrating technological awareness and forward thinking, they would differentiate themselves and attract skilled people looking for a dynamic working environment.

As analysed, the benefits that immersive technologies could bring to small and medium enterprises are diverse and can come from their application in many areas of activity. The role of an organisation should be to critically analyse its own business and find areas of application for this technology. However, this should be accompanied by a deeper understanding of these technologies, by seeking information from similar companies or simply by immersing oneself in the world of XR. Depending on the sector, product or core activity, each organisation should assess whether the benefits would be game-changing and able to enhance their business.

After listing all the positive outcomes that could be achieved by using immersive technologies, it is possible to categorise the drivers as motivating factors for adoption into three categories. The first is competitive pressure: SMEs may feel compelled to adopt innovative technologies after seeing the market advantages that other companies have gained. Secondly, customer demand could also influence the decision of SMEs to adopt VR and AR, as customers increasingly demand a personalised customer experience. Finally, the third main driver capable of leading the metaverse revolution in SMEs would be the internal need to overcome specific operational inefficiencies, in terms of cost or time.

Enablers

Enablers facilitating the adoption of immersive technologies by SMEs are fundamental due to the significant influence that they can exercise in the overall cost, accessibility and success of the process (Jalo & al, 2022).

Government grants and subsidies exist specifically to support digital innovation among SMEs. These enablers can significantly increase the economic accessibility of immersive technologies in enterprises that satisfy the requisites. Policies and grants pushing for sustainable innovation are becoming an important part of the actual political ecosystem. Moreover, accessibility and cost reduction could be enabled by other entities of the businesses ecosystem, such as technological enterprises and other companies that could cooperate with the SMEs. Cooperation, in fact, could be a strong enabler in sharing costs and also in fostering a knowledge-sharing environment. For this purpose, networking events and industry fairs can be additional valuable tools to make the research and first approach to the technology easier.
Increased diffusion of the technology figures as an enabler as well (Jalo & al., 2022). It is possible to suppose that the advancement of AR and VR and their acquisition becoming more common in business environments of large scale will facilitate the consequent acquisition in smaller enterprises.

However, internal enablers are also fundamental in the organizations for a successful implementation of the immersive technologies. These would include top management commitment, strategic alignment, and recognition of value in R&D (Machado & al, 2021). Strong leadership committed to digital innovation, with a clear vision of a strategy that includes the implementation of XR, could be a powerful motivator and enabler. Indeed, it could lead the way in committing economic and human resources to research and development, employee upskilling and successful implementation strategies. Moreover, the management should foster an agile way of working, which would allow

employees to easily adapt to the changes given by the introduction of immersive technologies into the operations.

2.2.3 Barriers to the adoption of Immersive Technologies

As was covered in chapter 2.1.3, SMEs must face many challenges in order to adopt sustainable and innovative practices in their businesses. When it comes to immersive technology, the same obstacles exist, but some of them are exacerbated by the nature of these specific technologies. Chapter 2.1.2**,** where all barriers have been systematically analysed, will then be used as a reference point, and only those that are more relevant in the context of immersive technologies will be discussed in this section.

There are several reasons why SMEs face challenges in investing in ER, related to the lack of economic resources. AR and especially VR require significant upfront investments in hardware, software, and related infrastructure (Bastug & al., 2017), which often exceed the financial capacity of SMEs. Moreover, their implementation and the complexity involved in their maintenance figures as additional costs. In fact, the rapid growth of ER technology requires continuous monitoring and therefore costs associated with specialised training and customisation.

In addition to their expensiveness, (Brettschuh & al, 2022) individuated features of immersive technologies that hinder the investment of SMEs in their implementation. As already noted, VR and AR technologies are advancing so rapidly that it has become common for companies to release newer versions of their devices every few years, to keep up with higher quality graphics etc. (Woodhead, 2023). The rapid growth has led many large companies to invest consistent amounts of money in this technology thus increasing the competition and adding uncertainty about whether the investment costs will pay off.

Lack of features for VR and lack of standardisation are two other important limitations mentioned in the literature. The first refers to the fact that it is not easy to convert existing work material into virtual environments, e.g. the converting 3D projects from CAD to VR. The second concept, on the other hand, refers to the fact that there are no standard interfaces for these technologies, which creates the need for specialised personnel in order to implement and use these technologies. However, as analysed in chapter 2.1.2, lack of knowledge and skills and difficulty in attracting talent are some of the main structural barriers of SMEs. When digitalizing their processes, SMEs are missing employees with competencies concerning technologies and methods outside their main business, but also skills of owner-manager, such as entrepreneurial thinking and personal competencies encompassing flexible and sustainable mindset (Madsen, 2023). In fact, in these organizations there is often a low level on information about VR and AR technology, making it difficult for them to individuate a system that best suits their need; moreover the high effort required to implement ER in business is a concern for some SMEs (Bellalouna, 2020).

In particular, (Pessot, 2023) performed a case study research involving six Italian SMEs in manufacturing and service sectors investing in AR and/or VR solutions and found that the organizational issues, such as the need to raise awareness of the potential value of ER and the perceived need for training, emerged as more relevant than technological issues, such as the integration with company information system.

In summary, the main challenges that SMEs face in adopting Virtual and Augmented Reality, as identified in the literature analysed, are related to two main areas. The first is the lack of economic resources and the second is the knowledge and skills gap. The technical characteristics of immersive technology require expertise that SMEs often do not have and cannot afford. Implementing VR and/or AR in companies in an efficient way requires a high level of effort, which SMEs do not always find worthwhile to deviate from their status quo.

3. Case studies

3.1 Current sustainable practices in SMEs

This chapter explores the current landscape of adoption of sustainable practices in SMEs. Starting with an overview of the state of the art, it looks in more detail at trends, adoption rates and prevailing methodologies. To illustrate the real-world application of sustainable practices, a series of case studies are then presented, showcasing initiatives undertaken by SMEs in different industries. By demonstrating how sustainable techniques are adapted and applied in specific industries, this sectoral breakdown aims to provide actionable guidance for SMEs seeking to integrate sustainable practices efficiently into their operations.

3.1.1 Trends on sustainable practices in SMEs

A prerequisite distinction in analysing the state of the art must be made between environmental and social sustainability. Advancements in one aspect may in fact differ from those in the other.

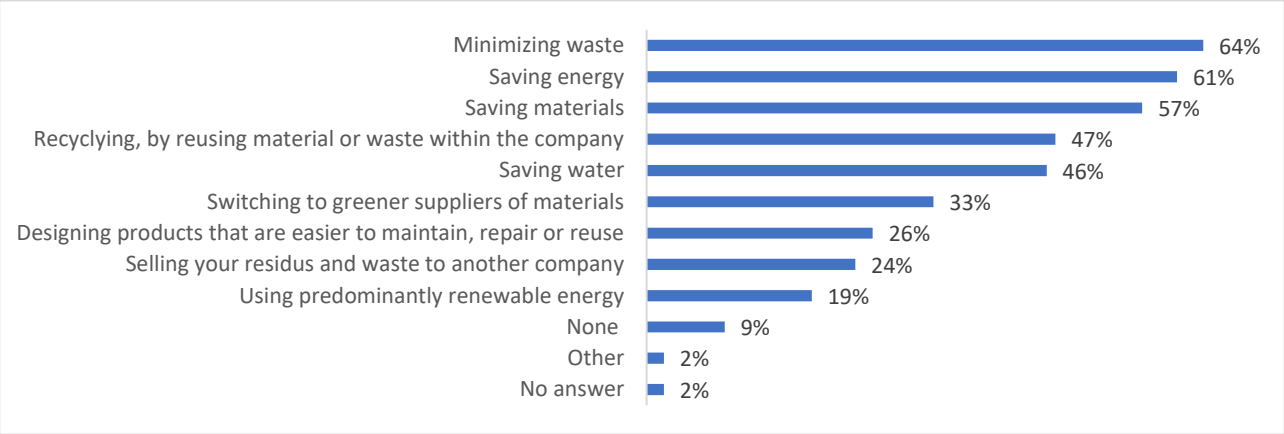
Recent years have seen a positive shift in the attitudes and behaviour of SMEs towards both environmental and social sustainability. While part of this can be explained by an increased awareness of environmental issues, it is also true that reporting standards and regulations are increasing and forcing SMEs to make changes. For example, the *Corporate Sustainability Due Diligence Directive*, an EU initiative, requires organisations to demonstrate that they have identified actual or potential risks to the environment and human rights throughout their supply chain. This means that all companies, including small and medium-sized enterprises, will have to demonstrate an awareness of environmental issues that was not previously required. This can only be a starting point to increase their knowledge and awareness in order to move their own business towards a greener path. Indeed, the chapter 2.1.1 has already discussed how lack of knowledge can be a major obstacle to innovative and sustainable business models. In this context, it was highlighted how important it is to show SMEs how ESG can be strategically important for them, for example in cementing relationships with key customers. IKEA, for example, is a large company that is indeed committed to creating a sustainable value chain and expects all its suppliers to sign a code of conduct based on the 10 principles of the UN Global Compact (World Economic Forum, 2023).

Consequently, despite the high barriers Small and Medium Enterprises (SMEs) face in pursuing sustainable and innovative business models, the importance of adapting to a greener world is rapidly being recognized, pushing forward an evolution that, whether wanted or not, must happen.

Environmental sustainability

The *2022 edition of the Eurobarometer on SMEs, resource efficiency and green markets* (European Commission, 2022) is a survey which covered around 16000 Small and Medium Enterprises in Manufacturing, industry, retail and services in the EU member states and in nine non-EU countries (Albania, North Macedonia, Montenegro, Serbia, Turkey, Iceland, Moldova, Norway and the US). The results of this survey clearly show how SMEs have taken action in recent years to make their operations more environmentally sustainable, and the following analysis is based on these results.

The first part of the analysis focuses on how small and medium-sized enterprises (SMEs) are implementing resource efficiency measures, as shown in *Figure 6.*



Source: own work based on the data from (European Commission, 2022)

Figure 6: What actions is your company undertaking to be more resource efficient?

It was discovered that the majority of SMEs (89%) are actively integrating practices to minimize resource usage into their day-to-day operations, such as energy conservation, waste reuse, and other sustainable actions. In particular, the most common resource efficiency actions undertaken by SMEs were those of minimizing waste, saving energy, and recycling materials within their own company. However, a minor part was also taking actions more impactful and strategic, such as switching to greener suppliers (33%), designing products easier to repair/reuse (26%), or using predominantly renewable energy (19%). These data show a positive trend in time: compared to 2017, SMEs using renewable energies increased of 5% and SMEs reusing material within their company grew of almost 10%.

Breaking down SMEs by sector allows for the identification of trends depending on the industry type to which they belong. Initially, it's important to note that SMEs collectively contribute significantly to total CO2 emissions by companies, accounting for 63% of all CO2 emissions. However,

Manufacturing, Electricity, Gas, Steam, and Air Conditioning Supply, and Transportation and Storage are the highest emitting sectors, while service sectors emit considerably less CO2.

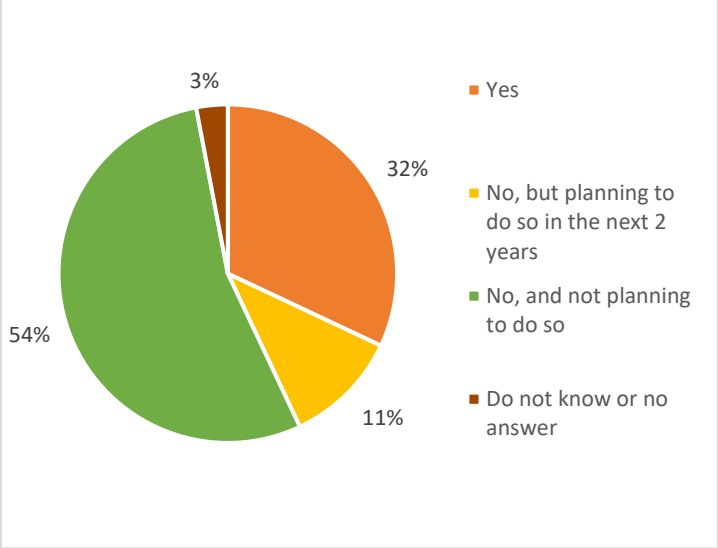
The trend indicates that, in general, sectors with lower emissions also demonstrate a smaller inclination to undertake resource-efficient measures. For example, the finance and insurance activities sector has the highest proportion of SMEs not implementing any actions (18%). Conversely, it is not always true that SMEs in the more polluting sectors (manufacturing and industry) have the lowest proportions of organizations not implementing measures. In fact, while manufacturing demonstrates one of the highest levels of implementation, with only 4% of SMEs not implementing any measures, the sectors of electricity, gas, steam, transportation and storage exhibit a high proportion of SMEs not implementing any measures.

Another trend observed was that the larger the SME in terms of employees, the more likely it was to implement most resource efficiency measures. However, when comparing in terms of turnover, a similar trend is only observed for the measure of selling residues and waste to another company, while no trend was observed for the more general measures of reducing waste, recycling, and saving energy. From this finding it is possible to hypothesise a possible correlation between the resource efficiency measures taken and the impact of the individuals working within the organisation: more employees may lead to greater awareness and reduced waste.

From a geographical perspective, the results show that the EU Member States most involved in resource efficiency measures are Sweden, Spain, Slovakia, Italy, and the Netherlands. In particular, SMEs in Sweden are highly active in several resource efficiency practices, including the use of renewable energy and the design of sustainable products. Spain, Slovakia, and Italy mostly show a prominent level of engagement in practices such as energy and material savings and waste minimisation. Ultimately, the Netherlands stands out for its use of renewable energy. On the other hand, Member States with a relatively low level of commitment, either by not participating in resource efficiency or by having a low level of commitment, are Bulgaria, Estonia and Poland. When comparing EU and US SMEs, the level of commitment varies depending on the practice. For example, US SMEs are less likely than their EU counterparts to engage in some actions such as energy and material conservation, but a higher proportion of US SMEs recycle by reusing materials and waste within the company than in the EU.

Overall, the adoption of resource-efficient practices is increasing among all SMEs, showing a growing awareness of sustainability issues. Despite differences between sectors and countries, most SMEs seem to have recognised the importance of resource efficiency for their business, in terms of cost savings, and for the planet.

The second part of the analysis aims to investigate the state of the art of SMEs in green markets, i.e. SMEs offering products or services with a predominant function of reducing environmental risks and pollution, including products with environmental features, such as eco-labelling or organic production. The results are presented in *Figure 7.*



Source: own work based on the data from (European Commission, 2022)

Figure 7: Does your company offer green products or services?

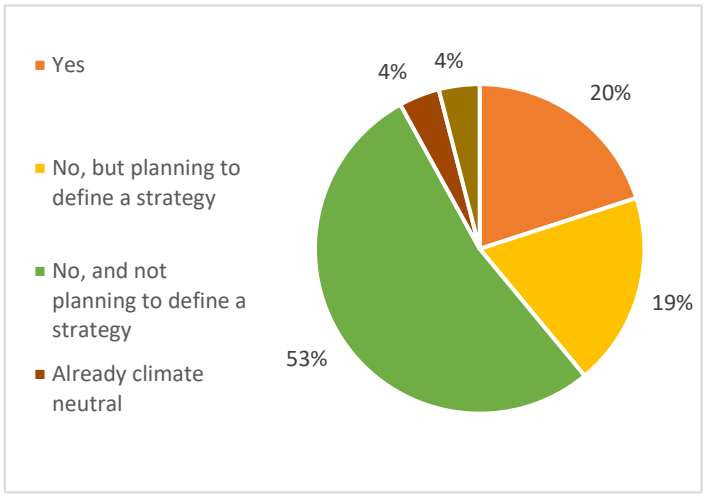
The data shows that almost a third of EU SMEs were offering green products or services in 2022, with a further 11% planning to do so within the next two years. These findings, together with those on the adoption of resource efficiency practices, show a positive trend. Specifically, compared to 2017, there was a 7% increase in the proportion of SMEs offering sustainable products or services and a 9% decrease of those not having plans to do so.

As expected, there are also differences in the level of involvement in green markets depending on the sector to which the SME belongs. Among the main findings, it was found that SMEs in the accommodation and food services sector were among the most likely to offer green products or services, while SMEs in other service sectors, such as real estate services and financial and insurance activities, were much less likely to do so. In the manufacturing sector, which was best placed in terms of resource-efficient applications, three out of ten SMEs report offering green products or services, indicating an average level of presence in green markets. However, SMEs in the industrial sector are slightly more likely to offer green products or services than those in manufacturing. For example, 35% of SMEs in construction and 42% in water supply, sewerage, waste management and remediation report offering green products or services, suggesting a relatively higher level of engagement in sustainability practices in these industries. One hypothesis to explain this discrepancy between these findings and the previous ones on resource efficiency may be that industrial sectors may produce or provide services that are more closely aligned with sustainability goals than

manufacturing processes. For example, the construction and water industries often involve projects or services that promote environmental sustainability, such as green buildings or water conservation measures.

A breakdown of the data by EU countries shows that SMEs that are more likely to offer green products or services are located in the Netherlands, Austria, Sweden, Finland and Luxembourg, suggesting a partial positive correlation with the finding on resource efficiency; however, Spain and Italy, which previously occupied high positions in the ranking, fall to average positions in terms of presence in green markets. On the other hand, the Czech Republic, Hungary, and Latvia have the lowest rates.
In terms of planned introduction, SMEs in Greece, Ireland and Romania were most likely to say that they were not offering green products or services but were planning to do so within the next two years. It is interesting to note that some countries at the opposite end of the scale in terms of actual uptake, such as the Netherlands and the Czech Republic, have relatively low proportions of SMEs planning to launch green products or services. The reasons for this result could be quite different basing on the country; perhaps Dutch SMEs are satisfied with their level of uptake, while the behaviour of Czech SMEs may be due to a low level of awareness.
Similar to the trend observed for resource efficiency measures, the presence of SMEs in green markets is growing positively, possibly indicating an increase in consumer demand for green products and services and a general awareness of the importance of having an environmentally friendly offer.

A third important part of this analysis, which aims to outline the future development of sustainable practices within SMEs, is the question of whether SMEs actually have a strategy to reduce their carbon footprint. The results are shown in *Figure 8.*



Source: own work based on the data from (European Commission, 2022)

Figure 8: Does your company has a concrete strategy in place to reduce your carbon footprint and become climate neutral or negative?

In this case, the percentage of SMEs not involved in developing a strategic plan for sustainability is quite high, reaching 72%. Only 20% of

the SMEs analysed claimed to have a concrete strategy on environmental issues, while only 4% claimed to have already achieved net-zero emissions.
Other key findings in the breakdown of the data reflect some of the trends already analysed. Firstly, organisations in the services sector are less likely to have or plan a strategy to reduce their carbon footprint. In addition, in line with their level of presence in green markets, SMEs in manufacturing are the least likely to have a carbon reduction strategy (15%), while those in industry are the most likely (23%). Again, the size of the SME in terms of number of employees seems to have an impact on the likelihood of having a concrete strategy. However, a trend not observed in the other cases is that SMEs founded between 2014 and 2020 are slightly more likely (24%) to plan to define a strategy to become carbon neutral than those founded after 2020 (22%) and those founded before 2014 (18%).

From a geographic perspective, the proportion of SMEs with a concrete strategy on environmental issues vary widely among countries: Sweden re-confirms itself as the country with most SMEs environmentally conscious in this sense, Austria stands out with 30% of surveyed SMEs stating they are already climate neutral. On the other hand, Cyprus, Hungary and Poland are the EU Member.
As part of this analysis, it might also be interesting to highlight the most common actions taken to become carbon neutral. Among the SMEs that report having a strategy, the most common actions taken are an overall reduction of the company's carbon emissions, the adoption/purchase of new technological solutions to reduce emissions and the development of new technological solutions to reduce emissions. The proportion of SMEs developing new technological solutions increases with the size of the enterprise and the impact of turnover on the decision to adopt or purchase new technological solutions.

To sum up, the *2022 Eurobarometer report on Small and Medium Enterprises (SMEs), resource efficiency, and green markets* offers a detailed overview of the current state of sustainability practices among SMEs. It shows that SMEs are becoming more conscious of the necessary changes they must make in their operations, with many already taking initial steps in this direction. However, a key finding from this analysis is that the green transition within SMEs is mainly starting with basic practices, such as resource efficiency, is slowly expanding to activities directly focused on reducing carbon footprints, but it’s still lacking strategic planning. These findings highlight the continued need to guide SMEs through the transition to a greener business in order to achieve consistent and meaningful change.

Tabella 3: Environmental sustainable practices in SMEs

Source: own work based on the data from (European Commission, 2022)

Sustainable Practice	Percentage of SMEs Engaging	Notes and Trends
Minimizing waste	64%	Top practice; reflects the high prioritization of waste reduction strategies due to regulatory pressures and operational cost benefits.
Saving energy	61%	A close second, highlighting the emphasis on energy efficiency for cost savings and the global push towards reducing carbon footprints.
Saving materials	57%	Significant efforts in sustainable sourcing and material efficiency, supporting the transition towards a circular economy.
Recycling within company	47%	Indicates a shift towards internal recycling initiatives, essential for resource conservation and reduction of environmental impact.
Saving water	46%	Reflects the growing awareness of water as a scarce resource and the importance of water management in sustainability reporting.
Greener suppliers	33%	Demonstrates SMEs' growing consideration of supply chain sustainability and preference for partners with green credentials.

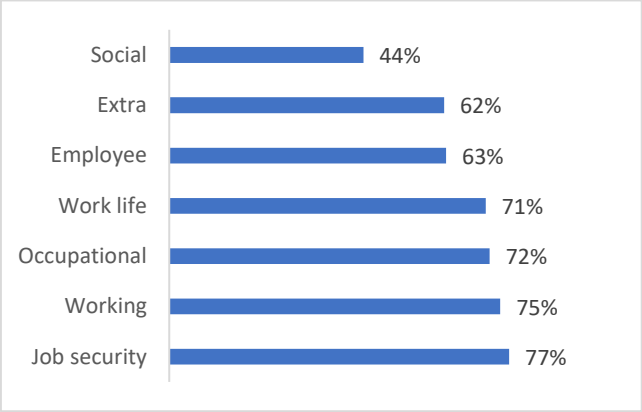
Repairable products	26%	Illustrates innovation in product design focused on durability, repairability, and the trend of moving away from the throwaway culture.
Selling waste	24%	Shows a strategic approach to waste as a resource, with potential revenue streams from waste sales and partnerships for waste-to-value conversions.
Renewable energy	19%	A clear trend of adoption, yet room for growth exists, especially in regions with renewable energy incentives and lowering technology costs.
Other practices	2%	Includes niche sustainability practices that could indicate emerging trends or industry-specific solutions.
None/No answer	2%	Potential area of opportunity for sustainability consultants and educational initiatives to engage with the non-responding segment.

Social sustainability

The state of social sustainability in SMEs is much less researched than environmental sustainability. Despite the lack of surveys and studies on the state of play focusing solely and systematically on social sustainability, the issue is becoming increasingly relevant and is included in the broader category of Corporate Social Responsibility (CSR). The following analysis will focus on those aspects that are closely related to social sustainability, defined as the practices adopted by enterprises to ensure inclusiveness and diversity, fairness and equity, social well-being and a good quality of life, inside and outside of the enterprise.

The report *Uptake of Corporate Social Responsibility (CSR) by European SMEs and start-ups* (European Commission, 2021) covers SMEs in 18 countries across Europe and can provide some insights into the current situation in some areas related to social sustainability. Those insights and the data they are based on will be used to explore the state of the art of social sustainability within SMEs, subdivided in different areas of activity.

'Decent work' was defined as fair treatment of all workers, decent working conditions and engagement in social dialogue, including freedom of association, elimination of forced labour and discriminatory practices. The results about the level of application in this area are shown in *Figure 9.*

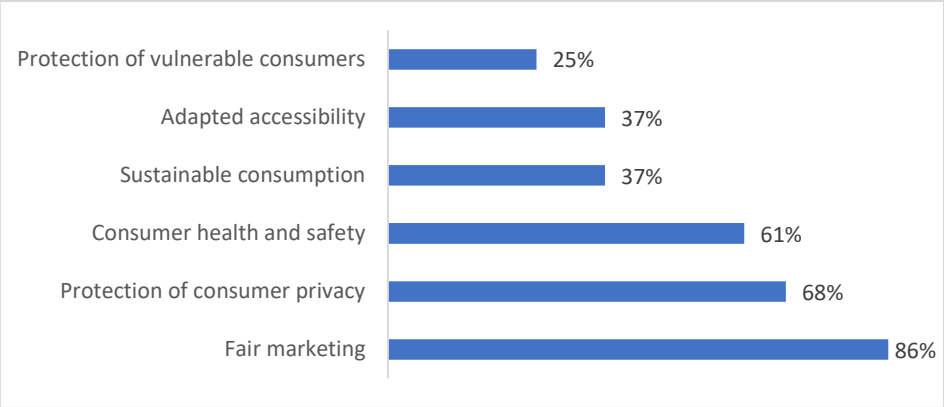


Source: own work based on the data from (European Commission, 2022)

Figure 9: Decent work practices covered by SMEs, by practice type

In this area, all SMEs showed a high level of compliance, albeit with differences based on specific practices. It was noted that practices linked to labour regulation (which is strong across the EU), such as job security, had the highest level of compliance, while practices left to the discretion of companies, such as employee development or social dialogue, had lower scores. Moreover, some activities remain mostly informal, especially within smaller enterprises, such as employee involvement or labour practices, including employment without official contracts.

Another area of interest of the analysis was that of 'business relationships with their consumer', meaning providing customers with accurate information, minimizing their risks, providing support and encouraging sustainable consumption. The results about the level of application in this area are shown in *Figure 10.*

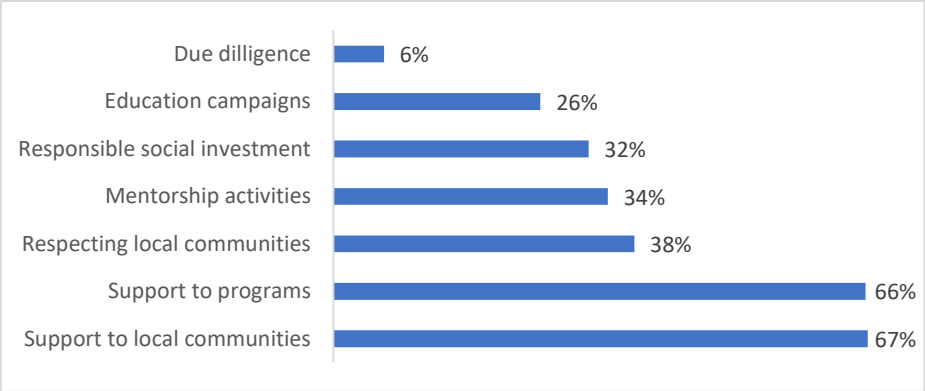


Source: own work based on the data from (European Commission, 2022)

Figure 10: Practices to ensure consumer benefit amongst SMEs, by practice type

As noted above in the discussion of decent work, it can be seen that those practices that are required by legislation are the most widely observed, while the voluntary measures, such as the protection of vulnerable groups, are less common. However, the overall treatment of customers remains at a good level, especially in the consumer-facing sector, as business success depends on customer satisfaction. An important factor to highlight in relation to environmental sustainability is that despite growing consumer awareness and demand for sustainable products/services, the provision of relevant information on sustainable issues and measures to promote sustainable consumption remains a major challenge for most SMEs. However, given the fact that consumer benefit is the second most important priority for SMEs after employees, it is reasonable to assume that these scores will increase in the coming years.

An additional analysis parameter was the ‘degree of community involvement’, which describes how responsively and positively a business engages with the community it belongs to. Examples of this include providing employment opportunities to individuals who are in need (such as refugees or people with disabilities) or dedicating a portion of employee work hours to volunteer work. The results, in *Figure 11*, show a general limited uptake of practices toward this goal within the surveyed SMEs.

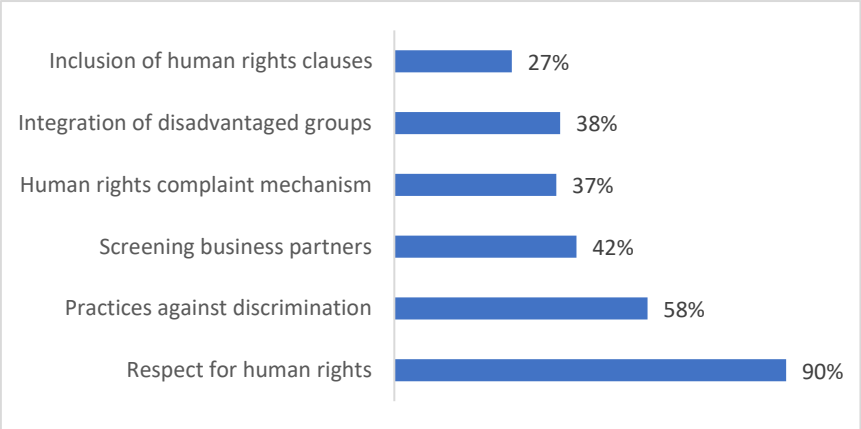


Source: own work based on the data from (European Commission, 2022)

Figure 11: Practices to benefit communities amongst SMEs, by practice type

The most common activities were: supporting sports, local institutions/programmes, training/employment of young people and buying local. An interesting trend was that SMEs in countries with strong traditions of cooperation and networking tended to be more involved in community activities: for example, Italian SMEs cooperate extensively with NGOs, church organisations and social cooperatives. In terms of sectors, it was found that certain sectors, such as banking, finance and insurance, tended to be more involved in community activities. However, the low overall average could be explained by the fact that engaging in community involvement and development activities requires companies to have sufficient capacity and knowledge, which SMEs often lack.

The area of human rights was analysed in terms of respectful treatment of all individuals, regardless of their personal characteristics, not only internally within the organisation, but also active efforts to ensure equal opportunities and to disadvantage those suppliers who do not comply with these standards, through the practices shown in *Figure 12*.

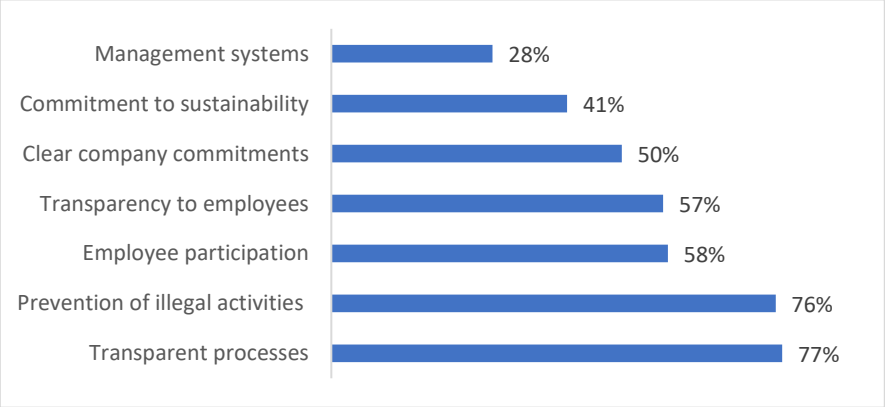


Source: own work based on the data from (European Commission, 2022)

Figure 12: Practices in the area of human rights amongst SMEs, by practice type

With the exception of the most common practice of respecting human rights, other practices were of limited adoption. Indeed, many of the SMEs surveyed reported having official internal protocols to ensure equal opportunities, non-discrimination, and protection against harassment. However, many SMEs lacked proactive efforts to address, for example, human rights issues downstream in their supply chain. In this sense, the textile and clothing sectors stood out as the most active, due to increasing social pressure.

Organisational governance was an area of the survey relating to the way in which business is conducted on a day-to-day basis, ideally in an accountable, transparent and ethical manner, avoiding illegal activities. The results of the adoption of some of the practices associated with this area are shown in Figure 13. Activity in this area was generally moderate among the SMEs surveyed, but more prevalent in sectors where transparency is necessary to ensure credibility, i.e. pharmaceuticals and financial services. Moreover, larger companies were more likely to engage in such activities, while small companies often considered them to be of little value. In fact, particularly in smaller family-owned enterprises, some of the owners of SMEs consider governance procedures and certifications to be unnecessary formalities.



Source: own work based on the data from (European Commission, 2022)

Figure 13: Practices in the area of governance amongst SMEs, by practice type

Table 4: Social sustainable practices in SMEs

Social Practice	Engagement Level	Notes and Trends
Decent Work	High compliance	Compliance driven by strong EU labor regulations; variability observed in voluntary practices like social dialogue and employee development.
Consumer Relations	Good overall treatment	Customer-facing sectors excel due to direct business impact; challenges remain in conveying sustainable values and information.
Community Involvement	Limited uptake	Higher engagement in SMEs from countries with cooperative cultures; sectors like banking and finance show notable participation.
Human Rights	Formal protocols in place	Textile and clothing sectors proactive due to social scrutiny; efforts to address supply chain human rights are emerging.
Organizational Governance	Moderate activity	Greater emphasis in sectors requiring transparency; larger SMEs more likely to engage, while smaller ones view it as less critical.

3.1.2 Best practices

Manufacturing industry

Garlita (*Figure 14)* is a family-owned, medium-sized Lithuanian company with 155 employees (rekvizitai.vz.lt, 2024) specialised in the production of knitwear. It was founded in 1990 by Juozas Martikaitis and is now run by him and his two daughters. The products they offer are knitwear for sports, fashion, uniforms, home textiles and other accessories. However, those products are more complex than average for the sector: they can have, for example, windproof linings, and different treatments, such as anti-mosquito or self-cleaning, can be applied to them. A statement by J. Martikaitis, *"Innovation and high technologies are the essence of all our products"*, is a basic starting point to understand the philosophy of this company, which follows up to date production techniques. However, the development that this company is pursuing is purely sustainable and, thanks to this, it has become an example of good practice in the SME sustainability landscape.

Figure 14: Garlita's logo

One of *Garlita*'s management goals is to involve as many people as possible in the movement towards sustainable, traceable, environmentally friendly and degradable knitwear. Their production processes are designed to minimise emissions and actively combat air pollution and global climate change. They produce organic knitwear made from natural fibres grown and processed without the use of synthetic pesticides, fertilisers or other harmful chemicals. They also use renewable energy produced by solar panels on the roof of their factory (*Figure 15*), another measure that demonstrates their commitment to the fight against global climate change. Their commitment is not only to environmental sustainability, but also to social sustainability. They believe in offering high quality products in order to build long-term and mutually fair relationships with their customers. At the same time, they aim to build strong relationships with their suppliers, emphasising transparency throughout their supply chain and prioritising suppliers who share their commitment to ethical and environmental responsibility.

The company has actively participated in numerous EU projects, seeking financial support to reduce its CO emissions and promote its positioning as a fully sustainable manufacturing company. In 2017, *Garlita* took advantage of the European funding measure "*Renewable energy sources for industry LT+*" to install a solar photovoltaic power plant with a capacity of 150 kW, which would produce 138000 kWh of energy per year and would allow to reduce electricity costs by approximately 43

thousand euros per year. In 2019, in order to increase energy efficiency, it was decided to install another solar power plant with a capacity of 150 kW, next to the one previously installed. Using the capacity of the existing and the newly installed solar power plant, *Garlita* was able to produce about 53% of the total energy consumed in the company from renewable sources.

Figure 15: Garlita's factory

In 2021, within the framework of sustainability of a social nature, the company implemented the project "Production of antiviral textile products", with the aim of introducing new products that protect against COVID-19 (i.e. antibacterial/antiviral protective masks, masks/scarves).

Finally, as an important recent milestone, Garlita has participated in the "Installation of electric car charging points in the workplace" project and has planned to install an electric car charging station with two access points in 2023.

Garlita also holds numerous certifications that demonstrate its commitment to ethics, sustainability and quality. The company is registered with EMAS (Eco-Management and Audit Scheme), a management tool that allows companies to evaluate and improve their environmental behaviour; to obtain this registration, the company had to carry out an environmental audit that took into account all the organisation's activities, establish an environmental management system with clear objectives and provide a statement of actual performance. The company is ISO 14001 certified and complies with this environmental management system standard, which covers everything from resource use and waste management to stakeholder involvement in environmental commitments. Garlita is also ISO 9001 certified, demonstrating its commitment to quality and continuous improvement of its quality management system.

Garlita's commitment to sustainable manufacturing is based on its desire to be innovative and environmentally friendly. From the information gathered, it can be individuated that EU-funded projects and investments in renewable energy have acted as important enablers for *Garlita*, enabling the company to implement green manufacturing processes. On the other hand, it can be inferred that among the barriers that can be encountered are those related to financial constraints and therefore the need for external funding for larger projects. In addition, maintaining a transparent and ethical supply chain is seen as a barrier that *Garlita* has succesfully overcome.

Retail Industry

Biovega is a medium-sized Croatian company with 170 employees and is a leader in the retail and distribution of organic products, from food and food supplements to household products and natural cosmetics. It has been founded in 1994 by Zlatko Pejić and Jadranka Boban Pejić as a result of their willing of sharing their lifestyle based on a passion for ecology and sustainability.
The company's main brand is *bio&bio*, a chain of 21 organic food stores throughout Croatia, but in addition to its core business, the *Biovega* group also includes an organic farm, a restaurant, an adult educational institute, and a publishing house.

All Biovega's activities and behaviours are based on three core values: ethics, ecology and economy. Firstly, ethics is manifested in every aspect of the company's behaviour, from the treatment of all stakeholders involved (employees, customers and partners) to compliance with legal regulations and business standards. Secondly, Ecology is the foundation of the business itself, in the quest for continuous improvement to be more environmentally sustainable by promoting eco-production, recycling materials and saving energy and resources. Finally, Economy, as a core value, outlines the sustainable development approach that this company puts into practice: the investment of profits in the development and improvement of the business through certifications and compliance with standards, the promotion of a transparent business model and the development and adoption of fair-trade business principles.

Figure 16: Logos of the Biovega activities

Biovega's mission is to educate customers and companies in the balance of ethical, environmental and economic values, to create an environment for sustainable development and to highlight the importance of the interrelationship between all stakeholders of the company. Recognising that employer and employee, producer and seller, and seller and buyer are partners, the company pursues a vision of 'development partnership', encouraging collaboration with the aim of creating a sustainable business ecosystem. For example, *Biovega* started a partnership with local organic farmers, encouraging them to increase production by guaranteeing the purchase of their crops, and today works with about 40 farmers in Croatia, offering fresh and organic produce in its *bio&bio* stores. As another example of cooperation, *Biovega* has standardised its business activities and offers interested partners the opportunity to open specialised stores.

The company also focuses on maintaining a strong and healthy relationship with its employees, encouraging them to participate in the business by expressing their opinions and contributing to a pleasant working environment. In recognition of its commitment to employee welfare, in 2014 the Croatian Association of Employers awarded *Biovega* a prize for special care of employees.

With regard to its core business activities, *Biovega* sets strict criteria for the selection of the organic products it offers. The products distributed must meet a number of business standards and conditions, including organic certification, pesticide and heavy metal analysis, clear labelling with LOT numbers and shelf-life information. In fact, the company maintains a comprehensive quality control system. For example, it uses an ISO 9001 system to improve business planning and develop quality awareness within the organisation, and it was registered to the HACCP food safety system before it became a legal requirement. It has also established an internal audit function to manage specific requirements in relation to ecological standards and environmental monitoring.
However, the fulfilment of the obligations and criteria guaranteed by the eco-certificates is only the basis of *Biovega*'s activities. Special attention is paid to the choice of partners, preferring those with more experience in the market of ecological products, for whom the ecological choice is also an activist mission, and domestic Croatian producers. Added value criteria are also fundamental in the selection of products sold in *bio&bio* shops, including offering food that is as little processed as possible, not selling any kind of meat, and requiring certified sustainable conditions for animals producing dairy products and eggs. By 2020, the company has been able to replace the plastic packaging of all products sold in *bio&bio* shops with compostable packaging made of cellulose fibres, which can be completely decomposed.

Makronova is the adult education institute that is part of the Biovega company and is worth mentioning as part of the best practices in the sustainability landscape. Its main objective is to promote healthy lifestyles and educate people on how to achieve a quality and sustainable lifestyle through educational programmes such as cooking workshops, exercises and seminars. To date, more than 50,000 people have participated in *Makronova* programmes.
Always in pursuit of educational goals, Zlatko Pejić implemented the "Earth Station" project, which consists of an ecological estate (called '*Zrno'*) that presents a model of self-sustaining agriculture and minimal ecological footprint. *Zrno* covers an area of 20 hectares of agricultural land, where space is observed, studied and reorganised at all levels (underground, surface, atmosphere and stratosphere). The entire living world, from micro-organisms to plants and animals, is treated synergistically, as part of a unique cellular system. As the mission of this estate is zero waste and sustainability, Zrno offers an example of the future of ecological, sustainable production in Croatia.

Biovega is guided by core values of ethics, ecology, and economy that drive the business toward sustainability. Their engagement is guided by partnerships with area organic producers and emphasis on education of consumers to view them with the community. The most important challenge they face is the strict requirements to be certified as organic, challenging them in maintaining the standards that are useful in operative complexities.

Hospitality Industry

Much Better Adventures is a small British travel agency with 50-55 employees (Linkedin, 2024). Founded in 2010 by Alex Narracott, Sam Bruce and Guy Bowden, it now offers over 180 outdoor adventures in wild places, including many activities (walking, cycling, snorkelling and more), with a focus on small group travel and low impact tourism.

Figure 17: Much Better Adventures' logo

Their aim is to encourage people to travel to wild places, to be in direct contact with nature, and at the same time to fight for the protection of these places by offering high adventure and low impact exploration. Their most important contribution to ensuring low impact is supporting a community of independent and locally owned businesses around the world and protecting the environment in which they live.

From a business perspective, *Much Better Adventures* offers instant online booking of exclusive, organised outdoor trips on the client side and a fully automated booking system on the host side. By working with 100% local, independent businesses, their platform model ensures that for every $100 spent, an average of $78 stays in the local economy. To compare, according to research by the United Nations Environment Programme (UNEP), in typical mass tourism, only $5 of every $100 spent goes to local communities. In fact, not only the hosts but also the guides who work with *Much Better Adventures* are local specialists who know their terrain better than anyone else. In this way, the company creates jobs and sustainable economies in rural areas, helping to preserve unique and fragile environments. In an educational effort, the company also offers a *magazine* of case studies exploring how ecotourism can help local communities and biodiversity around the world.

On the customers' management side, the company encourages sustainable travel practices, such as minimizing waste, conserving water and energy, and respecting wildlife and natural habitats, promoting a 'no-trace' principle to ensure that their activities have minimal impact on the environment.

Although its core business has the greatest impact on sustainability, *Much Better Adventures* also actively supports the fight against climate change through its own foundation, to which it donates 5% of its revenues. This foundation focuses primarily on reforestation and rewilding projects, selected for their potential to remove at least twice as much carbon from the atmosphere as is added by the company's tours. In particular, *Much Better Adventures* supports *World Land Trust* to achieve net-zero emissions from its trips and the *Buy an Acre* programme to help local communities protect their habitats and reserves.

In terms of internal sustainable management, the company has a climate action plan to reduce its emissions from 35kg/customer/night (data of 2021) to 17kg/customer/night by 2030. To achieve this, *Much Better Adventures* transparently reports its carbon footprint and an assessment of its progress each year. In particular, their action plan is made up of four areas: *measure*, *reduce*, *eliminate* and *campaign*. Firstly, a carbon footprint is calculated for each trip, estimating emissions for all local transport, accommodation, activities, guides, staff and office operations, and food, using a publicly available methodology. This in-depth analysis identifies areas for improvement to further reduce emissions (for example, phasing out higher carbon accommodation options, adjusting menus and transport options, but also expanding the range of destinations accessible by train). In addition, by partnering with a number of environmental organisations, the company aims to offset some of the emissions and spread its mission among global tourism leaders.
Indeed, part of *Much Better Adventure*'s mission is to spread the movement against climate change in tourism, working towards the widespread adoption of eco-practices throughout the hospitality sector. To this end, the company works with NGOs and environmentalists and co-founded the Tourism Declares movement in 2020. This movement led to the Glasgow Declaration at COP26 (UN Climate Change Conference) a year later, an agreement to accelerate climate action in tourism by halving emissions by 2030 and achieving net zero emissions by 2050.

Much Better Adventure's commitment to sustainability in all of its operations has led the company to achieve the B Corp certification in 2022, which recognises for-profit companies for good social and environmental performance. B-Lab, the non-profit company that issues this certification, calculates an impact score for companies based on an in-depth assessment of their governance and impact on employees, community, environment and customers. The minimum score to achieve B Corp status is 80, and Much Better Adventures scored 117, compared to an average of 51 for ordinary companies. Breaking down this score, the company has received the highest score in the 'Community' assessment thanks to its 'Impact Business Model', which is a business model that is intentionally designed to

create a specific positive outcome for one of its stakeholders (bcorporation, 2022), in this case, the local communities.

Much Better Adventures is driven by a mission to protect the world's wild places. In this case, the strong commitment and internal awareness of sustainability was the strongest driver for implementing a sustainable business model. On the other hand, from the information gathered, it is possible to hypothesise that the company faces the challenge of scaling its impact without compromising its core values. It is also possible to note that one obstacle that the company has successfully overcome is that of transparency in the 'supply chain', in this case the local communities involved in the organised trips.

Technology Industry

Fairphone is a Dutch electronics company with 70-80 employees that is building a market for ethical smartphones, including phone accessories and earphones. The company's exemplary nature is first and foremost demonstrated by the products they design and sell, all of which are modular in design. The company started as an awareness campaign about the use of conflict minerals and mining practices in the electronics industry, and the movement grew into a business in 2013. The pillars of *Fairphone* mission are longevity, circularity, fair materials and good working conditions.

Figure 18: Fairphone's logo

All *Fairphone* products are projected to last, pursuing a disruption of the average programmed obsolescence typical of the tech industry. *Fairphones*, which is the name of the phones of the company, possess hardwares designed to maximize longevity, featuring modular parts that make them easy to repair. Additionally, the company offers support to keep the software always up to date. Encouraging longevity is important: 1.5 billion smartphones are sold worldwide each year and, taking into account the carbon emissions caused by the production, transport, use and waste of each new phone, the selling of each phone creates CO2 emissions equivalent to the use of just one smartphone for 10 years. In fact, 75% of all emissions come from the production of a phone, so keeping it for longer reduces CO2 emissions significantly. In addition, the production of spare parts generates significantly less CO2 than the production of the phone itself, which is why *Fairphone* uses a modular design. For example, the latest model, *Fairphone5* (*Figure 19*), contains a battery that lasts for a day

and can be replaced immediately, a screen that can also be replaced with a screwdriver, as well as the power connector.

To reduce e-waste and increase circularity, *Fairphone* strives to use as many recycled materials as possible. Not only is 100% recycled plastic used in smartphones and other accessories, but also recycled rare earth elements. In particular, to achieve the best impact, the company seeks fair sourcing of recycled materials and invests in small-scale waste collectors. *Fairphone* is also encouraging new customers to recycle their old smartphones, exploring significant electronics recycling opportunities and reducing e-waste globally. In 2022, it has diverted 15 tonnes of e-waste from unsustainable disposal.

Fairphone chooses fair materials, meaning that the sourcing of these materials should benefit the people and communities involved in their production and processing, without leaving aside the aim of protecting nature and the environment. The company is focusing on 23 materials that have the greatest impact on people and the planet, and for which demand is growing with the electronics industry (e.g. bauxite, cobalt, copper, etc.), and aims to dig deep into the supply chain of each of these materials to determine best practices to undertake. At present, its guidelines for mined materials are to invest in, and source from, artisanal and small-scale mining, to ensure living wages and improve the quality of life for mining workers, and to protect and restore the natural environment.

Linked to fair materials sourcing, is *Fairphone'*s fourth and final pillar: good working conditions for all workers involved in the industry along the supply chain. Working with suppliers is fundamental to addressing the needs of all workers and local communities involved in the production of a smartphone, from source to assembly. Emphasis is placed on the workers as people, prioritising their job satisfaction with income and opportunities for growth. In addition, *Fairphone'*s supply chain is completely transparent, and many suppliers are featured directly on the company's website to demonstrate that everything should and can work in a sustainable way.

Fairphone's business is permeated with the activist ideology from which it has evolved, and in this sense it aims to share its activities and best practices to motivate the whole industry to act more responsibly. For this reason, they share many articles that highlight issues related to the electronics industry and its relationship with climate change, as well as others that showcase their practices to address these issues.

Fairphone has been certified as a B Corp since 2015 and has achieved a score of 122 in 2021. It has a strong commitment to consistently reporting its actions and has a climate action plan in place. The company's main goal is to be net-zero by 2045, which is a high ambition considering that only 2% of business-related emissions are directly dependent on the organisation, namely the CO2 emissions generated by *Fairphone*'s office in Amsterdam. The remaining 98% are Scope 3 emissions, i.e. all emissions that occur throughout the value chain. To eliminate these, the company is committed to working closely with its suppliers to help them adopt sustainable practices and reach a common green goal. With a target to reduce scope 1 and 2 emissions by 46% by 2030, compared to a base year of 2019, *Fairphone* is in line with the 1.5 degree pathway of the 2015 Paris Agreement.

Figure 19: Fairphone5

Fairphone's journey in the technology sector is driven by its core mission to integrate fair labour practices and reduce environmental impact. In this sense, awareness of the issue has been a key driver since the company's inception; in fact, mission and business are fundamentally intertwined. One barrier the company may face in its commitment to transparent and ethical sourcing is related to the challenges of transforming the complex electronics supply chains and overcoming industry inertia against sustainable practices.

Services Industry

Tomorrow is a German fintech company with 120 employees, offering sustainable banking services. It was founded in 2018 by Inas Nureldin, Jakob Berndt and Michael Schweikart with the vision of actively using money to create positive change for the environment and people. Today, it serves 120000 customers and operates in partnership with Solaris SE, which provides the banking infrastructure and licences, while Tomorrow focuses on the customer-facing factors.

Figure 20: Tomorrow's logo

The company's commitment to sustainability is integrated into all its operations, ensuring sustainable banking products and investment strategies. Customer deposits are invested in sustainable projects such as renewable energy, clean transport or social housing, and *Tomorrow* is committed to not financing industries that harm the environment or society, such as the arms or fossil fuel industries. To choose where to invest, *Tomorrow* follows a strict list of criteria based on the United Nations' SDGs, divided into five categories: meeting basic needs, empowerment, climate action, nature and equity. Only companies or projects dedicated to at least one

of these five categories are eligible for funding, even if the final assessment is made by the company's Impact Council, made up of independent and interdisciplinary members. Social bonds (which finance projects addressing social issues such as housing and basic needs), green bonds and blue bonds (which finance environmental projects and the conservation of marine resources respectively) play a key role in this investment strategy. It is worth noting that Tomorrow allows its users to invest easily through their banking app and with small amounts, motivating all customers to play their part in the fight against climate change. Moreover, from 2021, *Tomorrow* offers an equity fund (*Tomorrow Better Future*) in line with the Paris Climate Agreement, which only includes companies that meet more than 100 sustainability criteria, giving clients the opportunity to invest in a portfolio of fully sustainable companies.

Other sustainable initiatives are built into *Tomorrow*'s products: for example, every time a customer uses a *Tomorrow* card, a portion of the fees associated with the transaction is used to fund climate change projects. The impact of card payments in 2023 is equivalent to restoring 3.3 million m2 of land in South Africa by planting native spekboom. Another way to motivate customers to contribute to sustainable causes is the 'rounding up' feature, which allows users to choose to round up their payment to the nearest euro when making a payment. Funds raised through this feature supported education initiatives in Uganda and recycling infrastructure in Nepal in 2022.
The *Tomorrow Zero* account is a bank account that the company has launched to provide a comprehensive sustainability-focused banking option, starting with the provision of a wooden debit card instead of a plastic one. This type of account supports projects that have a holistic approach to climate change: not only to offset CO2 emissions, but also to restore ecosystems; in this context, a strategic choice made by Tomorrow was to invert money from reforestation in Brazil to the spekboom renaturation in South Africa.

Beyond banking, Tomorrow directly supports sustainability and social justice in lateral ways. First, it actively participates in social movements, community engagement and public demonstrations (such as the Friday for Future protests). Secondly, it regularly publishes transparent and detailed sustainability reports showing the impact of its financial activities. Finally, Tomorrow also works in partnership with other sustainable brands, giving its users the opportunity to discover new sustainable alternatives and take advantage of discounts. Given its activist commitment to sustainability, Tomorrow has been certified as a B Corp since 2020, with a score of 118.

Tomorrow's fintech solutions are driven by the vision of using finance for good social and environmental change. In this sense, community engagement and advocacy for sustainable banking practices are fundamental drivers that make their mission possible. On the other hand, the obstacles

they may face are related to strict financial regulation and the challenge of influencing traditional banking norms to fully integrate sustainability into financial services.

3.2 Current immersive technologies in SMEs

The aim of this chapter is to establish the current state of play in terms of the adoption of immersive technologies by SMEs, highlighting trends across industries and applications. The second part of the chapter presents a number of real-life case studies of SMEs either offering VR-AR platforms for other organizations or using immersive technologies in their operations. By showing how immersive technologies can be adapted to different industries, this part of the chapter aims to provide guidance to SMEs wishing to integrate these technologies into their business.

3.2.1 Trends on immersive technologies

The current adoption of Extended Reality technologies by businesses is still in its early stages. When it comes to small and medium enterprises, the uptake is even more limited, due to the fact that these companies tend to lag behind larger companies in the adoption of digital innovations. As a result, comprehensive reports on the adoption of XR technologies in SMEs are scarce, with only a few studies providing insight into the level of awareness and adoption. These existing studies are reviewed below, but broader trends in immersive technologies in the enterprise are also discussed, particularly in terms of sectors and purpose of use. Indeed, these trends are considered to be potentially relevant and relatable to the SME context and may provide valuable insights and implications for smaller businesses.

Researches by (Pessot, 2023) and (Jalo & al., 2022) show that European SMEs have variable levels of awareness and, consequently, of adoption regarding immersive technologies: while many companies recognize the potential of AR and VR to drive innovation in their business, significant constraints, already discussed in chapter 2.2.2, limit the effective adoption of these technologies. However, it was found that when SMEs do adopt XR technologies in their operations, they tend to innovate in multiple directions, suggesting that these companies are engaging in strategic and well-thought integration of these technologies. These are often companies in tech-savvy industries or those led by forward-thinking management.

In line with a wider trend affecting the diffusion of innovation in enterprises, it was also found that SMEs that are part of a dynamic network are more likely to adopt immersive technologies due to peer influence and shared learning. For example, industry clusters or technology hubs often facilitate events, workshops or seminars where SMEs can see practical applications of AR and VR and develop an interest in using them.

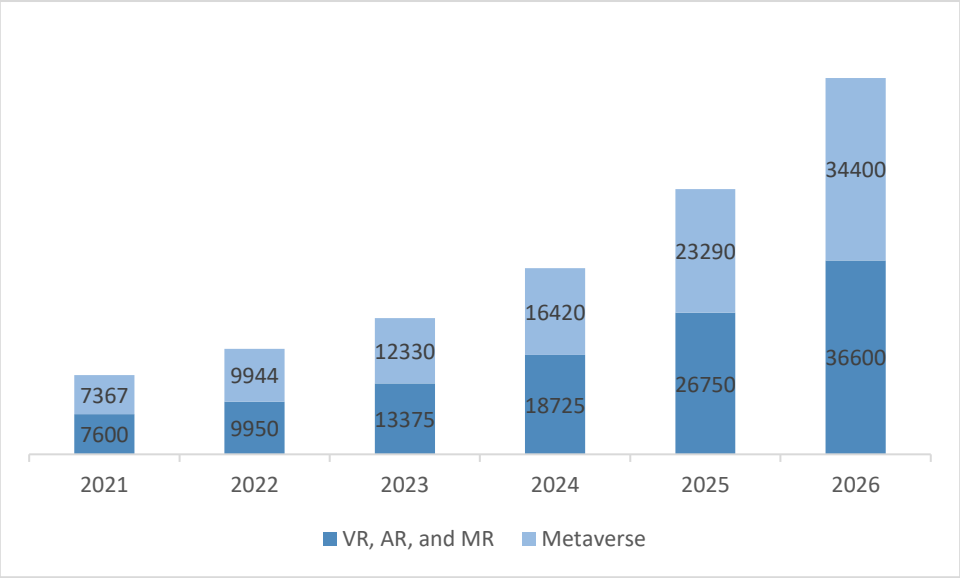
The adoption of VR technologies also shows clear trends across different sectors. According to the studies, in manufacturing, VR is primarily used to improve design accuracy and streamline production processes, while AR helps with maintenance and assembly tasks. In retail, AR enhances the customer

shopping experience through virtual try-ons and product visualisation, helping to reduce return rates and increase customer satisfaction. The service sector is also heavily impacted, particularly in healthcare, education and tourism, where immersive technologies offer more engaging and interactive experiences, particularly for learning or travel.

Other trends in the use of immersive technologies can be found by extending the scope to larger companies. Although not directly within the scope of this study, it may be interesting to highlight these trends in order to anticipate future developments that may impact SMEs in the near future. The consultancy firm *Pwc* recently published a comprehensive article (PWC, 2024) outlining how immersive technologies are currently approaching a critical mass of adoption across a range of industries. First and foremost, XR technologies will become increasingly embedded in everyday business operations, thanks to improved user experience and the integrated availability of everyday workplace applications. In fact, the now possible ability to use 2D applications in a 3D environment Immersive technologies are driving new ways of working that will become increasingly common: not only in terms of remote working, facilitated even when close collaboration is required, but also in terms of improved access to information thanks to mixed reality when performing highly technical and precise tasks. For example, Mixed Reality is already being used to visualise in 3D and in real time insights into machine components, infrastructures during design processes or insights into medical procedures.

XR aims to revolutionise commerce through virtual try-ons and visualisations of products in real-world environments. This capability will be fundamental not only to enhance the consumer experience, but also to improve the interaction with supply chain partners and support teams, gaining a very efficient process of decision-making.

The European market for immersive technologies is expected to grow at a rate of 36% per year to reach $71 billion by 2026 (Acciò, 2023). In addition, companies such as Meta are investing heavily in virtual environments and major European tech hubs are fostering innovation in immersive technologies by supporting R&D in hardware and software. These findings anticipate the potential scalability of the technology, with a variety of immersive devices expected to rapidly increase, encouraging adoption across different sectors and sizes of organisations. The process is also expected to be amplified by current advances in generative AI technology, which has the potential of speeding up the creation of complex immersive environments, thereby reducing costs.



Source: own work based on the data from (Acciò, 2023)

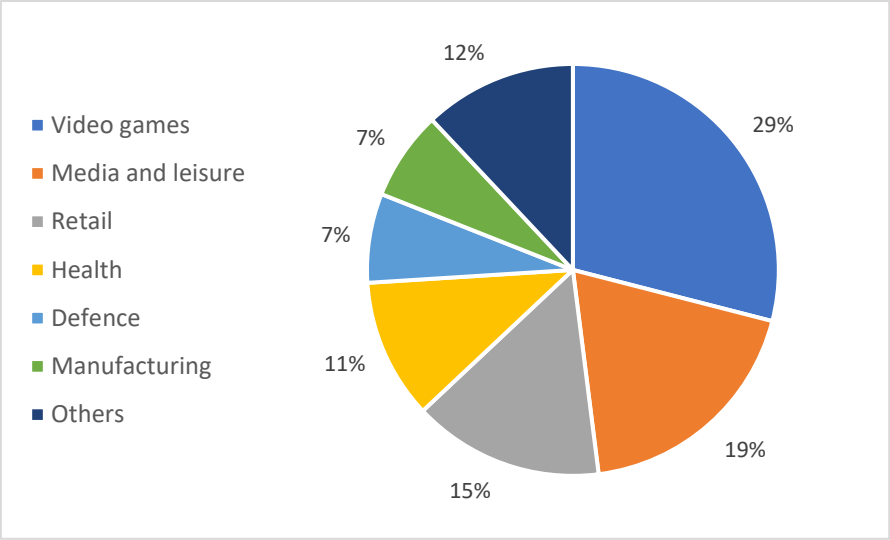
Figure 21: Size of the immersive technology market in Europe (M$)

From a sectoral perspective, (Acciò, 2023) reports the following findings. As expected, the sector currently integrating the most AR and VR is the video games sector, representing 29% of the European immersive technologies market.

Retail companies represent the 15% of the market, mainly using augmented reality to improve the in-store experience, visualising products in different contexts, and virtual reality to create e-store experiences, virtual platforms where customers can browse and buy as if they were in a physical store.

With 11% of the market, the health sector is the third most XR-intensive sector in Europe. Immersive technologies are being used in medical training to simulate real-life surgery and diagnostic procedures, enabling risk-free learning, as well as in therapy and rehabilitation, to create controlled environments in which patients can work through their conditions.

The manufacturing sector, with a 7% share of the European immersive technologies market, is one of the most affected sectors, as VR and AR can be used for a variety of use cases: designing and testing products virtually, providing real-time and hands-free access to information on assembly lines and for maintenance operations, and providing safe training environments for workers.



Source: own work based on the data from (Acciò, 2023)

Figure 22: European immersive technology market by sector (%, 2021):

Another interesting aspect of the adoption of immersive technologies, especially in the context of customer relations, is the current level of acceptance of the metaverse. Millennials and Gen Z, who are highly receptive to digital and immersive experiences, are particularly attracted to using these forms of interaction with companies. This trend implies that companies wishing to adopt these technologies should tailor their products and services to a young audience that may value more innovation and interactivity.

3.2.2 Best practices

Manufacturing industry (building sector)

Mecanoo is a medium-sized architectural enterprise with less than 200 employees, based in Delft, the Netherlands, that exemplifies the integration of Virtual Reality into the architectural design and prototyping process. Founded in 1984 by Francine Houben, the firm has gained international recognition for its innovative and sustainable architectural designs, often incorporating elements of contextual design, sustainability and human-centred approaches.

Figure 23: Mecanoo's logo

The sustainability aspect of this firm is worth mentioning in line with the whole of this study. *Mecanoo* emphasises the creation of spaces that are not only aesthetically pleasing, but also socially relevant and environmentally responsible. This approach is evident in the consideration given to the physical context, culture, and long-term functionality of projects, ensuring that each creation has a positive impact on local communities. In addition, by considering factors such as energy efficiency and life cycle assessment, *Mecanoo* aims to create buildings that remain functional and economically viable for years to come.

Moving the focus on the usage of immersive technologies, *Mecanoo* distinguishes itself thanks to the use of Virtual Reality in its operations. In this context, the company provides the clients with different offers of VR experiences, ranging from simply viewing the spaces with their smartphones on a secured webpage, to fully immersive walk through and interact with the spaces wearing a 3D headset. This approach significantly enhances the interaction between the architects and the clients, allowing the latter to have a realistic vision of the project before it is physically built. In this way, clients can explore various aspects of a design, from material finishes to spatial layout, with greater understanding from the beginning and potentially greater satisfaction in the end. From the company's point of view, this approach benefits in terms of time and cost: adjustments can be made more quickly, sometimes in real time, but certainly without the need of multiple iterations of physical prototyping. Examples of the virtual environments of *Mecanoo*'s projects are shown in the figures 24 and 25.

Figure 24: Virtual environment for an Engineering campus

Figure 25: Virtual environment for a residential area

Even if not specified in the available sources, it is possible to hypothesize what challenges *Mecanoo* has possibly overcome in its adoption of immersive technologies and what enablers have pushed it forward.

Among the main barriers, the costs associated with VR hardware and software development have to be considered. On the hardware side, the need of VR headsets and powerful computers with high-end graphics cards and processors may hinder the acquisition. On the software side, instead, using VR for a high-level architectural purpose requires high-level software for which licences must be paid; moreover, creating 3D models and renderings of architectural designs to be used in VR experiences may require additional resources, such as skilled 3D artists.

In addition to financial costs, it is possible to expect that integrating VR in existing workflows and disrupting traditional processes has had consequences in the company for what concerns changes in project management and interactions with clients.

When analysing their communication strategy, the use of immersive technologies can largely be attributed to an internal driver: a strong commitment to innovation. This may be closely linked to the fact that *Mecanoo* realised that differentiating itself from its competitors by offering an innovative approach to architecture could have given it a significant competitive advantage. In this case, it seems that the reason for pursuing this path lies in the strong leadership of the founder, Francine Houben, who plays an important role in communication through various interviews, all accessible on the website.

Retail industry

Style.me is a small company of around 50 employees advanced in the use of immersive technology in fashion retail by offering virtual fitting room solutions. They use augmented and virtual reality to create highly personalised shopping experiences, allowing users to create customised avatars based on their body measurements. Shoppers can then try on different outfits, trying on different sizes and styles. This type of service benefits fashion retailers by increasing user engagement, making online shopping interactive, and by reducing return rates through a more accurate sense of fit before purchase.

Figure 26: Style.me Logo

*Style.*me's solutions are tailored in two ways: digital fashion and virtual fitting.

In terms of digital fashion, the company provides end-to-end solutions for brands looking to bring their collections into the metaverse by hosting fashion events and experiences. Its technology can

digitise any fashion item to port it into AR, VR or MR environments, allowing consumers, external partners or internal teams to view and engage with virtual experiences through their device.
On the other hand, *Style.me* offers retailers virtual fitting solutions that can be integrated into their e-commerce stores. This allows users to create an avatar with accurate size recommendations and personalise their shopping experience, increasing engagement and loyalty. The benefits of this, in addition to the lower return rate already mentioned, include access to a large amount of data that can be used to better support product design and marketing.

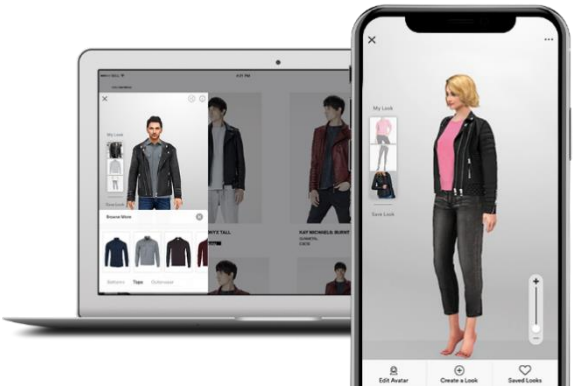


Figure 28: Style.me virtual fitting solution

Figure 27: Style.me digital fashion solution

The integration of such technologies, however, can present challenges. Firstly, the initial required investment can be substantial, caused by the need to integrate these systems into existing e-commerce platforms. Moreover, content update and ongoing maintenance must be an already well managed task inside of the company adopting the technology. Despite these hinders, the adoption of immersive technologies in fashion is driven by a growing consumer preference for online shopping and for personalized experiences. Finally, another aspect to consider is that, even if not explicitly outlined in the sources used, the nature of *Style.me* services indirectly supports sustainable practices. In fact, the virtual fitting offered has been proven to reduce returns by up to 50%, helping to reduce industry's carbon footprint and enhance sustainability.

Hospitality and tourism industry

ARtGlass is a small Italian company, founded in 2013, dedicated to the integration of Augmented Reality in the cultural heritage and tourism sectors. In 2018, by entering the US market, the company has achieved the status of pioneer firm in the augmented reality sector for tourism and culture.

Figure 29: ARtGlass Logo

Their aim is to revolutionise the visitor experience in museums, historical sites and cultural exhibitions through the development of AR tours. The company business is about offering a service capable of creating immersive experiences through wearable glasses or smartphones for cultural sites and associations. The service they offer is based on a proprietary technology (*ARtGlass* platform) that allows to capture multi-sensory information and materials and to create stories and experiences quickly and efficiently in a language that can be interpreted by smartglasses and mobile devices, such as smartphones and tablets. The *ARtGlass* solution has been used by more than 2 million users in museums, cultural institutions and events, and research conducted by *ARtGlass* in collaboration with cultural institutions shows that user satisfaction averages between 90 and 98 percent. In short, the *ARtGlass* software acts as a cultural navigator, superimposing points of interest and related 'augmented' information, such as text, images, audio, video and reconstruction with three-dimensional models of objects or non-visible details of monuments or works of art, on top of the visual reality, creating an immediate and immersive dissemination experience. As an aspect of social sustainability, the *ARtGlass* software also enhances accessibility for the hearing impaired by using a real-time multilingual captioning system.

Once the virtual environment and information have been created using *ARtGlass* software, the company offers two ways of using it. The first is through the use of smartglasses, which can be used in a guided or autonomous experience; in the first case, a group leader guides the visit and controls the smartglasses, a solution ideal for guiding groups of up to 50 people. On the other hand, it is also possible to provide smart glasses to individual users visiting a site or museum. The second way of using AR in the tourism sector, with less investment in hardware, is through the use of personal smartphones: by scanning a QR code, the user could access augmented information about the places they are in.

Figure 31: ARtGlass service example

Figure 30: ARtGlass service example

Although not specified in the available sources, it is possible to hypothesise what challenges *ARtGlass* may have overcome in its adoption of immersive technologies and what enablers have driven it forward.

The implementation of augmented reality by *ARtGlass* has probably involved overcoming challenges such as significant initial investment and lack of expertise. In this context, potential enablers have been partnerships and collaborations with experts to develop content that is both accurate and engaging, and with technology developers. The latter partnership can be considered crucial in keeping the company at the forefront of new developments. For example, the development of lightweight wearable AR glasses to make the technology more accessible and enable its use in environments where large and diverse groups of visitors.

In terms of drivers, the company probably capitalised on the growing demand from visitors for increasingly interactive, immersive and digital experiences. Another driver could have been its mission: a commitment to enhancing historical and artistic heritage and helping public and private organisations optimise their investments. In fact, the company is part of the Capitale Cultura Group, which supports the development of cultural and tourism organisations by complementing their excellence with digital innovation and multi-channel communication.
A key factor in the company's success has been its participation in regional projects funded by the European Union, such as POR and PON.

Healthcare industry

Oxford Medical Simulation (*OMS*) is a UK-based company of around 200 employees that specialises in providing virtual reality simulation training to healthcare systems and academic institutions. Its mission is to transform healthcare education and training by making realistic and immersive simulations accessible anytime, anywhere in the world, integrating the technology with AI and performance data analytics. By enhancing the training experience, OMS aims to enable healthcare professionals to practice complex medical procedures in a safe environment with maximum realism.

Figure 32: OMS Logo

Their solutions target two main categories of customers: academic institutions and healthcare systems. Academic institutions can use the offered services to teach to students, from applying foundational skills to assessing competencies and demonstrating readiness to practice, providing the

opportunity for students to assess patients, make treatment decisions, embrace mistakes, and reflect on evidence-based feedback - all in a psychologically safe learning environment. Healthcare systems might use these technologies to effectively and efficiently onboard new staff with customized scenarios and to upskill employees directly inside the organisation. From *OMS* studies we learn that, at 3 month follow up, 89% of trainees report using knowledge from VR training in daily practice and staffing and estate costs have been reduced of 74%.

OMS platform key features are the possibility of having both individual or team trainings, allowing to collaborate across disciplines and switch tasks, and hand interactions that develop psychomotor skills in procedural scenarios.

Figure 34: OMS virtual scenario

Figure 33: OMS virtual scenario

A key factor in the success of *Oxford Medical Simulation* has been the presence on the team of a wide range of professionals: healthcare professionals, educators, sim techs, developers and animators. Collaboration is essential not only within the company, but also externally. Partnerships with major universities and leading healthcare institutions have been crucial to the development and growth of this company, which is driven by a strong commitment to innovation and research. In fact, OMS' success is driven by the growing recognition of VR's potential in medical training and the general drive towards ever higher quality and more sophisticated healthcare. By showcasing the importance of its value proposition, *OMS* has been able to overcome barriers such as high costs and lack of expertise thanks to partnerships that have provided it with funding and support.

By providing VR-based solutions, OMS indirectly contributes to sustainability in healthcare. In fact, it reduces the need for physical resources typically used in medical training, such as mannequins and consumables. By increasing the competence and confidence of medical professionals, OMS solutions can be considered sustainable from a social perspective, leading to improved patient safety and outcomes. In addition, this approach improves the quality of healthcare by providing up-to-date and high quality training.

Services industry

Amelia Virtual Care is a Spanish company of around 60 employees that offers a VR platform for mental health professionals to conduct immersive therapy sessions. Nowadays, their platform is used by over 2000 therapists globally and it offers around 100 VR environments to address issues like anxiety disorders and phobias, providing a controlled setting for exposure therapy.

These immersive sessions not only can mimic real-life scenarios that may be difficult to replicate in a traditional office setting, but also allow for safer and more controlled therapeutic interventions. In fact, the virtual areas offer full immersion, control of display parameters and the ability to replay scenes. Moreover, *Amelia* platform supports remote and face-to-face care, providing an increased patient engagement and comfort, as it removes the physical office setting that can be a barrier to treatment for some individuals.

The different environments available allow psychological professionals to personalise the treatment of their patients in the way they need it most: among others, VR environments simulate social situations, small spaces, public speaking and flying. To recap the benefits, the use of virtual reality in mental health has the potential to provide greater flexibility in session time, increased cost-effectiveness and improved patient acceptance.

The company also offers the *Amelia Virtual Care Academy programme*, which prepares therapists to use the platform correctly and supports their continuing education to help them excel in their practice. In this way, interested psychotherapists can easily overcome the barrier of lack of knowledge, keep up to date with developments and easily learn how to use the platform.

Figure 35: Plane environment with heatmap to portray the orientation of the patient's head.

The adoption of such immersive technologies is supported by several strong enablers. First of all, there is a growing body of clinical research that underscores the efficacy of VR in therapy, which is

easily accessible from *Amelia* website, and that helps to boost its acceptance among health professionals and institutions. Fundamental in the actuation of this company has been its participation to projects funded by EU and Spanish government, such as *Innvierte* program and the *Plan de Recuperación, Transformación y Resiliencia*. An important driver to mention in this case, has probably been the global shift towards digital health solutions, especially highlighted during the COVID-19 pandemic.

4. Discussion

The objective of this paragraph is to examinate the case studies presented in the chapters 3.2.2 and 3.1.2 to identify patterns, common aspects and differences, regarding factors and practices, among the various SMEs cited.
The set of best practices regarding sustainability will be analysed in chapter 4.1, while chapter 4.2 will contain the analysis of best practices regarding the implementation of immersive technologies.

4.1 Analysis of case studies on sustainable practices

Garlita, Biovega, Much Better Adventures, Fairphone, and *Tomorrow* were all presented as best practices in the field of sustainability, albeit differing between each other's for belonging sectors and operations. What all these companies share is a strong commitment to sustainability, incorporating it into their core operations using renewable energy, adherence to high certification standards, emphasis on social responsibility, maintenance of transparency, and driving innovation.

Firstly, all the companies showed a strong commitment in reducing their carbon footprint, albeit through different strategies tailored to their industries. *Garlita*, for example, explicitly prioritize the use of renewable energy sources to power their operations, by integrating solar panels into its manufacturing plants. *Fairphone* focuses on product longevity and circularity, indirectly reducing carbon emissions associated with electronic waste and with rare earth mining operations. *Tomorrow* invests in renewable energy projects and avoids financing industries harmful to the environment.
All these different practices in the various SMEs, are strengthened by their adherence to certifications that demonstrate the veracity of their commitment, while at the same time keeping it measurable. *Garlita* holds certifications such as EMAS (Eco-Management and Audit Scheme) and ISO 14001, Biovega upholds stringent certifications for its organic products, ensuring they meet high sustainability standards, *Much Better Adventures*, *Tomorrow* and *Fairphone* are all B-corp certified. Moreover, they often provide detailed sustainability report on their impact, environmentally and socially.
Certifications and reporting are important, because they ensure that SMEs operations meet high environmental and social responsibility standards, with transparency and accountability. Thanks to this, companies can be more attractive for many stakeholders, leading to broader recognition and support.

Another common commitment, always considered in the operations of all SMEs analysed is the one towards social sustainability. All the companies foster transparent relationships with both the customers and the suppliers, ensuring fairness and equity of treatment. The importance of

safeguarding the community is strongly evident for example in *Biovega*, which emphasizes local partnerships, in *Much Better Adventures*, that supports tourism that benefits local communities, and in *Fairphone,* that addresses common ethical concerns in the electronics manufacturing.
Moreover, several companies included educational initiatives, to promote responsible practices. *Much Better Adventures*, for example, offers a magazine of case studies on ecotourism, with the aim of educating travelers on sustainable travel practices. *Biovega*'s 'Makronova' is an adult education institute that promotes healthy lifestyle through cooking workshops and seminars between other things. Moreover, *Tomorrow*, provides information to the customers on their financial choices. With these educational initiatives, sustainable companies raise awareness , but also empower people to make informed decisions about sustainability.
Being transparent, maintaining clear and open supply chains, allowing stakeholders to understand the origin of products and the impact of their operations, is a pattern that was found in all companies analysed, suggesting the importance of social commitment when acting sustainably.

Innovation was another central point in the sustainability efforts of the cited companies, albeit declined in ways tailored to the specific sector in which they operate. *Garlita* demonstrates innovation high-tech treatments in knitwear production, such as self-cleaning properties and special anti-mosquito coatings. *Fairphone* uses a very innovative modular design to reduce e-waste, going against the usual programmed obsolescence of tech companies. *Tomorrow* is very innovative in demonstrating how financial services can drive positive change, trough banking products that support social and environmental impact.
As highlighted, innovation is often correlated to the sustainable practices of these companies. This finding suggests a pattern according to which companies looking to be sustainable in nowadays fast evolving world, can be successful by also pursuing innovative ways to operate.

The set of companies of the case studies demonstrated a shared commitment to long-term sustainability goals, reflecting a vision that goes beyond immediate profitability considerations. All the five companies invested economic and time resources to achieve their sustainable strategy. For example, *Garlita* invested in solar panels and electric car charging stations, actions that represent a long-term strategy to reduce carbon emissions. Similarly, *Biovega* is committed to a long-term well-being of consumers and environments. *Fairphone* aims for lasting change in the entire electronic industry, promoting the most durable devices thanks to their modularity.
These strategies show the importance of having a strong vision and commitment to reach a successful implementation of sustainable practices. Often, in fact, the goals and strategies of these companies

perfectly align with socially and environmentally activist values. This pattern illustrates the significance of dedicated leadership in guiding the whole organization towards sustainability goals.

Despite the common patterns and factors found between the SMEs analysed, industry-specific approaches also create differences. For example, *Much Better Adventures*, in the hospitality industry, faces the problem of scaling up while maintaining low-impact tourisms, while industry specific approaches like the one of *Garlita,* focus on reducing emissions and improving energy efficiency.
Moreover, the scale of the investment, as well as the scope of the impact also vary. *Garlita* and *Biovega* focus on regional markets, while *Much Better Adventures, Fairphone, and Tomorrow* operate on a global scale. This is not linked to the size of the company, but only depends on the different contexts in which their initiatives are taking place. For example, *Garlita*'s solar panels function for the energy needs of their manufacturing process, while *Tomorrow*, as a finance service, can fund global environmental projects.
Consequently, the specific challenges that these SMEs face vary on the scope in which they act. Industries like *Garlita*, *Biovega*, and *Fairphone* would probably need to invest more for their sustainable practices, since they offer products. This means that they have to ensure that also their processes and supply chains are sustainable: *Garlita* must invest in green technologies, *Biovega* must ensure organic standards, and *Fairphone* must face the challenge of transforming a traditionally non-transparent supply chain into an ethical one. On the other hand, *Much Better Adventures* and *Tomorrow* offer services: this might reduce the financial investment in sustainable practices, but opens up for other challenges. *Tomorrow* must navigate financial regulations to promote effectively their sustainable investment business model and *Much Better Adventures* has to face the challenges of working with distant realities, such as building strong networks in local communities.

In summary, while these companies share a common commitment to sustainability and present similar enablers and drivers, their industry-specific approaches and the challenges they face highlight the diverse ways in which sustainable practices can be implemented and the different impacts they can have.

4.2 Analysis of case studies on immersive technologies

Mecanoo, *Style.me*, *ARtGlass*, *Oxford Medical Simulation* (*OMS*), and *Amelia Virtual Care* were all presented as best practices in the use of immersive technologies, albeit differing between each other's for belonging sectors and operations. All these SMEs showcased a diverse set of ways in which immersive technologies can be used in business operations, but it is possible to notice several common factors and practices between them.

A fundamental pattern is a strong commitment to innovation, that made it possible for the SMEs presented to stand out and implement immersive technologies in their activities. In *Mecanoo*'s case, this seems more explicitly influenced by a strong innovative mindset of the company's leader. In the other SMEs, this could not be explicitly retrieved, but it is safe to assume that strategic choices from the leadership must have impacted the path to innovation of these companies.

For what concerns the drivers, a common aspect between the companies is the strategic use of immersive technologies to improve operational efficiency and reduce costs. *Mecanoo* uses VR to allow clients to visualize architectural designs in a highly realistic way before constructing, saving time with real-time adjustments and costs, eliminating the need for physical prototyping. Similarly, *OMS* uses VR to provide realistic medical training simulations, which not only reduce the need for physical resources, but also make trainings more effective. Moreover, *Style.me*, by allowing clients to virtually try-on before buying, reduces returns and consequently increases efficiency.
This highlights how reduced use of resources can be achieved with the use of XR and how this factor can drive their implementation.

Another common pattern across the five SMEs was to enhance customer relationships by using immersive technologies to personalise their experience and increase engagement. *Style.me*, for example, allows customers to use virtual fitting rooms, creating personalized avatars and overall increasing their satisfaction with online shopping. *ARtGlass*, using AR in cultural tours, can give to users a more comprehensive informative view about what they are visiting, increasing their engagement through the always more common digital format. Finally, *Amelia Virtual Care* VR's therapy sessions provide tailored environments for patients, that address their specific needs and result in better outcomes. As previously noted in the literature, the possibility of personalization results as a fundamental factor in influencing the adoption of immersive technologies by SMEs.

The role of external support and partnerships, as well as in the cases of sustainable practices, seemed to facilitate some of the SMEs' XR acquisitions. *ARtGlass* participated in EU-funded projects to develop tourism, and *Amelia Virtual Care* used government funding for digital transformation.

Moreover, *OMS* collaborates with healthcare institutions and professionals, potentially increasing their expertise value.
These external collaborations and funding opportunities help these SMEs to overcome possible financial and knowledge challenges, allowing them to successfully implement XR and gain competitive advantage.
Overall, in fact, it can be noticed that each company uses immersive technologies to differentiate itself in their sector and gain a competitive edge. *Mecanoo* stands out in the architectural field, *ARtGlass* in the cultural tourism sector and so on. This pattern aligns with the literature's observation that competitive pressure can be a significant driver for the adoption of extended reality.

Despite the common patterns and factors found, the SMEs analysed vary considerably in terms of the sectors they operate in and the applications of immersive technologies. As a result, the scale and technical complexity of implementation also varies. *Mecanoo*, for example, requires detailed 3D modelling and real-time interaction capabilities to make effective use of its VR architectural solutions. Similarly, *OMS*'s VR training, which involves complex medical simulations, requires a high level of precision in user interactivity. On the other hand, *Style.me* and *Amelia*'s applications require a lower level of technological complexity.
This difference also affects the financial investment required to use AR and VR: some applications may require more sophisticated hardware and software, while others may be more basic.
Finally, another difference in the challenges faced by the five companies is in the area of compliance. *OMS* and *Amelia Virtual Care*, operating in healthcare, must comply with more stringent regulations than *Mecanoo* or *Style.me*.

In summary, the case studies of *Mecanoo*, *Style.me*, *ARtGlass*, *Oxford Medical Simulation* (*OMS*), and *Amelia Virtual Care,* demonstrated that from a strategic point of view, have shown that, from a strategic perspective, similar factors are driving the acquisition of XR, namely improving efficiency and enhancing the customer experience. Albeit practicing in very different sectors, key factors for each company's success were a strong focus on innovation and use of strategic partnerships and collaborations. Nevertheless, the differences analysed showcased how immersive technologies could be implemented in various scopes, as well as at various technical levels.

4.3 The intersection of immersive technologies and sustainability

This chapter will discuss the intersection of immersive technologies and sustainability, by highlighting the connection between the use of these technologies and possible sustainable outcomes. In fact, immersive technologies can offer innovative and unique opportunities for SMEs to address sustainability challenges across all three ESG dimensions. For example, AR, VR and MR can help reduce waste, increase employee engagement and improve decision making, all of which are benefits in terms of environmental, social and economic sustainability.

The aim of this chapter is to provide a comprehensive overview of all the ways in which the use of immersive technologies in business environments can contribute to one or more aspects of sustainability. For organisational reasons, this intersection is analysed under the three different perspectives in three different sub-chapters, but the potential of the use of immersive technologies is to address the issues of sustainable development in an integrated way.

4.3.1 Immersive technologies and environmental sustainability

This section explores the different ways in which immersive technologies can be used to improve environmental sustainability in SMEs.

The use of VR and AR could have an impact in the area of resource management and optimisation, both in terms of materials and energy. In this area, VR in particular, can be very useful in providing virtual environments with the same specifications that are needed in real environments in specific situations. By simulating different operating environments, SMEs can try before implementing, resulting in savings in energy and material waste. For example, by creating a factory layout in a virtual environment, SMEs could try out different setups to find the most energy-efficient one, without disrupting ongoing processes. Another example of resource saving is given by the possibility of analysing complex operations or entire production processes, with the goal of optimizing them, adjusting parameters only virtually. Similarly, product visualisation in virtual environments can significantly reduce the number of physical prototypes needed, allowing the making of adjustments in the ongoing virtual process. Design teams could indeed test functionality, aesthetics, and usability of products, changing parameters quickly and making refinements without the environmental impact associated with physical prototyping.

Augmented reality could also help minimise the use of materials: for example, by overlaying precise information on real production lines, it can help workers understand the steps involved and how different components fit together, reducing the likelihood of assembly errors and thus minimising rework and waste. Moreover, integrating immersive technologies with specific software, like Life

Cycle Assessment software, has the potential to analyse a product's environmental impact throughout its lifecycle measuring the emissions of different design options, for instance overlaying real-time environmental statistics and carbon footprint data. Assessing environmental impact of products and processes could also be helpful to SMEs in having a better understanding of which are the biggest sources of pollution inside their organization, allowing to focus waste reduction efforts on the most impactful activities. Always with the use of software, the assessment could help not only understanding the size of the impact, but also the ways this happen (for example, the potential effects of a chemical spill), allowing for a better planification of mitigation plans. Fundamentally, by enhancing the visualization and interaction with data, immersive technologies support decision making on waste management and sustainable aspects in a highly efficient and advanced way.

Extended reality used in the educational field through trainings for employees can help to promote the culture of sustainability in an organization, offering innovative methods of approaching this topic. In one sense, VR technologies can significantly increase environmental awareness of employees by placing them in virtual scenarios depicting impactful outcomes of unsustainable behaviours, for example places that are first-hand witnessing the impact of climate change. This strong visual impact, amplified by the immersive nature of the technology, would reinforce the commitment of employees to act with ecological awareness in their daily operations, both at work and in their private life. Similarly, interactive AR training tailored to teach specific practices within the organisation, such as how to deal with a particular type of waste (e.g. electronic), would enable employees to learn more effectively, further increasing their commitment. This would help reducing contamination rates in recycling, thus improving the recycled output.

The adoption of immersive technologies could significantly increase the capabilities of remote working in SMEs, even in the scope of complex tasks. Firstly, VR and MR platforms can enable fully realistic meetings that to levels that traditional video conferencing cannot achieve, allowing employees to have interactive sessions even at distance without the need of travelling, thus cutting associated emissions. For example, teams could work at the same time on the same virtual product, even if located in different locations. AR can also be a particularly useful tool in providing remote assistance: for instance, technicians wearing AR glasses can receive remotely information from experts located elsewhere, reducing their need to travel from one site to another. At the same time, augmented reality, overlaying real-time data, statistics and predictive analytics that can forecast potential breakdowns, could enhance predictive maintenance by allowing timely interventions and consequently managing resources in a more effective way.

Immersive technologies can be a powerful tool in the engagement of customers in ecological sustainability, thanks to their immersive nature. Eco-friendly behaviours could be encouraged by using those technologies to pilot sustainability related messages. This would showcase the commitment of the company, raising its value, and would create a more impactful experience, for example, than a normal marketing campaign with a consequent increase in the level of awareness of clients. Moreover, AR could be used to provide clients with more information about the products that they are buying, and this could be also used to encourage sustainable behaviours in customers. For example, by pointing smartphone camera to a QR code in the product packaging, customers could see layered information on methods of production, places of origin etc. and make more informed sustainable decisions. Moreover, as seen in the *Style.me* case study, virtual reality can be particularly eco-sustainable in the fashion industry, by allowing customers to try-on pieces of clothing before actually purchasing them. This reduces returns, thus waste linked to over-production and emissions caused by unnecessary transportations.

In summary, XR technologies contribute to environmental sustainability across five key areas: facilitating remote collaboration, enabling virtual prototyping, providing immersive training and educational materials, supporting virtual maintenance, and visualizing sustainability data.

4.3.2 Immersive technologies and social sustainability

This section will explore the impact that immersive technologies can have from a point of view of social sustainability, illustrating how they can create impactful strategies contributing to social well-being.

In revolutionizing employee training and skill development, immersive technologies offer high quality education, which is the fourth of the 17 Sustainable Development Goals. In particular, virtual reality offers safe and controlled environments in which employees working in high-risk fields can train before actually operating, such as healthcare (see *Oxford Medical Simulation* case study), or heavy manufacturing. Moreover, these virtual trainings can offer the possibility of being carried out with different paces and in a more personalized way, giving the opportunity to employees to achieve their full potential in learning.
Health and safety trainings, fundamental in any workplace, are greatly enhanced with an immersive approach, finally impacting on employees' wellbeing. In fact, AR and VR can simulate dangerous conditions in a realistic way, deepening employees' understanding of such situations and giving them the opportunity to practice responses to those. In this way, the workforce will be better prepared to such emergencies, fact that consequently reduces the number of accidents and injuries.

Augmented reality can overlay digital information onto the real world, providing guidance during work processes or maintenance, which is particularly important in industries in which accuracy is fundamental. In this way, complex tasks are simplified, and employees are empowered with crucial information in real time, achieving an efficient workforce. This helps fostering employees' wellbeing which is essential for a long-term social sustainability inside the organisation.
The enhanced remote working and collaboration offered by immersive technologies can also drastically improve efficiency and wellbeing of employees. In fact, by enabling a more flexible working environment, immersive technologies in workplaces can support a strong work-life balance and help obtain a higher satisfaction among the employees.

Immersive technologies can play a crucial role regarding inclusion and accessibility. Firstly, thanks to the possibility of personalization of environments, they can create accessible workspaces tailored to employees with disabilities. For example, XR can be integrated with existing assistive technologies: VR headsets could be equipped with screen reading software or gesture-based controls for employees with visual impairments, or AR could display captions or sign language interpreters for employees with hearing impairments. Mobility impairments could also be overcome through the immersive remote working capabilities of virtual reality. This shows how immersive technologies can

be fundamental in enabling effective communication for those who find it more difficult due to their physical disabilities, promoting inclusivity and equality.
It is important to highlight the opportunity that immersive technologies can offer in showcasing different cultural practices, above all when workforce is multicultural, or businesses are international. In fact, XR technologies can be used to educate employees about global perspectives, supporting cohesion within the workforce. Moreover, they can facilitate employees understanding during international interactions; for example, AR can overlay information regarding language translations or cultural norms, refining and speeding up communication.

AR and VR support informed and involved communities, particularly when actions impact them first hand. For example, XR could be used by architectural companies to show the outcomes of infrastructure projects (i.e., roads, buildings, parks…), giving everyone in the community a sense of positive engagement and a sense that they are being considered in actions that will affect their local environment. Furthermore, in a more general perspective, these technologies can be used to deliver messages that influence public awareness on various sustainability issues, creating a more conscious society and building sustainable communities.
Another impactful role of immersive technologies in social sustainability is linked to psychotherapeutic industry, as it was already demonstrated with *Amelia* case study. In fact, they offer innovative solutions for therapy that fundamentally change the way individuals can manage their conditions, potentially improving its efficiency. For example, VR can provide natural environments to improve mindfulness or simulate dangerous environments to help overcome phobias in a controlled way. These technologies could also be extended to any workplaces, giving employees regular mental health breaks sessions, which increase their productivity and satisfaction, and improve the organisation from a long-term social sustainability perspective.

In summary, immersive technologies have the potential to contribute to social sustainability improving wellbeing of employees through improved training opportunities in the scope of their operations or in general in safety and health. Moreover, they can promote inclusivity for those with disabilities and offer mental health support through therapeutic virtual support. Finally, by supporting remote working conditions and community participation, XR technologies can represent a valuable tool to obtain wellbeing and satisfaction of employees and communities.

4.3.3 Immersive technologies and economic sustainability

This section will analyse how immersive technologies can be used by SMEs to achieve an internal economic sustainability, contributing to increase efficiency, reduce costs and drive sustainable growth.

One of the primary benefits of immersive technologies from an economic perspective is cost reduction. VR and AR can allow SMEs to implement a number of processes and operations with decreased costs, thanks to a reduced use of materials and resources. This is particularly true in prototyping and testing of products, machines and processes. In fact, by moving these completely in a virtual environment, physical materials become unnecessary until the final steps of the development process. For example, VR can simulate a new system response under various conditions before actual implementation, substantially reducing costs and time. This outcome it's still valid also in the case in which immersive technologies are used for trainings: trainees can practice without the need for physical resources and setups, resulting in more practice of the skills, fewer errors on the real work (even in the long term), and less waste.

The application of XR in trainings for employees not only can have the effect of reducing costs, but it can also increase productivity, thanks to a better learning experience. Being immersed in a complex, but completely safe, virtual situation, employees can gain valuable expertise on how to act in their everyday work. Through this method of training, they can become more confident and better retain fundamental knowledge, consequently committing less operational errors. Moreover, the opportunity of repeating specific scenarios ensures that the learner can master its tasks, strengthening an outcome of enhanced productivity.

AR and VR applied in customer relationships offer innovative solutions to engage customers and build their loyalty. In this sense, immersive technologies can give the most advantage in markets such as fashion and home design, helping customers visualize the products in a realistic environment and facilitating their buying process. VR can also be used to create immersive and personalized marketing experiences, which can have a great impact on the engagement of clients towards the brand. By providing these types of customised experiences, SMEs can differentiate themselves from their competitors and attract new customers.

The role of immersive technologies in optimization of decision making must also be emphasized in the scope of the sustainable development. In logistics, for example, layout planning and process simulation can be visualized in three dimensions and in different situation, identifying inefficiencies before implementation. The same applies to large projects, such as infrastructure, that can be easily visualized and eventually adapted to changing demands smoothly. Moreover, thanks to the ability of

AR of overlaying information and data on processes and machinery, employees can monitor at an higher level, predicting failures more easily and being more efficient in their operations. Speeding up decision making without losing detail in analysis would increment precision and efficiency.

Immersive technologies can significantly strengthen the innovation capabilities of a business. They enable to visualize information rapidly, customize and modify with agility and thus respond to evolving trends and demands quickly. The ability of testing without physical prototyping can promote an experimental approach to product development, accelerating the innovation cycle within SMEs. Thanks to this, the company could keep up with the changing dynamics of today's world, maintaining a competitive position in the market. Whether it's to meet specific customers preferences or changing industry trends, immersive technologies could be a very powerful tool when planning a long-term economic sustainability.

The use of AR and VR inside the organization can boost competitivity not only for what regards gaining customer, but it could also attract talent among the employees. By prioritizing innovation, SMEs would show their commitment in staying ahead of the curve, a valuable characteristic for those who look for opportunities within forward-thinking companies. Attracting curious, skilled and driven individuals would allow SMEs to increased efficiency and reputation, which in turn would lead to economic profitability.

In summary, immersive technology utilization in SMEs could represent a key improvement in their financial situation in a long-term vision. In fact, XR can help in the short term to reduce costs and improve employees' productivity. In a middle-long term, they could elevate significantly the position of an organization among competitors, both from a perspective of talent attraction and customers loyalty.

The following table summarises the main impacts that the use of immersive technologies can have on the three dimensions of sustainability: environmental, social and economic.

Table 5: Intersection of immersive technologies and sustainability

	Environmental sustainability	**Social sustainability**	**Economic sustainability**
Resource management and optimization	VR and AR improve resource efficiency by allowing virtual testing of operations and setups, thus reducing material and energy waste.	-	AR and VR reduce costs by decreasing the need for physical resources during prototyping and operations.

Enhanced training and education	Use of VR for immersive training can indirectly lower environmental impact by reducing the need for physical resources.	Immersive technologies enhance the effectiveness of training, promoting safety and preparedness, which can lead to a healthier, more informed workforce.	Improved training through VR and AR can lead to better efficiency and productivity, which contributes to economic sustainability.
Improved decision-making	-	Immersive technologies support better planning and execution of tasks, fostering a sense of inclusion and lowering barriers for disabled employees.	VR and AR can streamline decision-making processes, increasing operational efficiency and reducing costs.
Customer engagement and market expansion	-	AR and VR can enhance community involvement and awareness on sustainability efforts, strengthening social bonds and cultural inclusivity.	By improving customer interaction and personalized experiences, businesses can boost loyalty and attract new clients, leading to economic growth.
Remote collaboration and telepresence	Reduction in travel and associated environmental impacts due to virtual meetings and remote operation capabilities.	Enhances the ability to work remotely, which can improve work-life balance and reduce workplace stress.	Reduces operational costs and can lead to more sustainable business models by minimizing physical office requirements.
Innovation capabilities	Allow to stay ahead of the curve with environmental matters. For instance, integration of XR with Life Cycle Assessment software to reduce emissions.	-	Boost a competitive advantage with other companies in the sector with regards to attracting customers and talent.

5. Guideline for immersive technologies implementation in SMEs

The objective of this last chapter is to give a practical contribution to the treated theme, offering a guideline to follow to those SMEs potentially interested in applying immersive technologies within their operations. Starting from the analysis of the structural barriers of SMEs, the guideline will touch on strategies to overcome them, and subsequently on action plan to follow for an efficient implementation. As part of that, opportunities and threats will be discussed in various areas, contributing to the building of a comprehensive instruction for small and medium enterprises. Finally, particular importance will be given to the opportunity of using XR technologies as tools to enhance sustainability factors in the organization, improving not only the level of innovation but also their resilience.

5.1 Implementation roadmap for immersive technologies in SMEs

Step A: Assess needs

The first step in the implementation roadmap for immersive technologies in SMEs consists in developing a plan for needs assessment and technology selection.

Different SMEs are driven by different purposes to the adoption of immersive technologies, basing on what their operations are and on what they see the benefits of implementation. However, even if the general need of each company could be easily individuated – for example, a retail company willing to integrate AR in its e-commerce – the needed technical specifications could be harder to define. SMEs should clearly define what are the objectives they want to achieve with XR implementation. This includes a careful analysis and evaluation of their whole business, from the products they offer to the processes they employ. This would allow to highlight opportunities and threats of the adoption, for example the presence of compatibility with the clients' expectations, or a difficult integration with existing systems. Analysing the business will underline the areas to focus on, as well as the requirements that should be more carefully weighted. Key criteria for the technology selections could be, for example, scalability, ease of integration or level of support provided by the technology suppliers. In fact, the needs assessment shouldn't just be at a technical level, but also in terms of the relationship with the supplier. In this sense, the main requirements to be considered could be after-sales support, proven reliability, or cost considerations.

In summary, step B should be a careful break down of the business, in order to find synergies and weaknesses linked to the implementation of the immersive technologies. This would allow a clear vision of what are the needs that the organisation must satisfy integrating new technologies, limiting the risk of over/underestimating them.

Step B: Address barriers

To effectively implement immersive technologies and follow a sustainable development pattern, SMEs will need to overcome the principal barriers identified earlier in the analysis, in chapter 2.1.2 and 2.2.2.

One of the most common constraints found in SMEs was financial constraints, which can be a strong barrier to the acquisition of immersive technologies. These, in fact, require large investments if compared with the economic availability of SMEs, due to the costs of acquisition of hardware and software and their integration within the already used technologies.

One effective approach in this regard could be that of applying for government grants and subsidies designed to support digital innovation. The approach of SMEs in this sense should be proactive, researching potential opportunities and staying up to date with the newest programs tailored to their purposes. European commission and country governments could be fundamental channels to this end, offering range of the different programs and funds that could significantly reduce the cost burden of acquiring XR. For example, some of these programmes offered nowadays by the EU are *Horizon Europe*, to support digital transformation programs, or *Digital Europe Programme*, which aims to accelerate the economic recovery post-covid, shaping the digital transformation of the European economy and society. Moreover, national plans are often available, such as the Italian *Transizione 4.0*, which allocates 100 million of euros to Italian SMEs to facilitate investment programmes in the field of environmental protection that make extensive use of technology. Active research and interest can be time-consuming, but it should be a must-have activity of the leaders of those SMEs willing to find financial support for their innovation through programme and funds.

Another strategy that SMEs could consider in the aim of reducing their financial barriers, is that of evaluating leasing options offered by technology providers or financial providers that offer financing arrangements for this purpose. In this way, the investment costs could be spread over time, allowing to a higher level of accessibility. Moreover, this often includes support and upgrades, partly releasing the need of having technical specialized expertise inside the organisation. This option could also be quite attractive for SMEs that are highly interested in implementing XR technologies, but still nourish doubts, allowing them to be sure that the implementation would fit their long-term needs.

Finally, SMEs could evaluate cost-sharing with similar businesses to share the expenses and benefit from common adoption. This could not only help reduce financial barriers, but also knowledge ones, helping to create a collaborative and supportive environment. To follow this strategy, SMEs should firstly identify potential partners in the same industry or with similar technological needs; in this sense, it would be very useful for them to participate to fairs and networking meetings, which would

allow them to explore their industry and get to know other companies with aligned interests. Also in this case, proactivity of SMEs is a must-have attribute, being fundamental in the task of researching for said events and, in general, of finding appropriate partners.

Secondly, strategies to overcome technological and skills barriers will be discussed. In this case is fundamental to understand what the long-term strategy of the organisation includes. In fact, SMEs could choose either to invest in upskilling their employees or outsource to specialists. If the company is committed to go through a full digital transformation and innovation is a primary pillar of the long-term strategy, it would be advisable to invest in employee trainings and development. In this way, the technological solutions could be more personalized and tailored to the specific needs and the knowledge would stay in house, potentially building up a competitive advantage. On the other hand, if the implementation of XR is driven by specific goals (i.e., enhancing efficiency) and it is not part of an organic innovation strategy, SMEs could consider outsourcing to IT and immersive technologies experts. In this case, the advantage would be that of relegating this part of the operations to someone outside of the organization, allowing to commit less in XR specialization and more on the core business. However, SMEs should also apply a widely collaborative approach with their technology providers, to facilitate the efficient adoption of immersive technologies inside their organization. Only outsourcing, without active interest, could limit the benefits of the innovation, missing on know-how that could potentially create a strong competitive advantage for the company.
Finally, another interesting solution to overcome technical and skills barriers would be that of collaborating with universities and academic institutions. In fact, through collaborative projects, SMEs could access to innovative research and to students looking to apply their knowledge through internships.

In any of these cases, SMEs should actively inform themselves about opportunities to fill their knowledge and technical gaps, such as programmes, conferences and seminars. For example, the University of Nottingham has offered a free business support programme specifically addressed to SMEs and immersive technologies to introduce them to key concepts, technologies and case studies. Maintaining an ongoing interest and fostering a strong learning culture within the organisation is the first step SMEs can take to start filling their knowledge gaps. Moreover, nowadays a large amount of information is easily and freely accessible through open source platforms and communities online, which make it easier to get informed and stay updated.
Trying to build a learning culture inside the organisation is fundamental to prepare the ground for a good adaptation of new technologies, in this case XR. In fact, between the operational and management barriers, there could be the employees' resistance to change. To overcome this,

management should also focus on ways to engage employees with small test projects, facilitating trainings and communicating transparently the benefits that the introduction of immersive technologies can have on the operations.

In general, management commitment to an effective adoption of XR is the most important element to overcome the limitations that SMEs structurally face. Manager's involvement and interest on this topic should be high enough to use time of its work in researching, networking and projecting the acquisition of immersive technologies.

Step C: Cost-benefit analysis

Once specific needs are identified, SMEs should perform a detailed cost-benefit analysis to understand if the investments in XR is justifiable. This analysis, in fact, helps in making informed decisions by comparing expected costs and benefits. Between the costs, companies should considerate initial setup investment like the purchases of hardware and software, but not only. They should also examinate costs of eventual ongoing maintenance, training programs and any other cost that could be specifically linked to the integration of immersive technologies in their business. To do so, it is very important to establish a collaborative and transparent relationship with the considered providers. In fact, having clear and precise needs will make it easier for SMEs to communicate them to their potential suppliers and receive tailored solutions. In this way, not only will the costing data be as reliable as possible, but a thorough understanding of needs will also give the company a stronger negotiating position.

On the other hand, SMEs should consider all the potential benefits that they could achieve from an efficient integration of XR in their operations. To do this, they could draw on data from similar implementations in other companies, from research and articles and apply them to their specific situation. Also, in evaluating the benefits, it is important to widely consider the many aspects that the integration of immersive technologies could impact. Between these, for example, increased productivity, reduced error rates, higher customer engagement, and also the possibility of owning useful tools for sustainability matters.

The use of financial modelling tools could be very useful in the complex task of a cost-benefit analysis; SMEs could for instance resort to methodologies such as Net Present Value (NPV), or Internal Rate of Return (IRR). By systematically evaluating all these factors, SMEs can take more conscious decisions and decrease the risk of implementation failure.

Step D: Action plan

If the cost-benefit analysis supports the implementation of immersive technologies in the business, the next step of implementation will be a detailed action plan to rely on for an effective project management.

First of all, resource allocation should be considered, in terms of monetary budget, but also of personnel and time. The cost benefit analysis has highlighted which costs the company will have to bear, simplifying the task of monetary budgeting. However, it would be effective to also allocate specific employees to the project, to support the decisions of the manager. This would enhance the workload distribution, allowing for a better accountability and focus on the project. In the scope of this collaboration, it will also be easier to set milestones and organize the various activities involved in the project: i.e. preparation of documents for funding request, research on specifics of the technology, contact with the vendors and all the remaining activities that can be linked to the specific use-case. Between these, it is important to not forget about the integration with existing business operations. This is a crucial point to ensure an effective implementation of the immersive technologies in the organization and it will require a consistent effort in regard to technical research and communication with third parties.

Another task to not underestimate in the making of the action plan, is that of planning a strategy for training of the employees that will use the new technology. They could be introduced to the technology trough videos, or dedicated sessions, but it is fundamental that they are aware and ready for the change before it is implemented. In fact, this preparation can facilitate a smoother transition and increase the level of acceptance of the employees.

Throughout all the phases of implementation, is good practice to identify risks that may arise and strategies to mitigate them. For example, if the internal team that is taking care of the implementation project is not expertise, is important to take in consideration that technical results might not be perfectly accurate.

In summary, a good management of all the parts involved in the project must support the implementation of immersive technologies in the operations of SMEs. Building and following a structured and detailed action plan will facilitate the integration of an innovative way of working, above all for smaller enterprises, often limited by smaller resources.

Step E: Monitoring and measuring impact

The full implementation phase could be preceded by a pilot phase if considered necessary. For example, if the integration of XR technologies will impact core operations, SMEs could choose a smaller segment for initial implementation, to ensure that everything works correctly. In this phase, it would be good practice to individuate some key performance indicators (KPIs) to monitor, for

instance if AR is integrated in logistics processes, it would be useful to measure the variation in efficiency.

Based on the pilot results, the SME will have to decide if the project still need adjustments and review or if it is ready to full implementation. In this latter case, it is always important to continue to monitor performance through KPIs and either employee or customer feedback, depending on which part of the operation the immersive technology is being integrated into. This will allow to individuate points for improvement and understand the impact of the change.

In this phase, it can also be useful to study eventual synergies that could come out of the integration of immersive technologies in other organizations contexts. For example, if VR has been integrated in the company with a product design purpose, it can also be used to train and upskill employees in related fields. Moreover, as already discussed in chapter 3.3, immersive technologies are tools that can be used to enhance the sustainable performances of the company, contributing to reduction of waste, remote collaboration and more. Guidelines to integrate sustainable outcomes to the application of XR technologies will be discussed in next chapter.

5.2 Practical steps for SMEs to integrate immersive technologies into their sustainability initiatives

As already seen in chapter 3.3, immersive technologies can be powerful tools to pursue the sustainability goals of small and medium enterprises. The aim of that chapter was to provide a comprehensive overview of all the ways in which the use of immersive technologies in business environments can contribute to one or more aspects of sustainability. On the other hand, this chapter aims to provide a practical guide to making the most of the use of immersive technologies for sustainability.

Step A: Identifying sustainable opportunities

The sustainability opportunities given by immersive technologies can vary basing on the use case for which the technology has been adopted. For this reason, the first step for SMEs willing to utilize their immersive technologies for sustainable purposes is to identify the specific ways in which this can be carried out.

Firstly, is fundamental to evaluate current practices and assess the current state of sustainability within the organization. This would include identifying areas that mostly have environmental impact, such as energy usage or resource consumption. In fact, it is worth focusing on these higher impact areas in order to achieve a greater positive impact. Once identified those areas, it could be useful to compare own metrics with the industry best ones, in order to define sustainability goals to pursue in the long term.

Once it is clear in which areas the effort should be addressed to, SMEs should focus on these and research how immersive technologies can help in their specific use cases. Being aware of the double utility of immersive technologies is a necessary step to maximize their use as sustainable tools. For this reason, research and networking stand as basic actions that SMEs should carry out for an effective implementation in terms of ESG pillars.

For instance, by analysing the use case of enterprises using AR and VR in product or process prototyping, it is possible to find out about the sustainable opportunities that this offers. They should focus on using these technologies to minimize resource consumption, both of materials and energy, planning down to the last detail in a virtual environment and only then taking final action in reality, with physical waste of materials and energy. At the same time, using these technologies allow for remote working and collaboration. SMEs could take advantage of these features to build a resilient remote working culture: sustainable for the environment, by reducing the need for transport, and for people, by giving them greater work-life flexibility. In the same use case, having immersive technologies also allows training and simulations to be delivered virtually, reducing the need for

resources in the short term and also in the long term by providing better training and minimising errors.

This process of analysis should be carried out in any kind of use-case for which the company is willing to adopt immersive technologies, trying to prioritise high-impact areas, but also taking advantage of potential opportunities in other areas.

In the step of identifying sustainable opportunities, is fundamental to engage internal and external stakeholders. Engaging with employees ensures that there is a clear understanding of the goals and helps gathering insights from the people that actually are in first contact with the technology. On the other hand, consulting with customers, suppliers and partners can help identifying improvement points and exploiting synergies. For example, co-developing virtual products with suppliers can lead to more sustainable production processes.

The outcome of Step A should be a clear definition of sustainable goals and a clear vision of the areas in which action should be taken to achieve them.

Step B: Selecting technologies

To achieve the defined sustainable goals, it could be necessary to expand the functionalities of the adopted technologies, for example with capabilities of data collection, with software integration.

To achieve customized solutions, inexperienced SMEs could decide to rely on tech companies such as *appinventiv*, dedicated to deliver software development services, for example a VR environment to train employees about sustainable practices.

With the advancement of AI and its capability to efficiently elaborate data, it would be also possible to integrate software in AR or VR capable to visualize processes and products and preventively indicate their carbon footprint. For instance, a software could allow the visualization through AR of the Life Cycle Assessment of a product in development phase, updating the information while changing the design. In a similar way, this could be applied to processes: integrating AR/VR with IoT could offer information on their states, which could be useful in pre-emptive inspection and maintenance. The potential of AR to overlay information on real-world operations can allow to see directly environmental insights on the activities carried out, encouraging not only adjustments in real time, but also a more responsible and sustainable behaviour.

VR could also be integrated with scenarios that can forecast long-term environmental impacts of various operations, which could guide strategic decisions, such as adjustments to supply chain logistics or the positioning of machinery within a plant.

Integrating advanced software for sustainability metrics visualization into immersive technologies is a very important step to foster a sustainability culture and take under control the impact of the company's operations. However, sustainable outcomes coming from actions such as remote

collaboration or minimization of resource utilization can consequently derive from to the adoption of the immersive technologies. In this case, no further technological integrations would be needed, and the focus could simply be shifted in how to optimize the processes.

Step C: Monitoring and measuring sustainability impact

Whether using advanced software or simpler methods, measuring the impact of immersive technologies on sustainability is really important to raise awareness of one's own sustainability performance. This is fundamental to correctly pursue the defined sustainability goals. Moreover, as already discussed, the issue of sustainability is growing in importance every day, resulting in more stringent legislation on the subject, which is beginning to affect small and medium-sized businesses. Reporting on sustainability performance will be increasingly required by governments and other stakeholders. Therefore, also for this reason, SMEs willing to adopt immersive technologies in their operations should maximize the functionalities of these tools.

In this phase, SMEs should prioritize having access to data related to all the processes integrated with XR. For example, data such as the amount of energy saved thanks to the implementation of VR in a defined process should be monitored and analysed, with the purposes of reporting and continuous improvement. Integrating immersive technologies with Environmental Management Systems (EMS) can automate the monitoring process, facilitating a consistent and accurate measurement.
The basis for a systematic measurement approach with consistent validity in this phase is the establishment of specific goals and KPIs in step A. Moreover, relying on solid frameworks such as the Plan Do Check Act (PDCA) methodology would be extremely beneficial in enhancing the sustainability performance of the company.

5.3 Ethical and social considerations

To comprehensively address the theme of immersive technologies adoption by SMEs, this paragraph aims to highlight ethical and social considerations that accompany this implementation.
In fact, it has been discussed how immersive technologies can offer important capabilities to enhance resilience and sustainability of SMEs. However, they also raise concerns that must be taken into account during the decision-making process of implementation.

AR and, above all, VR often require the collection of large amounts of data to function effectively. This data can include, for example, user location, physical movements, voice commands, and even biometric data, and the bad management of these could raise some privacy concerns. SMEs must ensure their adherence to data protection standards, safeguarding the personal data of their employees while using the new technologies. In this scope, they should consider implementing some level of cybersecurity in their action plan in order to reassure users about the safety of their data.
Privacy regulation should also be adopted towards the clients if the immersive technology is used in the customer relationship. Moreover, transparency must be adopted in regard to what data are used and for what purpose. SMEs should make policies easily accessible that outline how data is used and how technologies are impacting various aspects of the business and/or its stakeholders.

It is then fundamental for SMEs to familiarise themselves with legal frameworks applying to immersive technologies, such as data protection, but not only. For example, considering that XR often include unique content and software, SMEs should be cautious about intellectual property rights and similarly they should protect their own innovation, to maintain a competitive advantage.
Additionally, these technologies are still at a starting phase of deployment, thus the regulations about them are in continuous evolution and might impose in the future new and stronger compliance requirements. For this reason, SMEs willing to implement XR in their business need to stay up to date with emerging regulations, potentially being supported by legal experts.

The phase of development in which immersive technologies are nowadays open up for future rapid evolution that could also be considered by SMEs interested in the use of XR in their company. In fact, it is reasonable to hypothesize that the rapidity of evolution of this technologies may quickly render existing technologies obsolete. However, with strong commitment to a fully conscious digital transformation, SMEs could use these advancements to continuously improve and widen their competitive advantage.

From a social point of view, it has been analysed how immersive technologies can be beneficial in allowing high effective levels of remote working and promote inclusivity. However, it must be

considered that the full reliance on technology might lead to negative outcomes as well, such as reduced interpersonal interactions among the staff or job displacement. To manage these changes, SMEs should foster a culture that values both the technological and the human contribution. Employees, in fact, shouldn't feel like their impact is nullified by immersive technologies, but that the technologies complement and make more efficient their job.
Additionally to that, the extended use of AR and VR can lead to minor health issues for the employees using them, such as eye strain and migraines. For this reason, SMEs should proactively implement guidelines for safe use, including for example regular breaks or ergonomic considerations.

A final point to consider is the ecological impact that immersive technologies, like all technologies, have due to their deployment. It is fundamental that SMEs are conscious of the fact that XR technologies have a carbon footprint linked to their production and disposal. Their production involves the use and extraction of rare earth minerals and of plastics, practices that are harmful for the environment. For this reason, SMEs should adopt XR responsibly, focusing on long-term usage and maximization of use in various applications, trying to reduce replacements.

In conclusion, despite all the positive outcomes that immersive technologies can help achieve, for a fully conscious application, it is necessary that SMEs are aware of the ethical and social considerations posed by their use. Companies should ensure data protection and transparency regarding the usage of data, pay attention to the effect that those technologies have on their employees, both from a psychological and physical point of view, and adopt responsible practices in technology usage. By addressing all those considerations, SMEs can master the use of XR inside their organizations building a resilient and sustainable business model.

5.4 SWOT analysis

A table including a SWOT analysis on the implementation of immersive technologies by SMEs follows below.

Tabella 6: SWOT analysis on XR application by SMEs

Strengths	**Weaknesses**
• Innovation and differentiation • Enhanced efficiency • Improved trainings and development • Improved ESG sustainability	• High initial costs • Technical challenges • Structural barriers of SMEs
Opportunities	**Threats**
• Market expansion • Partnerships and collaborations • Government and industry support	• Security and privacy concerns • Rapid technological changes • Economic uncertainty

6. Conclusions

6.1 Summary and conclusions drawn from the study

This thesis has systematically explored the integration of immersive technologies within small and medium-sized enterprises to enhance their sustainability and resilience, in an environmental, social and economic sense.

The research began with an in-depth analysis of the relationship between SMEs and sustainability, highlighting the importance of the issue and the drivers that are currently driving them to adopt sustainable practices, as well as any barriers that SMEs need to successfully overcome in order to implement them. The same analysis was then carried out on the relationship between SMEs and immersive technologies: drivers and implementation factors were discussed, as well as barriers, which often reflected the same issues in the adoption of sustainable practices.

Particular emphasis was placed on the barriers faced by SMEs, in order to fully understand their position from a financial, technical and market perspective. The main findings of this first part revealed that SMEs often struggle to adopt sustainable practices and immersive technologies due to low financial resources, small scale of operations and lack of high level technological skills within the company. On the other hand, the main drivers for the acquisition of immersive technologies and the implementation of sustainable practices were technological advancement and the subsequent improvement of the business (albeit a higher brand reputation or improved efficiency in terms of time and cost).

After establishing a comprehensive background on SMEs and the factors and barriers they face, the thesis continued with a parallel research on the current state of the art, respectively the implementation of sustainable practices and the use of immersive technologies within SMEs in the European context. This phase included highlighting trends in the scope of different sectors and outlining the levels of adoption within SMEs of both sustainable practices and immersive technologies. In addition, the study was reinforced by the presentation of real companies belonging to the SME definition of the European Commission. The companies analysed, selected either for their strong commitment to sustainability or for their use of immersive technologies, were chosen from different sectors to highlight how, despite the barriers, sustainable development can be embraced by small and medium-sized companies in different and diverse ways.

Chapter 3.1 showed that the growing importance of sustainability can be seen in the adoption of sustainable practices by SMEs, especially in the area of environmental sustainability, with the implementation of initiatives such as recycling, energy efficiency and waste reduction. The

identification of good practices by real SMEs made it possible to highlight the link between commitment to sustainability and not only legal compliance, but also competitive advantage. Successful examples included the adoption of green energy solutions, sustainable supply chain management and CSR activities that enhance community engagement and employee well-being.

Instead, the conclusions of Chapter 3.2 showed that the current adoption of immersive technologies by SMEs is at a very early stage. However, in addition to video games and leisure, the sectors most likely to adopt them are manufacturing and retail. In terms of purpose, the technologies are mainly used for product/process development, trainings and improving of the customer experience. The real good practices identified provided a close-up view of the different use cases for which XR technologies can be implemented. In particular, their use was demonstrated in the context of architectural design, shopping experience, tourism and cultural experience, medical training and therapeutic purposes.

At this stage, both the concepts of sustainability in SMEs and immersive technologies in SMEs were widely discussed, providing a strong basis for discussing their integration. Chapter 3.3 discussed how immersive technologies can be important in facilitating the reach of sustainability in SMEs. The debate clearly highlighted all the ways in which XR can promote sustainability in all three dimensions: environmental, social and economic. Among other things, it was noted that immersive technologies can improve environmental sustainability by reducing the need for energy consumption and waste, optimising processes and providing a simple way of looking at the carbon footprint of processes. In terms of social sustainability, they were found to be helpful in increasing inclusivity and accessibility, facilitating more meaningful education, and improving safety and health. Finally, in the area of economic sustainability, they were found to reduce costs in the long term, increase employee productivity, improve customer relations and generally provide a significant competitive advantage.

Finally, Chapter 4 provided a practical contribution to the study by offering practical steps and advice to SMEs wishing to adopt immersive technologies in their operations The guideline included a discussion on how to overcome barriers and how to plan the implementation, as well as how to use immersive technologies to improve the company's sustainability. The implementation roadmap followed a step-by-step approach to the issues SMEs should consider when evaluating the integration of XR, starting with powerful insights into how to address the different types of barriers they may need to overcome. The following steps detailed how SMEs should assess their needs, evaluate the adoption with a cost-benefit analysis, and develop a detailed action plan to achieve effective implementation, as well as continuous monitoring and impact measurement after implementation. The guide then provided insights on how to integrate immersive technologies into a sustainable

framework. The steps included an initial identification of sustainable opportunities, followed by the right selection of technologies and software to match, and a final step of monitoring and evaluation for continuous improvement.

The chapter concluded with social and ethical considerations related to the use of immersive technologies. Incorporated into the implementation guide, the purpose of this section was to complete the comprehensive and objective view of the adoption of immersive technologies. It included threats and various considerations to be taken into account when deciding to integrate XR, such as privacy and evolving digital demands, reduced interpersonal interactions and the carbon footprint associated with the deployment of immersive technology hardware.

6.2 Speculation on the future role of immersive technologies

Looking ahead, it is possible to hypothesise that immersive technologies will see significant advances, such as more sophisticated AR and VR tools. This could include more affordable hardware, as well as software that requires less specialised knowledge to operate. These advancements could make immersive technologies more accessible to SMEs, potentially leading to higher levels of adoption compared to current levels.

The development of immersive technologies and their potential wider adoption could have a profound impact on many business sectors. For example, they could revolutionise the way in which training and education is delivered, significantly transforming the operations of SMEs that require specialised skills or operate in hazardous conditions. At the same time, they could reform B2C relationships, for example in e-commerce or in the planning of large projects, offering interactive experiences that customers will prefer.

Wider adoption in a variety of use cases will therefore drive the integration of sustainability, optimising resource allocation, reducing waste and improving decision-making processes, with benefits for the environment and for operational efficiency. In addition, wider adoption of XR technology would further strengthen its role as a useful tool for monitoring and reporting on environmental sustainability initiatives.

However, as the market grows, it is important to recognise that new challenges and social and ethical considerations may arise. For example, new regulatory issues may arise around technology reliability and data security.
Another ethical consideration is the potential impact of immersive technologies on mental health and social interactions. Extensive use of AR and VR could lead to issues such as digital addiction or social isolation. It is then crucial to address these risks from the outset and promote responsible use and healthy inclusion.

Nevertheless, it is uncertain how AR and VR will evolve and whether they will reach a level of widespread implementation capable of changing the way operations are carried out and the way people interact with them in general.
In conclusion, the future of immersive technologies holds great promise, but also great uncertainty. Factors such as technological feasibility, cost, user acceptance and the regulatory landscape may slow or change the predicted progress of these technologies. However, if these issues will be addressed proactively since the beginning, businesses could exploit the full potential of XR technologies to drive innovation, efficiency, and sustainability.

6.3 Recommendations for further research and future directions

The complexity and early stage of the topic of this thesis opens the door for further research to optimise the implementation of immersive technologies in SMEs and maximise their impact on sustainability.

Future research could explore ways to facilitate the use of immersive technologies for SMEs. This could include a focus on ways to reduce the technical complexity of XR to facilitate implementation in SMEs with low technical skills.

In addition, another focus could be on economic feasibility. Research could be carried out on detailed cost-benefit analyses for different types and sizes of SMEs to help clarify the economic viability and return on investment of adopting immersive technologies. Quantitative research on this topic could be very useful, especially if supported by strategies for scaling up the implementation of XR in an affordable way.

Useful research could focus on specific different sectors, analysing the impact of immersive technologies and the different ways in which they could be used among more restricted categories of SMEs within particular industries. Related studies could be conducted on organisational adoption models and tailored strategies for implementing these technologies.

The integration of immersive technologies and sustainability should also be further explored, with more comprehensive studies on the environmental, social and economic impacts of adoption. Again, quantitative studies could be very useful, as well as specific studies detailing the impact on the three different ESG pillars. In addition, also in this case, research focusing on different sectors would also be useful, as some use cases of immersive technologies in operations could significantly improve sustainability, while in other sectors and cases the impact could be more limited.

Finally, the integration between immersive technologies and artificial intelligence and its impact on companies and SMEs should be continuously researched. Indeed, the actual increase in the importance of AI leads to the hypothesis that the use of immersive technologies will be strongly influenced by this development, leading to an even greater increase in the efficiency and positive results of these technologies.

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