D1.2

Mapping of supply chain models to the industrial ecosystems with readiness and responsiveness measurement analysis

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Abstract	This deliverable will provide mapping of identified risk-driven supply chain models to targeted industrial ecosystems, while defining the drivers and challenges for each industrial ecosystem, considering the readiness and responsiveness of their supply chains in against disruptive events and improved resilience. The deliverable will comprise two parts: (1) the results of a systematic literature review that will present what is known and what is not known in the literature about the impact of resilience practices on resilience performance of supply chains. In addition to identifying current models of resilience and supply chain risk management, the intellectual structure of the literature will be presented, including the evolution of the theme in recent years, the main journals and authors; (2) the results of an abductive research-based approach, which will explore the causal relationships between the models and practices identified in the literature and the industrial ecosystems that are part of the project. This part of the deliverable will use and supplement the information presented in D1.1.

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RISE-SME: Resilient Industry Supply Chain Enhancement for SMEs

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Executive summary

The purpose of this second deliverable (D1.2) is to provide the mapping of identified risk-driven supply chain models to the targeted industrial ecosystems, while defining their drivers and challenges. It will also encompass the readiness and responsiveness of supply chains towards disruptive events and enhanced resilience. Following D1.1, relevant sectors within each ecosystem were defined – for the textile ecosystem, organizations related to the clothing sector; for the Agri-food ecosystem, organizations related to wine sector; for the Digital ecosystem, organizations related to mobility applications/services addressing the final consumer; and for the Mobility ecosystem, organizations related to the electric vehicle production sector.

The methodology implemented in this deliverable followed 3 activities: (1) systematic literature review to identify the indicators used to measure resilience capabilities in companies; (2) Analysis and presentation of the main technologies related to supply chain resilience; (3) a Focus Group (FG) methodology with organizations representing the 4 ecosystems to understand the relationship between resilience capabilities (based on their indicators – Activity 1). It was conducted one FG per sector, being the Textile, Agri-food and Mobility conducted in person and Digital conducted online.

Regarding activity #1, 106 articles were analysed and resulted in 19 indicators identified and organised according to resilience capabilities. For Activity #2, 23 advanced technologies supporting supply chain resilience in the targeted ecosystems were identified, based on scientific and grey literature. Activity #3 for each sector enabled to: (1) identify the main disruption events that happened in recent years; (2) rank the risk level for each Critical Factor; (3) rank the resilience capabilities more relevant for that sector; (4) Identify and rank the main technologies used by the sector to improve their resilience; and (5) Define the relationship between the resilience indicators and the critical factors, identifying how the resilience capabilities can be developed in each sector.

In conclusion, the above work enabled to identify that the *shortage of skilled labour*, *political conflicts and crises, and technological disruptions and low digital maturity* are main critical factors throughout the 4 sectors. Regarding resilience capabilities, *financial strength, market strength, visibility* and *adaptability & flexibility* are identified among the most critical resilience capabilities. When it comes to the technologies that contribute to increasing resilience, *AI, big data and analytics*, and *IoT* are central to all sectors, reflecting the broad need for data-driven decision-making, real-time monitoring, and process optimization. In addition, emerging technologies such as *digital twins*, *robotics*, and *new materials* reflect sector-specific priorities.

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SLR	Systematic Literature Review
FG	Focus Group
CF	Critical Factors
RC	Resilience Capabilities
WHO	World Health Organization
WP1	Work Package 1

1 Introduction

The RISE-SME project aims to support European ecosystems by developing a quantitative model to help SMEs detect and anticipate supply chain disruptions. This model will facilitate the adoption of advanced technologies and support new alliances, promoting flexible, agile, and resilient supply chains. RISE-SME will focus on the agri-food, digital, mobility and textile ecosystems, engaging sectorial clusters and Digital Innovation Hubs to ensure broad impact and support.

This document is part of Work Package 1 (WP1) and presents the results of tasks 1.3 and 1.4. The purpose of this second deliverable (D1.2) is to provide the mapping of identified risk-driven supply chain models to the targeted industrial ecosystems, while defining their drivers and challenges. It will also encompass the readiness and responsiveness of supply chains towards disruptive events and enhanced resilience.

Building on the "Supply Chain Resilience Fit Model" developed in T1.2 (presented in D1.1), this deliverable explores how context variables – understood as those that characterise the environment where companies act and that usually cannot be changed by supply chain actors – and more specifically critical factors, affect the ecosystems concerning their resilience; furthermore, it aims to identify how supply chains have responded to these challenges both in terms of the development of resilience capabilities and the use of digital technologies – named intervention variables in our model. Following the conclusions drawn in the first part of the project, relevant sectors were defined within each ecosystem based on their relevance for European countries and on specific challenges they are facing. For the textile ecosystem, companies related to the clothing sector were analysed, while in the Agri-food ecosystem, organizations related to wine production and commercialisation were involved. The Digital ecosystem included organizations related to mobility applications/services addressing the final consumer and, finally, for the Mobility ecosystem, organizations related to electric vehicle production were addressed.

This part of the project applies a practical approach based on collecting information from experts in the selected sectors. In addition to representatives from leading companies and SMEs, representatives from sectoral and technological associations, business clusters, and academics with proven experience in the sectors were involved. The aim was to have a comprehensive view of the problems and approaches used in the ecosystems, identifying best practices and current and future challenges.

The activities were structured to allow participants to share their knowledge about their respective sectors. Thus, the results reflect the perspectives of these actors involved in each analyzed sector. Considering that, results include the identification and discussion of the critical factors of each sector, as well as the capabilities that have been developed by reference companies. Additionally, a detailed analysis was made of the relationship between the critical factors considered most relevant and the capabilities that can act as moderators in reducing their negative impact on companies' performance.

The deliverable is structured in seven sections. The first section introduces the RISE-SME project and presents the purpose of the document, while the second describes the methodologies applied. Third section describes the different indicators to measure resilience, while the fourth section describe the technologies applied to the resilience capabilities. The fifth section outlines the relationship between resilience capabilities and critical factors, based on the results presented by each sector during the focus groups. The sixth section presents the main conclusions and section 7 the references.

2 Methodology

This deliverable presents the results of three activities that, although strongly related, were executed sequentially and with different methodologies, as shown in Figure 1. Activity 1 employed a systematic literature review to identify the indicators used to measure resilience capabilities in companies. Activity 2 analysed and presented the main technologies related to supply chain resilience. This analysis consisted of the analysis of the technologies preidentified in the early stages of the project (through a grey literature review), followed by an updated analysis of disruptive technologies impacting supply chain resilience in the upcoming 5 years horizon. Finally, Activity 3 applied a Focus Group methodology to understand the relationship between resilience capabilities (based on their indicators – Activity 1) and critical factors throughout the 4 ecosystems – agrifood, textile, logistics and digital.

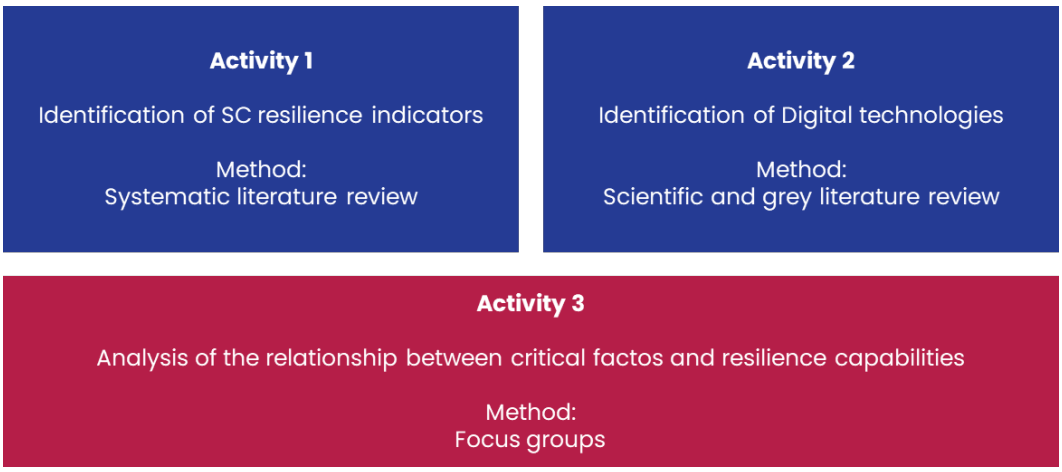

Figure 1: Methodology overview

2.1 Systematic Literature Review for Measure Resilience Capabilities

Although supply chain resilience is a current topic and has been much discussed by practitioners and academics lately, its application, and especially its measurement, still lacks greater clarity. This stage of the project is intended to make the concept of SC resilience tangible, both for its measurement by companies and to collect information from experts.

Thus, to identify the main indicators used to measure the resilience capabilities of SMEs, this task conducted a systematic literature review (SLR) [14]. The initial step involved searching in the Scopus database for journal articles containing relevant terms related to "measure" or "indicators" and "resilience capabilities" within the title, abstract, and keywords fields. Filters were added to limit the subject area (business, management and accounting, and decision science), document type (article) and language (English).

The SLR yielded a total of 106 articles. For refinement, articles unavailable online or out of the theme were excluded. Thus, 34 selected articles were analysed in pairs to identify the indicators empirically used to measure resilience capabilities. This analysis identified 19 indicators, which were classified according to the resilience capabilities (see Section 3).

2.2 Technology

Task 1.3 aimed at, among others, identifying appropriate digital technologies that can aid in the defined supply chain models. To identify the advanced digital technologies to support supply chain resilience, a review of secondary sources (grey literature consisting mainly of sectorial roadmaps and reports – more details in chapter 4) has been analysed.

This pre-identification of technologies will be further detailed in the framework of WP2, mainly under task 2.3 Mapping and scouting technologies.

2.3 Focus Group Methodology

A qualitative Focus Group (FG) study was conducted for each ecosystem (textile, agri-food, digital and mobility), aiming to: (1) validate the sectorial information identified in the first deliverable and the literature review; (2) discuss the best practices in managing SC resilience within the digital ecosystem; (3) Identify the most relevant resilience capabilities for SMEs; and (4) understand the relationship between critical factors and resilience capabilities. The FG method allows for the economical and immediate collection of relevant and up-to-date information on a specific topic through the perceptions of various stakeholders involved (e.g., companies, policymakers, academics) in a target reality [6].

The four FG sessions were conducted by a researcher acting as a facilitator, with two other researchers supporting the activities and taking notes on the discussions. Relevant stakeholders recognized as experts in the sectors, particularly companies and representative institutions, were invited to participate in all sessions. To facilitate

communication and discussions, the FGs of the Textile, Agri-food and Mobility were conducted in the local language (Agri-food and Textile in Portuguese, Mobility in Spanish). In turn, the workshop for the Digital stakeholders was conducted in English, as the actors of this sector usually establish their businesses in English. Collecting inputs directly from local stakeholders allowed to better understand the relevance of the specific context. Participants were invited via email, with support from sectoral organizations (both consortia members and external stakeholders). In total, 33 participants took part in the FGs (Table 1).

Table 1: Focus Group sessions information

Sector	Date	Local	Duration (hours)	Number of participants	Number of facilitators	Language
Clothing	November, 27 2024	Portugal	3,5	12	3	Portuguese
Wine	December, 10 2024	Portugal	2,5	11	3	Portuguese
Electric Vehicles	December, 11 2024	Spain	2	4	3	Spanish
Mobility Apps	December, 12 2024	Virtual (Zoom platform)	2	6	3	English

All FGs lasted between 2 hours and 3,5 hours. To gather relevant information, the activity was structured in two stages, enabling participants to share their knowledge on the topic. The first stage was individual, where participants responded to various questions using the Mentimeter[1] online tool, and the facilitator prompts discussion on each consolidated response. One researcher took notes throughout the activity to facilitate later analysis. Individual activities were important to keep participants' strategic information private, but still allowed us to identify general patterns.

This individual session consisted of four steps, all using Mentimeter:

(1) General preparation and levelling questions: participants were asked to identify the number of events that have impacted the ecosystem over the past five years and, beyond COVID-19 and war, to specify other disruptive events that have affected the ecosystem. This step led to an open discussion about the disruptive events and their relevance to the ecosystem.

(2) Risk analysis of the critical factors was conducted, based on two questions: (1) 'What is the probability/likelihood of these critical factors occurring in the ecosystem?'; and (2) 'What is the impact of these factors on your company?', both answered in a scale for 1-5 being '1' low likelihood/impact and '5' high likelihood/impact. Based on the scores of CF, a risk level was calculated by multiplying each score per CF.

(3) Questions on resilience capacities: evaluation of each company's resilience capabilities, based on the indicators presented in D1.1. An importance scale from 1 to 5 was

[1] www.mentimeter.com

used, where 1 represents "not very important" and 5 represents "very important". For respond and transform capabilities, an agreement scale from 1 to 5 was used, where 1 represents "totally disagree" and 5 represents "totally agree".

(4) Questions related to technology: Based on a list of technologies (presented in section 2.2), each participant had to indicate the technologies that they consider relevant to improving their resilience capabilities.

The second stage transitions to a group setting, encouraging collective engagement and discussion. At the face-to-face events, participants were divided into groups of up to 4 people and worked on posters to answer the following questions: "What resilience capabilities are needed to respond to each of the critical factors?" and "How can this be accomplished?".

In the virtual event, a virtual board was created using the Miro[2] online tool, and the participants were invited to contribute to the board during the meeting. In this case, the facilitators had a dual role to promote the debate and make questions to the participants to understand the relation between CF and RC.

[2] www.miro.com

3 Resilience Capabilities Indicators

Even though SC resilience is a topic that has recently received a lot of attention from scholars and practitioners, its application – and particularly its measurement – remains a challenge. Aiming to make SC resilience more tangible, a SLR was carried out to identify empirical indicators for each capability. Considering that indicators are selected or developed based on their ability to capture specific aspects, 19 indicators were identified and organised according to resilience capabilities (Table 2).

Table 2: Resilience Capabilities Indicators

N	Indicators	Description	Resilience Capabilities	Reference
1	Adaptability	Average production adjustment time or time to adapt operations to new demands	Adaptability & Flexibility	2; 4; 16; 21
2	Supplier Replacement Rate	Average time to replace critical suppliers		
3	Demand Change Response	Rate of fulfilment for atypical orders or response time to demand fluctuations		
4	Technological innovation	% invested in create or adapt technologies (new process)		
5	Expected Customer service level (ESC)	Proportion of demand met from stock.	Efficiency	10; 12
6	OTIF (On Time In Full)	On time in full/all deliveries (%)		
7	Cooperation	Stabilized relationship between the SC members	Visibility	8; 3; 1; 5; 9
8	Density	Ratio between number of total ties in the network and the number of potential ties		
9	Knowledge sharing	Frequency of information exchange		
10	Node complexity	Total number of nodes in the network		
11	Visibility	Frequent information exchange/feedback with customers		
12	Team Cross-Training Level	% of employees trained for multiple functions	Redundance	9; 1; 12

N	Indicators	Description	Resilience Capabilities	Reference
13	Flow complexity	Total number of forward and reverse material flows		
14	Stock level of high-risk parts	Time (How long would the stock last)		
15	Geographical risk	% of parts sourced in high-risk countries	Market Strength	12
16	Volume flexibility supplier (VF)	% flexibility negotiated in supplier contract		
17	Expected Net Present Value (ENPV)	Each scenario's NPV is multiplied by the corresponding probability of occurrence	Financial Strength	1
18	Agility	Reduction of manufacturing lead-times	Respond	8; 15; 7
19	Single sourcing with single plant (SS)	% of parts sourced from single suppliers with single plant		
20	Recovery Rate	Average post-incident recovery time and performance level achieved after recovery	Transform	3

Recognizing that these indicators serve as the foundation for assessing resilience capabilities, it is essential to evaluate each capacity individually. Based on the identified indicators, closed-ended questions were developed for each capability to measure this variable. As mentioned in D1.1, the resilience process encompasses three stages: readiness, response, and recovery. Following a social-ecological perspective of SC resilience, RISE-SME adopted the three dimensions [13]: prepare, respond and transform. As such, "prepare" is divided into six capabilities: adaptability and flexibility, visibility, efficiency, redundancy, market strength and financial strength. Furthermore, "respond" and "transform" can also be considered capabilities. Table 3 presents the set of questions developed to evaluate each resilience capability.

Table 3: List of variables by capability

N	Capability	Description	Question
1	Adaptability & Flexibility*	Reflect the ability to adjust and react as a response to a specific event. This may involve changes in production	Until the moment of disruption, how important was it for your company: • to adjust production to atypical orders? • to negotiate contracts or replace critical suppliers?

		patterns, supply routines, or distribution.	• to adopt new technologies or modify processes?
2	Efficiency*	The ability to operate with limited resources without compromising quality or response capacity.	Until the moment of disruption, how important was it for your company: • to adjust manufacturing lead time? • to meet demand using available inventory? • to make deliveries on time?
3	Visibility*	The ability to access and provide necessary information in a timely manner to relevant partners for better decision-making, including collaboration and information sharing.	Until the moment of disruption, how important was it for your company: • to have frequent information exchanges? • to access real-time data during the decision-making process? • to accurately track orders?
4	Redundancy*	The existence of resources or alternatives, such as multiple suppliers, alternative logistics routes, or safety stocks.	Until the moment of disruption, how important was it for your company: • to have access to alternative suppliers? • to have emergency stock available? • to have established alternative transportation modes?
5	Market Strength*	Involves the company's influence and competitive position related to supplier negotiation power and customer satisfaction.	Until the moment of disruption, how important was it for your company: • to have a stable relationship with suppliers? • to have a stable relationship with customers? • to establish new partnerships or access new markets?
6	Financial Strength*	Involves the capacity to absorb financial impacts caused by a specific event, including necessary investments for recovery.	Until the moment of disruption, how important was it for your company: • to have access to resources (short-term) to mitigate the impacts of supply chain interruptions? • to have access to resources (medium/long-term) to invest in changes prompted by the event?
7	Respond	The agility of the company in responding to consequences during the disruptive event.	During the disruption: • the company quickly responded to variations in customer demand. • the company quickly reacted to variations in supplier availability.

			• the company rapidly adapted its processes and products to the new context.
8	Transform	The company's ability to transform to achieve a new position after the disruptive event.	As a result of the disruption: • the company adopted new products, services, or business models. • the company significantly transformed its manufacturing process. • the company significantly changed its supplier network

* Part of 'prepare' dimension

These questions were used in the FG to understand each participant's vision of their company or the ecosystem. The results of this application are presented in section 5.

4 Identification of technologies

RISE-SME aimed to perform a mapping of advanced technologies supporting supply chain resilience in the targeted ecosystems. For that reason, several documents were analysed to complement the advanced technologies identified during project preparation - robotics, AI, IoT, Blockchain, edge computing, AR/VR solutions, B2B digital platforms, Big Data/analytics technology, 3D printing, advanced materials, micro- and nanoelectronics, nanotechnologies and photonics.

The table below shows the definition of each technology already identified in RISE-SME Description of Action. The definitions have been extracted from different roadmaps and strategies relevant for RISE-SME context:

Table 4: Definition of each technology – part 1

Cat.	Technology	Description	Reference
Advanced technologies	Robotics	Advanced robotics and automation are becoming more widespread due to reduced costs, enhanced capabilities, and industry-specific products. Key innovations include autonomous driving for mobile assets and flexible picking systems. Additionally, robots are now easier to integrate, thanks to machine learning and advanced sensors, enabling them to adapt quickly and work safely with logistics staff.	17
	AI	Artificial intelligence (AI) involves creating intelligent machines, particularly intelligent computer programs. Machine learning (ML), a key part of AI, focuses on automatically	20

		identifying meaningful patterns in data. ML tools enhance algorithm efficiency by learning and adapting through big-data analytics, helping to mitigate risks and optimize processes like supply chain planning, inventory management, demand prediction, logistics, and supplier selection.	
	IoT	The Internet of Things (IoT) is a network of physical devices with sensors, software, and other technologies that connect and share data via the internet. It typically has three layers: the device layer (hardware, sensors, embedded software), the connectivity layer (network communication protocols), and the IoT cloud layer (device control, analytics, data management, and application software). These layers enable seamless communication between people, processes, and things.	20
	Blockchain	Blockchain is a shared, immutable ledger used to record transactions and track assets in a business network. Its main advantage is the increased trust it provides within and between organizations by ensuring data accuracy and security without needing a third party.	20
	Edge Computing	Edge computing improves cloud logistics by processing data closer to its source, significantly reducing bandwidth needs.	19
Efficiency gains	Zero-Touch Production (ZTP)	ZTP is an automated process that configures a network device with no user interaction needed, aside from connecting the device to the network and powering it on.	18
	AR/VR	Augmented reality (AR) enhances logistics quality and productivity by providing workers with timely and relevant information. Virtual reality (VR) allows logistics providers to design, experience, and evaluate environments digitally, optimizing material flows and training processes.	17
	B2B digital platforms	B2B digital platforms have enable a shift from ownership to sharing goods, assets, and services. Logistics providers can enhance efficiency and create value by facilitating and participating in these networks through workforce allocation, transport utilization, and on-demand warehousing and fulfilment.	17

	Big Data/analytics	Data-driven insights are revolutionizing logistics. Thanks to digital transformation and the Internet of Things, supply chain big data can be captured. Leveraging this data can significantly boost operational efficiency, enhance customer experience, reduce risks, and enable new business models.	17
	3D printing	3D printing additive manufacturing allows companies to design and produce customized products to meet individual needs.	20
Product innovation	Advanced materials	Advanced materials play a crucial role in enhancing performance and sustainability in manufacturing by reducing energy consumption and supporting a circular economy.	18
	Micro- and nanoelectronics	Microelectronics, printed electronics, and nanoelectronics are relevant for smart products. Smart products can differ based on whether they use (1) an embedded sensor or (2) a manufacturing process like printed electronics.	18
	Nanotechnologies	Nanotechnologies can be used as raw material sources to manufacture high performance composite, metallic products or bio based and recycled materials and fibres for green products and textiles, among others.	18
	Photonics	Photonics, particularly lasers, play a key role in advanced manufacturing. They are used in additive manufacturing, surface treatments and texturing, joining technologies, and measuring technologies for high-precision manufacturing.	18

The above list of technologies was updated not only to better fit the supply chain resilience model, but also to include additional technologies that had arisen due to the rapid evolution of digitalization, bringing potential impact on supply chain resilience capabilities. This second iteration was mainly based on the 7th edition of the DHL Logistics Trend Radar[3] issued in September 2024.

As a result of this second analysis, new technologies have been added as relevant for RISE-SME. Their potential contribution to supply chain resilience can also be seen in the table 5.

[3] The DHL Logistics Trend Radar 7.0 | DHL Global

Table 5: Definition of each technology – part 2

Technology	Description	Relevance for supply chain resilience
3D printing	See Table 4	3D printing facilitates rapid prototyping, allowing for quick testing and iteration of new concepts. As this technology integrates into all stages of product development, it will enable the printing of objects with embedded electronic chips and sensors at a reasonable cost. This reduces reliance on third-party suppliers, giving companies more control over their production processes and mitigating supply chain risks
Advanced analytics	See Big data/analytics in Table 4	Forecasting in logistics and supply chain management is crucial for efficiency, customer satisfaction, sustainability, and strategic planning. Advanced analytics, especially AI-driven techniques, significantly improve forecasting. They help businesses anticipate market demands, adjust pricing, plan resources, and optimize inventory. Predicting weather patterns and climate impacts allows for risk mitigation and strategy adjustments. AI-enhanced analytics also consider geopolitical and social factors, enabling proactive measures against potential disruptions by analyzing social media sentiment and political news.
Audio AI	Audio AI is a branch of artificial intelligence that deals with analyzing, synthesizing, and understanding audio signals. It enables machines to perceive, process, and interpret sound similarly to human auditory systems. Associated techniques include speech recognition, sound classification, and environmental noise detection, all aimed at	Audio AI can detect unusual granular sounds, enabling predictive maintenance to prevent equipment breakdowns and delays. In logistics, it can analyze vehicle vibrations and sounds during operation. For cross-border freight, audio AI language translation can help truck drivers, customs officials, and warehouse personnel understand and comply with multilingual regulations and instructions.

Technology	Description	Relevance for supply chain resilience
	improving human-computer interaction.	
Bio-based materials	Bio-based materials are produced from substances derived from sustainable biomass and modern bio-synthetic processes.	Bio-based materials provide eco-friendly alternatives to traditional plastic packaging. By using biodegradable and bio-based packaging, logistics and supply chain organizations can address waste management throughout the entire product lifecycle, not just at the end.
Blockchains	See Table 4	Blockchain technology allows supply chain professionals and customers to view product shipment status and verify attributes like local production, organic growth, or certifications. It can help companies detect unauthorized product removal or insertion, aiding in theft, fraud, and counterfeiting investigations. Additionally, blockchain transparency can ensure compliance with international trade laws and regulations for suppliers and distributors.
Computer Vision	Computer Vision uses cameras to capture images or videos and applies AI algorithms to analyze the extracted data. Basic visual AI systems can differentiate objects, while more advanced versions can track objects across viewpoints, learn independently, and predict through pattern recognition.	Computer vision can safeguard logistics assets by enabling predictive maintenance. It can issue alerts, allowing maintenance teams to address potential issues before they occur.
Digital Twins	Digital Twins are virtual models that replicate the real-time conditions and behaviors of physical objects or processes. They offer value by enabling visualization, diagnosis, analysis,	Stress testing a supply chain with digital twins helps build resilience by simulating disruptions like natural disasters, cyberattacks, and market changes. These simulations provide insights into potential impacts on service levels, costs, and supply chain integrity without affecting real operations. Logistics planners can identify vulnerabilities and optimize response

Technology	Description	Relevance for supply chain resilience
	prediction, simulation, and optimization without needing someone to interact with the physical counterpart.	strategies in real time. Digital twins also allow for testing various strategic adjustments, enhancing overall supply chain resilience and ensuring continuity, reliability, and sustainability in service delivery.
Drones	Drones, or unmanned aerial vehicles (UAVs), are aircraft without human pilots. They can be remotely controlled or fly autonomously using software-controlled flight plans. They perform tasks like package delivery, operational support, security enhancement, and inventory counting.	Using drones with cameras can enhance the security of large facilities by improving detection of intruders and increasing the frequency of patrols. Enabled by AI-based systems, companies can attain more accurate threat identification, reduce the chances of missing suspicious activity, and provide comprehensive visual data from a bird's eye view.
Edge Computing	See Table 4	Edge computing can enhance supply chain resilience by improving stock transparency and enabling real-time monitoring through IoT devices.
Extended Reality	See AR/VR in Table 4	Using VR for training effectively simulates real-world scenarios, enabling safe decision-making and learning.
Gen AI	Generative AI (Gen AI) can autonomously create new content, like images, text, audio, or videos, by learning patterns from existing data.	AI-based predictive analytics assistants in logistics can forecast demand, optimize inventory, and anticipate supply chain disruptions, enabling proactive decisions and resource allocation. Additionally, supply chain visibility assistants offer real-time tracking of goods, identify bottlenecks, mitigate risks, and enhance transparency and responsiveness in logistics processes.
Indoor Mobile Robots	See robotics in Table 4	Loading and unloading containers are physically demanding tasks in logistics, often exposing workers to harsh conditions. To maintain efficiency, companies can use automation to handle these activities.
Next-Generation Connectivity	Next-Generation Connectivity involves developing and	Predicted benefits of 5G rollout include better network stability, smoother and faster data transfers, and enhanced warehouse

Technology	Description	Relevance for supply chain resilience
	implementing advanced communication technologies and their associated infrastructure. It includes the utilization of various frequencies and bandwidths.	automation. 5G's low latency and high bandwidth are anticipated to support advanced automation for picking, packing, and sorting goods. Additionally, 5G-powered AI warehouse management systems can improve efficiency in multi-storey warehouses.
Outdoor Autonomous Vehicles	See robotics in Table 4	Automation in long-haul trucking can tackle the global shortage of drivers and the fact that human error is a major cause of road accidents. Automation can address issues like driver fatigue, speeding, and poor driving habits that lead to increased carbon emissions, making it a compelling solution for the industry.
Vehicle Electrification	Vehicle electrification involves replacing internal combustion engines with electric powertrains, using electric motors and batteries or fuel cells. This reduces reliance on fossil fuels, cuts carbon emissions and air pollution, and promotes sustainability in transportation.	Electric vehicles for ground transportation allow for adaptability and flexibility to comply with sustainability regulation.
Wearable Sensors	Wearable sensors are devices worn on or near the body to track movement or vital functions.	Deploying wearable sensors can help companies automate data collection and gain valuable insights during logistics operations.

5 Results by Ecosystems

The main results obtained during the workshops are presented in this session, divided by Sectors. For each sector, results are divided into: (1) Debate about the main disruption events that happened in recent years; (2) Analysis of the critical Factors (considering the likelihood of occurrence and Impact); (3) Analysis of the relevant Resilience Capabilities; (4) Analysis of the main technologies used by the Ecosystem; and (5) The relationship between the indicators and the critical factors.

5.1 Clothing Sector (Textile Ecosystem)

The activity began with a preparation and alignment phase, during which participants addressed the following questions: (i) How many disruptive events have affected your ecosystem in the last 5 years? and (ii) Beyond COVID-19 and wars, what other disruptive events have affected your sector?

The results indicate that 7 out of 10 respondents experienced between 1 and 3 disruptive events in the past 5 years. Furthermore, when identifying the main disruptive events participants highlighted the lack of raw materials and the increase in raw material costs (Figure 2). According to the participants, these events are primarily driven by political crises, which can disrupt supply chains and significantly impact the availability and accessibility of raw materials.

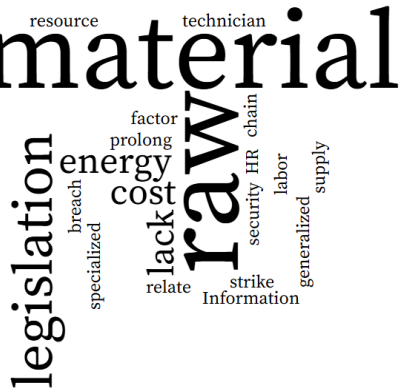

Figure 2: Disruptive events that impact the clothing sector

The barriers created by environmental legislation were also widely discussed, as the lack of technical staff (many training courses in textile were closed in recent years) and the importance of promoting training activities at the companies - particularly in the context of product development. Prolonged strikes and supply shortages were also mentioned.

5.1.1 Critical factors

During the FG, participants were asked to inform about the probability/likelihood of occurrence of each critical factor, as well as their impact on the ecosystem in case of

occurrence, leading to the definition of a Risk Level (probability X impact) for each CF. Table 6 presents a ranking based on the CF's risk level.

Table 6: Risk matrix by critical factor – clothing sector

N	Critical Factors	Probability	Impact	Risk Level
1	Shortage of skilled labour	3.8	4.3	16.3
2	Challenges in sustaining existing business model	3.3	3.8	12.5
3	Political conflicts and crises	3.0	3.6	10.8
4	Health and pandemic disruptions	2.5	3.6	9.0
5	Global and complex supply chains (decentralization of supply and demand)	2.6	3.2	8.3
6	Infrastructure and logistics disruptions	2.2	3.2	7.0
7	Technological disruptions and low digital maturity	2.1	3.2	6.7
8	Environmental crises and natural disasters	2.3	2.9	6.7
9	Supplier and customer concentration (overdependencies)	2.0	3.3	6.6
10	Waste management	1.9	3.1	5.9

The top three responses – in categories Probability and Impact - were: "shortage of skilled labour", "challenges in sustaining existing business model" and "Conflicts and political crises". It can be observed that some topics that emerged in the previous session, such as the shortage of skilled labour, were observed again in this activity. In addition, lack of raw material (presented in 4.1.1) is currently a consequence of Political conflicts and crisis, since the logistic channels that brings raw material from Asia to Europe are being impacted by Middle-East conflicts. Finally, for the participants, there is a need to assess critical factors in terms of short and long term.

5.1.2 Resilience capabilities

Regarding the company's resilience capabilities, participants assigned scores to different indicators related to each capability (as presented in Section 2). Table 7 shows the average for each capability.

Table 7: Resilience capabilities in the clothing sector

N	Capability	Indicator	Grade	Mean
1	Financial Strength	have access to resources (short-term) to mitigate the impacts of supply chain interruptions	4,5	4.6
		have access to resources (medium/long-term) to invest in changes prompted by the event	4,8	
		have a stable relationship with suppliers	4,5	4,6

N	Capability	Indicator	Grade	Mean
2	Market Strength	have a stable relationship with customers	4,7	
		establish new partnerships or access new markets	4,5	
3	Visibility	have frequent information exchanges	4,5	4.4
		access real-time data during the decision-making process	4,7	
		accurately track orders	4,0	
4	Adaptability & Flexibility	adjust production to atypical orders	4,6	4,3
		negotiate contracts or replace critical suppliers	3,7	
		adopt new technologies or modify processes	4,7	
5	Respond	the company quickly responded to variations in customer demand	4,4	4,3
		the company quickly reacted to variations in supplier availability	4,1	
		the company rapidly adapted its processes and products to the new context	4,4	
6	Efficiency	adjust manufacturing lead time	3,9	4,1
		meet demand using available inventory	3,5	
		make deliveries on time	4,8	
7	Redundancy	have access to alternative suppliers	4,3	3,7
		have emergency stock available	3,5	
		have established alternative transportation modes	3,4	
8	Transform	the company adopted new products, services, or business models	4,2	3,6
		the company significantly transformed its manufacturing process	3,2	
		the company significantly changed its supplier network	3,3	

The focus group session results indicated “financial strength” as the most relevant resilience capability, with experts emphasising the importance of having access to both short-term and long-term resources. This reflects the significant role financial liquidity plays in ensuring the industry can absorb shocks during times of crisis and invest in necessary adaptation and transformation after these events.

“Market strength” was also considered crucial, particularly in maintaining stable relationships with customers, as well as maintaining and establishing new partnerships with customers or accessing new markets. “Visibility” was another important factor for resilience, with the ability to access real-time data and engage in frequent information exchanges being rated highly by the participants. Given the decentralized nature of global supply chains in the textile ecosystem, having timely access to accurate information is essential for navigating disruptions effectively and making informed decisions. “Adaptability & flexibility” were also considered significant, particularly in terms of adopting new technologies or modifying processes and adjusting production to atypical orders (although the ability to negotiate contracts or replace critical suppliers was considered less

important). Still within the set of capabilities understood as preparation, efficiency and redundancy were the least relevant to the participants.

The ability to respond swiftly to disruptions was emphasized, underscoring the sector's need for rapid response capabilities. Finally, transformation, including adopting new products or services and significantly changing manufacturing processes or supplier networks, was seen as less urgent in the face of disruptions. This can reflect a focus on maintaining operational continuity rather than making large-scale structural changes in response to crises.

Analysing the three main capabilities – prepare, respond and transform – the highest scores were given to respond and prepare, while transform had a lower score (Figure 3). This could reflect the tradition and stability of this sector, mainly regarding technologies and business models, making it vulnerable to impactful events and dependent on external/governmental support to overcome those.

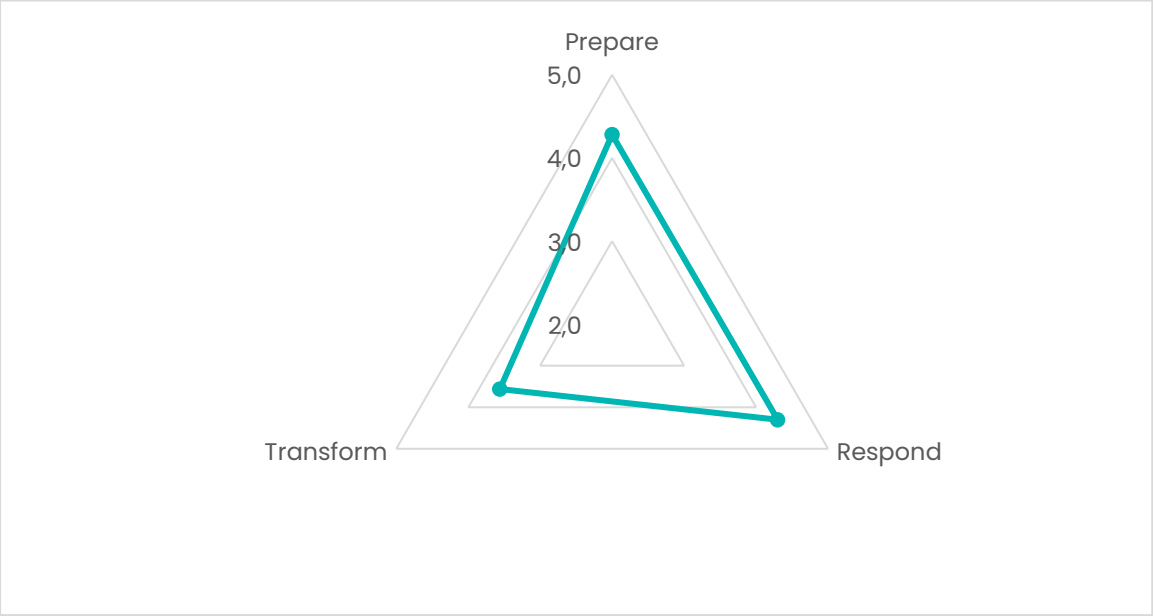

Figure 3: Average per capability in the clothing sector

5.1.3 Technologies to develop resilience capabilities

When asked about which technologies can be used to develop resilience capabilities, the respondents highlighted the adoption of new materials as the most relevant for the clothing sector in the textile ecosystem. Next, digital technologies such as IoT and AI were emphasized. Figure 4 presents the technologies in order of importance given by the participants.

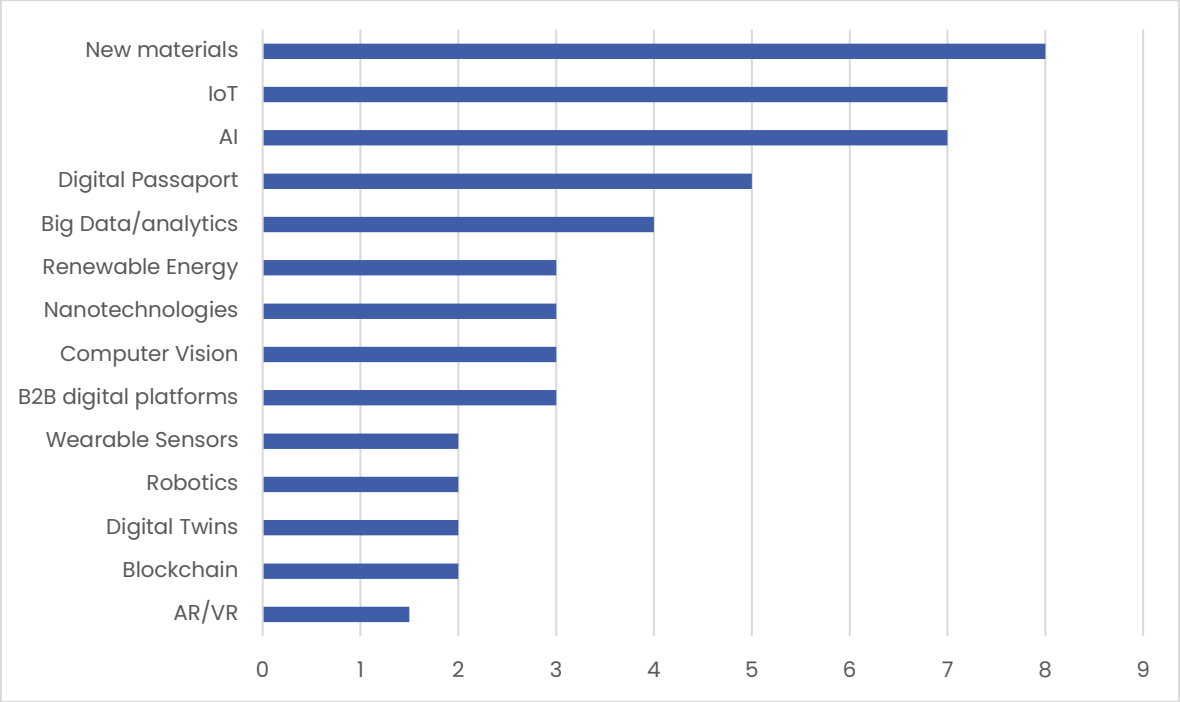

Figure 4: Relevant technologies for the clothing sector

5.1.4 Relationship between resilience capabilities and critical factors

Based on the understanding of different resilience capabilities, participants were asked to determine which capabilities are necessary to address each of the critical factors and how this can made. Thus, as described in Section 2.3, Table 8 demonstrates the relationships between the resilience capabilities and the critical factors.

Table 8: Relationship between resilience capabilities and critical factors in the clothing sector

	Adaptability & Flexibility	Efficiency	Visibility	Redundancy	Market Strength	Financial Strength	Respond	Transform
Health and pandemic disruptions	X	X	X	X	X	X	X	X
Environmental crises and natural disasters	X	X		X	X			
Political conflicts and crises	X			X	X	X	X	
Supplier and customer concentration (overdependencies)	X		X	X		X		
Global and complex supply chains (decentralization of supply and demand)	X		X			X		
Infrastructure and logistics disruptions	X	X	X	X	X	X	X	
Technological disruptions and low digital maturity	X	X		X		X	X	
Challenges in sustaining existing business model	X				X	X		X
Shortage of skilled labor	X		X				X	X
Waste management		X	X			X		X

Adaptability and flexibility were the most cited by participants, who considered that this capability contributes to facing most of the critical factors (except waste management). As practices that help to develop adaptability and flexibility, the participants highlighted the development of new products and markets (e.g., to reduce dependencies and centralization) and demonstrated a focus on logistics, particularly the creation of new routes, a peculiarity intrinsic to the sector. This capability also involves process changes, product adaptation, and modifications in production lines, which are directly linked to critical factors such as health, business models, and digitalization. In this context, technology emerges as a key element, particularly in terms of the need for a qualified workforce to keep pace with technological advancements, highlighting the interdependence between critical factors like technology and professional qualification.

Financial strength was considered the second most relevant capability by the participants when it comes to its ability to tackle critical factors (only environmental crises and natural disasters and shortage of skilled labour were not highlighted). Participants emphasized the importance of strategically using the companies' own capital, as well as the ability to carry out efficient material provisioning, with particular emphasis on stock anticipation and reinforcement. This practice is seen as essential for ensuring resilience in contexts of uncertainty, providing greater stability in the face of market fluctuations and specific crises, particularly those impacting global supply chains. Visibility and redundancy were also considered relevant capabilities by the experts, contributing to addressing six critical factors each, while transform appeared only four times.

Logistics emerged as a widely discussed topic, underscoring its significance in the sector due to the strong dependence on suppliers located outside Europe (especially China). This dependence not only highlights the need for diversification of routes and suppliers but also reinforces the strategic role of logistics in pursuing greater autonomy and operational resilience. Thus, the discussion of organizational capabilities points to an alignment between adaptability, flexibility, and financial strength, integrated with robust logistics strategies and supported by technological advancements.

5.2 Wine Sector (Agri-food Ecosystem)

The activity began with a preparation and alignment phase, during which participants addressed the following questions: (i) How many disruptive events have affected your ecosystem in the last 5 years? and (ii) Beyond COVID-19 and wars, what other disruptive events have affected your sector?

The results indicate that 10 out of 12 respondents experienced up to 5 disruptive events in the past 5 years. Furthermore, when identifying the main disruptive events, participants highlighted production costs, inflation and climate change as the main events (Figure 5).

Figure 5: Disruptive events that impact the wine sector

5.2.1 Critical factors

During the FG, participants were asked to inform about the probability/likelihood of occurrence of each critical factor, as well as their impact on the ecosystem in case of occurrence, leading to the definition of a Risk Level (probability X impact) for each CF. Table 9 presents a ranking based on the CF's risk level.

Table 9: Risk matrix by critical factor – wine sector

N	Title 2	Probability	Impact	Risk Level
1	Environmental crises and natural disasters	4.2	4.5	18.9
2	Shortage of skilled labour	4.2	4.5	18.9
3	Political conflicts and crises	4.2	3.5	14.7
4	Challenges in sustaining existing business model	3.6	3.7	13.3
5	Technological disruptions and low digital maturity	3.6	3.6	13.0
6	Supplier and customer concentration (overdependencies)	3.5	3.5	12.2

N	Title 2	Probability	Impact	Risk Level
7	Infrastructure and logistics disruptions	3.2	3.3	10.6
8	Health and pandemic disruptions	3.1	3.3	10.2
9	Global and complex supply chains (decentralization of supply and demand)	3.2	2.7	8.6
10	Waste management	3.3	2.5	8,2

The top two responses – in both categories Probability and Impact - were: "environmental crises and natural disasters" and "shortage of skilled labour". Climate change is affecting the seasonality and quality of wines, presenting a significant challenge for producers. Although it is a recognized phenomenon with long-term impacts, individual events occur unpredictably. In addition, FG participants reinforced that the lack of workforce was mostly related to qualified positions (not necessarily harvesting), with a heavy reliance on foreign workers. One issue related to foreign workers is the high turnover rates, creating a cycle of reinvestment in training.

The third item, "political conflicts and crises", has a high probability but not the highest impact, being mostly related to changes in local legislation (not only at the national level but mostly at the regional level). These changes impact the competitiveness of producers who follow the protected designation of origin and/or geographical indication. The fourth item - Challenges sustaining existing business model - doesn´t have a high probability but has a relevant impact. Here two topics were mostly discussed – the lower consumption of wine by young adults and the negative influence of the media towards alcoholic beverages, impacting "the Mediterranean tradition of drinking wine".

5.2.2 Resilience Capabilities

Regarding the company's resilience capabilities, participants assigned scores to different indicators related to each capability (as presented in Section 2). Table 10 shows the average for each capability.

Table 10: Resilience capabilities in the wine sector

N	Capability	Indicator	Grade	Mean
1	Visibility	have frequent information exchanges	4.3	4.1
		access real-time data during the decision-making process	4.2	
		accurately track orders	3.8	
2	Market Strength	have a stable relationship with suppliers	4.2	4.1
		have a stable relationship with customers	4.5	
		establish new partnerships or access new markets	3.7	
3	Financial Strength	have access to resources (short-term) to mitigate the impacts of supply chain interruptions	4.3	4.1
		have access to resources (medium/long-term) to invest in changes prompted by the event	3.9	

N	Capability	Indicator	Grade	Mean
4	Adaptability & Flexibility	adjust production to atypical orders	3.8	3.9
		negotiate contracts or replace critical suppliers	3.9	
		adopt new technologies or modify processes	4.1	
5	Redundancy	have access to alternative suppliers	3.6	3.4
		have emergency stock available	3.5	
		have established alternative transportation modes	3.2	
6	Efficiency	adjust manufacturing lead time	2.6	3.2
		meet demand using available inventory	3.5	
		make deliveries on time	3.5	
7	Respond	the company quickly responded to variations in customer demand	3.5	3.6
		the company quickly reacted to variations in supplier availability	3.5	
		the company rapidly adapted its processes and products to the new context	3.8	
8	Transform	the company adopted new products, services, or business models	3.3	2.6
		the company significantly transformed its manufacturing process	2.1	
		the company significantly changed its supplier network	2.4	

The focus group session results indicated visibility, market strength and financial strength as the most relevant resilience capability, with the same score. Analyzing the capability of visibility, the experts emphasized the importance of frequent information exchanges (with a remark to "valuable" information, not all information) and access to real-time data to enhance the decision-making process. This is crucial because it enables better monitoring and management of the entire supply chain. In addition, the sector's visibility should also be enhanced through the communication of product qualities and attributes. According to the participants, it is necessary to reach consumers in a different way, moving beyond the traditional health appeal.

Considering the relevance of the supply chain, market strength was another important capability for resilience which highlights the importance of establishing strong relationships with actors in the supply chain. Furthermore, financial strength is recognized as a key resilience capability, with experts stressing the importance of access to both short-term and long-term resources. Adaptability & Flexibility was also considered a relevant capability, mostly for the adoption of new technologies or the modification of processes.

Analysing the three main capabilities – prepare, respond and transform – the highest scores were given to respond and prepare, while transform had a lower score (Figure 6). This may reflect the agri-food sector's tradition and stability, particularly in terms of technologies and business models, which can render it more vulnerable to disruptive events and reliant on external or governmental support to recover and adapt.

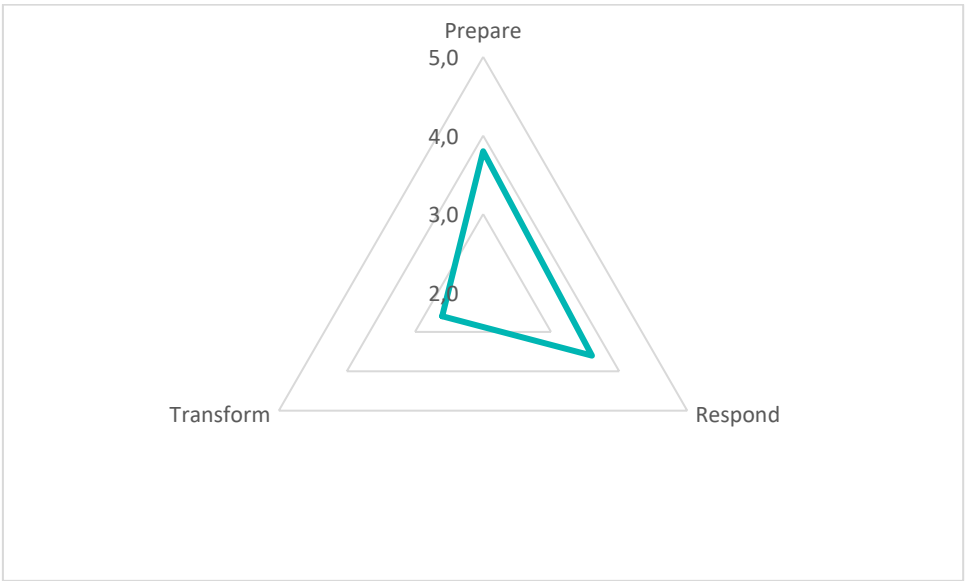

Figure 6: Average per capability in the wine sector

5.2.3 Technologies to develop resilience capabilities

When asked about the technologies that can enhance resilience in the agri-food ecosystem, respondents identified renewable energy as the most relevant for the wine sector (Figure 6). This choice reflects the importance of sustainable solutions in addressing challenges such as climate change, rising production costs, and dependence on traditional energy sources. The adoption of renewable energy, such as solar, wind, or biomass, can significantly contribute to reducing carbon emissions and promoting environmental sustainability—critical aspects in a sector that is highly dependent on ecological balance.

The participants then highlighted big data/analytics and AI, as these technologies drive efficiency, quality, resilience, and sustainability—key elements for tackling the environmental and economic challenges faced by the wine sector. Figure 7 presents the technologies in order of importance given by the participants.

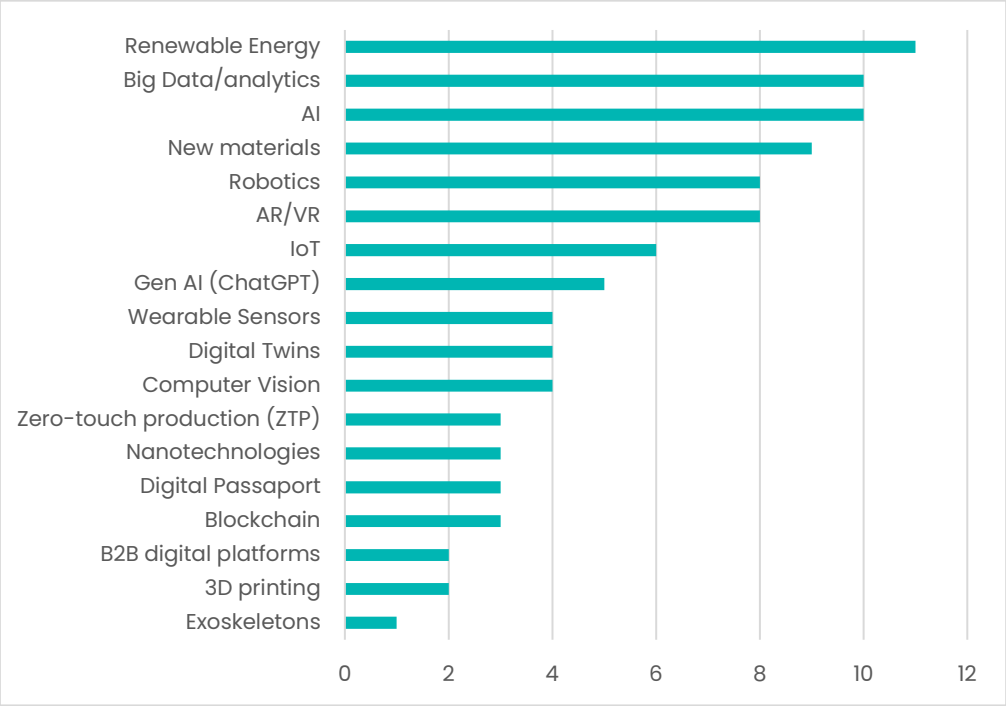

Figure 7: Relevant technologies for the wine sector

5.2.4 Relationship between resilience capabilities and critical factors

The experts were also engaged in identifying which capabilities are necessary to address each of the critical factors and how this can made. In that sense, the capability of respond, adaptability & flexibility and Financial Strength were the most relevant. The relevance of Respond might be related to the sector's characteristics, which might be more used to react to an event instead of preparing for it. In that sense, alternatives such as launching new products, finding new markets and relying on different types of insurance to prevent financial issues are the main aspects discussed.

Regarding Adaptability & Flexibility, participants highlighted aspects related to internal resource management, such as inventory, human capital, and training levels, as well as the intrinsic processes of change within the wine supply chain. Specifically, strategies aimed at acquiring new customers, exploring new markets, and adopting new distribution methods, including online channels, were discussed.

When discussing financial strength, the participants' focus was on optimizing resource use, encompassing input management, maximizing available resources, and inventory management. Thus, it is understood that, in the face of market crises, there is a movement toward finding alternatives for generating new revenue streams.

In addition to the previously mentioned capabilities, there is an overlap around other competencies, focusing primarily on three aspects: the exploration of new markets and products, driven by the strong presence of young audiences in the online market, which requires companies to expand into new business models (linked to the overdependence of the supply chain); the expansion of brand exposure as a strategy to attract new customers,

especially in response to the critical factor of "health, pandemic, and sanitary crises," reinforced by the World Health Organization (WHO) statements about the risks of alcohol consumption[4]; and, finally, workforce qualification, highlighting the shortage of skilled professionals in the sector.

[4]https://www.who.int/europe/news-room/04-01-2023-no-level-of-alcohol-consumption-is-safe-for-our-health

Table 11: Relationship between resilience capabilities and critical factors in the wine sector

	Adaptability & Flexibility	Efficiency	Visibility	Redundancy	Market Strength	Financial Strength	Respond	Transform
Health and pandemic disruptions	X	X	X		X	X	X	X
Environmental crises and natural disasters	X	X	X		X	X	X	X
Political conflicts and crises	X		X	X	X	X	X	
Supplier and customer concentration (overdependencie)	X	X	X	X	X		X	
Global and complex supply chains (decentralization of supply and demand)	X	X	X	X		X	X	
Infrastructure and logistics disruptions	X			X		X	X	
Technological disruptions and low digital maturity		X				X	X	X
Challenges in sustaining existing business model	X		X		X	X	X	X
Shortage of skilled labor	X	X	X		X	X	X	X
Waste management		X					X	X

5.3 Mobility Apps (Digital Ecosystem)

As well as in the previous ecosystems, the focus group session began with a preparation and alignment phase, during which participants addressed the following questions: (i) How many disruptive events have affected your ecosystem in the last 5 years? and (ii) Beyond COVID-19 and wars, what other disruptive events have affected your sector?

The results indicate that 4 out of 6 participants experienced between 1 and 3 disruptive events in the past 5 years. Figure 8 shows the most cited disruptions considered by the experts. Lack of raw material, AI and climate change were highlighted.

Figure 8: Disruptive events that impact the mobility apps

5.3.1 Critical factors

The experts were asked to inform about the probability/likelihood of occurrence of each critical factor, as well as their impact on the ecosystem in case of occurrence, leading to the definition of a Risk Level (probability X impact) for each CF. Table 12 presents a ranking based on the CF's risk level.

Table 12: Risk matrix by critical factor – mobility apps

N	Critical Factor	Probability	Impact	Risk Level
1	Political conflicts and crises	4.2	4.3	18.0
2	Technological disruptions and low digital maturity	3.9	4.0	15.6
3	Shortage of skilled labour	3.6	3.7	13.3
4	Infrastructure and logistics disruptions	4.0	3.2	12.8
5	Environmental crises and natural disasters	3.8	3.3	12.5

N	Critical Factor	Probability	Impact	Risk Level
6	Global and complex supply chains (decentralization of supply and demand)	3.4	3.4	11.6
7	Supplier and customer concentration (overdependencies)	3.4	3.2	10.9
8	Health and pandemic disruptions	3.0	3.5	10.5
9	Challenges in sustaining existing business model	2.9	3.3	9.6
10	Waste management	3.0	2.5	7.5

"Political conflicts and crises" was considered by experts to be the most critical of the factors, with a high probability of occurrence and great impact on the ecosystem. In addition to the potential effect on markets (difficulty in accessing markets in crisis and creation of "blocs"), political instability can influence public policies and the free circulation of information.

"Technological disruptions and low digital maturity" and "shortage of skilled labour" emerged next. A close relationship can be observed between these critical factors, which reflect the sector's challenges both on the market side, which are often not prepared for disruptive technologies (either by companies or legislation) and on the service offering side, which may face the lack of qualified workforce.

5.3.2 Resilience Capabilities

Table 13 presents the classification given by the experts for each resilience capability.

Table 13: Resilience capabilities in the mobility apps

N	Capability	Indicator	Grade	Mean
	Efficiency	adjust manufacturing lead time	3.5	4.0
		meet demand using available inventory	4.0	
		make deliveries on time	4.5	
	Market Strength	have a stable relationship with suppliers	3.8	4.0
		have a stable relationship with customers	4.5	
		establish new partnerships or access new markets	3.8	
	Visibility	have frequent information exchanges	3,2	3,6
		access real-time data during the decision-making process	3.5	
		accurately track orders	4.2	

N	Capability	Indicator	Grade	Mean
	Financial Strength	have access to resources (short-term) to mitigate the impacts of supply chain interruptions	3,5	3.6
		have access to resources (medium/long-term) to invest in changes prompted by the event	3,8	
	Adaptability & Flexibility	adjust production to atypical orders	3.2	3.2
		negotiate contracts or replace critical suppliers	2.7	
		adopt new technologies or modify processes	3.8	
	Redundancy	have access to alternative suppliers	2.3	3.1
		have emergency stock available	3.2	
		have established alternative transportation modes	3.7	
	Respond	the company quickly responded to variations in customer demand	2.7	2.7
		the company quickly reacted to variations in supplier availability	2.7	
		the company rapidly adapted its processes and products to the new context	2.8	
	Transform	the company adopted new products, services, or business models	2.7	2.5
		the company significantly transformed its manufacturing process	2.5	
		the company significantly changed its supplier network	2.2	

Among the capabilities, efficiency and market strength stand out as the highest priorities for the participants. Efficiency was particularly strongly rated for the ability to make deliveries on time and to meet demand using available inventory. These findings reflect the sector's focus on maintaining operational continuity, ensuring that services are delivered as expected despite potential disruptions, which is critical in a service-oriented, time-sensitive industry like "mobility as a service".

When it comes to market strength, high importance is given to maintaining stable relationships with customers. This suggests that, in the face of disruptions, digital companies prioritize their existing relationships and seek to expand their network to ensure stability and adaptability. Strong customer relationships are especially crucial in this sector, where customer satisfaction and trust in service continuity are essential for success. Visibility is another relevant resilience capability, particularly the ability to accurately track orders, suggesting that companies prioritize precise, transparent information flows, enabling them to respond efficiently to changes in service delivery. Real-time data is also

essential for decision-making, helping companies navigate disruptions and adjust their strategies quickly.

On the other hand, respond and transform received lower ratings (as also can be seen in Figure 9). These results suggest that while resilience is important, the sector may be less focused on transformation or immediate responses to disruptions, prioritizing instead the maintenance of current service model.

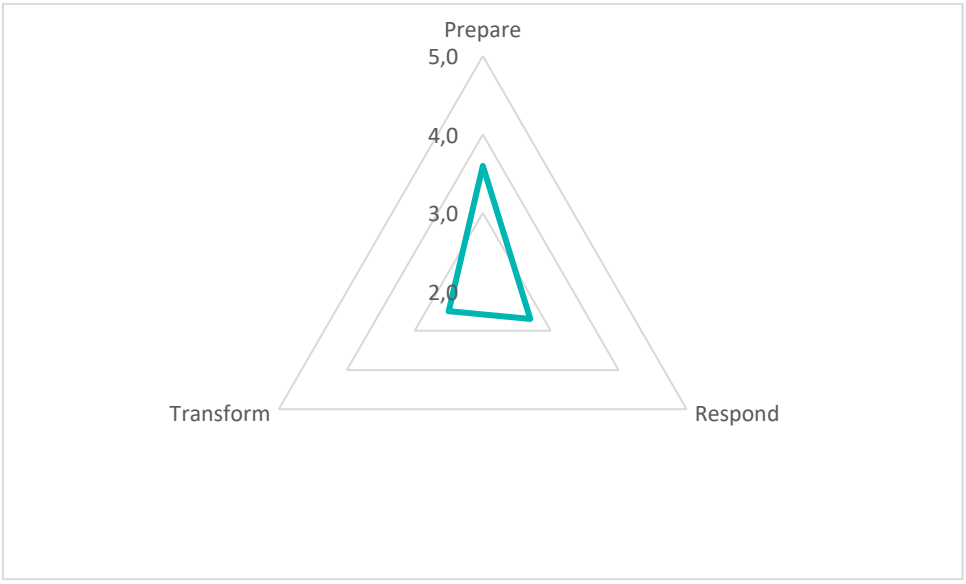

Figure 9: Average per capability in the mobility apps

5.3.3 Technologies to develop resilience capabilities

Figure 10 presents the technologies cited by the participants as most relevant to the sector. AI was highlighted by all participants, while Renewable Energy and Digital Twins were identified by 5 of the 6 experts, AI was unanimously recognized as a technology that is part of the sector's present, with great disruptive potential for the coming years. The recognition of renewable energy as one of the main technologies demonstrates the commitment of this sector (specifically digital platforms focused on mobility) to contribute to reducing the impact generated by current ways of moving people and products.

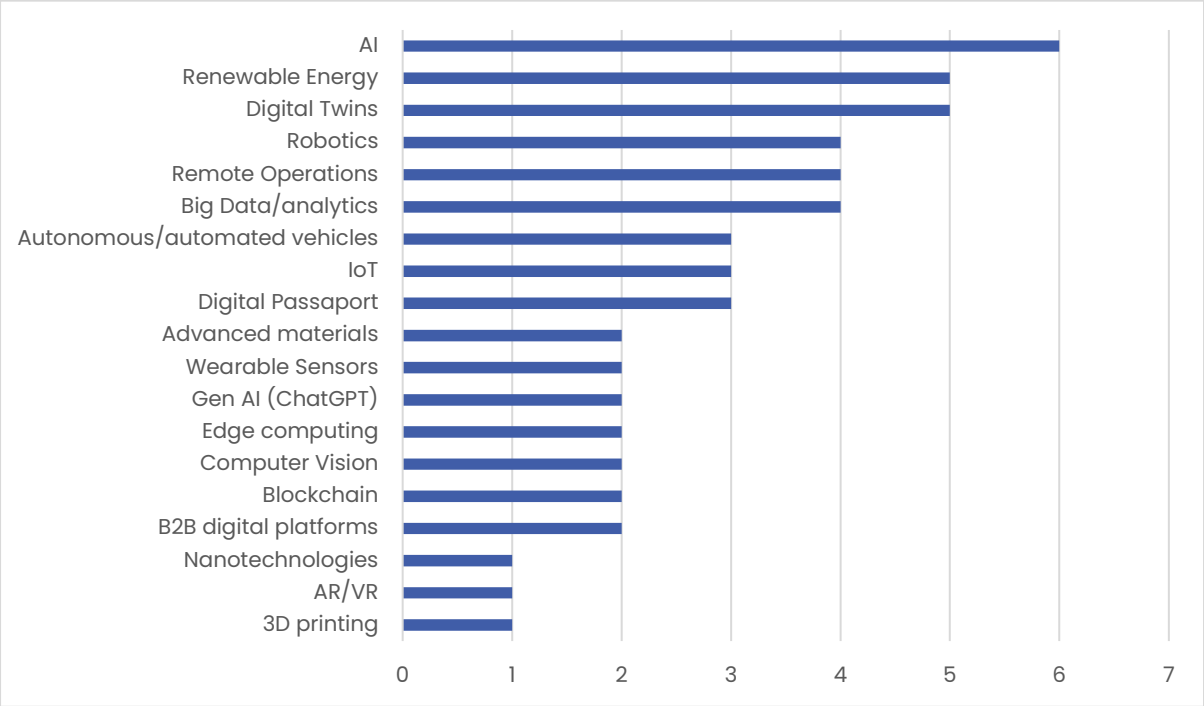

Figure 10: Relevant technologies for the mobility apps

5.3.4 Relationship between resilience capabilities and critical factors

Table 14: Relationship between resilience capabilities and critical factors in the mobility apps

	Adaptability & Flexibility	Efficiency	Visibility	Redundancy	Market Strength	Financial Strength	Respond	Transform
Health and pandemic disruptions	X	X	X	X	X		X	X
Environmental crises and natural disasters	X			X				
Political conflicts and crises	X			X	X		X	
Supplier and customer concentration (overdependencie)				X	X		X	
Global and complex supply chains (decentralization of supply and demand)		X	X					
Infrastructure and logistics disruptions	X		X				X	
Technological disruptions and low digital maturity	X		X		X	X		
Challenges in sustaining existing business model	X							X
Shortage of skilled labor	X					X		X
Waste management		X				X		

"Adaptability & flexibility" stood out again as the most relevant capability, particularly regarding external factors. Participants emphasized the importance of market diversification, both in terms of developing new products and exploring new sales channels (downstream), as well as adapting to remote work dynamics and online sales (upstream). This approach reflects the necessity of adjusting processes and strategies to rapidly changing global contexts, highlighting companies' ability to adapt to new business models and market evolutions.

Alongside health and pandemic disruptions, the critical factor "technological disruptions and low digital maturity" emerged as a central element in the discussions, with an emphasis on the capability to recruit programmers on a global scale, demonstrating the growing importance of advanced technical skills in the current landscape. Complementing the workforce domain, participants highlighted the use of AI for automating less strategic functions, enabling companies to redirect efforts and resources toward higher value-added activities. This integration of technology and workforce reinforces the role of technological innovation as a driving force for competitiveness and efficiency in the sector.

It is also worth highlighting the critical factor" political conflicts and crises", which was considered the most critical in the analysis of probability and impact, and which here appears linked to the capabilities of adaptability and flexibility, redundancy, market strength and respond.

5.4 Electric Vehicles (Mobility Ecosystem)

The activity began with a preparation and alignment phase, during which participants addressed the following questions: (i) How many disruptive events have affected your ecosystem in the last 6 years? and (ii) Beyond COVID-19 and wars, what other disruptive events have affected your sector?

The results indicate that 4 out of 7 respondents experienced up to 5 disruptive events in the past 5 years. Furthermore, when identifying the main disruptive events participants highlighted the local politic crisis, wars (Figure 11).

Figure 11: Disruptive events that impact the ecosystem

5.4.1 Critical Factors

The experts, coming from the automotive sector, were asked to inform about the probability/likelihood of occurrence of each critical factor, as well as their impact on the ecosystem in case of occurrence, leading to the definition of a Risk Level (probability X impact) for each CF. Table 15 presents a ranking based on the CF's risk level.

Table 15: Risk matrix by critical factor – mobility ecosystem

N	Critical Factor	Probability	Impact	Risk Level
1	Supplier and customer concentration (overdependencies)	2,8	3,6	10,1
2	Global and complex supply chains (decentralization of supply and demand)	2,3	3,6	8,3
3	Technological disruptions and low digital maturity	2,8	2,9	8,0
4	Political conflicts and crises	1,6	4,1	6,4
5	Shortage of skilled labour	1,5	3,4	4,9
6	Challenges in sustaining existing business model	1,9	2,6	4,8

N	Critical Factor	Probability	Impact	Risk Level
7	Infrastructure and logistics disruptions	1,3	3,6	4,7
8	Waste management	0,9	4,1	3,7
9	Health and pandemic disruptions	1,1	3,3	3,6
10	Environmental crises and natural disasters	0,8	3,6	2,9

"Supplier and customer concentration" was considered by experts to be the most critical of the factors, with a high probability of occurrence and great impact on the ecosystem, reflecting the overdependency the sector faces on important components from outside Europe (e.g., China).

"Global and complex supply chains" was also considered a relevant critical factor for the sector, aligned with the decentralization of the sector and the logistics challenges it brings. "Technological disruptions and low digital maturity" was the third most relevant critical factor and addresses the challenges faced by the sector to disruptive technologies in an increasingly competitive market.

5.4.2 Resilience Capabilities

Table 16 presents the classification given by the experts for each resilience capability.

Table 16: Resilience capabilities in the mobility ecosystem

N	Capability	Indicator	Grade	Mean
1	Visibility	have frequent information exchanges	3.7	3.8
		access real-time data during the decision-making process	3.9	
		accurately track orders	3.9	
2	Market Strength	have a stable relationship with suppliers	3.7	3.7
		have a stable relationship with customers	4.1	
		establish new partnerships or access new markets	3.3	
3	Efficiency	adjust manufacturing lead time	3.3	3.7
		meet demand using available inventory	3.6	
		make deliveries on time	4.1	
4	Adaptability & Flexibility	adjust production to atypical orders	3.4	3.5
		negotiate contracts or replace critical suppliers	3.4	
		adopt new technologies or modify processes	3.6	
5	Redundancy	have access to alternative suppliers	3.4	3.2
		have emergency stock available	3.1	
		have established alternative transportation modes	3.1	
6	Financial Strength	have access to resources (short-term) to mitigate the impacts of supply chain interruptions	3.7	3.2

N	Capability	Indicator	Grade	Mean
		have access to resources (medium/long-term) to invest in changes prompted by the event	2.6	
7	Respond	the company quickly responded to variations in customer demand	3.1	3.0
		the company quickly reacted to variations in supplier availability	3.0	
		the company rapidly adapted its processes and products to the new context	3.0	
8	Transform	the company adopted new products, services, or business models	3.1	3.0
		the company significantly transformed its manufacturing process	3.6	
		the company significantly changed its supplier network	2.4	

Among the capabilities, Visibility is the highest priority, addressing specifically the availability of data for order tracking and access to real-time data for decision process.

These findings reflect the sector's focus on visibility that started after COVID but was deeply increased due to the semiconductor crisis. Indeed, OEMs are incorporating this capability specially to avoid issues with sub-tier suppliers. Second highest score is related to Market Strength and Efficiency, being the first mainly represented by having a stable relationship with customers, while the second related to making deliveries on time. This suggests that, in the face of disruptions, automotive companies focus on their main customers (either those providing higher margin or being considered a priority due to any other corporate reasoning). Additionally, they focus on reducing transit times to avoid and/or minimize any component stockout in the manufacturing plants.

Analysing the three main capabilities – prepare, respond and transform – the highest scores were given to prepare, while respond and transform had a lower score (Figure 12). This may reflect the automotive sector's stability, particularly in terms of technologies and business models, which can render it more vulnerable to disruptive events and reliant on external or governmental support to recover and adapt.

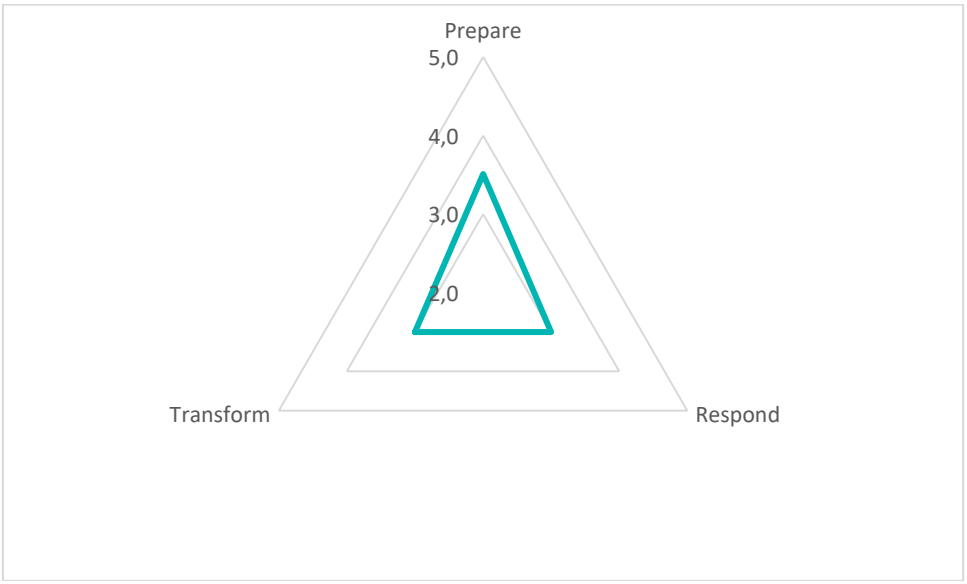

Figure 12: Average per capability in the mobility ecosystem

5.4.3 Technologies to develop resilience capabilities

Figure 13 presents the technologies cited by the participants as most relevant to the sector. Advanced analytics was the technology with higher score, making a clear relation to the Visibility Capability. Robotics was listed as second more relevant, mostly related to Autonomous vehicles and drones. By its turn, B2B digital platforms is key for communication and data sharing among the SC actors, what was also mentioned by the experts through capabilities Market Strength and Efficiency.

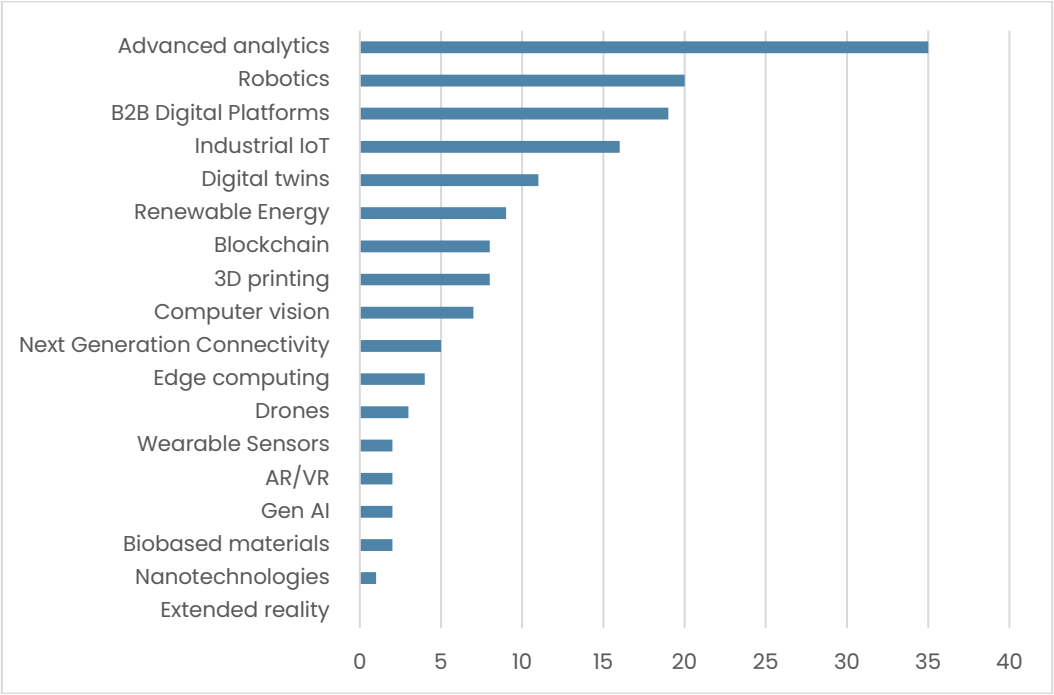

Figure 13: Relevant technologies for the mobility ecosystem

This shows that the automotive industry is currently focused on utilizing very mature technologies and the role of more disruptive ones (such as Gen AI or digital twins) is still not fully envisioned by the sector.

5.4.4 Relationship between resilience capabilities and critical factors

Table 17 shows that "adaptability & flexibility" were the most cited by participants, who considered that this capability contributes to facing most of the critical factors (except "Political conflicts and crises" and "supplier and customer concentration"). The discussion highlighted the significance of digitalizing production lines in the electric vehicle sector, as it facilitates efficient testing of new approaches and process simulations, driven by data-informed decision-making.

This discussion highlights an overlap with efficiency capability. Efficiency was considered the second most relevant capability by the participants (only "environmental crises and natural disasters", "political conflicts and crises" and "Challenges in sustaining existing business model" were not highlighted). The participants highlighted the significance of process adaptation, lead time reduction, and digitalization in advancing smart manufacturing.

Furthermore, the experts also identified visibility as a relevant capability. When discussing the critical factor of "shortage of skilled labor," the participants emphasized the importance of component traceability. In the case of electric vehicles, where technology and processes are complex, tracing components from manufacturing to the end consumer helps identify bottlenecks and improve operational efficiency. This becomes even more critical in a scenario where a shortage of skilled professionals can compromise production and meeting market demand.

This debate paves the way for the implementation of the digital passport. The digital passport is essential for ensuring complete traceability of components in the electric car sector, enabling the monitoring of the origin, lifecycle, and sustainability of materials used. Furthermore, it facilitates compliance with environmental regulations and enhances supply chain transparency, fostering greater trust among manufacturers, suppliers, and consumers.

Additionally, participants from the automotive sector provided best practices on how to overcome critical factors by applying resilience capabilities. In addition to leveraging advanced technologies, the experts highlighted the role of education, external funding, supplier diversification and customer prioritization.

Table 17: Relationship between resilience capabilities and critical factors in the mobility ecosystem

	Adaptability & Flexibility	Efficiency	Visibility	Redundancy	Market Strength	Financial Strength	Respond	Transform
Health and pandemic disruptions	X	X	X	X	X	X	X	X
Environmental crises and natural disasters	X			X			X	
Political conflicts and crises			X	X	X	X	X	
Supplier and customer concentration (overdependencies)		X		X	X		X	
Global and complex supply chains (decentralization of supply and demand)	X	X	X					
Infrastructure and logistics disruptions	X	X	X	X				
Technological disruptions and low digital maturity	X	X	X			X	X	X
Challenges in sustaining existing business model	X				X			X
Shortage of skilled labor	X	X	X			X		X
Waste management	X	X			X			X

6 Conclusion

This deliverable presented the results of tasks T1.3 and 1.4 of the RISE-SME project. This document presents an analysis of specific supply chains within the four ecosystems that are the focus of the project. Using mixed methods, four workshops were conducted to identify the main critical factors that affect each ecosystem, the most relevant resilience capabilities for the sector, the technologies that support this process, as well as the relationship between disruptive factors and capabilities were identified and discussed. An extensive number of practices adopted by reference companies were identified and their possible application in SMEs was discussed with a carefully selected group of experts.

It is important to emphasize that the activities were designed to allow participants to share their insights about their respective sectors. Consequently, the results presented below represent the perspectives of the actors involved in each analyzed sector.

The shortage of skilled labour stood out as one of the main critical factors among all ecosystems, being the first in textile and agri-food, third in Digital and Fifth in Mobility. This fact reveals that labour challenges cut across sectors with very diverse characteristics, which could demonstrate a demand for comprehensive public policies on this topic. In addition, Textile and agrifood are traditional sectors that in past years was undervalued by new generations, what led to the closure of technical training that are nowadays being missed. It can also be noted that this is an especially challenging factor for SMEs, which often suffer from a lack of resources of different types.

Political conflicts and crises have also emerged as a critical factor with high impact on all ecosystems, being the first in digital and mobility. While current conflicts are impacting logistics routes and access to “low-cost-high-skilled” remote workforce, local political instability impacts the competitivity of traditional value chains, thus increasing uncertainty in many markets and raise doubts about the future of relations between different regions and economic blocs. As discussed in the digital workshop, this scenario could lead some countries to adopt market policies such as “reshoring”, “nearshoring” and “friendshoring”, which could change the dynamics of existing global supply chains.

Technological disruptions and low digital maturity were also considered relevant by most ecosystems. On the other hand, environmental crises and natural disasters were considered the most critical factors for the agrifood ecosystem, while it was considered of little relevance for textile. This difference may reflect the direct impact that each sector suffers during a period of crisis, clearly high in the agri-food sector. However, as the numbers in the mobility and digital ecosystems demonstrate, the impact of this type of event is increasingly transversal to the most varied sectors.

Analysing the resilience capabilities across the different ecosystems, a few key patterns emerge. Across all sectors, financial strength and market strength are identified among the most critical resilience capabilities, with a particular emphasis on having short-term resources to mitigate disruptions and maintaining stable supplier and customer relationships. This indicates that, regardless of industry, SMEs prioritize financial stability and strong external partnerships as a foundational strategy to withstand disruptions. For instance, the textile and agrifood sectors highlighted the importance of long-term financial

investment for recovery, while the digital and mobility sectors focused more on maintaining operational efficiency in the face of disruptions.

Visibility is another resilience capability that stands out across sectors, especially the ability to access real-time data and engage in frequent information exchanges. This capability is crucial for SMEs to make informed decisions and quickly respond to changing circumstances, particularly when faced with unpredictable disruptions. However, the importance of visibility varies between sectors. The textile and agrifood sectors placed a high value on information sharing and real-time data for operational flexibility, while the digital sector gave more importance to accurately tracking orders, and the mobility sector focused on real-time data during the decision-making process. Despite these differences, the need for transparency and timely information is a shared priority in all sectors.

While adaptability & flexibility is a high priority in some sectors, particularly in the textile and agrifood industries, where companies often need to adjust production schedules and negotiate with suppliers, other sectors like digital and mobility place less emphasis on this capability. The sector-specific differences reflect the unique operational challenges each industry faces in maintaining flexibility during crises. Lastly, the transform capability, which involves making significant changes in business models, manufacturing processes, or supplier networks, is perceived as less urgent in most sectors. The textile, agrifood, and mobility sectors rated transformation as a secondary concern, suggesting that these industries prioritize operational stability over radical change. The digital sector, while not placing high importance on transformation either, focuses more on maintaining operational efficiency and adapting technologies.

When it comes to the technologies that contribute to increasing resilience, AI, big data and analytics, and IoT are central to all sectors, reflecting the broad need for data-driven decision-making, real-time monitoring, and process optimization. These technologies enable businesses to anticipate disruptions, optimize inventory and production processes, and improve forecasting accuracy, which are crucial in maintaining flexibility and agility during crises. While these technologies are universally applicable, their implementation varies according to the sector's operational needs. For example, the textile sector prioritizes AI for production optimization and IoT for supply chain visibility, while mobility focuses more on big data for route planning and customer demand prediction.

The sectors also share an increasing emphasis on sustainability and energy resilience, in different forms. The agrifood sector highlights renewable energy as essential for managing energy costs and enhancing environmental resilience, while the digital sector integrates renewable energy solutions as part of its broader operational sustainability goals. The textile sector also aligns with this trend by focusing on new materials, which not only drive product innovation but also contribute to more sustainable practices. The mobility sector, however, emphasizes the importance of efficiency-driven technologies such as robotics and B2B digital platforms, which improve automation and collaboration between supply chain partners, supporting resilience through operational efficiencies.

Finally, emerging technologies such as digital twins, robotics, and new materials reflect sector-specific priorities. The textile and agrifood sectors focus on using new materials to drive innovation and sustainability, particularly in product development and packaging. In contrast, the digital and mobility sectors emphasize technologies like robotics

and digital twins for operational optimization, with mobility focusing on improving logistics through data and real-time tracking.

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