



DRIVING MANUFACTURING SME TRANSFORMATION TOWARDS
GREEN, DIGITAL AND SOCIAL SUSTAINABILITY

Deliverable 1.2
Manufacturing SMEs' sustainability strategies in
regional and sectoral ecosystems
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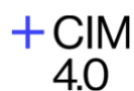
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Executive Summary

In the twin transition of the European industry, the manufacturing industry and its SMEs play a crucial role in achieving the set sustainability goals across the three dimensions: environmental, social and economic. This paper aims to better understand the sustainability strategies of manufacturing SMEs and their relationship with regional and sectoral ecosystems. It also aims at identifying success factors and obstacles faced by manufacturing SMEs in their efforts to become more sustainable. Four research questions guide the work:

- What aspects of sustainability in manufacturing are of particular relevance and interest of the manufacturing SMEs?
- What is the SMEs' motivation to start the process of introducing sustainability measures?
- What are challenges and success factors faced by manufacturing SMEs in terms of planning and implementing sustainability measures?
- What role do internal and external actors play and what are the connections to the regional and sectoral ecosystems?

Methodology

The report examines different kinds of data, including a comprehensive literature review, analysis of Self-Assessments from the SAT tool, information from the funded sustainability projects of the Open Call 1 in the greenSME project, interviews with manufacturing SMEs, and interviews with cluster representatives from selected regional pilot ecosystems conducted.

Background

SMEs are facing a range of challenges, including rising costs, disrupted supply chains, high inflation, shortage of qualified workers, and digitalisation. High costs and inflation are largely due to the Covid-19 pandemic, the war in Ukraine, disruptions in supply chains, and uncertainty about energy costs. Considering these overarching challenges, SMEs need to adjust their business models to address resource scarcity, including a focus on sustainability. However, SMEs often lack the resources to establish structures similar to those of large companies for development.

For the analysis of the regional sectoral ecosystems, the authors developed an understanding of regional sustainability ecosystems based on literature about business and innovation ecosystems. The following table explains the important elements.

Regional Sustainability Ecosystem Elements		References
Access to Knowledge and Resources	Funding and Finance	Jiang et al., 2022; Zhang et al., 2021
	Partnerships	
	Supply chain networks	
	Research institutions and universities	
	Government agencies and regulatory bodies	
	Technology development platforms and innovation hubs	

	Knowledge-sharing networks and communities	
Collaboration and co-creation	Collaboration and co-creation among actors of the ecosystem on business and innovation (projects, joint ventures etc.)	Eckhardt et al., 2021; Ketonen-Oksi & Valkokari, 2019
	What networking activities are offered?	
Market Access and Commercialisation	Access to distribution channels, networks, and market platforms	Huang et al. 2018; Leone et al., 2021
	Any support in terms of commercialisation	
Policy and Regulatory Support	Any policy and regulations in support of sustainability	Clarysse et al., 2014; Rinkinen & Harmaakorpi, 2019
	What is the role of the actors and of collaboration in facilitating compliance with sustainability standards and certifications	
Capacity Building and Learning	Are there any practices of mentorship, guidance, coaching, training on sustainable business models / strategies / practices / products / processes?	Álvarez Arregui et al., 2017; Walrave et al., 2018

The literature review on the relationship between SMEs and their regional ecosystems shows that SMEs must engage with external partners on matters of innovation, sustainability, and business competitiveness. The establishment of decentralized ecosystems centred around shared value propositions is the basis of the Open innovation approach. This approach encourages collaboration and partnerships with a variety of stakeholders to drive innovation more efficiently and effectively. This paradigm shift motivates firms to engage in partnerships, licensing agreements, and other collaborative arrangements to enhance their innovative capabilities and achieve competitive advantages. The role of open innovation in SMEs has received increased interest in recent years. The value creation process is supported by shared objectives and financial backing from the ecosystem stakeholders, while companies must manage a balance between their primary activities and their commitment to collaborative efforts.

Empirical results

1. What aspects of sustainability in manufacturing are of particular relevance and interest of manufacturing SMEs?

The Sustainability Assessment Tool (SAT), developed by the greenSME project partners, allows SMEs to test their sustainability status across environmental, social, and economic dimensions. 43 SAT reports were developed for the first open call period (2023), where indicators were calculated for the general sustainability score and its three pillars. The results show that the calculated and expected sustainability performance for the economic pillar deviate the least, while the social pillar has the largest performance gap. The variability in SME responses suggests a diversity of knowledge and understanding regarding sustainability and its integration into business operations. Some SMEs demonstrate a clear commitment to sustainability, while others may require further education or support.

The review of 41 ASAPs highlighted "Processes and production system" as the most critical action field for 41% of the assessed organisations, emphasising the need for efficiency improvements in production processes. Energy, materials, workplace, skills, and training were also identified as crucial action fields for approximately 30% of SMEs. Stakeholders' engagement was deemed most important for 34% of organisations but least important for 39% (Deliverable 3.3, Kononova et al. 2024). Sustainable Business Model Innovation was acknowledged by 41% of organisations as important and by 24% as less important.

These findings were echoed by the interviews conducted. Energy management also surfaced as a significant topic, encompassing initiatives such as purchasing electricity from renewable sources, installing solar panels, and implementing energy reduction measures. Materials management was another commonly identified action field, with a focus on using alternative sustainable materials and using materials more efficiently. Additionally, interviewees frequently discussed the importance of reporting environmental sustainability indicators, such as life cycle assessments, carbon footprint, waste production, and others. These reports are often linked to the certifications required for market eligibility and supplier approval.

Social sustainability aspects were also highlighted, including workers' safety, work-life balance, training and upskilling, gender equality, and establishing a new sustainable business model, selling a product with greater longevity compared to previous offers.

2. What is the SMEs' motivation to start the process of introducing sustainability measures?

Important internal drivers of sustainability for manufacturing SMEs include the commitment of the owner or CEO to sustainability goals, as well as the company's efforts to increase efficiency, productivity, profitability, and competitiveness. External motivators include customer requirements, regulations, high costs and the need to reduce them, competition for employees, and the rising sustainability of similar companies.

3. What are challenges and success factors faced by manufacturing SMEs in terms of planning and implementing sustainability measures

Challenges for the SMEs in planning and implementing sustainability measures are:

- The cost of investments required for sustainability
- Scarcity of adequate funding schemes for SMEs
- The rapid pace and complex design of environmental and social regulations
- Increase of product prices due to sustainability solutions
- Uncertainty about which actions are genuinely beneficial and which technologies can enhance sustainability and fit the company (often combined with inherent constraints of the production process)
- Uncertainty about real outputs and adequate goals and KPIs
- Resistance from employees
- Uncertainty of reception by the public or customers (not worth it if perceived as greenwashing)

Success factors are:

- Adapted financial instruments and funded open calls
- A robust knowledge and information base provided by consultants, networks, collaborations, or research projects
- Successful relationship and collaboration with partners, including Universities, R&D Institutions, or Competence Centres, which are essential for the practical implementation of sustainability measures and strategies, complementing SMEs' capabilities and facilitating operational success.

4. What role do internal and external actors play and what are the connections to the regional and sectoral ecosystems?

Manufacturing SMEs operate within ecosystems that extend beyond formal cluster memberships, involving significant roles played by policymakers, consultants, and education providers. While clusters inform SMEs on current topics, essential support often comes from paid service providers, such as consultants and training providers. Financial resources are critical for SMEs' sustainability, with funding typically managed by public entities, influencing the development of targeted funding programs.

Government initiatives are vital for regional economic support structures, including clusters, economic development agencies, and tax incentives. For instance, Poland's special economic zones highlight such efforts. However, SMEs often view governments as disconnected policymakers imposing regulations that complicate operations.

Clusters and networks are valuable to SMEs, providing necessary support such as:

- Identifying partners and service providers
- Organizing information events and trend forecasting
- Assisting in finding land and facilities
- Supporting funding opportunities at various levels

Consultancies help SMEs identify improvement areas and influence actions, while banks play a crucial role by offering loans, despite often hesitating to support long-term investments. Partnerships with universities and R&D institutions are leveraged for acquiring new knowledge and implementing sustainability measures.

Regional ecosystems also involve SMEs partnering with similar firms for knowledge exchange and shared experiences. The commitment of CEOs significantly influences SMEs' sustainability goals. Strong leading companies within pilot regional ecosystems foster industrial clusters, innovation, and collaboration.

Technical universities and industry associations support sustainability issues, while NGOs and citizens are underrepresented. Regional administrations facilitate SMEs' access to funding programs, with clusters acting as brokers. There is a need for better SME-friendly funding programs and regulations, highlighting the importance of cooperation with policymakers.

The pilot regional sectoral ecosystems fulfil all elements of the regional sustainability ecosystem approach, and manufacturing SMEs benefit greatly from the support of their ecosystems.¹

¹ The Executive Summary encompasses paragraphs that have been written on the basis of a summary of this original text generated with the AI based tool Semrush at <https://de.semrush.com>. This summary has then been reviewed and corrected by the authors.

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1. Introduction

For the twin transition of the European industry to succeed, it is imperative that all industries must actively engage in implementing effective solutions. The manufacturing sector, in particular, has a crucial role to play in both transitions and needs to foster sustainability. In 2022, small and medium-sized enterprises (SMEs) constituted over 99% of all enterprises in this sector, accounting for one-third of its total value added. Consequently, it is essential for SMEs to participate in this transition and find their paths towards sustainability (Di Bella et al., 2023). The greenSME project aims at strengthening manufacturing SMEs' capacity to use advanced technology and non-technological solutions to become more sustainable, involving all stakeholders and fostering collaboration. As part of the greenSME project, one report has been published that maps the current state of the European Sustainable Manufacturing Ecosystem (EUSME) (Behrend & Götting, 2023) and another report provides an initial roadmap for the development of a more sustainable EUSME by 2035 (Behrend et al., 2023).

Based on the understanding of sustainability and ecosystems from these works, this paper examines the sustainability strategies of manufacturing SMEs and the relation with regional and sectoral ecosystems. The aim is to identify the success factors and obstacles in implementing sustainability measures and to elucidate the roles that regional and sectoral ecosystems play in shaping these strategies. Also, the aim is to identify what role manufacturing SMEs play within these ecosystems. The analysis is informed by ecosystem literature, which aptly provides a framework for understanding the interrelations between manufacturing SMEs and other influential stakeholders.

The focus of this analysis is placed on manufacturing SMEs and their sustainability strategies. To this end, the deliverable conducts a detailed analysis of the supporting and inhibiting framework conditions, describing their influence and supportive content on the implementation of sustainability measures. To address this central issue, the following research questions are formulated to guide the operationalisation of the study:

- What aspects of sustainability in manufacturing are of particular relevance and interest of the manufacturing SMEs?
- What is the SMEs' motivation to start the process of introducing sustainability measures?
- What are challenges and success factors faced by manufacturing SMEs in terms of planning and implementing sustainability measures?
- What role do internal and external actors play and what are the connections to the regional and sectoral ecosystems?

Along these research questions, it is possible to take a much closer look at the situation of SMEs and trace their overall situation in general. In addition, the specific challenges, solutions and approaches of SMEs are summarised on the basis of empirical studies.

Methodology

In order to find answers to the presented research questions, several types of data were analysed. The authors provide a comprehensive literature review and document analysis on the topics of sustainability in SMEs, ecosystems, the relation between SMEs and ecosystems and about the two presented pilot ecosystems. Data collected and analysed in the greenSME project from the conducted self-assessments of SMEs on sustainability and from the projects funded in Open Call 1 were used to get an insight on important sustainability aspects for manufacturing SMEs. Also, 12 semi-standardised interviews with CEOs or middle managers from manufacturing SMEs have been conducted and analysed using qualitative content analysis. Additionally, for the pilot ecosystem in the Silesia Voivodeship in Poland, one expert interview was conducted with two representatives of a regional

cluster and for the Piedmont pilot ecosystem, one interview was conducted with a representative from a regional cluster. The pilot ecosystems have been selected according to three criteria: there were manufacturing SMEs from the ecosystem among the interviews, the ecosystems work towards sustainability in the manufacturing sector and there was access to interview partners for research.

The interviewed manufacturing SMEs were anonymised by using pseudonyms from the Greek alphabet. The table gives an overview about the conducted interviews.

Table 1 - Interviews with manufacturing SMEs and cluster representatives

Pseudonym	Category	Sub-sector	Country
Alpha	Manufacturing SME	Bulk goods treatment (powder)	Netherlands
Beta	Manufacturing SME	Industrial automation	Romania
Gamma	Manufacturing SME	Metal-plastic parts	Poland
Delta	Manufacturing SME	Surface treatments	Germany
Epsilon	Manufacturing SME	Metal parts	Poland
Zeta	Manufacturing SME	Metal parts	Poland
Eta	Manufacturing SME	Knives for textiles production	Italy
Theta	Manufacturing SME	Rubber and plastic	Slovenia
Iota	Manufacturing SME	Textiles	Germany
Kappa	Manufacturing SME	Electronic industrial parts	Italy
Lambda	Manufacturing SME	Rubber parts	Italy
Mu	Manufacturing SME	Honey	Spain
SA&AM	Cluster	Automotive and advanced manufacturing	Poland
MESAP	Cluster	Smart products and manufacturing	Italy

1.1. Sustainability in manufacturing SMEs

As outlined in D1.1 (Behrend & Götting, 2023) and D1.3 (Behrend et al., 2023), SMEs are currently facing a whole range of challenges they must overcome. Rising costs, disrupted supply chains and high inflation are challenges that are currently affecting all companies, but SMEs in particular. Added to this is a shortage of qualified workers and the rapid advance of digitalisation (Behrend et al., 2023). It is above all the multitude of simultaneous challenges that are currently having a massive impact on companies, and they are challenged to find solutions. It seems impossible to deal with everything at the same time, but it is precisely this simultaneity that needs to be mastered.

The high costs (and therefore also high inflation rates) are largely due to the current developments following the Covid pandemic and the war in Ukraine. In addition to disrupted supply chains, another

major impact is the relatively high level of uncertainty regarding energy costs. These developments paint a picture which not only presents SMEs with a whole range of challenges, but also seems to make it impossible to overcome them in one simultaneous action.

In order to meet current challenges, SMEs need to make adjustments that vary greatly from traditional solutions, including changes in their business models. The increasing scarcity of resources (human, financial and organisational) therefore makes it necessary to counter this scarcity with business models that focus precisely on this point (Wienzek 2014). Here, considerations of sustainability do represent an additional challenge, but also open opportunities to counter this scarcity of resources. So far, however, it is mainly an increasing "green attitude" among SMEs that can be observed, which is certainly present and is also lived to some extent but has found little entry into the business models (Behrend et al., 2023). This shows two things. Firstly, SMEs are heavily dependent on day-to-day business and are also heavily involved in it. This makes it particularly difficult to face up to strategic challenges and adjust their business models accordingly. On the other hand, they also lack the necessary human and financial resources to set up organisational structures similar to large companies, which could then be used for development. Nevertheless, these fundamental challenges faced by SMEs are not new and have remained unchanged in recent years (Bender 2005, Wienzek 2014). They are only becoming more pronounced due to the current problems and the increasing simultaneity of challenges (Behrend et al., 2023).

Sustainable processes and business models can meet the challenges described in various forms, help to solve them and ensure future production. These considerations have also been incorporated into the EU guidelines (European Commission, 2021; European Commission 2019a,b). Specific measures are required in order to align a company with these (see chapter 4). To this end, it seems worthwhile to first take a brief look at the concept of sustainability and how SMEs understand it.

- Sustainability is thus understood as defined in the European Green Deal (EGD), encompassing the three pillars - environmental, economic and social sustainability - and other relevant European policy, such as the industrial strategy. (European Commission, 2019a).
- With environmental sustainability, the EGD defines "the ability to use natural resources in a way that does not deplete them and does not harm the environment". (EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil', 2021)
- Social sustainability is defined "as the ability to create a society that is inclusive, equitable, and cohesive". (European Commission, 2019b)
- Economic sustainability is basically defined as "the ability to create a prosperous and competitive economy that is resilient to economic, environmental and social risks. The EGD promotes the development of low-carbon and circular industries, supporting innovation and research, and ensuring that the financial system supports sustainable investments". (European Commission, 2019b).

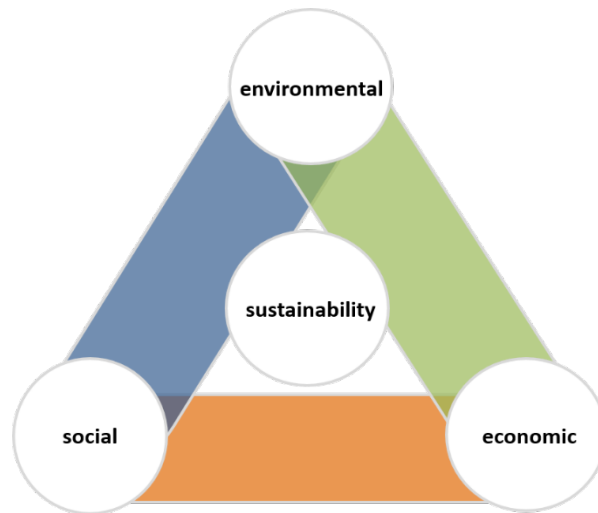


Figure 1: Three pillars of sustainability (source Behrend et al., 2023)

The efforts of SMEs can and should therefore be understood and categorised according to this understanding of sustainability. At the same time, they serve as a basic framework on which future business models can be orientated and trace the basic picture of SMEs that have already addressed the issue of sustainability. Nevertheless, obtaining information remains a central problem for SMEs in this context. The simultaneity of change requirements for SMEs leaves them with more questions than answers and thus hinders the adaptation of business models and the alignment with new goals. This problem can currently be summarised as information overload. It clearly shows that new tasks and challenges are constantly being added to the "normal" tasks and challenges faced by SMEs.²

The greenSME project rationale relies on the basic assumption that EU sustainable manufacturing industry shift depends on SMEs' awareness of their sustainable performance. The sustainability assessment tool (SAT) offers SMEs to test their own status of sustainability in the three pillars (environmental, social, economic). It is performed by an online survey, through a questionnaire, that is filled out by each SME willing to go into the sustainability transformation pathway. There are 101 questions grouped in 12 sections, such as External Drivers for Sustainability development, Internal Management (divided in 5 additional subsections), digitalization, advanced technology awareness, environmental assessment, social assessment, and economic assessment (Revilla et al. 2022). Analysis of the conducted SATs already provide first insights on manufacturing SMEs' sustainability status.

43 SAT reports were developed for the 1st open call period (2023), where indicators are calculated for the general sustainability score and its three pillars. Figure 3 shows SAT responses mean results. Putting together all calculated indicators, as well as the reference values of the expected performance (goals) for each company in each sustainability dimension (represented by a black line over each pillar gauge chart in Figure 3, a mean value of 44% for sustainability score was obtained for the 43 participating SMEs. The results of the self-assessment show, that the calculated and expected sustainability performance for the economic pillar deviate the least, whereas for the social pillar the biggest performance gap can be identified. In average, the calculated performance of SMEs within all dimensions (economic, social, and environmental) was under the expected goals resulting in need to address the dimensions in future actions.

² This summarised presentation only provides a condensed view. For more details refer to D1.1 and 1.3 (Behrend & Götting 2023; Behrend et al., 2023)

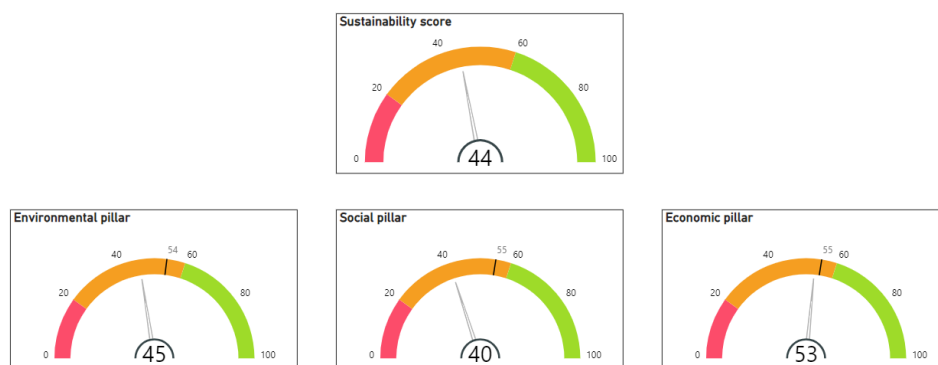


Figure 2: SAT Responses - mean sustainability indicators from the 43 SAT Reports

From the greenSME perspective, the review of 41 ASAPs highlighted "Processes and production system" as the most critical action field for 41% of the assessed organizations, emphasizing the need for efficiency improvements in production processes. Energy, materials, workplace, skills & training were also identified as crucial action fields for approximately 30% of SMEs. Stakeholders' engagement was deemed most important for 34% of organizations but least important for 39% (Deliverable 3.3, Kononova et al. 2024). Sustainable Business Model Innovation was acknowledged by 41% organisations as important and 24% as less important.

To better understand the level of awareness and knowledge on sustainability topics in SMEs, the manufacturing companies' answers from the first project period before the Open Call can be analysed where 43 SMEs have undergone the self-assessment. Environmental sustainability was claimed by 31 SMEs to be included in their current Business Model (BM). 23 reported the inclusion of both environmental and social sustainability in their BM, while 9 did not include environmental sustainability and 15 did not include social sustainability (Figure 2). Three SMEs provided a "don't know" response for environmental sustainability, and three for social sustainability. More detailed discussions within the Advanced Sustainability Action Plan (ASAP) workshops (18 workshops) revealed that some SMEs lacked a comprehensive understanding of the concept of a Business Model, as well as the nuances of social and environmental sustainability and how those can be integrated into the BM. Consequently, responses varied, with some SMEs uncertain about inclusion, while others definitively answered "yes" or "no".

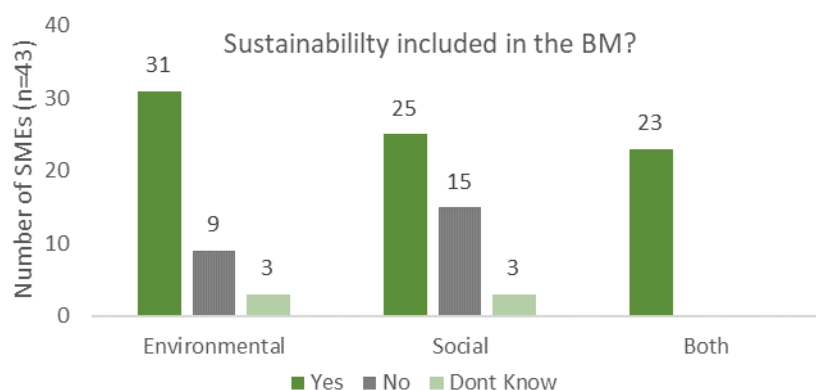


Figure 3: Answers by SMEs from the self-assessment on whether the environmental and social sustainability were included in the Business Model of the organisation.

The variability in SME responses suggests a diversity of knowledge and understanding regarding sustainability and its integration into business operations. While some SMEs demonstrate a clear commitment to sustainability, others may require further education or support to fully grasp the implications and opportunities associated with sustainable business practices.

However, with regard to the need for change and the need to make their own business model more sustainable, SMEs are sometimes very successful (see chapter 4) and use this change to integrate other approaches (such as lean management, Industry 4.0 technologies). The concept of the business model varies, although the function of business models is to describe, analyse and design the business activities of companies systematically (Zollenkop, 2006: 48; quoted from Kohlgrüber, 2017: 25). Building on this understanding, the adaptation or change of a company's own business model can then be understood as business model innovation. With a view to sustainability, it is then logically understood as sustainable business model innovation, which Kohlgrüber defines as follows: They represent the development and implementation of new or modified business models that result from a conscious reconfiguration of elements. Sustainable business model innovations also create better paths than the existing alternatives and contribute to the long-term availability of required economic, ecological and social resources (Kohlgrüber, 2017).

This overview is intended to summarise the key terms and the current understanding of sustainability in SMEs. It has become clear that SMEs are facing challenges in relation to the current issues surrounding sustainability that may be new in terms of content, but do not change the fundamental problems faced by SMEs. The fundamental scarcity of resources for SMEs remains unchanged. Their strong involvement in day-to-day business will not change either. The increasing simultaneity of the need for change already described in the discussion about Industry 4.0 increases with the integration of sustainability as an additional factor. In the current situation, SMEs primarily need reliable framework conditions and support services that are more closely tailored to their needs.

2. The relation of ecosystems and SMEs on the regional and sectoral level

This paper aims to give insight into the meaning of regional and sectoral ecosystems for manufacturing SMEs' sustainability strategies and into the role of manufacturing SMEs within these ecosystems. For this, the relation between SMEs and other stakeholders is analysed. This analysis is informed by the academic literature on ecosystems. The understanding of relevant elements and functions of a sustainability ecosystem will be specified in the following sections.

2.1. Sustainability ecosystems in the context of regional manufacturing sectors

The term "ecosystem" originated in the field of biology, being firstly introduced by the British ecologist Sir Arthur Tansley in 1935 to describe the complex interactions between living organisms and their physical environment within a defined geographical area. Tansley used the term to emphasise the interconnectedness and interdependence of different species and their environment. Over time, the concept of an ecosystem proved to be a powerful framework for understanding not only biological systems but also systems in other disciplines. As a result, the term was adopted and adapted by various fields, including environmental science, ecology, sociology, economics, and management (Scaringella & Radziwon, 2018; Willis, 1997).

The biological metaphor of the ecosystem in an entrepreneurial and economic context was coined by James Moore (1993), it is taken up in various approaches (see Brown & Mason 2017: 14; Stam & Van de Ven 2019: 809), and it has been studied through the lens of different theories, such as the resource dependency theory (Pfeffer & Salancik, 1978) or the institutional theory (DiMaggio & Powell, 1983), and at three different levels of analysis, such as the individual level (Nambisan & Baron, 2013), the firm level (Zott & Amit, 2010), and the industrial or network level (Nambisan & Sawhney, 2011; Teece, 2007). The link to biological ecosystems refers to complex interactions and interdependencies between different actors (cf. Moore 1993: 76; Brown & Mason 2017: 14). As in nature, ecosystems are able to maintain themselves and are therefore not dependent on external factors to ensure their maintenance (Vysna et al., 2021).

Despite its broader applicability and significance across various disciplines, the concept of ecosystem can be characterised by some common elements, being it a community of *actors and entities* (i.e. the various individuals/organisms, organisations, or components) that *interact and relate* with each other (in a cooperative, competitive, or symbiotic way), forming dynamic behavioural chains, where exchanges of resources, information, or services occur within defined *boundaries* (e.g., physical, such as geographical or territorial limits, or conceptual, such as industry sectors or market segments) (Tsujimoto et al., 2018). Ecosystems exhibit *complexity* arising from the multitude of interactions and interdependencies among their components, leading to emergent properties and *self-organisation*, where patterns, structures, or behaviours emerge spontaneously from the interactions among the actors without centralised control (Yoon et al., 2022). Moreover, ecosystems are *adaptive* and *resilient*, capable of responding to changes in internal or external conditions, allowing them to evolve over time and maintain their functionality despite disturbances or disruptions. Finally, regardless of the specific goals, ecosystems generally aim to sustainably support the activities and interactions of their constituents while *generating collective value or outcomes* (Khademi, 2020).

2.1.1. Four main types of ecosystems

In the economic and business management literature on ecosystems, four main types of ecosystems dominate the debate: *business* ecosystems (Moore 1993), *innovation* ecosystems (Adner, 2006),

entrepreneurial ecosystems (Prahalad, 2005), and *knowledge-based* ecosystems (van der Borgh et al., 2012). The four ecosystem approaches overlap in many ways and are closely interrelated; yet they can be differentiated by their actors, goals/foci and application areas (see Table 1). Understanding the differences can help identify relevant actors and resources for a particular ecosystem and develop appropriate strategies and actions to address the specific goals and challenges.

Business Ecosystems refer to the interconnected network of organisations, stakeholders and entities that collaborate, compete, and interacts within a particular industry or market to create, distribute and capture value (Wulf & Butel, 2017). Business Ecosystems often revolve around a key member – also referred to as platform leader (Cusumano & Gawer, 2002) or ecosystem leader (Moore, 1993) who are responsible of overseeing the overall operations of the ecosystem and consequently its actions exert a significant impact on the success of all other participants, including itself. By creating and sharing value, the key member is able to attract and retain other companies to the ecosystem, which is crucial for ongoing ecosystem growth and development (Mäkinen & Dedehayir, 2018). A part of creating and capturing value, no less important is the achievement of competitive advantage, which usually happens through collaboration that leads to economies of scale. In this ecosystem, a distinct form of value creation characterised by interactions rooted in mutual complementarity can be identified. In cases where a company faces challenges in commercialising a product or service due to internal limitations in competencies, innovation resources, skills, or assets, external sources may be necessary to address these internal deficiencies (Clarysse et al., 2014). In this sense, the existence of coopetition relationships is pointed out: companies simultaneously collaborate and compete. However, entities in a business ecosystem are not only working cooperatively and competitively, but also co-evolving in response to new innovations aimed at delivering novel products and/or services to meet evolving customer demands. This co-evolution occurs in a mutually beneficial manner, as the evolution of one company will impact the evolution of the others (Rong et al., 2018)³.

Despite business ecosystems have been usually defined with a region or a certain territory, the advancement of digital technology has led to the development of new collaborative organisational networks such as *digital business ecosystems*. These are collaborative environment encompassing different entities that co-create value through information and communication technologies, thus transcending traditional industry boundaries to foster open and flexible collaboration and competition (Senyo et al., 2019).

Innovation Ecosystems focus on the role of innovation in promoting sustainability, economic growth, or competitiveness by fostering the creation, development, and commercialisation of new products, services, or processes. The primary distinction between business ecosystems and innovation ecosystems lies in their different orientation towards customers or users. In business ecosystems, customer needs and preferences play a central role in shaping strategies and outcomes, whereas in innovation ecosystems, the emphasis is more on creativity, experimentation, and the development of novel solutions, with user engagement being secondary or implicit rather than explicit (Scaringella & Radziwon, 2018). Innovation Ecosystems encompass a wide range of actors from different stakeholder groups, including research institutes, technology hubs, venture capital firms, incubators, accelerators, and supportive policy frameworks. Their goal is to create a dynamic and open environment that fosters collaboration to create novel technologies, business models, and solutions that address market needs

³ Apple represents an example of business ecosystem. The company has created a vast ecosystem around its products, including the iPhone, iPad, Mac computers, and various services such as the App Store, iCloud, and Apple Music. This ecosystem involves app developers, accessory manufacturers, retailers, and service providers, all contributing to the overall user experience and value proposition.

or disrupt existing industries ⁴. In a broader approach, innovation is understood in a variety of ways, referring not only to technological but also to social innovations. All institutions and practices with defining effects on the introduction, implementation and diffusion of innovations are included in the innovation ecosystem approach (Granstrand & Holgersson, 2020; Thomas & Autio, 2019). The approach of Innovation Ecosystems is most fitting to the purposes of the European Sustainable Manufacturing Ecosystem (EUSME).

Entrepreneurial Ecosystems are different from other ecosystem types and focus on the conditions and factors that support the creation and growth of new businesses, such as Start-ups. Indeed, the entrepreneurship – defined as the generation of new value by agents – is the output of this type of ecosystem, giving prominence to the role of “servant” leadership exhibited by successful entrepreneurs who demonstrate a long-term commitment to the region. These entrepreneurs are inclined to form alliances with the public sector, and in some cases, may even integrate into it by assuming roles such as mayor or leader of a regional economic board. This form of entrepreneurial leadership entails a method of self-organisation within the entrepreneurial ecosystem, where entrepreneurship serves not only as an outcome but also as a catalyst for the system (Acs et al., 2017).

The focus of entrepreneurial ecosystems is on the external environment of such businesses, explaining the dynamics between entrepreneurs and actors who are in close geographical, institutional and relational proximity (Brown & Mason, 2017; Stam, 2015). Entrepreneurship Ecosystems include a variety of actors, such as founders, investors, mentors, incubators, accelerators and support organisations, working together to foster innovation, build capabilities and strengthen entrepreneurial culture ⁵. Entrepreneurial Ecosystems are in some cases defined by further elements, going beyond an actor-based understanding. These elements include, for example, infrastructure, entrepreneurial culture and knowledge (Stam, 2015).

Knowledge Ecosystems focus on the generation, sharing, and utilisation of knowledge as a fundamental driver of growth. These ecosystems aim to leverage intellectual capital, research, education, and technology transfer as a fundamental resource and driver of value creation, with a focus on the creation, acquisition, dissemination, and application of knowledge across various domains (Clarysse et al., 2014). This ecosystem encompasses an interdependent set of heterogeneous and knowledge-intensive actors that depend on each other for their effectiveness and efficiency, and as such need to be located in close proximity (Iansiti & Levien, 2004a). These actors include universities, research institutes, libraries, think tanks, industry associations, and policymakers. Knowledge-based ecosystems are confined to small geographical areas – for example, park- or campus-based initiatives, extensively draw on high-tech knowledge, and leverage high levels of managerial support (European Commission, 2002). Knowledge-based ecosystems facilitate growth by fostering a conducive environment for learning, skill development, and knowledge creation. They enable industries to enhance their competitiveness by leveraging intellectual assets, best practices, and continuous learning⁶.

⁴ Silicon Valley in California (USA) is an example of innovation ecosystem as it encompasses a dense network of tech companies, startups, venture capital firms, research institutions (like Stanford University), accelerators, and incubators. This ecosystem fosters collaboration, knowledge sharing, and the rapid development of new technologies and business models.

⁵ Accelerators like Y Combinator or Techstars serve as hubs for entrepreneurial ecosystems. They provide early-stage startups with mentorship, funding, networking opportunities, and resources to help them grow and succeed. These ecosystems thrive on the energy and innovation of startups, mentors, investors, and supporting organisations

⁶ A biopharmaceutical cluster, such as the one in the Boston-Cambridge area (often referred to as "BioPharma Hub"), exemplifies a knowledge-based ecosystem. It involves pharmaceutical companies, biotech startups, research universities, hospitals, government agencies, and specialized service providers. Collaboration and knowledge sharing in this ecosystem drive advancements in drug discovery, development, and healthcare innovation.

Table 2 - Comparison between different types of ecosystems and their features

		<i>Features</i>		
		<i>Actors/Entities</i>	<i>Goals</i>	<i>Application area</i>
<i>Type of ecosystem</i>	BUSINESS	Companies, organisations and other stakeholders	Create, distribute and capture value, and promote the growth and development of the industry or market as a whole	Various industries and markets
	INNOVATION	Research institutes, technology hubs, venture capital firms, incubators, accelerators	Create a dynamic and open environment that fosters the creation, development, and commercialisation of new products, services, or processes	Research and development, innovation hubs, technology parks and clusters
	ENTREPRENEURIAL	Entrepreneurs, investors, accelerators, incubators, universities, policymakers	Support start-up formation, attract investments and facilitate access to capital, and stimulate economic development	Innovation districts, entrepreneurial communities, business incubators
	KNOWLEDGE-BASED	Universities, research institutes, libraries, think tanks, policymakers	Promotion of knowledge creation, dissemination and utilisation in driving economic and social development	Research institutions, knowledge hubs, technology transfer

2.1.2. Ecosystem Approach as a regional concept

The ecosystem approach is often understood as a regional concept because it emphasizes the interconnectedness and interdependence of various actors, institutions, and resources within a specific geographical area. The ecosystem approach, when applied to regions, refers to viewing a region's economic, social, and environmental dynamics through the lens of an ecosystem. Just as ecosystems in nature involve interconnected relationships between various organisms and their environment, regions consist of interconnected networks of actors, institutions, and resources that interact and influence each other's activities and outcomes. Indeed, as regions are defined by geographical boundaries, making them tangible units for analysis and management, the ecosystem approach acknowledges the importance of spatial context in understanding the dynamics of interactions between different components within a system (Solodilova et al., 2020).

Particularly the concept of *entrepreneurial ecosystems* also serves the purpose of explaining why certain places have a higher level of entrepreneurial activity than others (cf. Brown & Mason 2017: 14). Within the entrepreneurial ecosystem approach, it is argued that communication, innovation and information are facilitated by personal contacts, co-presence and the co-location of people and companies in one place or region (cf. Brown & Mason 2017: 20). The exchange of knowledge on effective business models is also favoured by direct contact and physical proximity. Start-ups play a central role in entrepreneurial ecosystems in particular, which means that specialised resources such as venture financing, accelerators for start-ups or specialised consulting are important, which can also be exploited more easily through geographical proximity (Thomas, 2020). While it is argued that start-ups and entrepreneurs can benefit from the immediate availability of resources, mentors, investors and a supportive environment and that geographical proximity is therefore of particular importance

for entrepreneurial ecosystems, a more differentiated picture emerges for business ecosystems and innovation ecosystems.

The basic assumption is that geographical proximity can also play an important role in business and innovation ecosystems. For example, spatial proximity can lead to a more efficient exchange of information, better cooperation and stronger synergies between the players. Here, empirical observations and historical records show that economic development, industrial areas and also technology clusters tend to grow together geographically (Nachira et al., 2011: 10). Spatial proximity and the shared use of physical infrastructure also reduce transport costs, while other factors might also play a role. For example, it is assumed that the common culture and a "common language" in regions simplifies cooperation and developments and leads to a similar perception of reality, which in turn leads to common means of expression and thus to similar and interdependent technologies (Nachira et al., 2011: 10). Accordingly, it is also assumed that business and innovation ecosystems differ from region to region and reflect the respective culture, systems and institutions (Durst & Poutanen, 2013: 10). For these reasons, too, ecosystems and the concrete cooperation between different stakeholder groups often function more effectively at regional level than at national, European or international level. At the same time, it can be seen that certain regions can specialise in specific industries or technologies. This not only leads to a network of companies, research institutions and suppliers, but also to the establishment of specialised universities and further education institutions - accordingly, the supply of skilled workers in a region can also be influenced by such a specialisation. The role of the public sector and regional governments also plays a role in the development and promotion of business and innovation ecosystems. Accordingly, the right mix of talent, funding, infrastructure, scientific research capacity, institutional resources, supportive public policy and creative culture to produce innovative, ground-breaking and commercially viable green technologies is particularly important for the subject of this study, and thus for the sustainability of small and medium-sized enterprises.

On the other hand, companies can also work together over long distances and drive innovation even without physical proximity. Digitalisation in particular makes it possible to share knowledge and innovations quickly and without the restrictions of geographical distances. Technologies such as cloud computing, social media and various online platforms, for example, enable actors to interact and collaborate regardless of their physical location. At the same time, companies are often part of global value chains in which geographical proximity to other players is less important than the ability to operate effectively across borders. Purchasers and costumers in particular are not necessarily located in the same region, but have a national, European or international expansion. Important support instruments and institutions (such as clusters) are located at a supra-regional, often national or European level, which can be referred to as ecosystems (see Behrend & Götting, 2023).

In order to analyse the regional and sectoral ecosystems of SMEs in the manufacturing sector that aim at becoming more sustainable, implementing green technologies and social innovations, a combination of the innovation ecosystem and business ecosystem approach can be particularly advantageous for several reasons:

- **Access to Knowledge and Resources:** Innovation ecosystems provide SMEs with access to a diverse range of knowledge, expertise, and resources necessary for developing and implementing sustainable technologies and practices. This includes access to research institutions, universities, government agencies, and other organisations involved in sustainability research and development. An innovation ecosystem supports SMEs in gaining access to new technologies and research results that are crucial for the implementation of environmental sustainability in their production processes. At the same time, business

ecosystems offer SMEs access to funding, partnerships, supply chain networks, and market opportunities essential for scaling up sustainable innovations.

- **Collaboration and Co-Creation:** A business ecosystem can help build strong networks and partnerships that are important for implementing economically sustainable practices and maintaining competitiveness. By engaging with actors within both innovation and business ecosystems, SMEs can foster collaboration and co-creation of sustainable solutions. Collaboration with researchers, innovators, and industry experts within the innovation ecosystem can help SMEs seek and develop cutting-edge green technologies and social innovations. Meanwhile, collaboration with suppliers, customers, and industry partners within the business ecosystem can facilitate the integration and commercialisation of these innovations within existing value chains.
- **Market Access and Commercialisation:** Business ecosystems provide SMEs with access to markets and distribution channels necessary for commercialising sustainable products and services. By leveraging partnerships and networks within the business ecosystem, SMEs can effectively market and sell their sustainable offerings to customers, thereby driving demand and generating revenue. Additionally, collaboration with stakeholders within the innovation ecosystem can help SMEs refine their sustainable innovations to meet market needs and preferences.
- **Policy and Regulatory Support:** Both innovation and business ecosystems can provide SMEs with access to policy advocacy, regulatory support, and incentives aimed at promoting sustainability. Engagement with government agencies, industry associations, and advocacy groups within the innovation ecosystem can help SMEs navigate regulatory requirements and access financial incentives for sustainable initiatives. Similarly, collaboration with industry stakeholders within the business ecosystem can facilitate compliance with sustainability standards and certifications, enhancing market credibility and competitiveness.
- **Capacity Building and Learning:** By participating in both innovation and business ecosystems, SMEs can access capacity-building programs, training opportunities, and knowledge-sharing platforms aimed at enhancing sustainability expertise and skills. Collaboration with academic institutions, training providers, and industry peers within the innovation ecosystem can facilitate knowledge transfer and skill development in areas such as sustainable design, manufacturing processes, and supply chain management. Likewise, engagement with industry partners and business support organisations within the business ecosystem can provide SMEs with mentorship, coaching, and best practices for implementing sustainable business models and practices.

This integrated approach describes those elements of both types of ecosystems, that would allow SMEs to leverage both the benefits of innovation and technology and the strengths of a supportive business network to achieve their sustainability goals while remaining economically competitive. Incorporating these elements into a matrix of sustainability ecosystem (see Table 3) can help mapping the main areas of actions in terms of fostering an SMEs' approach to sustainability. This matrix includes the different actors, resources, relationships and processes that interact to support sustainability goals. It helps to identify key players, resources, and opportunities within the ecosystem, guiding effective decision-making and fostering collaboration for achieving sustainability goals. It guided the empirical analysis of the selected pilot ecosystems as presented in section 3.3.

Table 3 - Matrix of Regional Sustainability Ecosystem Elements

Regional Sustainability Ecosystem Elements		References
Access to Knowledge and Resources	Funding and Finance	Jiang et al., 2022; Zhang et al., 2021
	Partnerships	
	Supply chain networks	
	Research institutions and universities	
	Government agencies and regulatory bodies	
	Technology development platforms and innovation hubs	
	Knowledge-sharing networks and communities	
Collaboration and co-creation	Collaboration and co-creation among actors of the ecosystem on business and innovation (projects, joint ventures etc.)	Eckhardt et al., 2021; Ketonen-Oksi & Valkokari, 2019
	What networking activities are offered?	
Market Access and Commercialisation	Access to distribution channels, networks, and market platforms	Huang et al. 2018; Leone et al., 2021
	Any support in terms of commercialisation	
Policy and Regulatory Support	Any policy and regulations in support of sustainability	Clarysse et al., 2014; Rinkinen & Harmaakorpi, 2019
	What is the role of the actors and of collaboration in facilitating compliance with sustainability standards and certifications	
Capacity Building and Learning	Are there any practices of mentorship, guidance, coaching, training on sustainable business models / strategies / practices / products / processes?	Álvarez Arregui et al., 2017; Walrave et al., 2018

2.2. The role of ecosystems for innovation in SMEs

Small and medium-sized enterprises (SMEs) are essential to stimulating economic progress and fostering innovation in the manufacturing industry, contributing to the robust and sustainable advancement of the national economy by boosting job creation and upholding social cohesion (Gherghina et al., 2020). In Europe, around 24.3 million SMEs operated in 2022, making up 99.8% of all companies in the non-financial business sector and playing a key role in value-added production and job opportunities, yet also being significant contributors to energy and material usage, waste generation, and greenhouse gas emissions (Di Bella et al., 2023). Their involvement in achieving the European Green Deal's objective of net zero carbon emissions by 2050 is crucial to the EU's green

transition (Gorgels et al., 2022). Nevertheless, compared to larger corporations, SMEs often encounter obstacles in implementing sustainable practices and fostering innovation due to constraints in resources, expertise, and research and development capabilities, which in turn can impact their technological innovation and competitiveness (Bertello et al., 2021; Johnson & Schaltegger, 2016). Given this scenario, SMEs must engage with external partners on matters of innovation, sustainability, and business competitiveness to gradually transform into a decentralized ecosystem centred around shared value propositions and composed of diverse participants engaged in innovation and sustainability initiatives, which can adapt continually through a feedback loop with the surrounding environment (Xie & Wang, 2020).

To date, existing research has centred on examining various facets of open innovation and, consequently, the innovation ecosystem in relation to SMEs (cf. Bertello et al., 2021; Radziwon et al., 2017; Radziwon & Bogers, 2019), as well as the role of entrepreneurial ecosystems in the growth of SMEs (cf., Ferreira et al., 2023; Hadzic & Pavlovic, 2019; Khurana et al., 2022) and their integration into business ecosystems (cf., Chen et al., 2022; Georgescu et al., 2022; Perrone et al., 2010). Open Innovation refers roughly to the idea to use internal and external resources of a company to innovate rather than approaching innovation in a closed, strictly company-internal process. This approach encourages collaboration and partnerships with a variety of stakeholders such as customers, suppliers, universities, research institutions, start-ups, and other organisations. It allows companies to share knowledge, technologies, and intellectual property to drive innovation more efficiently and effectively. Thus, other stakeholders, the exchange of knowledge and ideas are in focus in this strand of literature and can be seen here as the innovation type happening within an innovation ecosystem. This paradigm shift encourages firms to engage in partnerships, licensing agreements, and other collaborative arrangements to enhance their innovative capabilities and achieve competitive advantages (Chesbrough, 2006; Huizingh, 2011).

The role of open innovation in SMEs is an area that has received increased interest in recent years (cf., Albats et al., 2023; Brunswicker & Van de Vrande 2014; Brunswicker & Vanhaverbeke 2015; Sabando-Vera et al., 2022). While emerging research has highlighted key trends and mechanisms, Radziwon et al. (2017) emphasized a deeper exploration of the precise conditions that enable SMEs to effectively adopt an open innovation approach at the firm or ecosystem level. Understanding how collaboration facilitates value creation and capture within business ecosystems is critical for developing successful innovation ecosystems (Moore 1993; Iansiti & Levien 2004b; Adner & Kapoor 2010). Their study identified key drivers and challenges faced by these firms in creating and capturing value for themselves and the broader ecosystem. They found that the value creation process is supported by shared objectives and financial backing of the ecosystem stakeholders, while companies must manage a balance between their primary activities and their commitment to collaborative efforts. Furthermore, ecosystem growth hinges significantly on the value capture process on an inter-organisational level. This open innovation process needs strategic management of knowledge flows within the innovation ecosystem, aligning with a multifaceted business model structure, intended here as an open system business model which evolves at ecosystem level and describes the value creation-capture logic for all involved partners.

Their findings demonstrate that both large companies and SMEs can positively influence the development and orchestration of a business ecosystem, bridging gaps between different approaches to examine practical aspects of business model development and open innovation practices by SMEs in a broader ecosystem context.

In another study, Radziwon and Bogers (2019) examined the collaboration between SMEs and other stakeholders within a regional innovation ecosystem, focusing on how SMEs perceive, organize, and manage open innovation through strong partnerships with other ecosystem participants. They identified specific challenges for SMEs due to the misalignment between their business models and those of their surrounding ecosystem. Their research revealed a connection between the type of

innovation and differing interpretations of innovation across the ecosystem, which needs to be managed and organized across various levels of analysis (SME, inter-organisational, and ecosystem). Important considerations for SMEs when choosing suitable partners at the organisational and inter-organisational levels include factors such as regulation, market, customer, and user orientation; complexity of product and technology; readiness of product, market, and customer; availability of tangible and intangible resources; balance of power; trustworthiness; and established agreements.

Remaining at this organisational level, Mei et al. (2019) studied the effects of inter-firm linkages on the open innovation of SMEs from an innovation ecosystem perspective. The authors state that, compared with large firms, SMEs in their nature are more relevant to open innovation. On the one hand, due to the "liability of smallness", SMEs lack internal means and resources to coordinate innovation activities, which makes them more reliant on open innovation partnerships in their ecosystems; on the other hand, SMEs are also less bureaucratic, more flexible for strategy- and decision-making, greater risk-taking and knowledge concentrating, and faster reaction to market fluctuations; all these features are conducive to SMEs' profiting effectively from open innovation activities. However, it is important to note that this risk-taking behaviour may be specific to the sample in this study and may not necessarily be representative of all SMEs. Different SMEs may vary in their risk tolerance based on factors such as industry, market conditions, organisational culture, and access to resources. Additionally, the geographical location and regulatory environment may play a role in influencing how SMEs approach risk-taking. Consequently, while the study's findings provide valuable insights into the relationship between risk-taking and open innovation in the sampled SMEs, they may not apply universally to all SMEs.

Based on the resource dependence theory, they divide a focal SME's external linkages with its partners in an innovation ecosystem into two types (i.e. the linkages of a SME with its prominent organisations and the linkages of the SME with its service intermediaries). They then examine the influence on the SME's innovation performance and analyse the effect of the SME's absorptive capacity on the two relationships, finding a positive relationship between the different linkages and shedding light on the mechanisms of SMEs' open innovation. In particular, using data from Chinese manufacturing SMEs, the research results indicated that both linkages of a SME with its Prominent Organisations and Service Intermediaries within an innovation ecosystem significantly and positively impacted the innovation performance of the focal SME. The linkages of the SME with its Service Intermediaries served a dual role in the focal SME's innovation activities within the ecosystem. Besides positively affecting the innovation performance, this linkage also had a beneficial impact on the linkages of a SME with its Prominent Organisations, acting as a bridge to enhance the efficiency of knowledge transfer within the SME's innovation ecosystem. Moreover, the study revealed the moderating role of absorptive capacity in the relationships between the linkages and the innovation performance of the focal SME. When absorptive capacity was measured by internal R&D intensity, it weakened both positive relationships; however, when measured by IT adoption, absorptive capacity strengthened both positive relationships, aligning with research on IT-enabled absorptive capacity.

Also, Song (2023) examined the impact of SMEs' interactions with ecosystem participants within an innovation ecosystem on their technological innovation capability. The study utilizes ecological theory to segment the innovation ecosystem and investigates how various ecosystem levels influence SMEs' technological innovation capacity. It distinguishes the roles of different stakeholders in the innovation process by breaking them down into species, population, and community levels. At the species level, universities and scientific research institutions play a key role in supplying scientific and technological knowledge. The population level encompasses the industrial chain, comprising upstream suppliers and downstream distributors, as well as the network of complementary enterprises, competitors, and users. The community level includes the broader environment in which the innovation ecosystem operates, such as the policy support provided by the government. Despite having different functional objectives, these various actors all contribute to knowledge generation and value co-creation within the innovation ecosystem.

The research enhances the understanding of the innovation ecosystem by categorizing it into universities and research institutions, the industrial chain and ecosphere, and the innovation ecological environment based on the roles of actors with varying attributes. The author demonstrated that the focal SME's connections with universities and research institutions positively affect independent and collaborative innovation capability at the species level. Additionally, the study found that a robust innovation ecological environment amplifies the influence of the innovation ecosystem on both, independent and collaborative open innovation capabilities of an SME. A supportive innovation ecological environment facilitates the swift and effective transfer of knowledge, technology, and information resources within innovation ecosystems. This increased resource flow provides the focal SME with opportunities to access a wider range of knowledge and complementary resources, thereby enhancing independent and collaborative innovation capabilities.

A more specialized study looked at the role that Italian Competence Centres play for the adoption of Industry 4.0 technologies by SMEs (Ietto et al. 2024). Competence Centres are a public-private partnership consisting of collaboration among several stakeholders, but of at least one research organisation and one or more companies (Ietto et al. 2024). Their mission is "to conduct experimental research and implement radical innovation projects via the adoption of Industry 4.0 technologies" (p. 1058). They are perceived by the article as innovation ecosystems in themselves. The authors concluded that the most important ways of support and influence on the SMEs by the Competence Centres towards the adoption of human-centred innovation are the following:

1. Extensive training
2. Opportunities for testing technologies on CC's facilities
3. Tailored open calls
4. Consulting, orientation, project development, sensitisation/awareness raising
5. Addressing ethical issues in research and results guide SMEs to some extent

(Ietto et al., 2024: 1066)

Another perspective is offered by Bashuri and Bailetti (2021), who explored the strategies SMEs can adopt to integrate into existing ecosystems for value creation. They observed that one of the main obstacles for SMEs attempting to join an existing ecosystem is the absence of a clear process that guides their entry. The article adds to the existing literature on SME involvement in ecosystems by presenting three distinct engagement strategies. The first one is an ecosystem engagement strategy for a SME based on the ecosystem theory (cf. Jacobides et al., 2018). This is, a small or medium-sized enterprise forms its engagement strategy within an existing ecosystem by identifying complementarities in both production and consumption. Production complementarities arise when offerings from existing ecosystem partners enhance the ecosystem's main offering (ecosystem's core value proposition) by providing additional value. Consumption complementarities occur when customers choose to combine the ecosystem's core offering (ecosystem's main product or service) with complementary offerings from individual partners within the ecosystem.

The second one is an ecosystem engagement strategy based on a comprehensive model derived from the authors' review of the literature on ecosystems. The proposed model consists of three key components: 1) the SME's entry strategy, 2) the results of the entry strategy in terms of performance (e.g., revenue, number of customers, time to cash) and 3) the ecosystem characteristics that lead to these results (e.g. ecosystem type, shared objective, number of dominant players, diversity of partners and customers, ecosystem openness).

The third one is an ecosystem engagement strategy for a SME based on the Minimum Viable Footprint (MVF) introduced by Adner (2012). Adner (2012) suggests that SMEs can successfully create value in an ecosystem by following a step-by-step approach that begins with the MVF strategy. This involves forming the minimum set of components that can work together to create unique commercial value. Once the MVF is established, SMEs can use it as a foundation for strengthening the ecosystem's core

value proposition. The MVF approach allows SMEs to start with a focus on solving a subset of problems where they excel and can maximize ecosystem partners' engagement. This limited-scope strategy helps SMEs build a dense network of partners and customers quickly, with the goal of achieving full scale. As the SME evolves, it can expand its value proposition by collaborating with new complementors.

All these previous studies do not emphasize sustainability as a key component in the context of SME involvement in innovation/business ecosystems. Sustainability is essential for SMEs and ecosystems in Europe as it aligns with regulatory requirements, supports long-term economic viability, and fosters innovation and collaboration across different sectors.

In this context, sustainability ecosystems stand out as essential frameworks that enable collaboration, knowledge sharing, and resource access among various stakeholders. This support helps SMEs integrate sustainability into their operations while also promoting technological and social innovation (Journault et al., 2021). Sustainability ecosystems are a specialized type of innovation ecosystem (Adner, 2006; Visscher et al., 2021), forming networks of diverse stakeholders who work together to achieve environmental, social, and economic sustainability (Fukuda & Watanabe, 2012). They are also recognized as mission-oriented innovation ecosystems (Jütting, 2020) and have gained prominence in the aftermath of the pandemic, during which manufacturing SMEs experienced a 9.8% decrease in value-added output (Di Bella et al., 2023).

To date, substantial research has focused on achieving sustainability through firms' internal R&D and supply chain collaboration. However, the involvement of different stakeholders—such as customers, partners, governments, and universities—in creating a sustainable innovation ecosystem has not been thoroughly studied (Liu & Stephens, 2019). Therefore, a comprehensive understanding of the most significant stakeholders from the SMEs' point of view, along with the roles they play in sustainability ecosystems, is crucial. This knowledge can shed light on how their interactions can drive technological and social innovation within manufacturing SMEs (Carayannis et al., 2019).

3. SMEs relations to regional sectoral ecosystems and Pilot Regions' sustainable manufacturing ecosystems

3.1. Overall findings on relations between the manufacturing SMEs and their regional sectoral ecosystems

Overall, the manufacturing SMEs who aim at realising more sustainable processes and practices draw on different stakeholders from their regional and sectoral ecosystems.

The twelve manufacturing SMEs we interviewed from the different ecosystems and countries all mention a number of external actors they cooperate with. These come from different stakeholder groups, namely, other companies, suppliers, service or technology providers, consultants, auditors, customers, cluster organisations, training providers, universities and other research organisations, and policy makers or public authorities.

The minimum of cooperation mentioned, is that SMEs exchange experiences and advice with other companies from either the same region or the same value chain. For example, CEOs call CEOs or managers from other SMEs, who they know, about good technology or service providers or about how to start a process of implementing sustainability measures. This connection to other companies is reported by several interview partners (companies Iota, Kappa, Beta, Zeta, Gamma and Eta).

More advanced collaboration happens in projects among different stakeholders, such as implementation projects and research projects. They are usually organised in a business relation through contracts, or research and development projects. They range from private tailor-made projects between a research organisation and a manufacturing company to European-wide projects with large consortia with several different companies, research organisations and other stakeholders.

Company Eta, for example, a company focused on knives production for the textile industry, reported that they developed a project together with a machine producing company. Company Beta, that is active in the field of industrial automation, reports that it integrates its product with automation products of a larger company. Representatives of Beta also say they look at actors from their ecosystem to “keep up” with what others are doing and look at other companies' practices to learn from their approaches and adapt best practices:

“[...]for example, we look a lot at our suppliers. So, as we work with very large companies [...],so, industrial automation suppliers, this helps us also to adopt some of their best practices, of course at a lower scale. But as they focus on the improvement of energy efficiency in your products with more capabilities with IoT functionalities, that also reflects on our products because we integrate their components. And, also, when we go to trade fairs, we try to see the trends. Also, we have good collaboration, so, being also a supplier. But we are also a partner of academic environment, so we are experiencing also some research projects and I think that's good, it does not help us directly but indirectly to understand the trends and to become more sustainable” (Beta, Pos. 39)

For those companies, that are strategically advanced in sustainability, many make use of collaboration with universities and other research organisations and are involved in research projects. The goals are to gain knowledge and an overview of potential technological and non-technological solutions, and in some cases, to get a partial or full funding for the implementation of a sustainability measure within the company.

One example for this is the company Delta that reported to work regularly in research projects for over ten years now. This company has developed a sustainability strategy that includes over 20

environmental and social sustainability measures. For this, ongoing collaboration with two different technical universities (engineering and chemical institutes) was important. Nonetheless, many ideas also were then developed within the company, based on the growing knowledge of different aspects of sustainability. Examples are employee engagement in organisational improvements, capturing and using heat and waste from production processes, renewable energy and electricity networks and the use of advanced materials among others. The insights the company gained in the research projects helped the company to evaluate own processes of production, energy supply, waste management and also social aspects like, engaging employees in this process of evaluation and the knowledge transfer and upskilling of employees.

Company Beta, as mentioned above, also relies on research projects as a source for best practices and fitting sustainability measures for their company. They also have received some funding in this context:

"But we had a good experience because this greenSME is not the first cascade funding programme we participated in, I think it's the 3rd or 4th. So, we found this to be quite efficient for our company. So, participating in this type of cascade funding programmes where the overhead of managing the project is very low and you can focus on a certain task and also having access to the resources of the larger project. I think this was quite good, we started in 2021 with applying to this type of programmes and so far, we had a good experiences." (Beta, Pos. 43)

Most companies, we interviewed, have not reported to regularly take part in research projects. Nonetheless, almost all of them apply for public funding fostering sustainability. Finance or funding of the sustainability measures are a crucial point for the companies' decisions to start implementing. The companies report that they first try to invest in sustainability measures within the company on their own account. But, if this does not work, they seek out funding schemes and apply for bank loans, preferably with a known local or national bank. Overall, stakeholders who can provide finance or funding for sustainability measures can be understood as influential on sustainability among SMEs. For many examples in the interviews, the external funding was crucial for the full implementation. In some cases, the manufacturing SMEs had considered certain sustainability measures, but did not manage to secure the financing and decided against them (more details in chapter 4.3).

Other stakeholders, who play an influential role for the topics addressed and the decisions of SMEs to implement sustainability measures, are consultants. Delta mentioned that they invited energy consultants into the company to help with developing a strategy towards energy efficiency. Company Zeta has a more continuous relationship with a consultant who mostly helps to identify potential customers, but also made the company aware of sustainability topics and opportunities for funding. Company Eta mentions how a consultant suggested connecting with the greenSME project to advance knowledge about sustainability of manufacturing SMEs and maybe apply in the Open Call.

Similarly, auditing organisations and sustainability reporting have quite an impact on the understanding and awareness about sustainability aspects among manufacturing SMEs. Some SMEs we interviewed had started auditing processes to be able to report the results to their customers and then became aware of potential measures to improve their sustainability:

"[...] I can tell you that the ECOVADIS audits for sure uh support us as well as we have to answer hundreds of questions. So, we also keep in mind that, oh, that is missing, that can be improved, that can be done better." (Epsilon, Pos. 232-234)

Others started with the intention to become more sustainable and used an assessment platform to understand which steps could be taken that would be most effective for becoming more sustainable.

The stakeholder group of education and training providers was rarely mentioned in the interviews. But, sometimes, when companies are already aiming at implementing sustainability measures, training

from external education providers is used. Generally, it seems that training offers are lacking for specific topics that are relevant to the SMEs:

"Just for the carbon footprint calculations we had some training external training and one of our co-workers has learned to do that. But, maybe this is just the basics. I'm afraid that if it comes to the calculation of the carbon footprint in the whole chain supply chain it will be much more difficult. So, still in that areas that would be good if there are some service providers for that." (Epsilon, Pos. 215-219)

We are currently running a course with [laminating company] to train unemployed individuals in rubber moulding. While there are many skilled workers in plastic moulding, rubber moulding is less common, and the technology isn't as widely known. Since we struggled to find skilled workers, we decided to train them ourselves. (Lambda, Pos. 21)

Customers in general are important stakeholders of the ecosystems, although they are often not mainly located in the SMEs' regions. Rather, in many cases, large companies who act internationally and have their headquarters in other countries have a direct effect on the SMEs. This is especially true for certain sectoral ecosystems, such as the automotive industry or the textiles production industry. Large industrial companies as customers have standards and legal requirements for suppliers that they have to fulfil if they even want to be considered. In other manufacturing sub-sectors, where SMEs produce for the end consumer, the mechanism functions differently: sustainability can become a selling point, but the requirements of customers can be diverse and unclear.

Customers' willingness to buy a more sustainable product influences whether sustainability measures are taken. Sometimes, customers would not want to adapt their processes between contracts and changes in standardisations, sometimes customers do not accept elevated prices for sustainable products:

"Even in the automotive industry - always so sustainable and so green and so streamlined and what, that always present themselves completely ... But, when it comes to redeveloping your own products or bringing sustainable products into it, then it becomes difficult. It's really like that. It's no longer about money. Even if it were cheaper, just the work of changing it, testing it and bringing it in - that makes it incredibly difficult." (Delta, Pos. 186)

"But we also see higher and higher requirements in terms of natural environment protection coming from the customers. Customers means, for example, calculating the CO2 footprint that is today not necessary for the medium companies, but as I know in the future will be necessary. There is more and more discussion on the market that even small and medium companies will have to issue or present to their customers the carbon footprint for each product that they offer or deliver to the customers. And in my opinion, this is a time-consuming activity and new people have to be dedicated, but parallelly nobody wants to pay for that." (Epsilon, Pos. 58-65)

SMEs also refer to cluster coordination organisations as important contacts. They get information from them about trends and important overarching influences, such as new technologies and implementations, non-technological aspects (e.g. training, HR, recruiting, lean management, business model development), upcoming legislation and reporting requirements. But they are also understood as an important node to other cluster members or even beyond that to the regional ecosystem:

"In any case, the knowledge, i.e. the expertise, is also imparted. [...] And that is always the help I receive [...] from the cluster - because they are always very well informed. - They also know the latest trends, what's available in practice, where you have to look, exactly, where you have to be interested in which topics. - And that's also the support I get there." (Zeta, Pos. 97)

They are also believed to have a good overview of the situation, needs and reality of manufacturing SMEs and to be able to represent the SMEs on an overarching level:

"Epsilon: I think that the activities of the clusters can help because clusters are more on the side of SMEs, and they understand better their needs and can represent them in terms of national regulations or European regulations, and they can help to fit some regulations for the real life of SMEs."

Interviewer: Do you think at this moment the cluster you are in contact with has enough information to represent you?

Epsilon: Yes, because the cluster who represent us is still in constant contact with us. But, also at least once a year we are fulfilling a huge interview with all the many questions about the different kind of areas, also sustainability." (Epsilon, Pos. 410-423)

On the other hand, when asked about sector associations, some companies did not stay in contact with them or did not believe the association to be able to know about the every-day business of SMEs. Some manufacturing SMEs we interviewed had positive relations to their sector associations:

"No, I don't think they [sector associations] counsel many companies in Poland, or almost none, that have a good impression of the associations. They're a bit more of a drag than a help. At least for the bosses." (Zeta, Pos. 302-309)

"I try to invent something and about the sustainability, so I try to see something different out of my company or my circle of people. What I can see is looking what's happened with my friends in Union Industrial and Confindustria or in the other area where I have a lot of partners or I have some friend of mine that has a company and they are moving in that way." (Eta, Pos. 35)

"But we also have a network, the German Society for Electroplating and Surface Technology, where people exchange ideas. There are various events, where we go, get inspiration, but also often things that we invent ourselves." (Delta, Pos. 142)

When asked about the role of policy, public authorities and regulation, most interviewed manufacturing SMEs had a bad image of regulations and the responsible public authorities, as they experience the current changes in legislation and compliance requirements as too much in too little time.

"Epsilon: Frankly speaking, I would prefer not to have any kind of additional policies because it will mean only something worse to SMEs, not better."

Interviewer: What kind of problem arises?

Epsilon: New requirements, new costs. So, I don't expect that it will be something less work and less costs. If you would see in the automotive sector, if you look at the automotive market, there is yet something more and more and more. So, cars are more expensive due to the policies." (Epsilon, Pos. 388-389)

“Who can establish the standard? My customer, we can make all together or the association of entrepreneurs. It can be a person in charge to establish the standard because if they do the standard or the standardisation by the law or by European Community we make a disaster.” (Eta, Pos. 46)

Also, it was mentioned, that the control of new regulations is not consequential in a way that one company put a lot of effort to fulfil new regulation but reports that competition did not and gained an unfair advantage.

Others did agree that policy is an important agent of change and that new environmental regulations were necessary to combat the current climate change but complained that laws are being made in a way that it is hard for companies to know how they can comply correctly.

“So ESG is already a bigger driving force [...] who are now saying, now we have to do something. What and how do you do that? Who say, how are you going to do that? How do you go about it? Well, there are a lot of companies that want to. Some of them who don't really know yet, who need some kind of counselling, support. That's how we started.” (Delta, Pos. 172)

On the other hand, public funding is accepted widely and most companies have either received public funding or are currently applying for it. This holds mainly true for European funds, although they are also handled by national and regional stakeholders. Some member states and regions do have funding programs for sustainability in which manufacturing SMEs can also apply.

Nonetheless, the role of owners or CEOs in SMEs should not be underestimated. The interviews have shown how the perspective and conviction of a company's leader does influence if, how much, what and how is done in the direction of sustainability. While some CEOs have actively searched for opportunities all over the company to raise sustainability (e.g. in terms of processes, energy efficiency, and employee wellbeing) other companies go slower and cautiously. One interview partner reported he must put effort in convincing their CEO to invest in sustainability although they find it would increase efficiency of production.

“As soon as we get into the implementation, in other words the factory implementation, - in our own company, it's relatively easy: Yes, the people are there, they know that they want that. And in the end, there's also a boss at the table who says we'll do it now if we have to.” (Delta, Pos. 146)

“No, our boss is the planning service for our company. Yeah, especially if it comes into details about the construction sites, he takes a big part in in the area of construction of our buildings or he has in his mind all the most important data of that building surfaces.” (Epsilon, Pos. 255-269)

“As I mentioned earlier, most of the company's network comes from the network of the management team because [Name of CEO of Lambda] is deeply involved in various networks, especially at the regional level, particularly in female entrepreneurship and corporate social responsibility, with a focus on ESG sustainability—these are her two main networks.” (Lambda, Pos. 33)

It becomes clear, that the ecosystem's influence is also limited by the willingness and goals of the CEOs or owners of a manufacturing SME.

3.2. Gaps in support for sustainability by the regional and sectoral ecosystem

The sustainability ecosystems on the regional and sectoral levels provide many opportunities and support to manufacturing SMEs. In order to understand potential to facilitate sustainability among the SMEs further, the analysis also included to look for gaps in this regard.

One often mentioned gap in the ecosystems was missing consideration of SMEs in new regulations by policy makers. The new sustainability-related regulations, coming from Europe and the member states, are perceived as being developed without integrating the needs of SMEs. The need for adaptations grows too much too quickly for the SMEs to keep up.

“Gamma: Make an evolution, not the revolution. So, if the new policies that comes very fast and not do not take reality in mind, so it's very difficult, because in even in Europe, there are differences. There are different backgrounds. There are companies from Western Europe that have easier start to easier transform for a new law. And Eastern Europe or Central Europe have more problems about this, about the infrastructure and other matters. And if the policy goes too fast or is like a measurement is taken from Western Europe and given exactly the one to one to Central Europe, it's difficult to adjust. So, this is like should be: The new policies, everything, should be taken into consideration, not only going fast and fast to achieve the goals, but also to think about if they can be made a little bit slower, but more efficiently. So... so not just making something to look good on paper, but also in reality to be achieved. And I think this is the thing that that would help.

Interviewer: When you say slow, but more efficient...?

Gamma: Yes, because doing something fast, going very fast into the into changes doesn't mean that it will be made good, correctly and efficiently. So, changing, usually, is better if it's like evolution. So, you are just in things to everything, to test them, to check them, to work good and not to make something from day to day.” (Gamma, Pos. 135-137)

“Boric acid, that was at some point it was irritating for us. Yes, and at some point, through the GHS Global Harmonising of Chemicals it suddenly became toxic - at the request of the Americans. Because they said, come on, it looks like salt, before someone sprinkles it on the egg, then he dies, we put a skull on it. And that means, here in Germany, a skull, special storage, more bureaucracy in ordering verification requirements, TÜV obligations for plants, wastewater plants. So, with us there's always another rat's tail, that somewhere you say, yes, with the normal things you sometimes don't feel like it anymore. Because, then it's just us Germans, we bureaucratise and persecute and always a bit more than everyone else.” (Delta, Pos. 70)

This means, that a lot of different types of resources need to be allocated to sustain compliance in a short amount of time. Also, some SMEs report, that production processes cannot be planned with security, so investments are at risk to be in vain. Overall, there is a need for policy makers to construct laws in a way that they are clear and provide a long-term perspective. This would help make compliance attainable also for SMEs:

“It means not only money. But I think that if we are speaking about the sustainability in the right sense, we can obtain a big support from everybody. Then, these matter are very... we spent a lot of money. I spent a lot of time, so if someone...that the European Community can sustain some cost are welcome

because if you do this goal in a good way, you need to spend a lot of time to do and it means that time is costing. And also people are costing. [...] is normal that we ask for support, but also for the gender sustainability, or other things. This is some support that would be useful and specially simplification in the law, the directive, the common law in order to be very simple, we can obtain everything because if it is clear we can obtain the result easily.” (Eta, Pos. 37)

“This is what I tell you is also what we are asking in this moment to the bank: try to create a common platform, it means we fill up one like for National Forum, try to create one national forum and in order that to be clear in Europe, clear in Italy, clear in my region. That if a German customer asked me for something, I have a one platform to do it.” (Eta, Pos. 42)

Many interviewed manufacturing SMEs also said that additional funding to support SMEs with the investments needed for compliance would bring sustainability forward better and quicker and without risking the economic sustainability of the SMEs:

“So, it is easy for the customers or for the European Union to give new requirements, but there [is] no additional money for that and everything costs. That's how we see it. Of course, we respect that the natural environment has to be protected. We respect that there are some requirements that have to be fulfilled to reduce the wastes to recycle, to implement in the company the rules in order to protect the natural environment and we do it as much as we can. But not all the requirements are easy to fulfil or some of them are connected with paying some extra money for that.” (Epsilon, Pos. 66-72)

“And I think that the state with its laws is important. That sustainable behaviour is supported by funding, for example. And non-sustainable behaviour and decisions are sanctioned by higher taxes, by, I don't know, laws to prohibit poisonous materials. And to rise the standards in the way that a small company can keep up. Otherwise, we will have in 20 years' time just big companies in the market. And I think that's not what most people want. But to set up a framework, what pushes companies to more sustainability and to sustainable business models. [...] The banks are important that they make sure that they support these ideas without expecting or taking risks as well in this kind of field. So, the banks are important. If they are too careful with handing out money because they think that they are not sure where to put the money in, then it stops us investing. So that definitely plays a big role.” (Iota, Pos. 430-443)

“I think that there are so many companies that need subsidies. So, it's difficult to be in this part that gets the subsidy. So, it's like many of companies need that movement for ecological production and so on. This is so big demand and it's not comparable with the subsidies, the number of subsidies and the money that are available.” (Gamma, Pos. 68)

“Many people are also worried. I think, it's in the SME sector in Poland, in these medium-sized small companies, I think that as long as you're a small company, at least in Poland, you're basically fighting for survival, to somehow make ends meet every year. And I think most small companies really think about sustainability, at least they tend to think about where I can save something, or where I can get financing for something somewhere, so that I can then introduce something in my company.” (Zeta, Pos. 177)

Another point that was raised with regards to policy-initiatives and funding was the need for long-term oriented sustainability strategies of SMEs. Some SMEs said that there was a gap in funding and finance for long-term initiatives, that need larger and long-term investments.

"Of course, every time it is connected with the investment and it is very nice and very good if the investment can be co-funded because normally those paybacks are very long without any special funds the paybacks for the solar panels are more than 10 years so normally in the companies you do not invest anything for in anything that will not have a payback less than four years so that's why this kind of special funds for improving the sustainability are really necessary." (Epsilon, Pos. 174-179)

Also, some mentioned that they see a gap in long-term policy initiatives for manufacturing SMEs' sustainability:

"Interviewer: Did you expect anything more from the policy or at the European levels in terms of fostering the sustainability of manufacturing SMEs?"

Beta: I think this is a very current topic, so it is becoming more and more difficult with the problems of skilled personnel, with energy costs, there are many challenges that make it manufacturing in Europe quite a challenge in this period, so I think there should be permanently some programmes which support this, I mean long term programmes like 5-10 years. Yes, because these challenges, I don't think they will go away with the energy challenges, with the problems of a skilled personnel. " (Beta, Pos. 50-51)

Funding, reducing bureaucracy, creating reliable standards for reporting and clear and effective policy are the major gaps from the perspective of the interviewed SMEs. Nonetheless, there were also some mentions of other gaps in the company's ecosystems.

Two SMEs reported that they did not find adequate consultants for their questions of choosing the right sustainability measures and solutions, because either, the present consultants were not neutral as they represented providers, or they did not tailor their advice to the specific company:

"And so, this is this is probably the biggest challenge, that that we don't have the knowledge in all these specific fields. And we don't know where to start. And the people who can advise us are often not neutral because they try to sell you something. If it's about heating, for example, or effective use of energy in the rooms we have, it's difficult to find someone who gives you a proper and neutral answer to what kind of heating system we need in the future. Things like that, because the companies who do that, they try to sell you something. So a neutral, neutral consultants, that's probably the biggest challenge." (Iota, Pos. 165-171)

"No, we actually started with projects. 2010, that was the first project. Consultancy comes after...I have often rather bad experiences with consulting. I used to work in a company, I always have to put up with counselling. That was standard X. They would have advised a flower shop just like an electroplating shop, like a corporation, like a haulage company. That was always standard F." (Delta, Pos. 178)

Another interview partner reported that there was no adequate solution for CO₂-analysis for their company:

"I wish to work in that direction, but I hope to receive some concrete items in order to see also how we can develop our production, our company in the right way. Nobody asked me to account CO2 analysis, but I wish to do it. As I've done a lot of years ago some elementary strategy in order to obtain a better result and also reduction in the waste. But now my problem is how I can manage this thing. I don't want to lose a person. I am sure that can help a person, but I don't know how my dimension can be supported by the new technologies? And we are thinking. But I am not a service company, I am manufacturing. So, it means that I need something in production, but I don't need the numbers. I need something but I cannot tell you now. Because it could be that it doesn't exist because I also visit exhibitions, I go for specific things, but I don't see some application that I can bring and put in my company for the moment. I am sure that, from today in a year, I will find some solutions, but this is the difficulties that I have." (Eta, Pos. 22)

3.3. Pilot Regional and sectoral sustainability ecosystems

In order to get a deeper understanding of regional and sectoral ecosystems in practice, two pilot ecosystems were identified and examined more closely, using the matrix presented in section 2.1. Additionally, the interviews with the SMEs from these ecosystems and of the cluster representatives were analysed and compared in order to get a better impression of the way that SMEs step into relations with the other stakeholders and how the ecosystems approach fostering sustainability of the manufacturing SMEs. The aim is to see what elements of the described sustainability ecosystems can be found in the examples, what they look like in practice and how the SMEs perceive them.

3.3.1. Silesia Automotive & Advanced Manufacturing Ecosystem

One of the pilot sectoral regional ecosystems we chose to describe here, is the automotive manufacturing ecosystem in the Silesia Voivodeship in Poland. It is an ecosystem, well established in the region, with large internationally operating vehicle manufacturers (of the Stellantis group) and suppliers. The region is one of the most important industrial regions of Poland – around 9% of the enterprises in Silesia are counted as manufacturing companies (Górecki & Dudzic-Widera, 2024).

The region was formerly mainly characterised by coal mining, metallurgical and chemicals production activities. From the late 1990s until the middle of the 2000s, many coal mines and metallurgy companies closed, while most of the remaining companies in the metallurgical industry got integrated into multinationals. Also in the 1990s, automotive companies became more significant for the regional economy with new jobs created in cities like for instance Bielsko-Biala, Gliwice and Tychy. In a period of two decades a significant number of automotive suppliers settled in the Silesia Voivodeship, contributing as such to the transition process towards a more sophisticated and technology-oriented industry. Nowadays, the region faces challenges in energy transition.

The Silesian Automotive and Advanced Manufacturing Cluster (SA&AM) has been founded in the region to support the automotive and manufacturing industry and connect the companies and other stakeholders. The mission of the cluster is twofold: "The mission of the cluster in the area of Innovation and Cooperation is to effectively combine engineering with the latest technologies to streamline manufacturing processes, increase productivity, optimise resource consumption, minimise waste production and losses, and, consequently, provide businesses with a competitive edge in the international arena.

The mission in the area of Labour Market and Education is to establish and preserve the competitive advantages of employers in terms of human resources by developing and implementing system solutions which tap into the potential offered by cooperation between employers and employees, as well as between employers and the educational market." (Górecki & Dudzic-Widera, 2024)

The cluster brings together important stakeholders from the industry, including Original Equipment Manufacturers (vehicle manufacturers of the Stellantis group), component suppliers and technology providers. It also integrates key stakeholders from the fields of finance, innovation, research and education, as well as business support and professional services.

The cluster is one of the clusters that operate within the Katowice Special Economic Zone (KSSE). The KSSE was founded under the Regulation of the Council of Ministers of 18 June 1996 in order to support and advance restructuring processes. The status as special economic zone allows the companies to obtain a tax relief, buy appropriate developed land (with the possibility of also obtaining a property tax relief) and get professional advice for business development in terms of finance, human resources, certifications and other topics (KSSE, 2022). Since 2018, the former regional special economic zones operate under the umbrella of the Polish Investment Zone and can now rely on national funding and can operate in a greater radius geographically, which allows for a more comprehensive integration of the business and innovation ecosystem into the KSSE operations.

For the analysis of the regional sectoral ecosystem, the cluster and the KSSE play a central role as a connecting node between the different stakeholders and in making information to manufacturing SMEs more accessible.

This holds true for a variety of topics, including overarching trends that affect the industry and the companies' business and more specific topics of the regional industry. The KSSE and the cluster put significant effort into awareness raising for all three pillars of sustainability in the manufacturing sector. As described in the sustainability ecosystem table for the Silesian automotive manufacturing industry, the ecosystem stakeholders are widely organised within the KSSE and the SA&AM. Further influential stakeholders and networks of the automotive ecosystem in Poland are the Polish Chamber of Automotive, which is the national automotive chamber of commerce and thus a self-governing body of the sector, the Polish Automotive Industry Association (PZPM) which is the biggest association of Polish automotive industry employers, and the Polish-German chamber of commerce, that facilitates partnerships between the German and Polish industry and administration. There are also other networking organisations, such as for instance "automotive suppliers.pl", that specialise in consultancy, brokerage activities and branch conferences.

3.3.1.1. The elements of the ecosystem according to the framework for sustainability ecosystems

Table 4 - Elements of the Silesia Voivodeship sustainability ecosystem⁷

Sustainability Ecosystem Elements		The sustainability ecosystem in the Silesia Voivodeship (Poland)
Access to Knowledge and Resources	Funding and Finance	<p>In the Silesia Voivodeship the regional self-government manages the programme <i>European Funds for Silesia</i> including dedicated measures for SMEs in the field of research and development, digital transformation, energy efficiency, competencies development.</p> <p>On national level, public support instruments in the framework of which companies can apply for funding for sustainability-related projects are managed by organisations such like: the Polish Agency for Enterprise Development, the National Centre for Research and Development, the National Fund for Environmental Protection and Water Management and Bank Gospodarstwa Krajowego - the Polish development bank supporting among others sustainable social and economic growth. The Polish Development Fund Group provides own financial instruments (credits, loans, capital investments) and cooperates with a network of risk capital funds. Among these funds several are focused on financing start-ups and existing companies dealing with sustainable technologies.</p> <p>The Katowice Special Economic Zone (Katowicka Specjalna Strefa Ekonomiczna S.A. – KSSE) was established under the Regulation of the Council of Ministers of 18 June 1996 in order to support and advance restructuring processes, as well as to generate employment in the Silesia Voivodeship. Currently KSSE is involved in delivering administrative decisions on tax relief for new investments under the programme Polish Investment Zone. Companies that would like to make use of this tax relief instrument have to demonstrate their investments follow sustainable economic and social development principles.</p> <p>In the region there are several loan and guarantee funds supporting companies, among others in their twin transition process. Cluster members cooperate with consultancy firms and business support organisations in identifying public and private financing instruments and in preparing business plans and project applications.</p>

⁷ Sources: As depicted and the interview with the cluster representatives from SA&AM.

	Partnerships	<p>KSSE has numerous partnerships, among others with business support organisations, local and regional self-governments, universities and schools as well as with organisations on national and international level involved in economic development and people competencies development. KSSE strongly believes in the competitive advantage of a skilled labour force and flexible labour market as a prerequisite for regional industrial growth and innovation.</p> <p>KSSE is the coordinator of Silesia Automotive & Advanced Manufacturing, a cluster established in 2011 counting currently over 220 members. Among these members there are several business and technology parks that developed their own partnerships, for example to provide projects supporting companies' competitiveness through technology development and innovation.</p> <p>KSSE is also coordinating the European Digital Innovation Hub Silesia Smart Systems, a consortium of business support organisations, research and development organisations and universities supporting digital transformation in SMEs. Social and environmental sustainability is being promoted within these partnerships through workshops, training and matchmaking between demand and supply of advanced technologies and specialised services.</p> <p>The self-government of the Silesia Voivodeship coordinates a regional network of technology observatories. These thematic observatories are dedicated to technology areas prioritised in the region's smart specialisation portfolio in the regional innovation strategy. Among them, the observatory for green economy analyses trends in environmental technologies, provides entrepreneurial discovery activities to identify needs and opportunities in the field of sustainable transformation and promotes eco-innovation solutions developed in the region.</p> <p>KSSE is member and coordinator of several energy clusters. These clusters are established according to the Act on Renewable Energy Sources. Local governments, business support organisations, companies and energy suppliers cooperate together in defining energy needs and providing decentralised investments in renewable energy production and distribution.</p>
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Supply chain networks	<p>Silesia Automotive & Advanced Manufacturing (SA&AM) integrates companies in the automotive supply chain. The automotive supply chain is a global supply chain. As such companies need to ensure price competitiveness through process innovation, cost efficiency and reliable supply chains. Based on challenges and problems raised by the companies, SA&AM provides workshops and best practice exchange. Sustainability-related issues have become more important during the last years, mostly due to the European Taxonomy regulation and sustainable financing preferences of financial institutions in Europe, the Corporate Sustainability Reporting Directive and pressure from society. As such automotive brands expect social and ecological sustainability measures to be taken by their suppliers, in the coming years, one shall see a growing need for reduction of the overall carbon footprint, for increased application of recyclates and for improved man-machine cooperation.</p> <p>Also, over 50 companies dealing with advanced technologies are member of the cluster. They organise workshops and activities promoting digital transformation, not only for automotive companies but also for a wider group of industrial companies. Observing trends, advanced technology suppliers are including sustainability issues in their support services, for example: diminishing product carbon footprint, providing efficient energy management, diminishing scrap, improving product quality, improving remote cooperation with employees and business partners, employee empowerment through data-sharing. As such new relationships are being built between technology suppliers, integrators and service companies.</p>
Research institutions and universities	<p>At the end of 2023, SA&AM counted 23 universities and research institutions among its members. Research teams specialised in engineering, machine and machine tool engineering, new materials, IT engineering and other research disciplines are being involved in problem-solving workshops and Science2Business matchmaking events.</p> <p>Several teams are engaged in the E-DIH Silesia Smart Systems delivering services (training, technology demonstration, technical advice) in the fields of robotics and automation, new materials and 3D printing. In these fields environmental sustainability plays an important role. E-DIH Silesia Smart Systems also offers training in man-machine cooperation and applying solutions having a positive impact on the work environment (employee readiness to cooperate with cobots, automation and AI, employee empowerment).</p>

Government agencies and regulatory bodies	<p>On national level, the agencies and financial institutions related to the Polish Development Fund Group (https://pfr.pl/en/who-we-are.html) are involved in support instruments for SMEs, large companies, research and development organisations, business support organisations and local governments, among others providing services and financing for sustainability-related projects.</p> <p>Also, the National Fund for Environmental Protection and Water Management provides specific support measures for green transformation.</p> <p>On regional level, there are several business support organisations that were set up by local and regional self-governments about 30 years ago to manage economic transformation processes. KSSE cooperates with these organisations as well as with the regional self-government of the Silesia Voivodeship and the Opole Voivodeship on policy matters and in areas such as economic development and competencies development. Małopolska Regional Development Agency and the Kraków Technology Park, both SA&AM members, are agencies focusing on the Małopolska Voivodeship and cooperating with the Małopolska regional self-government.</p> <p>KSSE is a state-owned company (State Treasury has majority of votes), other shareholders include 10 municipalities. KSSE is one of the 14 special economic zones in Poland. The zones' representatives meet regularly and discuss good practices in investment support and economic development.</p> <p>On national level the Ministry of Economic Development and Technology shapes the economic policy and defines supports measures in the field of digital transformation, green technologies and closed-loop economy with the aim to increase the competitiveness of the Polish economy on the global markets. The Minister of Climate and Environment conducts a policy of sustainable development while preserving native natural resources. On regional level the regional self-governments provide their policy by way of strategies and programmes, among which the regional innovation strategy. KSSE is involved at the policy preparation stage in workgroups and discussion forums. It is also among the stakeholders mentioned in policy documents responsible for specific fields of economic and sustainable development.</p>
Technology development platforms and innovation hubs	<p>SA&AM is a cluster dedicated to development in the automotive sector and advanced manufacturing companies. Within the cluster cooperation between companies, technology providers and educational and research institutions is stimulated through workshops, matchmaking events and direct contacts. Taking into account that the automotive sector is a globally networked sector, main technology development platforms are concentrated around competency centres of automotive original equipment manufacturers and tier-1 suppliers. Here, innovation projects happen in partnerships.</p> <p>On regional level the SA&AM members have little impact on technologies. However, from the point of view of continuous improvement in processes, companies do need support in providing technological solutions positively impacting cost efficiency, productivity and quality. Among the SA&AM members there are technology parks and risk capital funds supporting the development of technologies, including solutions for social and environmentally sustainable development.</p> <p>KSSE is the consortium leader of E-DIH Silesia Smart Systems - a cooperation platform between business support organisations, research organisations and universities, focusing on supporting industrial enterprises in digital transformation. Companies can choose out of a series of technology demonstration activities and advisory services as a result of which they can better prepare their digital transformation process.</p>

	Knowledge-sharing networks and communities	<p>KSSE is co-organisier and partner in several networking initiatives in the region, among which: European Economic Congress, European Congress of Small and Medium-Sized Enterprises, local business events, investment fairs. During these events, sustainability issues are being discussed in panels and solutions are being presented at exhibitions.</p> <p>On the level of SA&AM, knowledge sharing takes place during workshops and best practice exchange meetings.</p> <p>KSSE runs an online platform (Strefa Klastra) on which thematic groups are formed, including the groups dealing with environmental sustainability (green organisation, digital organisation, logistics) and social sustainability (health & safety, HR).</p> <p>Meetings to exchange best practices are intended for promotional, business and reference purposes. They are hosted by businesses with own specific solutions willing to share their successes with other interested cluster members. These meetings are also intended for image-building and business purposes, as in addition to conferences and expert panels, they traditionally include plant tours and B2B meetings.</p> <p>On the European level KSSE is member of the European Automotive Clusters Network (https://www.eacn-initiative.eu/). The EACN members regularly meet online to discuss important issues for the automotive sector, including issues related to social and environmental sustainability.</p>
Collaboration and co-creation	Collaboration and co-creation among actors of the ecosystem on business and innovation (projects, joint ventures and others)	<p>Since the automotive sector is a global high-competitive networked sector with high concentration of multinationals and industrial groups, co-operation is mainly organised within multinational structures.</p> <p>However, on local level, collaboration is promoted by SA&AM in the form of business-to-business matchmaking events, science-to-business matchmaking events and direct contacts between demand and supply in case of very specific needs. Cooperation is determined by non-disclosure contracts and strict rules. As such these processes take place beyond the knowledge of the cluster management team. One can observe cooperation between the advanced technology suppliers in the cluster to create joint offers for potential clients. Also, these suppliers are involved in the greenSME project, teaming up with automotive suppliers (SMEs) in preparing and implementing pilot projects on sustainability.</p> <p>KSSE has been active in several European projects in which it also engaged cluster members. For example, within the EACN project (COSME) international project teams were formed between automotive suppliers and advanced technology suppliers. Three SA&AM members joined international project consortia. In the Boost4BSO project (Interreg CE) 4 Polish SMEs were supported in their digital transformation process. Also, several business support organisations received training in applying advisory tools to support the digital transformation process in SMEs.</p>

	What networking activities are offered?	<p>Within the cluster, each manufacturing SME has appointed one contact person, who is in direct contact with the cluster management team. Should a company have a problem, or would like to find a partner or supplier, this contact person creates a post on the online cooperation platform "Strefa Klastra" (Cluster Zone) or calls the cluster management team. Based on specific issues or requests the cluster management team takes up an intermediary role in linking demand and supply, at the same time safeguarding its neutrality.</p> <p>For issues requiring best practice exchange or expert input the cluster management team verifies available competencies among cluster members and organisations in the wider eco-system. Workshops, training sessions and discussion groups are organised within thematic groups. Each company has the possibility to dedicate specific employees to these thematic groups on the online cooperation platform.</p> <p>KSSE organises business mixer events and matchmaking events during which cluster members get to know each other and develop new relations. Informal networking takes place during the SA&AM Happy Hours meetings. Cluster members also have the opportunity to network during the monthly online meetings for their first-contact persons.</p>
Market Access and Commercialisation	Access to distribution channels, networks, and market platforms	<p>Since the automotive sector is a global high-competitive networked sector with high concentration of multinationals and industrial groups, and the cluster members are production companies in the supply chain in the automotive industry, large and medium-sized companies have long-standing cooperation relationships with their clients through centralised sales activities. However, for small and medium-sized companies with decision making centres in Poland, the cluster management team organises national and international business missions and exhibition groups.</p> <p>On local level SA&AM organises business-to-business matchmaking events, science-to-business matchmaking events and direct contacts between demand and supply in case of very specific needs. Cooperation is determined by non-disclosure contracts and strict rules. As such these processes take place beyond the knowledge of the cluster management team.</p> <p>For what concerns the advanced technology suppliers and specialists service companies in the cluster, the cluster management team organises information sessions, trainings and demonstration sessions for industrial companies under the brand "SME – Go digital". During these sessions industrial companies receive information about the suppliers' solutions and the role of these technologies in ensuring competitiveness. Suppliers are participating in these activities by way of demonstrating their solutions. Meetings take place in the KSSE premises as well as in the mobile demonstration centre. Currently the cluster management team is developing a new service by broadening this concept towards sustainability, including social and ecological issues.</p>
	Any support in terms of commercialisation	<p>Within SA&AM there are several technology parks and risk capital funds supporting technology start-ups. Through dedicated advisory services and financing they strengthen the capacities of young companies. KSSE is also co-organizer of start-up events. Among SA&AM members there are several young technology companies providing advanced technologies and new materials to the market. Through the business mixer events and other matchmaking events they are brought into contact with potential clients.</p>

Policy and Regulatory Support	Any policy and regulations in support of sustainability	<p>KSSE and the cluster management team have been involved in policy preparation processes and strategy development initiatives on national and regional level. Among others, KSSE took part in discussion forums and the draft consultation process of the Development Strategy of the Silesian Voivodeship "Śląskie 2030" (Marshal's Office of the Silesian Voivodeship, 2019) and of the Regional Innovation Strategy of the Silesian Voivodeship 2030 (Marshal's Office of the Silesian Voivodeship, 2019).</p> <p>As a member of EACN, KSSE is engaged in discussion groups and delivers recommendations to the EACN headquarters, that operates as an interlocutor for the European Commission and other European institutions in matters important for the automotive industry.</p>
	role of the actors and of collaboration in facilitating compliance with sustainability standards and certifications	<p>Sustainability issues in automotive are related on the one hand to specific global and European regulations on safety, quality and environmental responsibility. On the other hand, global automotive original equipment manufacturers provide their specific sustainability policies, most of them in line with the United Nations 2030 Agenda for Sustainable Development.</p> <p>There are several service companies (for instance: Dekra Polska, SQD Alliance, QSence, Quality Austria Polska) in the cluster delivering training and certification to ensure compliance with norms and standards.</p> <p>The cluster management team organises information and training sessions for the thematic group called Automotive Green Organisation. During these sessions service companies present the legal framework, train employees and inform about their service portfolio.</p>
Capacity Building and Learning	mentorship, guidance, coaching, training on sustainable business models/ strategies / practices / products / processes	<p>The cluster management team provides the service "SME Go digital" during which it delivers information and training to industrial companies in preparing for digital transformation. Currently the team is developing a new service with specific focus on sustainability issues to improve companies' overall resilience.</p> <p>Also, in the E-DIH Silesia Smart Systems offers support in preparing transformation roadmaps. Specific aspects of sustainable business models are being covered in the workshops organised for the thematic group called Automotive Green Organisation and for the thematic group called Automotive Health & Safety. Cluster members send their issues and challenges to the cluster management team, on the basis of which training packages and workshops are organised.</p> <p>Within European projects such as the EACN project, BOOST4BSO and national projects, the cluster management team provides dedicated coaching and guidance on business model transformation including sustainability issues. SMEs in the cluster are happy to make use of these opportunities.</p>

3.3.1.2. The relations between the manufacturing SMEs and the regional sustainability ecosystem

The main reference point for the manufacturing SMEs in the SA&AM ecosystem are the customers, the larger automotive manufacturers. The customers have an enormous influence over the SMEs as they usually can set high requirements and are responsible for a significant part of the SMEs' revenues. Those companies who have a diversified portfolio are less dependent but will still try and stay suppliers to the larger companies. Thus, requirements from the customers influence the behaviour of the SMEs. This also means that support and service providers to the SMEs adapt the offer to these requirements of larger companies. This can be in the form of help with certifications, consultancy about trending topics, consultancy for sustainable business models, training, the brokering of energy contracts for renewable energy and similar offers.

The other group of stakeholders that is very influential is policy. Regulations from legislative bodies, strategic decisions on economic development, such as the establishment of the special economic zones, tax relief rules and the funding of support structures, such as tenders, clusters and economic development agencies all influence the conditions and behaviour of the SMEs.

In term of actively making use of support from the regional sectoral ecosystem, the manufacturing SMEs from Silesia reported a few connections that they have.

For one, the connection within the ecosystem between SMEs beyond direct transaction is important to the CEOs of the SMEs. One interview partner from the company Zeta explicitly mentioned, to call **other CEOs** that he knows, from companies in similar industries as his own, to get ideas, exchange experience and getting recommendations for service and technology providers. Others mentioned similar experiences:

"Yes. As I said, we have some when we make investments, then there are people who know the matter, who know how to increase efficiency. So, they are making some advice, but there's like no main company or some person who is one of them to go with us through every step. But, like, we are getting many people who give us some advice and we accumulate the knowledge. [...] We have many partners in the special economic area and who build themselves a production hall or warehouse. And we contact with them, and they help us, I think. So other companies who also build. Other companies in our neighbourhood, and it was facilitated by SA&AM." (Gamma, Pos. 115-120)

The companies report how they receive information and some specific advice or the connection to other stakeholders from the offices of the **special economic zone and the SA&AM cluster**:

"But one time, a couple of years ago, we had people from economic area in our place. And they showed us ways to develop our company. So, there are some people from the special economic area here that we are also part of. And they are showing some places where it [construction of a new company building] can be done. And what can be done to be more efficient." (Gamma, Pos. 49-54)

"And currently we are researching the option to buy the external energy only from the green sources. There are some special agreements that guarantee that the energy that company consumes is only from the green source. However, currently the minimum limits are a little bit too high for our company but that is why we are cooperating with Silesian cluster to combine a couple of companies to be able together to get such a contract." (Epsilon, Pos. 101-106)

“So that's practical, they also get in touch from the cluster or in the economic zone. And, with every offer... and they [the offers] are then also referred, practically. From time to time, when we then ask, we would like to do this and that, then you can also say, okay, we have...we know a few companies here that can help us. So, that's always the case. The companies also have all the contacts.”
(Zeta, Pos. 101)

The cluster representative sees the role of SA&AM as mainly intermediary:

“[...]in terms of being the coordinator of a cluster, we are performing an intermediary role between owners of problems and challenges and suppliers of solutions. So, it means that we try to avoid taking up the role of existing advisory companies, technology companies, training companies, and so on. So, we organize workshops, we organize trainings, but in those areas where companies do not find solutions on the market, or not in a way they needed. So, it means that, yes, we organise workshops during which experts deliver advice or training where companies show their best practices.” (SA&AM, Pos. 14)

The companies have connections to Polish banks and build long relationships with them. This was reported by the SMEs and the cluster representatives.

For public funding, the European funds play a bigger role for the funding of sustainability measures from the point of view of the SMEs than national or regional funds.

“Regarding these subsidies, usually the national are connected with EU subsidies. So, we don't have, I guess, I don't know exactly, but in our branch and in the subsidies that we were fighting for, it were mostly EU subsidies. And I don't think that there are any meaningful national subsidies for this type of operation. So, this is the thing. And so, about the loans, we are dealing with Polish banks mainly.”
(Gamma, Pos. 65)

When summarising the perceived benefits of the automotive ecosystem with regards to implementing sustainability measures, the manufacturing SMEs have emphasised the direct connections to other companies, the information provision of the cluster and the KSSE, and the consultants from the region as well as funding from the European funds.

The cluster representatives have additionally pointed out how the presence of skilled workers and the connection to research and development organisations is benefitting the local companies. Additionally, the tax reliefs, the networking activities and the brokering of land seem to have a direct beneficial impact on the manufacturing SMEs, giving them more leeway to invest in sustainability measures.

The SMEs also see the cluster as a potential representative of their own interests and needs on overarching levels. This role is traditionally expected from sector or employer associations. When asked about those, the companies expressed doubt about the associations' capacity to represent their interests. This gap should be taken seriously by associations and Should be addressed.

Training providers are part of the ecosystem, although some of the needed skills for the transition towards more sustainability seem not to be provided by the current training offers, as the example of one SME shows, that needs further competence to develop a full Life Cycle Assessment (LCA) for their products:

“[For] the carbon footprint calculations we had some training, external training and one of our co-workers has learned to do that but, maybe, this is just the basics, I'm afraid that, if it comes to the calculation of the carbon footprint in the

whole chain supply chain, it will be much more difficult. So, still in that areas that would be good if there are some service providers for that.” (Epsilon, Pos. 215-219)

Civil society stakeholders are not represented in the business and innovation ecosystem in Silesia beyond the elected governments. The cluster representative did mention the risk of protest of the local population when companies do not abide with current regulations, but there was no mention of any engagement activities of citizens or NGOs.

The alignment of the ecosystem's activities with European policies relevant for sustainability in the manufacturing sector is implemented strongly, insofar there are regulations or OEMs' requirements that put pressure on the SMEs. For those, there are several stakeholders supporting or offering solutions to the SMEs in the ecosystem. As long as European and national policy makers are still discussing future legislation, SMEs seem to not be interested early on and it is rare for SMEs to develop a pro-active strategy. Thus, it is also difficult for the ecosystem stakeholders to provide information on the legislative activity at European and national levels to the manufacturing SMEs themselves. Nonetheless, there are several opportunities offered by the ecosystem for the SMEs to learn about funding opportunities. Consultants, the cluster, and research institutions all provide this type of relevant information.

The SA&AM cluster and the special economic zone foster inter-regional and international collaboration, including on sustainability topics. This holds true for activities that foster business relations, exchange of knowledge and joint innovation. The KSSE also brings together different sector clusters which fosters the cross-sectoral collaboration.

In terms of direct support offers for the manufacturing SMEs, it can be summarised that support for social aspects of sustainability seem to be well addressed in the Silesian ecosystems in terms of skills, sustainable business model development and the exchange of best practices and experience. Support with change management and co-creation processes seem to be offered and promoted less than the aforementioned topics or technological solutions.

3.3.2. Piedmont Manufacturing Ecosystem

The other pilot sectoral regional ecosystem we chose to describe here, is the **manufacturing ecosystem** of Piedmont. Piedmont ranks among the top five regional economies in Italy, with a GDP of approximately € 140 billion (8% of the national total), 430,000 companies (7% of the national total), and an export of about € 50 billion (10% of the national total)⁸.

Piedmont's strategic location plays a significant role in its prominence as a hub for the automotive and transportation sectors, as well as in other areas of industry and commerce. Being located in the north-western part of Italy, bordering France and Switzerland, it has excellent access to major European markets, making it a critical transit point for trade and transportation between Italy and other European countries. Indeed, Piedmont belongs to the TEN-T Network of the Trans-European Corridors and the European high-speed rail links. These corridors are essential transport routes that link key cities and regions across Europe, facilitating the movement of people and goods. Notably, Piedmont is a part of the Mediterranean Corridor and the Rhine-Alpine Corridor, which connect the region to major European economic hubs. Whereas the high-speed rail line between Turin and Lyon, is a key element improving connections between Italy and France⁹.

⁸ <https://www.centroestero.org/en/invest-in-piemonte/why-invest-in-piemonte.html>

⁹ <https://www.centroestero.org/en/download.html>

The region has an industrial DNA. It is the national reference point for the **automotive and transportation sector** (mobility), accounting for about 45% of the national automotive sector's total revenue and proving to be the leader in terms of automotive and transportation component companies¹⁰. Historically, the region's industrialisation began in the late 19th and early 20th centuries, when Turin, the capital of Piedmont, became a hub for manufacturing and engineering. This period saw the emergence of several key companies and industries that contributed to Piedmont's reputation as an industrial powerhouse. Piedmont's association with the automotive industry can be traced back to the early 20th century. Fiat (Fabbrica Italiana Automobili Torino), one of Italy's most iconic automotive companies, was founded in Turin in 1899. Fiat played a pivotal role in shaping Piedmont's industrial landscape and remains one of the most influential players in the global automotive market. Today, Fiat Chrysler Automobiles (now part of the Stellantis group), Iveco, and CNH Industrial contribute to its leading position in this sector. The region also has a strong tradition in railway engineering and production. Historical companies such as Breda and Ansaldo, while based in other parts of Italy, have had significant ties to Piedmont's industrial base through collaborations and partnerships.

Another significant contributor to the region's economy is the **aerospace sector** with a turnover of € 8 bn, 35,000 employees, over 450 SMEs¹¹ (such as APR, EICAS Automazione, LMA) and thanks to big players such Leonardo, Thales Alenia Space, GE Avio, ALTEC, Collins Aerospace and Mecaer to mention a few. The region's tradition of precision engineering and mechanical production provided a foundation for the aerospace industry. The global conflicts of the 20th century spurred significant advancements in aerospace technology. Companies in Piedmont, like Fiat, began producing aircraft and engines to support the war effort, thus laying the groundwork for the region's future role in the aerospace sector. After World War II, the aerospace industry in Piedmont began to shift focus from military to civil aviation. Companies like Aeritalia (now part of Leonardo) played key roles in the development of civil and military aircraft, helping establish Piedmont as an aerospace hub. From the late 20th century onwards, companies in Piedmont established partnerships with global aerospace giants and participated in international projects. This included collaborations with organisations like the European Space Agency (ESA) and involvement in major space missions.

Piedmont's **manufacturing sector** remains a significant asset for the region, thriving due to a well-developed ecosystem that encompasses both large corporations and dynamic SMEs. This ecosystem is central to the region's reputation as an industrial hub, with companies specializing in manufacturing equipment, machines and automation, semiconductors, and Industry 5.0 technologies (to mention a few, Prima Industrie, Comau, Kuka, Fidia, Vishay, SPEA, Engineering, Inpeco, SKF and dynamic SMEs such as Eurofork, Novasis Innovazione, IDT Solution, Beond, IRIS).

In particular, SMEs in Piedmont have leveraged the presence of big players in the region's industrial landscape to fuel their own growth and success. This dynamic has created a mutually beneficial ecosystem where large companies and SMEs work together to drive innovation, competitiveness, and economic prosperity. In terms of collaborative relationships, many SMEs in Piedmont serve as suppliers to large companies such as Stellantis, Leonardo, and Thales Alenia Space. These partnerships provide SMEs with a stable customer base and opportunities for steady revenue streams. Moreover, SMEs often collaborate with larger companies on research and development projects, gaining access to advanced technologies, expertise, and resources, fostering innovation and developing cutting-edge products and services. In general, the presence of big players creates a supportive ecosystem for SMEs,

¹⁰ Automotive Industry 2020 by ITA - Italian Trade Agency

¹¹ 2023 analysis by Piemonte Agency and Piedmont Aerospace Cluster on 2022 figures

including industry associations and clusters that provide resources, networking opportunities, and advocacy for shared interests.

The interconnected ecosystem of large corporations and dynamic SMEs in Piedmont's manufacturing sector is also playing a pivotal role in the region's transition towards **sustainability**, characterized by a focus on environmentally friendly practices, the development of sustainable technologies, and a commitment to meeting global sustainability standards.

The area has been selected to receive tailored support under the Commission pilot action for industrial transition (Regions in industrial transition)¹² starting by redesigning a strategy for regional economic transformation based on its S3 smart specialisation strategy and priorities (2014-2020) that have been recently revised according to the green transition, the digital transformation and the well-being of local communities (2021-2027). The regional meta-cluster Sistema Poli Innovazione Piemonte¹³ made of seven clusters specialized in thematic areas works by considering this approach. Sistema Poli Piedmont is the new organisational model launched in 2022 to enhance the sectorial skills acquired since 2009 by the clusters, to amplify knowledge and opportunities for companies and SMEs and for the whole territory. The new governance model transformed the innovation ecosystem from a synergy model to a systematic one, to contribute to the digital and sustainable objectives. Sistema Poli Piemonte has four main aims: to increase the impact of regional R&I policies; to foster the technology transfer for a smarter region; to accelerate the growth of the Piedmontese production ecosystem; to identify a common methodology aiming to systematize data and expertise to create more effective actions. It is participated by seven regional Innovation clusters, managed by 10 organisations as follow: CLEVER (Environment Park & Un.I.Ver.); CGREEN (Proplast, Science and Technology Park in Valle Scrivia & IBIS Consortium); MESAP (Centro Servizi Industrie); PO.IN.TEX (Città Studi); Agrifood (M.I.A.C.); BioPmed (Bioindustry Park Silvano Fumero); ICT (Piemonte Innova Foundation).

Piedmonte is also part of the Vanguard initiative¹⁴ where almost 40 EU regions work together to stimulate industrial innovation based on complementarities in regional smart specialisation strategies to develop solutions for significant societal challenges while delivering on the EU's ambitions for improved international competitiveness.

Moreover, Piedmont has finalized its Regional Strategy for Sustainable Development (SRSvS)¹⁵ to outline the areas and objectives that the Piedmont Region intends to pursue within the UN Agenda 2030, the EU Green Deal and the implementation of the National Strategy for Sustainable Development.

¹² https://ec.europa.eu/regional_policy/en/information/publications/factsheets/2018/pilot-action-regions-in-industrial-transition

¹³ <https://sistemapolipiemonte.it/clusters/?lang=en>

¹⁴ <https://www.s3vanguardinitiative.eu/members>

¹⁵ <https://www.regione.piemonte.it/web/temi/strategia-sviluppo-sostenibile/strategia-regionale-per-sviluppo-sostenibile-0>

3.3.2.1. Elements of the ecosystem according to the framework for sustainability ecosystem

Table 5 - Elements of the Piedmont sustainability ecosystem¹⁶

Sustainability Ecosystem Element		Piedmont Ecosystem
Access to Knowledge and Resources	Funding and Finance	<p>SMEs in the Piedmont region have access to a range of funding and finance opportunities specifically aimed at promoting sustainability and environmental responsibility:</p> <ul style="list-style-type: none"> - Green Economy Funds: Finpiemonte offers funding programs to support projects in the green economy. These funds are aimed at promoting sustainable development, energy efficiency, renewable energy, and the circular economy. For example, the <i>Green New Deal fund</i> offers loans and grants to SMEs for projects that contribute to the reduction of greenhouse gas emissions and the transition to a low-carbon economy. Another example is the <i>Green Energy Transition Fund</i> that can be used for projects such as the installation of renewable energy systems (e.g., solar, wind, or hydroelectric) or the upgrade of existing equipment to more energy-efficient alternatives. - SME Climate Action Voucher: This program provides financial support to SMEs for projects that reduce their carbon footprint and improve their environmental performance. It can be used for investments in energy-efficient equipment, renewable energy systems, and sustainable production processes. - Innovation for Sustainability: Piedmont's Regional Operational Program (ROP) includes funding for research and innovation projects focused on sustainability. SMEs can receive grants for developing and implementing eco-friendly products, services, and technologies. - Voucher for Energy Efficiency: The region offers vouchers to help SMEs invest in energy-efficient technologies and practices. These vouchers can be used to offset the costs of upgrading equipment, optimizing production processes, and reducing energy consumption. - Circular Economy Initiatives: The Piedmont region supports circular economy projects through various funding programs and partnerships. These initiatives aim to promote recycling, waste reduction, and resource efficiency in SMEs. For example, <i>Progetto Ecofuturo</i> is a project that aims to promote the circular economy in the Piedmont region providing financial support and resources to SMEs for projects focused on recycling, reusing materials, and minimizing waste. <p>The Piedmont region offers various specific programs and initiatives aimed at supporting SMEs in terms of funding and finance, for example:</p>

¹⁶ Sources as depicted and the interview with the cluster representative from MESAP.

		<ul style="list-style-type: none"> - Finpiemonte: Finpiemonte is a regional financial agency that offers various funding programs and financial support to SMEs in the region. It provides grants, loans, and guarantees to support projects in innovation, research and development, digitalisation, and <u>energy efficiency</u>. Finpiemonte also supports SMEs through initiatives such as Fondo di Garanzia, which provides loan guarantees to facilitate access to credit. - Start-up Voucher: The Piedmont region provides a program called Start-up Voucher, which offers financial support to new enterprises and innovative SMEs. This program provides vouchers to help cover the costs of professional services such as legal, accounting, and consulting services for new businesses. - Voucher for Digitalisation: SMEs in Piedmont can benefit from vouchers for digital transformation. These vouchers offer financial support to cover expenses related to the adoption of digital technologies, such as e-commerce, cloud services, and cybersecurity solutions. - Piemonte Agency for Investments, Export, and Tourism: This agency supports the internationalisation of SMEs in the region by providing assistance with market research, trade missions, and participation in international trade fairs. The agency helps SMEs expand their presence in foreign markets and access new export opportunities. - Piedmont Region's Regional Operational Program (ROP): This program is part of the European Regional Development Fund (ERDF) and provides funding for projects that promote economic growth, innovation, and competitiveness in the region. It includes support for SMEs in areas such as research and development, technology transfer, and <u>environmental sustainability</u>. - RIT - Research and Innovation Tool: This initiative provides grants and financing to SMEs for research and innovation projects in strategic sectors such as automotive, aerospace, and biotechnology. It aims to promote collaboration between SMEs, research centres, and universities. - Club degli Investitori: This is a network of business angels and private investors in Piedmont that invests in early-stage startups and innovative SMEs. They provide not only funding but also mentorship and strategic advice to help businesses grow. - Tecnogrande: Tecnogrande is an innovation hub in the Cuneo province of Piedmont that supports SMEs and startups in the technology sector. It offers incubation and acceleration programs, as well as access to funding through partnerships with venture capital firms.
Partnerships	<p><u>Industry Associations and Clusters</u></p> <ul style="list-style-type: none"> - <i>Green Industry Association</i> (Associazione Industria Verde) promotes sustainable practices among its members, which include SMEs from various sectors. For instance, the association may organize training sessions and workshops on topics such as eco-friendly manufacturing techniques or waste reduction strategies for member SMEs. SMEs may also collaborate on group projects, such as developing shared recycling facilities or circular economy initiatives within the association. - Piedmont is home to <i>several industrial districts and clusters</i> that focus on specific sectors, such as textiles, automotive, and agro-food. In the textile sector, for example, SMEs may work together in a cluster to implement sustainable dyeing processes or water recycling systems, benefiting from shared knowledge and resources. <p><u>Public-Private Partnerships:</u></p>	

		<ul style="list-style-type: none"> - <i>Sustainable Urban Development Projects</i> focus on green infrastructure and energy-efficient buildings to develop smart city solutions, such as energy-efficient lighting or green transportation system. - <i>Green Energy Retrofits Projects</i> focus on retrofitting existing buildings with energy-efficient technologies - <i>Green Mobility Projects</i> in collaboration with the Turin city government for the development of electric vehicle (EV) charging infrastructure or bike-sharing systems - <i>Smart Waste Management Projects</i> in collaboration with municipalities to implement waste separation systems or recycling initiatives - <i>Renewable Energy Installation Projects</i> in collaboration with public institutions to install solar panels on public buildings or land. <p><u>Joint Ventures and Alliances:</u></p> <ul style="list-style-type: none"> - <i>Sustainable Product Development - Eco-Friendly Packaging:</i> Two SMEs in Piedmont, one specializing in materials science and another in packaging, formed a joint venture to develop biodegradable packaging materials. By combining their expertise, they successfully produced eco-friendly packaging that is now being used by local food and beverage companies. - <i>Resource-Sharing Alliances - Organic Farming Alliance:</i> A group of SMEs in the agro-food sector established an alliance to promote organic farming practices in the region. This alliance shares knowledge on sustainable agriculture methods, offers joint training sessions for farmers, and provides a shared distribution network for organic products - <i>Clean Tech Innovation - Energy Storage Project:</i> Two clean tech SMEs in Piedmont partnered to develop an innovative energy storage system using advanced battery technology. Their joint venture resulted in the production of an efficient, cost-effective energy storage solution for renewable energy sources like solar and wind power. - <i>Waste Management Initiatives - Recycling and Upcycling:</i> Several SMEs in Piedmont's manufacturing sector formed an alliance to collaborate on recycling and upcycling projects. Together, they established a shared recycling facility to process and repurpose industrial waste materials, reducing their environmental impact and creating new revenue streams. - <i>Green Building Materials - Sustainable Construction Collaboration:</i> A construction company and a materials supplier in Piedmont joined forces to develop sustainable building materials such as low-carbon concrete and recycled steel. Their partnership led to the construction of eco-friendly buildings across the region. - <i>Renewable Energy Projects - Solar Farm Joint Venture:</i> SMEs in the energy sector collaborated to develop a solar farm in Piedmont. By sharing the costs and responsibilities of the project, they were able to generate clean energy for local use and sell excess energy to the grid. - <i>Circular Economy Projects - Shared Economy Platforms:</i> SMEs in Piedmont's service sector partnered to create shared economy platforms such as equipment rental services and ride-sharing applications. These initiatives promote resource efficiency and reduce the carbon footprint of businesses and consumers. <p>Here some examples of SMEs that have been active in the past in promoting sustainability through partnerships</p> <ul style="list-style-type: none"> - Ecospray, based in Alessandria, is an SME specializing in exhaust gas cleaning systems for ships. The company actively collaborates with research institutions and other companies to develop environmentally friendly technologies for the maritime industry. In particular, Ecospray has partnered with universities and other maritime industry players to create exhaust gas cleaning solutions that reduce emissions and comply with international standards.
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	Supply chain networks	<p>The Piedmont region has a strong industrial base and a rich tradition of manufacturing, particularly in sectors such as <i>automotive</i>, <i>aerospace</i>, <i>textiles</i>, and <i>food production</i>. Here are some specific examples of how SMEs in Piedmont are participating in sustainable supply chain networks:</p> <p>Automotive Sector:</p> <ul style="list-style-type: none"> - <i>Magneti Marelli</i>, a leading automotive supplier, is active in sustainable supply chain practices. The company collaborates with local SMEs to source eco-friendly materials and components for automotive parts, such as using recycled plastics and metals in production. - <i>Karmann</i>, a subsidiary of Magna International, has a production facility in Piedmont that focuses on sustainable automotive design. The company partners with local suppliers to source lightweight materials and components that reduce vehicle emissions and improve fuel efficiency. <p>Food Production:</p> <ul style="list-style-type: none"> - <i>Eataly</i>, a well-known food retailer based in Turin, works with local food producers to promote sustainable and organic farming practices. Eataly's supply chain network emphasizes transparency, supporting SMEs that adhere to high standards of sustainability and quality in their products. - <i>La Perla</i>, a chocolate manufacturer in Turin, collaborates with local farmers and suppliers to source sustainable cocoa and other ingredients. The company works with its suppliers to ensure ethical sourcing and minimal environmental impact. <p>Textiles and Fashion:</p> <ul style="list-style-type: none"> - <i>Ermenegildo Zegna</i>, a luxury fashion brand based in Piedmont, emphasizes sustainability in its supply chain. The company works closely with wool producers to ensure ethical practices and sustainable land management. - <i>Lanificio Cerruti</i>, a prestigious wool manufacturer in Biella, focuses on sustainable sourcing of raw materials. The company collaborates with local farmers and suppliers to ensure the highest standards of quality and sustainability in its textiles. <p>Aerospace and Engineering:</p>

		<ul style="list-style-type: none"> - <i>Avio Aero</i>, an aerospace company with facilities in Piedmont, collaborates with local engineering firms and component suppliers to promote sustainability in its supply chain. The company prioritizes eco-friendly materials and energy-efficient production processes. <p>Advanced Manufacturing:</p> <ul style="list-style-type: none"> - <i>Prima Industrie</i>, an advanced manufacturing company, works with local suppliers to source sustainable materials and components for its laser and sheet metal processing systems. The company encourages its suppliers to adopt green practices and supports circular economy initiatives.
Research institutions and universities		<p>Collaborations with research centres and universities in the Piedmont region provide SMEs with opportunities to leverage academic expertise for sustainable projects and innovations. Here are some specific examples of partnerships between SMEs and research institutions focused on sustainability:</p> <p><u>Politecnico di Torino</u></p> <ul style="list-style-type: none"> - <i>Energy Efficiency Research initiatives</i> in collaboration with the university's Energy Department to optimize SMEs' production line for lower energy consumption. - <i>Sustainable Mobility Research initiatives</i> for the development of electric or hydrogen fuel cell vehicles. <p><u>University of Turin</u></p> <ul style="list-style-type: none"> - <i>Biotechnology Collaborations</i> for research projects related to sustainable agriculture and natural resource management - <i>Circular Economy Research</i> in collaboration with the university's Department of Management, such as designing sustainable supply chains and developing strategies for waste reduction and recycling. - <i>Innovative Material Research</i> in collaboration with the University's Department of Material Science, such as to develop biodegradable plastics or other sustainable materials for packaging or production <p><u>Centro Ricerche Fiat (CRF)</u> is an advanced research centre with strong ties to the automotive industry. SMEs in the automotive sector might collaborate with CRF to work on projects such as developing more efficient engines or lightweight materials for vehicles.</p> <p><u>Environment Park (Envipark)</u>, located in Turin, is an innovation hub focused on <i>clean tech and sustainability</i>. SMEs can collaborate with researchers at the park to work on projects such as developing new renewable energy solutions or water purification technologies. Moreover, SMEs interested in sustainable construction can partner with researchers at Environment Park to explore green building materials and energy-efficient architectural designs.</p>
Government agencies and regulatory bodies		<p>Regione Piemonte, the regional government, plays a key role in promoting sustainability across various sectors, through its extensive network, by providing financial support, training, and access to resources. For example, the government has launched programs such as the "<i>Piemonte In Green</i>" initiative, which provides funding and support for SMEs to invest in renewable energy projects and energy-efficient technologies. It also offers grants and subsidies for businesses pursuing circular economy initiatives. Regione Piemonte also</p>

	<p>launched the <i>Bando Energia initiative</i> to support SMEs in improving their energy efficiency. The program provides financial incentives and grants to businesses that invest in renewable energy sources such as solar and wind power or implement energy-saving technologies.</p> <p>ARPA Piemonte (Regional Environmental Protection Agency): is responsible for monitoring and enforcing environmental regulations in the region. For example, the agency works with SMEs to help them comply with air, water, and soil quality standards. ARPA offers guidance on waste management practices and assists businesses in obtaining necessary environmental permits.</p> <p>Camera di Commercio di Torino (Chamber of Commerce of Turin) supports SMEs in adopting sustainable practices. For example it provides training and resources on topics such as eco-design, energy efficiency, and waste reduction. The Chamber also organizes events and workshops to connect SMEs with experts and potential partners in the field of sustainability.</p> <p>Unioncamere Piemonte (Union of Chambers of Commerce of Piemonte) is the regional branch of the national chambers of commerce network. For example, it offers programs such as "<i>Green to Grow</i>," which provides resources and funding for SMEs to pursue green initiatives. Unioncamere Piemonte also supports SMEs in obtaining sustainability certifications and complying with environmental standards.</p> <p>Finpiemonte is the regional development finance agency that offers financial support for sustainable projects. The agency provides loans and grants for SMEs to invest in clean energy technologies and sustainable production methods.</p>
Technology development platforms and innovation hubs	<p>The region includes several technology development platforms and innovation hubs, that support startups:</p> <ul style="list-style-type: none"> - ESA BIC Turin supports space-related start-ups in Piedmont: it refers to applications that use space-based systems, such as satellite navigation, earth observation, or satellite communication. - I3P Incubator of Politecnico di Torino supports the ecosystem of entrepreneurship, by collaborating with private subjects and institutions, engaged in research and advanced training, in services for technology transfer, in the financing of innovation, in internationalisation. I3P is the best public business incubator in the world, as recognized by the World Rankings of Business Incubators and Accelerators 2019-2020 published by UBI Global. - 2i3T's mission is to diffuse and foster knowledge transfer within the University environment to develop local economy creating new businesses coming out from academic research and SMEs. The Incubator started activities in April 2007 and since that time it launched 96 startups knowledge based in the following sectors: 34% Health Science, 20% in Agrofood, Digital for 16%, 14% Social Innovation and 14% Cleantech. - Competence Industry Manufacturing 4.0 is an innovation hub in Turin that focuses on digital transformation and advanced manufacturing. CIM 4.0 supports SMEs in implementing sustainable practices through smart manufacturing technologies such as IoT, data analytics, and automation. This enables businesses to optimize resource use and reduce waste. - Città della Conoscenza (City of Knowledge) is a science and technology park in Alessandria that promotes innovation and sustainability. The park provides SMEs with access to shared research facilities, labs, and expertise in fields such as green chemistry, environmental engineering, and renewable energy.

		<ul style="list-style-type: none"> - Digital Innovation Hub Piemonte is part of a national network of digital innovation hubs that supports the digital transformation of SMEs. The hub helps SMEs integrate digital technologies for improved sustainability, such as optimizing energy use and streamlining production processes. - Eurac Research, while based in Bolzano, has collaborations and projects in Piedmont related to sustainability. Eurac Research works with SMEs in Piedmont on projects such as renewable energy solutions and sustainable urban planning. - Torino Wireless is a foundation that promotes the development of the ICT (information and communications technology) sector in Piedmont. SMEs collaborate with Torino Wireless to work on projects related to digital transformation and sustainability in areas such as smart cities and IoT (Internet of Things) applications. Torino Wireless has supported SMEs in developing smart city solutions, including energy-efficient lighting systems and intelligent traffic management.
	Knowledge-sharing networks and communities	<p>Green Business Networks:</p> <ul style="list-style-type: none"> - The region has established networks and associations for green businesses, such as <i>Ecogruppo Italia</i>, which offer resources, networking opportunities, and access to funding for sustainable projects. - Also <i>Piemonte Green Network</i> is a regional network that brings together SMEs, research institutions, and government agencies to promote sustainable practices. The network organizes events and workshops on topics such as circular economy, renewable energy, and sustainable supply chains. SMEs can share experiences and collaborate on projects with other network members. <p>Sustainability Networks:</p> <ul style="list-style-type: none"> - <i>Associazione Nazionale Comuni Italiani (ANCI) Piemonte</i> is the regional branch of the National Association of Italian Municipalities, which focuses on promoting sustainability at the local level. ANCI Piemonte works with SMEs and local governments to support sustainable urban development projects, including eco-friendly infrastructure and waste management initiatives. - <i>Fondazione Torino Smart City</i> is a foundation that promotes sustainable urban development and innovation in the city of Turin and the surrounding region. The foundation supports knowledge-sharing among SMEs, research institutions, and local governments on smart city projects. These projects often focus on sustainability issues such as green mobility, energy efficiency, and circular economy practices. - <i>Unioncamere Piemonte</i>, the regional branch of the national chambers of commerce network, offers a platform for SMEs to share knowledge and resources related to sustainability. The organisation hosts seminars, webinars, and networking events on sustainable business practices, eco-design, and energy efficiency. <p>Circular Economy Network: Piemonte has established a network of businesses and institutions dedicated to advancing the circular economy. This network helps connect SMEs with resources, potential partners, and funding opportunities for circular economy projects.</p> <ul style="list-style-type: none"> - For example, <i>EcoNetwork Piemonte</i> is a network of companies, research institutions, and public bodies dedicated to promoting the circular economy in the region. It hosts regular workshops and training sessions on topics such as waste reduction, recycling, and eco-design. SMEs can connect with experts and other businesses to share knowledge and best practices in circular economy initiatives. - <i>Piemonte Circular</i> is an initiative launched by Regione Piemonte to promote the circular economy across the region. The initiative offers funding and resources for SMEs to invest in circular economy projects, such as the development of products from recycled materials

		<p>and the implementation of closed-loop production systems. Piemonte Circular also organizes events and webinars to raise awareness about circular practices.</p> <ul style="list-style-type: none"> - <i>Environment Park's Circular Economy Projects</i> has a strong focus on circular economy projects and provides support to SMEs in the region. Envipark has collaborated with SMEs on projects such as creating bio-based and biodegradable materials from agricultural waste. These projects enable SMEs to reduce waste and create value from byproducts, contributing to a more circular approach. - <i>CIRCE (Interdepartmental Center for Renewable Energy and Environment)</i>, based at Politecnico di Torino, supports circular economy research and projects for SMEs. CIRCE works with local businesses to develop circular production processes, such as converting industrial waste into useful products or developing eco-friendly packaging materials. The centre offers SMEs access to its research facilities and expertise. <p>Energy Communities: The Piedmont region supports the creation of energy communities, where groups of SMEs, households, and public entities come together to produce and share renewable energy locally. An example is a cluster of SMEs forming an energy community to install a shared wind turbine or solar farm, allowing them to generate their own clean energy and reduce energy costs. For example</p> <ul style="list-style-type: none"> - the <i>Energy Center Initiative</i> is an energy research centre located at Politecnico di Torino which supports SMEs in adopting sustainable energy practices and technologies, such as optimizing energy consumption and integrating renewable energy sources into production processes. - <i>Energy Community Torino</i> is a collaborative network that brings together businesses, institutions, and citizens to promote the use of renewable energy in the city of Turin. SMEs participating in the community benefit from group purchasing power for renewable energy installations and equipment. The community also facilitates the sharing of best practices and experiences related to energy efficiency and sustainability. - <i>Consorzio Energia Piemonte</i> is a consortium that focuses on providing energy solutions and consulting services to businesses in the region. The consortium supports SMEs in adopting sustainable energy practices such as energy-saving measures and the use of alternative energy sources. Consorzio Energia Piemonte also offers training and workshops on topics like energy audits and renewable energy technologies. - <i>Smart Grids Piemonte</i> is a regional initiative that focuses on modernizing the energy grid and promoting the use of smart technologies. SMEs participating in this initiative benefit from improved energy management systems, real-time monitoring of energy use, and incentives for integrating renewable energy sources such as solar and wind power. <p>Sustainability Fairs, Events, Initiatives</p> <ul style="list-style-type: none"> - Piedmont hosts various sustainability-focused fairs and events, such as the <i>Green Italy Exhibition</i>, where SMEs can collaborate with other stakeholders. These events provide opportunities for SMEs to showcase their innovations, network with potential partners, and learn about the latest trends in sustainability. - The <i>Agrifood Innovation Initiative</i> in Piedmont supports SMEs in developing sustainable agriculture practices and food processing technologies, such as precision agriculture and low-impact farming methods.
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Collaboration and co-creation	Collaboration and co-creation among actors of the ecosystem on business and innovation (projects, joint ventures etc.)	<p>Collaboration and co-creation among SMEs, research institutions, government agencies, and other stakeholders in Piedmont are set up through various formal and informal mechanisms that facilitate the sharing of knowledge, resources, and expertise.</p> <p>SMEs in Piedmont are actively participating in co-creation projects related to sustainability, for example:</p> <ul style="list-style-type: none"> - To Be s.r.l. is an SME that focuses on producing sustainable, energy-efficient lighting solutions. It has collaborated with Green Pea, a sustainability-focused retail project in Turin, to provide eco-friendly lighting for the store. To Be s.r.l. designed and installed energy-efficient LED lighting throughout Green Pea's retail space, demonstrating a successful co-creation project that combines sustainability and innovative business practices. - Made for a Better World is an SME that specializes in sustainable textile products and fashion accessories. The company has co-created sustainable fashion lines with local designers and suppliers using recycled materials and eco-friendly production methods. These collaborations help reduce waste and promote ethical fashion in the region. - Ecomate is an SME specializing in sustainable solutions for buildings, including insulation and soundproofing materials made from recycled or natural materials. The company has collaborated with construction firms and architectural studios to develop energy-efficient buildings and reduce carbon footprints. This co-creation has led to the adoption of green building practices in Piedmont. - The Green Watch is an SME that designs and manufactures eco-friendly wristwatches using sustainable materials such as recycled wood and bamboo. The company has partnered with local artisans and material suppliers to co-create unique and sustainable watch designs that appeal to environmentally conscious consumers. - Free2Move, an SME in the car-sharing sector, work with the city of Turin and other partners to provide electric car-sharing services. This collaboration contributes to reducing emissions and promoting sustainable urban transportation - Cartiera di Voghera, a paper manufacturing company, work with research centers to produce recycled and biodegradable paper products, reducing waste and promoting circular economy practices.
	What networking activities are offered?	<p>GreenTo Network is a regional initiative that promotes sustainability in the business community by connecting SMEs with other companies, research centres, and government bodies. GreenTo organizes events such as workshops, seminars, and networking sessions that focus on sustainable practices and green technologies. SMEs can learn from industry experts and share best practices with peers.</p> <p>Piemonte Agency is the regional development agency that supports local businesses by providing access to networks, funding, and internationalisation opportunities. The agency hosts events and workshops on topics such as sustainable development, circular economy, and renewable energy, providing SMEs with opportunities to network with other businesses and experts in the field.</p> <p>Innovation hubs such as i3P at Politecnico di Torino offer networking opportunities for SMEs focused on sustainability. i3P organizes pitch events, hackathons, and mentoring sessions where SMEs can connect with startups, researchers, and potential investors in the sustainability sector.</p> <p>Trade associations such as Confindustria Piemonte offer networking opportunities for SMEs in specific industries, including sustainability-focused sectors. Confindustria organizes industry-specific events, forums, and networking sessions where SMEs can meet other businesses, share knowledge, and explore potential collaborations.</p>

		<p>Sustainable business forums and conferences bring together SMEs, policymakers, and industry leaders to discuss sustainable business practices and innovations. Events such as the <i>Green Economy Summit</i> provide a platform for SMEs to network with sustainability experts, learn about new technologies, and explore potential partnerships.</p> <p>Business incubators and accelerators in Piedmont, such as <i>SocialFare</i> and <i>Startup Torino</i>, offer networking opportunities for SMEs in the sustainability sector. SocialFare focuses on social impact and sustainability, offering SMEs access to networking events, mentorship, and workshops on sustainable business models.</p> <p>Piedmont hosts international trade fairs and exhibitions where SMEs can showcase their sustainable products and services while networking with potential partners and customers. Events such as <i>Terra Madre Salone del Gusto</i> and <i>Paratissima</i> attract a global audience and provide SMEs with opportunities to connect with international businesses and sustainability-focused stakeholders.</p>
Market Access and Commercialisation	Access to distribution channels, networks, and market platforms	<p>Trade associations and industry networks such as <i>Confartigianato Imprese Piemonte</i> and <i>Confindustria Piemonte</i> offer SMEs opportunities to connect with local businesses and access regional distribution channels. These associations provide support with identifying potential partners, suppliers, and distributors within the region.</p> <p>The Piemonte Agency assists SMEs in accessing international markets and distribution channels. Through their programs, SMEs focusing on sustainability can participate in trade missions, international trade fairs, and B2B matchmaking events to expand their market reach globally.</p> <p>SMEs can leverage online marketplaces and platforms such as Amazon and eBay to sell their sustainable products to a global audience. Local platforms such as <i>Chicco di Buono</i> and <i>Piedmont Agricoltura</i> also provide access to regional and national markets for food and agricultural products from SMEs.</p> <p>Incubators and accelerators such as <i>i3P</i> and <i>SocialFare</i> provide SMEs with guidance and support in establishing their distribution channels and market presence. These organisations offer mentorship on market strategies, business development, and product commercialisation.</p> <p>Initiatives like <i>Hub Sostenibile</i> provide a collaborative marketplace for sustainable products and services, helping SMEs gain visibility and access to potential customers. These collaborative hubs foster partnerships and create opportunities for SMEs to showcase their offerings.</p> <p>Consumer cooperatives and sustainable retail chains in Piedmont collaborate with SMEs to stock sustainable products, providing access to local and regional markets. <i>Naturasì</i> and <i>Biocoop</i> are retailers focusing on organic and sustainable products, providing a market platform for SMEs in these areas.</p> <p>B2B events and trade shows offer SMEs opportunities to connect directly with distributors, wholesalers, and other businesses looking for sustainable products and services. Events such as <i>Biofach</i> (when held in the region) bring together businesses focused on organic and sustainable products, helping SMEs establish connections and explore distribution opportunities.</p>
	Any support in terms of	<p>Piemonte Agency, the regional development agency, offers internationalisation support to SMEs in terms of trade missions and international exhibitions. The agency organizes participation in events such as <i>SIAL Paris</i> (Salon International de l'Alimentation), where</p>

	commercialisation	<p>SMEs can showcase their sustainable food products and network with potential international buyers. SMEs may receive grants or subsidies to cover the costs of attending international trade fairs.</p> <p>Piemonte Innovazione provides funding and grants for SMEs focusing on sustainability, with specific calls for proposals on topics such as circular economy and renewable energy. A recent grant of €50,000 was awarded to an SME developing biodegradable packaging made from agricultural waste. These funds can be used for product development and commercialisation efforts.</p> <p>i3P offers incubation services, including mentorship, access to funding, and commercialisation support for innovative SMEs in Piedmont. i3P helped an SME in the renewable energy sector secure €100,000 in venture capital funding for commercializing its solar panel technology.</p> <p>SocialFare is an incubator focused on social impact and sustainability projects, providing mentorship and funding opportunities. SocialFare supported an SME working on a sustainable mobility platform with a €40,000 investment and ongoing mentorship in areas such as product market fit and scaling.</p> <p>Confartigianato Imprese Piemonte is a trade association that offers business development services and networking opportunities for SMEs in Piedmont. It organizes B2B networking events and workshops on commercializing sustainable products, allowing SMEs to connect with local retailers and distributors.</p> <p>ICE – Italian Trade Agency supports SMEs in exporting their products by providing market entry strategies and guidance on international trade regulations. An SME producing organic food products received assistance from ICE in penetrating the Japanese market, resulting in increased sales and an expansion of its international market.</p> <p>Unioncamere Piemonte (Regional Chamber of Commerce) supports SMEs in their commercial efforts by organizing trade shows, networking events, and providing market intelligence. An SME producing eco-friendly cleaning products gained access to regional and national retail chains through Unioncamere Piedmont's industry connections.</p>
Policy and Regulatory Support	Any policy and regulations in support of sustainability	<p>Piedmont's Regional Environmental Protection Plan outlines the region's objectives and strategies for promoting sustainability, including measures for reducing pollution and conserving natural resources.</p> <p>Piedmont has embraced the European Union's Circular Economy Action Plan, which includes regulations to promote recycling, waste reduction, and resource efficiency. Policies focus on supporting businesses that adopt circular practices, such as product lifecycle management and waste-to-resource initiatives.</p> <p>The region offers incentives and grants for the adoption of renewable energy sources such as solar, wind, and hydroelectric power.</p> <p>The regional government promotes green public procurement policies that require public institutions to purchase environmentally friendly products and services.</p> <p>Piedmont enforces regulations on energy efficiency in buildings and industrial processes to reduce energy consumption and carbon emissions.</p>

		<p>The region has implemented policies for sustainable water management, including measures to promote water conservation and efficient use of water resources, for waste management and recycling to promote proper disposal and recycling of waste.</p> <p>SMEs undertaking new projects that may have an impact on the environment are required to conduct an Environmental Impact Assessment to evaluate and mitigate potential negative effects. This ensures that businesses consider sustainability in their project planning and development.</p>
What is the role of the actors and of collaboration in facilitating compliance with sustainability standards and certifications		<p>Government Agencies:</p> <ul style="list-style-type: none"> - The <i>Regional Agency for Environmental Protection</i> (ARPA) provides SMEs with guidance on compliance with environmental regulations and standards. For example, ARPA offers workshops and resources on proper waste management and emissions control, helping SMEs meet regulatory requirements. - The <i>regional government</i> offers funding programs and support for SMEs to adopt sustainability certifications such as ISO 14001 (Environmental Management System) or EMAS (Eco-Management and Audit Scheme). <p>Industry Associations:</p> <ul style="list-style-type: none"> - <i>Confartigianato Imprese Piemonte</i> provides SMEs with training and resources on sustainability standards and certifications, such as FSC (Forest Stewardship Council) for sustainable forestry and chain of custody. For example, it organized a seminar for wood processing SMEs to learn about FSC certification and its benefits for their businesses. - <i>Confindustria Piemonte</i> provides support to SMEs in achieving sustainability certifications and complying with industry-specific standards <p>Certification Bodies:</p> <ul style="list-style-type: none"> - <i>Bureau Veritas Italia</i>: This certification body provides SMEs with certification services for various sustainability standards, including ISO 14001, EMAS, and ISO 45001 (Occupational Health and Safety Management System). - <i>RINA</i> is an international certification body with a strong presence in Piedmont, offering a range of sustainability certifications, including ISO 14001 and ISO 50001 (Energy Management System). - <i>CSI Piemonte</i> offers various certification and testing services to SMEs, particularly in sectors such as ICT, energy, and healthcare. - <i>Dekra</i> provides certification services in areas such as environmental management (ISO 14001), energy management (ISO 50001), and occupational health and safety (ISO 45001). - <i>ICIM</i> is an Italian certification body with a focus on industry and energy sectors, offering certifications such as ISO 14001 and ISO 50001. <p>Collaborative Platforms and Networks:</p> <ul style="list-style-type: none"> - <i>Cleantech Piemonte</i> connects SMEs with sustainability experts and peers, facilitating knowledge exchange on compliance with standards and certifications. - <i>Fondazione Torino Wireless</i>: This innovation hub supports SMEs in the ICT sector, promoting sustainability through digital transformation and smart technologies

		<ul style="list-style-type: none"> - <i>Green Pea</i> is a sustainable shopping mall in Turin that promotes eco-friendly products and practices. It provides a collaborative platform for SMEs to showcase their sustainable products and engage with customers. - <i>Bio Piemonte</i> is an association that supports organic agriculture in the region. It offers guidance to SMEs in the agri-food sector on achieving certifications such as Organic and Global G.A.P. - <i>Cleantech Piemonte</i> is a network that connects SMEs with sustainability experts and potential partners in the cleantech sector. It provides guidance on compliance with standards such as ISO 14001 and EMAS. - <i>Fondazione ESD</i> (Foundation for Education to Sustainable Development) promotes sustainable development and offers training and support to SMEs on sustainability standards and certifications. - <i>Torino Piemonte Aerospace</i> is a network that supports aerospace SMEs in achieving industry-specific sustainability standards and certifications, such as NADCAP for special processes and ISO 14001 for environmental management. <p>Consulting Firms:</p> <ul style="list-style-type: none"> - <i>Ernst & Young</i> (EY) Italy offer SMEs advisory services on achieving sustainability certifications and standards compliance. - <i>Deloitte</i> offers advisory services to SMEs on achieving sustainability certifications such as ISO 14001 and B Corporation. - <i>PwC Italia</i> offers advisory services to SMEs in Piedmont on achieving sustainability certifications such as ISO 14001 and ISO 50001. The firm provides customized solutions to improve environmental and energy management systems. - <i>KPMG Italy</i> supports SMEs in Piedmont with consulting services for sustainability certifications such as GRI (Global Reporting Initiative) and CDP (Carbon Disclosure Project). The firm also offers assistance with ESG (environmental, social, and governance) reporting. - <i>Sinteco</i> is a consulting firm based in Piedmont that offers advisory services on sustainability certifications such as ISO 14001 and EMAS (Eco-Management and Audit Scheme). The firm helps SMEs optimize their environmental management systems. - <i>Ambiente Italia</i> is an environmental consultancy that helps SMEs in Piedmont comply with sustainability standards and certifications such as FSC (Forest Stewardship Council) and PEFC (Program for the Endorsement of Forest Certification).
Capacity Building and Learning	Are there any practices of mentorship, guidance, coaching, training on sustainable business models / strategies / practices /	<p>These initiatives are supported by government agencies, industry associations, research institutions, and consulting firms, for example</p> <ul style="list-style-type: none"> - The regional government offers mentorship and coaching programs to support SMEs in adopting sustainable practices and achieving certifications such as ISO 14001 and EMAS. - The Chambers of Commerce in Piedmont organize training workshops and seminars on sustainable business models and strategies for SMEs. For example, it hosted a seminar for SMEs on circular economy practices and how to implement them in business operations. - Confindustria Piemonte provides SMEs with training on sustainability standards and practices, such as energy efficiency and waste management. For example, it conducted a training session for SMEs on sustainable supply chain management and achieving ISO 14001 certification. - Research Institutions offers training and guidance to SMEs on sustainable engineering practices and product development. - Consulting Firms offers training and coaching to SMEs on sustainable business models and strategies, including workshops on achieving certifications such as ISO 14001. - Cleantech Piemonte provides guidance and mentorship to SMEs in the clean technology sector, helping them adopt sustainable practices and achieve certifications.

	products / processes?	
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3.3.2.2. *The relations between the manufacturing SMEs and the regional sustainable ecosystem*

Piedmont, one of Italy's most industrialised regions, has addressed the challenges of sustainability in manufacturing enterprises through an ecosystem approach that involves public institutions, research centres, universities, and companies. The MESAP cluster plays a central role in this ecosystem providing a variety of services to support its associated enterprises. First, in term of institutional support and funding, the Piedmont Region offers support through laws and regulations that promote sustainable practices, along with economic incentives for companies adopting green technologies. Through the MESAP cluster, companies can access European funds (such as those from the National Recovery and Resilience Plan) and national funds dedicated to sustainability projects. Second, regarding innovation and research, the MESAP¹⁷ cluster facilitates collaboration between enterprises and academic institutions for the development of new sustainable technologies (technology transfer). In this vein, applied research projects aimed at reducing the environmental impact of production, such as efficient resource use and waste minimisation, are promoted. Third, the cluster offers training and refresher courses for workers in the manufacturing sector, with a particular focus on sustainability-related skills. Moreover, events are organised to disseminate best practices and innovations in sustainability. Fourth, concerning networking and collaboration, the MESAP cluster creates a network among companies, allowing them to share experiences, resources, and knowledge on sustainable practices. It encourages the formation of strategic partnerships between companies, universities, and institutions for joint sustainability projects. Finally, the cluster promotes the integration of advanced technologies (such as IoT, AI, robotics) to optimise production processes and reduce waste and energy consumption. Thus, the MESAP cluster and Piedmont's institutional ecosystem support manufacturing enterprises not only through funding and incentives but also by promoting innovation, training, and strategic collaboration—key elements for effectively addressing sustainability challenges.

The transition to sustainability for manufacturing SMEs presents a significant challenge. Within the context of the Piedmont ecosystem, various factors influence the effectiveness with which SMEs can utilise available resources. Not all SMEs are fully aware of the benefits associated with sustainability or the resources offered by the Piedmont ecosystem; this lack of information can hinder the adoption of sustainable strategies. Additionally, SMEs may not have direct or easy access to information regarding incentives, funding, and technical support available through the Piedmont ecosystem. Despite the availability of incentives and funds, accessing these resources can be complex due to bureaucratic procedures and stringent eligibility criteria. The initial investment required for sustainable technologies can be substantial, and not all SMEs can afford it without adequate financial support. Moreover, integrating new technologies and sustainable processes requires expertise that may not always be present within SMEs. Although the MESAP cluster and other institutions offer support, more personalised assistance may be necessary to address the specific needs of each SME:

“Calculating carbon emissions is a priority right now because we don't have the internal resources for it, and I believe it is the most crucial project for us at the moment. (Lambda, Pos.30)”

¹⁷ MESAP – MECHATRONICS AND ADVANCED PRODUCTION SYSTEMS – is the Innovation Cluster established by the Piedmont Region with the support of the 2007-2013 Structural Funds to promote innovation in SMEs and facilitate technology transfer between research centers and businesses in relevant technological sectors. It brings together companies of all sizes, research centers, and universities in the Piedmont area.

In terms of collaboration and networking, SMEs could benefit more from closer collaboration not only with institutions but also among themselves, sharing resources, knowledge, and technologies. In this vein, active participation in clusters such as the MESAP cluster can enhance the effectiveness of adopting sustainable practices. Finally, some SMEs may resist adopting new processes and technologies due to a traditional corporate culture and proposed solutions must be adaptable and scalable to fit the realities of SMEs, which often operate with limited resources.

*“Among the cultural and organisational barriers, we find resistance to change – some SMEs might show resistance towards adopting new processes and technologies due to a traditional corporate culture and solution scale – the suggested solutions need to be flexible and capable of scaling to accommodate the circumstances of SMEs, which frequently function with constrained resources”
(MESAP cluster)*

In conclusion, while the Piedmont ecosystem offers numerous opportunities for SMEs in their transition towards sustainability, the effectiveness of leveraging these opportunities can vary significantly. Greater efforts are needed to raise awareness, facilitate access to resources, customize technical support, and foster a collaborative and innovative culture among SMEs to maximize their sustainable potential.

Within the Piedmont ecosystem, manufacturing SMEs frequently require various services to support their transition toward sustainability, though there are also underutilised opportunities that could provide significant advantages. Among the frequently asked services, SMEs seek financial support to modernise infrastructure and implement green technologies leveraging the access to regional, national, and European funds dedicated to innovation and sustainability. They also require specific training courses to update workers' skills in new technologies and sustainable practices, including workshops on energy efficiency and waste management. In terms of environmental certifications, Piedmonts' SMEs look for assistance in obtaining certifications such as ISO 14001, which attest to the effective adoption of environmental management systems. Finally, in terms of technical consultancy and innovation, they necessitate support in research and development of innovative solutions, such as introducing cleaner production processes and using sustainable materials.

Among the potentially underutilised services/opportunities, many SMEs overlook the utility of life cycle assessment, which can help businesses understand the overall environmental impact of their products from production to end-of-life. This analysis can guide more sustainable decision-making. Second, while collaboration networks exist, many SMEs may not fully exploit the possibility of sharing resources, technologies, and knowledge with other companies, even across different sectors, to co-create innovative solutions and reduce costs. Third, despite the importance of digitalisation, some SMEs may be reluctant to fully adopt Industry 4.0 technologies such as the Internet of Things (IoT), advanced robotics, and artificial intelligence, which can optimize operational sustainability. Additionally, opportunities to participate in circular economy systems, such as material or energy exchange platforms, are often overlooked. These platforms can help SMEs reduce waste and operational costs. Finally, mentoring programs from larger or more advanced companies in sustainability are undervalued but crucial for transferring practical knowledge and accelerating change. Encouraging SMEs to take advantage of these opportunities requires a concerted effort from institutions, technology clusters like the MESAP cluster, and the enterprises themselves to create an environment where sustainable innovation can thrive through increased awareness and collaboration.

The Piedmont sustainability ecosystem is characterised by a complex network of key actors spanning the public and private sectors, including academic institutions and non-governmental organisations. Among the government institutions, Piedmont Region plays a crucial role in establishing environmental

policies, providing funding, and promoting sustainability initiatives; local authorities (e.g. Municipalities, provinces, and the Chamber of Commerce system) implement regional and national policies and support local enterprises in transitioning to more sustainable practices. Whereas, among the research institutes and universities, we can mention Politecnico di Torino, a leader in research and innovation, particularly in engineering and sustainable technologies; University of Turin, active in environmental research, sustainable agriculture, and natural sciences; and specialised research centres, such as IREN (Institute for Energy Research) and INRIM (National Institute of Metrological Research), which develop innovative technologies and measurement methods for sustainability. In terms of technological clusters and innovation hubs, MESAP cluster (Mechatronics and Advanced Production Systems) supports enterprises in the areas of mechatronics and Industry 4.0, with a strong focus on sustainable solutions; Environment Park is a technology park that hosts companies and startups focused on environmental technologies and promotes research projects for sustainability; Sistema Poli Piemonte is a collaboration among the seven Piedmont innovation clusters to develop a common action program focused on three key transitions: ecological transition, digital transformation, and community well-being.

“In 2023 there was this event at the OGR where in practice we were invited to tell some successful projects. There was a digital showcase, that is, the opportunity to be included in the digital showcase of the Innovation clusters system [...] Obviously, Envipark and Fondazione Piemonte Innova were not the only ones to speak, but also other Piedmontese technological Hubs were given a voice, and therefore Fabrizio Fallarini presented this project, greenSME, which I immediately liked and therefore already from the excellent idea that the Innovation clusters system had to do this networking table, I had the opportunity to exchange a few words with him and logically from what comes, we joined. Thanks also to MESAP, which provided service providers, we found a project partner that allowed us to start and carry out this project” (Kappa, Pos. 19).

“The Poli system itself is helping us to carry out in what way, not necessarily, let's write, we do, but the various steps” (Kappa, Pos. 29)

Among businesses and industries, large companies and SMEs are central to the adoption of sustainable technologies, from improving energy efficiency to reducing the environmental impact of production processes; while innovative startups play a key role in developing and implementing new sustainable technological solutions. In terms of industry associations and non-governmental organisations, Confindustria Piemonte and Industrial Union Torino support enterprises in implementing sustainable strategies and complying with environmental regulations; while environmental organisations such as Legambiente and WWF Piemonte, are actively involved in raising awareness and promoting sustainable practices¹⁸. Finally, among the foundations and philanthropic entities, Compagnia di San

¹⁸ For instance, Legambiente with the “LIFE CLIMAX PO” project promotes adaptation to climate change through intelligent management of water resources in the Po River Basin District, implementing measures from the National Strategy for Adaptation to Climate Change tailored to local characteristics and climatic peculiarities at the district level. While with the project “proBEST” (Bioeconomy, Health, and Territory project) aims for the full economic and ecological functionality of the forestry sector (particularly, but not exclusively, wood-energy), integrating profitability and sustainability aspects towards an advanced circular economy model. (<https://www.legambientepiemonte.it/progetti/>).

“Together Possible” is the challenge that WWF extends to the private sector to build a world where humans live in harmony with nature. WWF collaborates with businesses willing to tackle the challenge of change, learning to operate and produce within the limits of one planet, reducing environmental impacts, and guiding business policies and practices towards greater environmental sustainability. With the “Businesses for Nature” program, WWF brings together all companies sharing WWF's mission and choosing to take a leading role by investing in the future of the planet. (<https://www.wwf.it/cosa-facciamo/aziende-e-markets/>).

Paolo Foundation funds projects and initiatives that promote sustainable development and environmental research in the region. These actors not only promote sustainability through various initiatives and projects but also collaborate with each other to form an integrated ecosystem that addresses environmental challenges in a coordinated and strategic manner. The interaction among these diverse actors is essential to accelerate the transition towards greater sustainability in businesses and the community at large.

In the Piedmont sustainability ecosystem, despite the presence of a strong and diverse network of key actors, there are sectors where stakeholders are insufficiently integrated or engaged, and areas where collaboration could be improved. Small enterprises and artisans often are not fully integrated into sustainability initiatives promoted at the regional level or by large technological clusters. This may be due to poor communication of available opportunities or bureaucratic barriers that make access to funding and technical support difficult. Despite the importance of agriculture in Piedmont, collaboration between the agricultural sector and institutions or technological enterprises could be enhanced, particularly in terms of sustainable innovation and precision agriculture technologies, which could help reduce the sector's environmental impact. The involvement of consumers and local communities often remains superficial. Increasing environmental awareness and education among citizens is essential to stimulate a stronger demand for sustainable products and services, which in turn could accelerate the adoption of sustainable practices in businesses. While the region and major cities are very active, some smaller local entities may lack the resources or expertise to effectively implement sustainability policies or adequately support local initiatives. Non-profit organisations and social enterprises working on issues such as social inclusion, education, and environmental sustainability may not be fully integrated into broader ecosystem efforts. Their experience in directly engaging communities could be better utilized to promote sustainable practices on a larger scale.

Industries such as heavy manufacturing and automotive are crucial for Piedmont's economy but may be slow to adopt sustainable technologies due to high costs and technical complexity. Greater collaboration between these sectors and providers of innovative solutions could accelerate the ecological transition. Addressing these gaps requires coordinated efforts to improve communication, reduce bureaucratic barriers, and foster stronger collaboration among all stakeholders within the ecosystem. This will help leverage the full potential of each sector to contribute to a more sustainable future.

Regarding the regional ecosystem of Piedmont and its impact on small and medium enterprises (SMEs) concerning sustainability measures, some issues could be discussed.

There appears to be a mixed perception of the support received by SMEs in Piedmont. While some express satisfaction with the support received so far, others highlight significant challenges and gaps in the support system. This disparity suggests a need for a more comprehensive and consistent approach to supporting SMEs in their sustainability endeavours:

“For now, I would say we are receiving the support we expected, also because I have praised and praised all our partners at all levels, so let's say, it's not that I want to take back what I said, but it's the reality of things.” (Kappa, Pos. 33)

“There is also a lack of a true industrial policy, with no consideration given to supporting key industries, favouring or not favouring specific sectors, or creating genuine and credible incentives to follow a particular direction” (Lambda, Pos. 47)

There are also various regulatory challenges faced by SMEs in Piedmont, including incomplete or outdated waste regulations and a lack of clarity on regulations pertaining to secondary raw materials. These regulatory hurdles not only create uncertainty for businesses but also pose legal and economic risks, hindering the effective implementation of sustainability measures:

"The waste regulations create a series of problems and should be revised, as the by-product regulations are existing but incomplete [...] The regulations on secondary raw materials are non-existent; there is a circular from 2011 that expired long ago, and it's unclear what references to use in that area" (Lambda, Pos. 43)

Concerns are also raised regarding the allocation of resources, particularly with regard to grants. The predominance of funding for consulting services over direct industry support may limit the tangible impact of sustainability initiatives undertaken by SMEs in Piedmont:

"Another issue is how resources are often allocated for grants. Most grants do not finance industries but rather consulting services, giving access to services that may quickly become outdated and have limited impact" (Lambda, Pos. 45)

The absence of a coherent industrial policy tailored to Piedmont's unique needs and challenges is also a significant barrier to sustainability efforts. Without clear incentives and support mechanisms, SMEs may struggle to navigate the transition towards sustainable practices effectively:

"These are two sides of the same problem: either such investments are not funded because they are deemed too expensive, or when they are funded, the resources are not targeted toward creating real impact." (Lambda, Pos. 47)"

Moreover, delays and inaccessibility of public support mechanisms are identified as significant challenges for SMEs in Piedmont. The complexity and bureaucratic nature of the application process may deter businesses from seeking assistance, further exacerbating the gap in support for sustainability initiatives:

"The big problem that we have about is I think are more Italian than European, if there are some public help, like normal open call, are very delayed in this moment and are either too big for small and medium enterprise, or the goal are so high that is quite impossible without lie to obtain something." (Eta, Pos. 32)

Finally, SMEs express a clear desire for concrete support, both financial and in terms of regulatory simplification, to facilitate the development of sustainable production practices. This underscores the importance of tailored and accessible support mechanisms to drive meaningful change within the regional ecosystem:

"I wish to work in that direction, but I hope to receive some concrete items in order to see also how we can develop our production, our company in the right way." (Eta, Pos. 22)

In conclusion, while some progress has been made in supporting SMEs in Piedmont with their sustainability efforts, significant challenges and gaps remain. Addressing these challenges will require a concerted effort from policymakers, industry stakeholders, and SMEs themselves to develop targeted support mechanisms, streamline regulations, and foster a culture of sustainability within the regional ecosystem.

Building on the previous discussion, different proposals can be suggested in terms of:

- Collaboration Platforms: establish online and physical platforms where stakeholders can meet, exchange ideas, and collaborate on joint projects.
- Community Engagement Initiatives: organise workshops and awareness campaigns targeting consumers and local communities to increase awareness and adoption of sustainable behaviours.

- Streamlining Access to Funding: reduce bureaucracy and simplify processes to make funding and support more accessible (e.g., activating cascade funds), especially for small businesses and startups.
- Training and Mentoring Programs: expand training and mentoring programs to include all sectors and levels of business, ensuring that the skills necessary for sustainable transition are widely available.

Through these strategies, it is possible to bridge existing gaps in the Piedmont sustainable ecosystem, promoting broader integration and more effective collaboration among all stakeholders involved.

4. Findings on manufacturing SMEs' approaches to sustainability

This chapter presents the results from the interviews and the analysis of the projects of greenSME's Open Call 1 that give some answers to the research questions about the aspects of sustainability in manufacturing that are of particular relevance and interest of the manufacturing SMEs, the SMEs' motivation to start introducing sustainability measures and about the challenges and success factors that the manufacturing SMEs face in the process of planning and implementation.

The empirical research shows that SMEs essentially approach this challenge in a similar way and often face similar challenges and problems. However, these are still company-specific and not universal in their specifications. All the SMEs interviewed here have approached the topic of sustainability in some way and see this topic as a key factor for the continued existence of their own company. The selection of the companies interviewed took place within the manufacturing sector, but was not sub-sector specific, so that typical results for individual sub-sectors or specific industries within the manufacturing sector cannot be made. But even with different sub-sectors represented by the SMEs interviewed, there are some parallels regarding the results. To better understand the way in which SMEs approach the topic of sustainability we present the results in the following sections.

4.1. Sustainability topics and technologies favoured

One of the research questions asks, what aspects of sustainability in manufacturing are of particular relevance for and interest of manufacturing SMEs. One question here is whether SMEs mainly focus on technologies or whether they are also interested in non-technological topics to address sustainability. Another question is what types of technological and non-technological measures are being implemented and which are of great interest but are not (yet) being introduced. To answer these questions, we looked at the projects funded in the greenSME Open Call and asked the SMEs in the conducted interviews. Among the 21 current projects from the greenSME Open Call 1, six projects focus solely on advanced technologies or combinations thereof ("AT" - bar in Figure 4). For instance, two projects combine pilot testing of advanced or recycled materials with testing of advanced manufacturing technology to ensure the materials' suitability in production. In the food industry, one project employs artificial intelligence (AI) and Internet of Things for quality control, while in metal parts production, AI algorithms directly manage manufacturing conditions. Tracking of the production execution is being incorporated into resource management systems to reduce over-consumption. One project plans the introduction of upskilling needs identification processes alongside with AI-based solution but does not actively mention Social Innovation expertise being used (light blue part of the bar in Figure 4).

Two projects recognize the need to support technological innovation with social considerations ("AT + SI"). Implementing new IT solutions with AI and Big Data requires workers' acceptance and suitable skills, prompting analysis of potential upskilling needs. SMEs also acknowledge that integrating new technology may necessitate adapting their business models and organisational processes. Thus, one project establishes cloud-based IT infrastructure and customer-oriented communication processes, while another revises its business model for AI implementation.

Six projects in total combine technological solutions with environmental expertise ("AT + ES"), introducing new materials with Life Cycle Assessment preparation or analysing carbon and water footprint alongside a digital platform for real-time resource evaluation. Two of these projects also introduce trainings on circular economy and lean manufacturing, emphasizing the importance of combining social innovation with technological advances. However, in their proposal they do not mention social innovation services being used.

Three projects solely focus on social innovation, all prioritizing business model revision and improving collaborative relationships, customer-oriented processes, and defining worker skills to enhance social and economic sustainability.

Lastly, three projects understand the value of using life cycle assessment expertise to evaluate the environmental impacts of their products and processes. These projects also incorporate social innovation by providing coaching for workers, adjusting their business processes, and enhancing collaborative relationships. Additionally, one project mentions solely the environmental expertise, particularly in developing biodegradable products. However, this project also plans to build collaborative relationships with key partners and to adapt the business model to accommodate the new product.

The light-blue bars in Figure 4 indicate that social innovation services are sometimes essential for the sustainable transformation of SMEs, even though they may not always be immediately obvious for the decision makers.

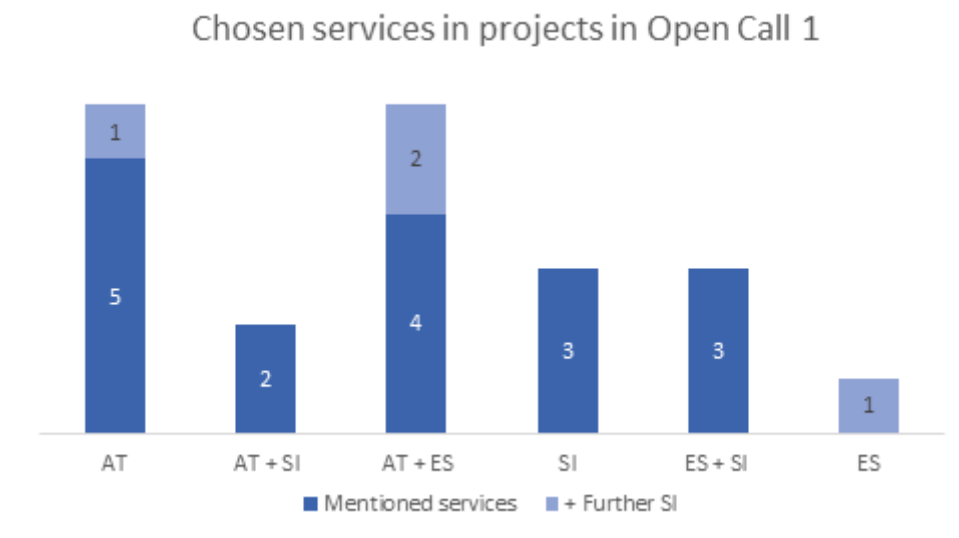


Figure 4: Overview of the chosen services within 21 projects of the first open call.

The most important sustainability issues for the manufacturing SMEs naturally vary from company to company. The same also applies if companies do not come from the same or similar sectors. However, the topic of sustainability is important for all companies and, in terms of how it is organised, tends to be generally valid and universal for all companies. In principle it can be said that SMEs across all manufacturing sectors have an understanding of sustainability and are concerned with the avoidance of waste, the use of renewable energy sources, the optimised use of potentially environmentally hazardous substances and the recycling of products. The same applies to a fundamental understanding of CO₂ savings.

“So they compensate all the emissions, the transportation of the goods creates. So, we definitely have taken some actions and they definitely have a big effect. And we have reduced the plastic waste, for example, by approx. 80% since we talked about that.” (Iota, Pos. 264-266)

“We were able to minimise CO₂ emissions by 8.7 per cent - and from 1st of January we have now green electricity and gas with compensation. Green electricity and gas with compensation at the moment - we were able to reduce our electricity consumption by another 6.9 gigawatt hours, 6.5 gigawatt hours of gas in total, we have captured almost 75 per cent of what we consume.” (Delta, Pos. 54)

The topic of sustainable energy generation or storage is of great importance to all SMEs. In many cases, photovoltaic systems are used for this purpose and their expansion is also being driven forward.

“So, we will have solar panels installed, more efficient heating devices and other elements because in our branch, in our industry, the power consumption is quite big. So, this is the way we can deal with to be more sustainable.” (Gamma, Pos. 14)

“But especially because of the cost of power energy is rising, we find a way to be 80% or 90% autonomous with the solar panel, it means that we can cut a lot of problems.” (Eta, Pos. 29)

The focus is not only on increasing the environmental sustainability, but also has a significant financial aspect. Depending on the country and its subsidies, these systems pay for themselves in a relatively short time and offer tax advantages in some cases. Another important argument has also come to the fore since the Covid 19 pandemic and the war in Ukraine.

“After COVID, like everybody, with energy shock we started looking into the energy costs and try first of all to understand them better so not have just one bill at the end but try to understand which are the drivers of the energy costs and which are the areas and where we can improve.” (Beta, Pos. 15)

Such systems offer a certain degree of independence from rising energy prices and thus make SMEs more resilient.

“We started to implement the own solar energy production in our factory. So, we started means that last year we implemented 75 kilowatts and that year we want to extend it at least by 100%.” (Epsilon, Pos. 94-95)

“We put to the solar panel in our company and in the next I hope 10 days we can turn on and we can be sufficient with the energy” (Eta, Pos. 20)

The first important "trend" for rapid and broad acceptance of sustainability measures can already be seen here. SMEs need a certain degree of planning security for the investment and must be able to pass on higher costs for an investment.

Another point for SMEs regarding sustainability is the constant further development of their own processes.

“We also conducted two projects, one was developing a state-of-the-art modelling and simulation environment for industrial automation application development and training. The project integrates, adapts and further develops the [...] technology for model-based simulation of industrial PLC applications in the process industries in accordance to the end-user requirements. [...] The other project aims to develop a new solution for embedded vision using AI/ML technology in order to improve the productivity and quality of industrial robotic cells. The solution leverages commercial-off-the-shelf components and open-source software libraries for cost effectiveness and flexibility.” (Beta, Pos. 22)

Although very different technologies are used here, the goal is clearly recognisable. By optimising processes, manufacturing SMEs are trying to reduce the use of potentially hazardous substances and thus make their end products more sustainable. However, this only seems possible to a limited extent, as SMEs are often located in supply chains and must orientate themselves strongly towards their customers.

“And so, the first thing we noticed is when we talked about sustainability, that a big part of the emissions, for example, our products are going to produce” (Iota, Pos. 46-47)

“While this can be done, the resulting material can't be reused for industrial purposes because major companies' specifications don't permit the use of recycled compounds or secondary raw materials” (Lambda, Pos. 16)

Another important issue for SMEs regarding sustainability concerns their position in the supply chain. SMEs are often suppliers and therefore to a certain extent dependent on large companies. This is where certifications play an increasingly important role. SMEs are therefore in the position of having to demonstrate certain certifications in order to remain active as a supplier. Although many processes in SMEs fulfil the requirements of certifications, these certificates are often not available, as certification requires a certain amount of effort, and not just financially. This now seems to be changing more and more and SMEs are also making use of certifications.

“In addition, Lambda is venturing into the aerospace sector, as it has made contacts with Leonardo and recently obtained the 9100 certification required to work in the aerospace field. Hence, operations in this sector will also begin soon.” (Lambda, Pos. 12)

“So, consider that we are already ISO 9001 certified” (Kappa, Pos. 23)

“For example, we want to get certified in ISO 50001 which is for energy management system, and that is also a cost, but it's manageable so it's not such a large expense” (Beta, Pos. 35)

Although these certifications are not a direct guarantee of greater sustainability, it does show that the topic is being addressed and that there is a broad discussion about evidence and ways of documenting and collecting relevant data. This not only leads to a broader understanding of the topic of sustainability in companies, but also to broad acceptance among the workforce.

4.2. Manufacturing SMEs' strategies to approach sustainability

SMEs pursue different strategies to address the issue of sustainability. On the one hand, purely organisational measures such as certifications (see previous section). These enable a standardised external presentation of the company and are often a mandatory requirement of large customers and also partly the subject of national legislation (Supply Chain Act).

“That means there is already a high level of figures which we already have. Otherwise, we wouldn't have been able to do the sustainability charts. So, we have a lot there. The good thing is we said there was no properly organised template.” (Delta, Pos. 200)

In addition, the SMEs also see the workforce as an important part of the implementation and, above all, the daily application. Creating an awareness of sustainability and the associated change in work processes is a major challenge but can also be the key lever for SMEs. Therefore, the qualification and involvement of the workforce is often a central component of the strategy of SMEs.

“The aim of the project is developing and implementing a resource efficient model for us to increase sustainability of the company and add value to company's competitiveness by decreasing production prices through resources efficiency including energy and manufacturing processes optimisation by also up-skilling staff.” (Beta, Pos. 17)

“So, it's not a huge and that's why we don't have so much automation. So mostly the skilled persons are very important.” (Beta, Pos. 28)

“And the big issue, I always say, we have nice technical issues, awareness and staff training, because if they don't understand what it's about. That's why I'm glad you're here. We can talk about blooming technology, if people don't get it, they don't understand, why you switch off the lights when you leave. It's just a huge issue.” (Delta, Pos. 66)

It is clear that SMEs have a fundamental understanding of sustainability and have already implemented measures to this end. Certifications are one measure that can deliver standardised results. As these are often customer requirements along the supply chain, SMEs often utilise this strategy or are forced to do so.

In principle, however, it is also evident that there is a deeper awareness of sustainability and therefore a different attitude is being propagated in SMEs. The central element of this change is the involvement and training of the workforce. Many SMEs are already taking this approach.

The approaches and strategies of SMEs in addressing the topic of sustainability are initially no different from other topics such as the increasing demand for digitalisation. SMEs often implement measures due to external influences or customer requirements. Their position in (international) supply chains also suggests such an approach.

“This is likely a common issue for small businesses since they are suppliers to large companies and must gather data to provide them.” (Lambda, Pos. 31)

Nevertheless, it is clear that many SMEs also go beyond the minimum requirements to be able to meet future developments.

One of the strategies to do this is to take part in funded research projects with partners from research and development, such as universities, technology platforms and research and developments companies. This could be shown for companies Delta and Beta in section 3.1 *Overall findings on relations between the manufacturing SMEs and their regional sectoral ecosystems*.

4.3. Challenges and solutions in manufacturing SMEs' sustainability strategies

The paper also set out to investigate challenges or barriers that SMEs face when planning or implementing sustainability measures and whether and how they manage to overcome them. In the interviews, we found several examples of common challenges and some solutions.

Across all companies, money is cited as a key challenge. More public funding or financial support is also frequently mentioned as a possible solution.

“When we talk about the project I've just mentioned, like maybe even creating a new building, then the banks and investment companies are factors as well. Because so the financial side depends on sustainability as well.” (Iota, Pos. 331-332)

“The thing is that mainly, maybe it's so simple, but mainly it's about financing the investments. So the problem is usually if you want to be more ecologic, it's the need to make some additional costs to cover some investments. And that's the main problem usually.” (Gamma, Pos. 58)

This is hardly surprising for SMEs, which often must contend with a fundamental shortage of resources. Additionally, access to information and expertise is also a major challenge for SMEs.

"I mean, a general challenge is to get the knowledge about what kind of actions are actually effective when it comes to sustainability." (Iota, Pos. 140-141)

However, this is also where the potential solutions for SMEs come into play. Many SMEs use external partners and networks to obtain information. These can be independent consultants as well as clusters or innovation networks as also described in the previous chapters of this paper.

"We have energy consultants. But we also have a network. German Society for Electroplating and Surface Technology, where people exchange ideas. There are various events where we go to get inspiration." (Delta, Pos. 142)

"We have many partners in the special economic area and who build themselves a production hall or warehouse. And we contact with them, and they help us." (Gamma, Pos. 117)

"And not usually in our field. So we are mainly talking with the companies from other branches. But mainly focus on what they do to look not exactly about the company who produces the same as us. But there are companies who produce different things but have the same issues at the moment of production. (...) Sometimes it's better to also look for other branches to see the solutions, not only the one you have. So, in our branch, I think we do not follow any other companies." (Gamma, Pos. 125)

The large amount of information that affects SMEs is often very challenging. In addition, many change requirements affect SMEs at a higher speed and often even occur simultaneously. This simultaneity makes it difficult for SMEs without large departments for strategy development, research and development to make suitable decisions in ever shorter timeframes. SMEs are responding to this by utilising network structures, for example, or by turning to traditional research institutes in order to generate technical and social knowledge.

"I've just had various research projects with various research partners. The [Technical University 1] is different, so [researcher at Technical University 1] and I also know about different projects or other people. We work with the [Technical University 2] when it comes to chemistry. We're relatively fit there. Or the [research institute] down in Stuttgart." (Delta, Pos. 138)

However, traditional personnel development strategies can also help SMEs to find suitable employees and inspire them to join their company.

"We focus on environmental and social aspects. Regarding social aspects, there's an emphasis on including students and young talent. Many of our employees, including myself, started through simultaneous work and study programs, with most individuals my age entering through advanced apprenticeship programs that combine education with work hours. We often collaborate with schools on various projects, where I, as the ESG office, frequently go with our owner to schools to discuss benefit corporations' principles and their societal impact." (Lambda, Pos. 22)

5. Conclusions

This study aimed to explore the sustainability of manufacturing SMEs in Europe and their relationships with regional and sectoral ecosystems. The investigation centres on the practical realities of sustainability ecosystems at both the regional and sectoral levels, with a particular focus on SMEs that engage with the multifaceted issue of sustainability. The primary objective is to understand how SMEs address sustainability challenges and integrate this topic into their own business models. The findings reveal that while sustainability introduces new content-related challenges for SMEs, it also offers significant advantages, such as improved supply chain position and better management of scarce resources. The issue of sustainability adds a crucial dimension to the fundamental challenges (i.e., resource shortages) faced by SMEs that needs to be considered. However, SMEs widely recognise and address this additional challenge, often perceiving more opportunities than risks in adopting more sustainable production practices

The following research questions guided the analysis:

1. What aspects of sustainability in manufacturing are of particular relevance and interest of the manufacturing SMEs?
2. What is the SMEs' motivation to start the process of introducing sustainability measures?
3. What are challenges and success factors faced by manufacturing SMEs in terms of planning and implementing sustainability measures?
4. What role do internal and external actors play and what are the connections to the regional/sectoral ecosystems?

Drawing on a comprehensive literature review and data from the greenSME project, multiple insights have emerged. The analysis incorporates data from the Self-Assessment tool results, the Advanced Sustainability Action Plan results, and the projects implemented during Open Call 1 of the greenSME initiative. Additionally, interviews were conducted with twelve manufacturing SMEs (primarily CEOs/owners, with some middle managers) and two cluster representatives within pilot ecosystems. This data has been analysed to address the research questions from different perspectives.

1. What aspects of sustainability in manufacturing are of particular relevance and interest of the manufacturing SMEs?

Data from the greenSME project's online Self-Assessment tool for manufacturing SMEs and the funded projects within Open Call 1 revealed that the initiatives addressed a wide range of sustainability aspects. The three identified dimensions - advanced technology, environmental services, and social innovation – were all deemed important and addressed in the projects. However, advanced technologies received the majority of the funding.

Several recurring themes emerged from various interviews and were corroborated by the SATs as important or most important action fields. The evaluation of the 43 SATs conducted in the first reporting period of greenSME identified “**processes and production system**” as the most frequently identified action field, and this was echoed in multiple interviews.

Energy management also surfaced as a significant topic, encompassing initiatives such as purchasing electricity from renewable sources, installing solar panels, and implementing energy reduction measures. **Materials** management was another commonly identified action field, with a focus on using alternative sustainable materials and using materials more efficiently. Additionally, interviewees frequently discussed the importance of **reporting environmental sustainability** indicators, such as life cycle assessments, carbon footprint, waste production and others. These reports are often linked to the certifications required for market eligibility and supplier approval.

Social sustainability aspects were also highlighted, including **workers' safety** and **workers' work-life balance, training and upskilling** and **gender equality** as well as establishing a **new sustainable business model**, selling a product with greater longevity compared to previous offers.

2. What is the SMEs' motivation to start the process of introducing sustainability measures?

A critical driver of sustainability within manufacturing SMEs is the commitment of the owner or CEO. Interviews revealed that the belief in the necessity for industry to adopt more sustainable practices to mitigate environmental and climate impact often initiates the pursuit of sustainability. Internal motivations for implementing sustainability measures include increasing efficiency, productivity, profitability, and competitiveness.

Externally, customer requirements significantly influence SMEs' motivation towards adopting sustainable practices, particularly when customers are large companies subject to environmental regulations or sustainability criteria in their supplier selection processes.

Laws and regulations mandating compliance are also strong motivators for manufacturing SMEs to start implementing sustainability measures.

Other motivations include reducing costs, especially related to energy use and expensive materials, and enhancing attractiveness to potential customers and employees. The challenge of recruiting and retaining skilled workers is a significant concern for manufacturing SMEs, and sustainability initiatives can improve their appeal to talent.

Finally, observing similar companies successfully implementing cost-effective and straightforward sustainability practices serves as inspiration for SMEs to adopt and adapt these practices.

3. What are challenges and success factors faced by manufacturing SMEs in terms of planning and implementing sustainability measures

In the interviews, the most frequently emphasised challenge was the **cost of investments required for sustainability** implementations. Currently, many such investments, while beneficial for environmental sustainability, threaten the economic sustainability/viability of SMEs due to their long payback periods, often extending to 10 years or more. Current funding and financing offers fail to accommodate these time frames.

Similarly, SMEs reported a proliferation of short-term funding schemes, but a lack of financial support for long-term strategies essential for addressing sustainability issues. These include training and upskilling employees, adapt to energy crises, and producing with more efficient machines. SMEs often manage to implement one or two sustainability measures at a time, but they identify numerous other potential improvements that remain unaddressed due to funding limitations, necessitating prioritisation and resulting in missed opportunities for significant sustainability advancements.

Another significant challenge highlighted by many interviewed manufacturing SMEs was the rapid **pace and complex design of environmental and social regulations and laws**. Laws and regulations are introduced too swiftly for SMEs to effectively plan changes and adapt their organisational structures, processes, and supplier relationships. Furthermore, the multitude of required changes, coupled with related evaluations and certifications, are perceived as overly complicated, costly, and time-consuming. This regulatory complexity hampers SMEs' ability to plan effectively and adapt in a timely manner, potentially resulting in lost business opportunities

The (mostly public) funding aimed at supporting industry sustainability efforts is seen as beneficial, yet manufacturing SMEs feel that the available funding is insufficient to meet the extensive needs of all SMEs. Specific challenges identified in this context include:

- Bureaucracy and the absence of a centralised European platform where companies can enter their details once

- High and ambitious thresholds in sustainability Key Performance Indicators that are unattainable for SMEs within the prescribed timeframes
- Lack of smaller but attainable grants
- Funding that is limited to few publicly accepted topics (e.g. electric cars) with insufficient flexibility to accommodate the diverse needs of manufacturing SMEs, where alternative measures could have a greater impact on sustainability, encompassing environmental, social and economic dimensions
- The extensive effort required to apply for funding, which demands significant time from employees – a resource often scarce in SMEs

A few market-related challenges have also been identified as important. One major issue is that sustainability efforts often increase product prices. In Europe, rising compliance requirements similarly affect competitor prices, but this is not always the case in international market, where competitors from countries with lower sustainability and labour standards gain a competitive advantage over European SMEs. Furthermore, customers do not always value more sustainable products, prioritising other factors, such as costs or specific product characteristics relevant to their production needs.

A critical challenge mentioned by nearly all interviewees is the lack of knowledge about practical sustainability solutions. In general, for many SMEs, the initial barrier to starting sustainability initiatives is to gain **knowledge** about sustainability and understanding **which actions are genuinely beneficial for their company**. Here, a centralised repository of information would be highly beneficial, as the effort required to search for relevant information can be prohibitive. Related to this topic is the challenge of **uncertainty of the real outputs** of sustainability measures, including doubts about reaching planned goals, the method to achieve them, and the true efficacy of these goals (e.g., whether carbon offsets genuinely contribute to sustainability). In this context, the lack of guidelines on implementing sustainability measures and appropriate levels of key performance indicators also poses a significant challenge.

Understanding how advanced digital technologies can be used to enhance sustainability tailored to the SMEs' specific needs is another hurdle. For example, many manufacturing SMEs often face **inherent productive constraints related to raw materials use** specific to their products, highlighting the need for bespoke **solutions or applications that are not yet available**.

Implementing new technologies and practices also involves overcoming resistance from employees, who may be reluctant to change processes and accept new methods or technologies in their daily work. Therefore, it is crucial to **engage employees** early in the process and clearly communicate the necessity and benefits of these changes.

Last but not least, there is also concern that sustainability measures may only be worthwhile if they are not perceived as greenwashing by customers or the public. This perception can undermine the effort and investment put into such measures.

Regarding factors for successful implementation of sustainability measures, the topics echo the challenges: resources, knowledge and access and intention.

Interviewees highlighted the need for **adapted financial instruments** to cushion the impact of the currently volatile market situation. **Funded open calls**, such as those in the greenSME project (with a limited amount of time and funding) are perceived as useful because they allow for the implementation of smaller projects can help SMEs achieve significant goals incrementally, fitting their adaptive processes better than large grants with very ambitious thresholds.

A **robust knowledge and information base** is also crucial. SMEs benefit from obtaining information quickly and easily **through networks and collaborations**, often leveraging **research projects** or tailored information provided by **local or sectoral networks, such as cluster organisations or local consultants**.

Consultants can efficiently filter and deliver relevant information, saving SMEs time and effort.

Successful relationship and collaboration with partners, including Universities, R&D Institutions, or Competence Centres, are essential for the practical implementation of sustainability measures and strategies, complementing SMEs' capabilities and facilitating operational success.

4. What role do internal and external actors play and what are the connections to the regional and sectoral ecosystems?

While clusters serve as connectors and sometimes coordinators within ecosystems, the scope of ecosystems extends beyond the formal membership boundaries of clusters. In supporting manufacturing SMEs, policymakers, consultants, and education and training providers also play significant roles. Although clusters inform SMEs about relevant and current topics, support is frequently provided by paid service providers, including consultants, technology and training providers. Also, financial resources are crucial for SMEs aiming to enhance their sustainability, making funding opportunities fundamental. These opportunities are typically managed by public entities, which have a substantial influence over the development of targeted funding programmes.

Government initiatives are also vital for the development of regional economic support structures, such as clusters, economic development agencies, designated industrial zones, and tax incentives. An example of this is the establishment of special economic zones in Poland. Nonetheless, SMEs often perceive governments primarily as policymakers who impose new laws and regulations, requiring additional reporting and limiting material choices, while being somewhat disconnected from the realities faced by manufacturing SMEs.

clusters (and networking clubs) are frequently mentioned by SMEs as valuable contact points and partners. They maintain close relationship with SMEs, understand their needs, can represent their interests, and provide necessary support, including:

- Identifying partners for specific projects or providers for technology, construction, and advisory services, for particular endeavours.
- Organising information events, participating in fairs, raising awareness about trends, and providing trend forecasting and insights on important topics
- Assisting in locating suitable land and facilities, as mentioned in one case
- Supporting the search for funding opportunities (projects) at regional, national and EU level

Consultancies and auditing companies play a crucial role in identifying key areas for improvement and influencing SMEs' subsequent actions. Some SMEs retain their general consultants, while others hire experts for specific implementations.

Banks are essential for many SMEs' sustainability initiatives by providing necessary loans. SMEs perceive that banks now increasingly prioritise financing sustainability measures. Despite this, banks often shy away from supporting long-term investments due to perceived risks, which hampers SMEs' ability to develop comprehensive long-term strategies encompassing environmental, social and economic sustainability.

Partnerships with universities and R&D institutions are leveraged by many manufacturing SMEs to acquire new knowledge and ideas, understand trends and foresights, and complement their core competencies. This collaboration, often within funded projects, enable SMEs to implement and test new technologies or other sustainability measures, aiding in the practical implementation of sustainability measures.

Funded projects also help SMEs enhance their reputation for high-quality products and services, ultimately building customer trust.

Other companies, especially SMEs in similar sectors, are also important stakeholders in the regional ecosystems of the manufacturing SMEs. SMEs often seek partnerships with other firms to coordinate necessary actions or maintain contact with other business owners for knowledge exchange, provider contacts, and shared experiences. Nonetheless, the interviews highlighted that the commitment of CEOs or owners significantly shapes the direction and scope of SMEs' sustainability goals.

While many points of the overall findings on the relations between SMEs and their regional ecosystems appear again in the analysis of the pilot ecosystems, there are some specific conclusions that can be drawn from the latter.

For both pilot regional ecosystems, the presence of strong leading large companies was important for the regional economy and the growth of an ecosystem around them. Many regionally located SMEs work with the larger companies. In many cases they supply the larger companies with their products and in some cases, they work together on innovation projects. Beyond the direct connection between these stakeholders, the presence of large important companies favours the establishment of corresponding industrial clusters, multi-stakeholder collaboration on innovation, and networks. The presence of the industrial clusters and innovation platforms foster awareness raising about certain topics, like sustainability or advanced technologies (digitalisation), and the active exchange of experience between different actors.

The inclusion of the technical universities is important for both ecosystems, and innovation and research projects in tandem with companies are fostered by the ecosystems. In Italy, the industrial association Confindustria and the employers' association actively work on supporting companies with sustainability issues, while in Silesia, the associations are less prominent for the SMEs and the innovation networks. NGOs and citizens are underrepresented in both ecosystems, but two environmental organisations are active in the Piedmont ecosystem, raising awareness about environmental sustainability and offering collaboration on the topic to businesses.

In both cases, examples showed that regional administration of national and European funding programmes helps SMEs to make use of the funding. The clusters function as a broker for the right eligible funding schemes of the SMEs and help to facilitate application by SMEs.

In both pilot ecosystems, the industrial clusters see a need to connect to other industrial clusters in the same region to work on certain topics and strategies together better. They also make active use of meta-clusters and interregional exchange of ideas and experiences to improve their knowledge and offers to the companies. The regional economic strategies that are developed in partnership between industry and regional governments seem to have a great influence on the direction of fostered development, topics, and services of the ecosystem stakeholders.

The biggest gap perceived by the stakeholders of the Piedmont pilot ecosystem (SMEs and cluster) are the lack of SME-friendly national or regional funding-programmes and regulations. This shows the need for regional sustainability ecosystems to work together with policymakers, as the ecosystem literature promotes.

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