



D2.2

Mapping of Advanced Technologies

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Abstract	This deliverable will describe the critical advanced technologies that supply chain business relies on, and the suppliers that currently provide them. It will be complemented with alternate suppliers and an evaluation of their reliability. The report contains a description of advanced technologies that are important for supply chain management. It provides a description of the technologies and how they can influence the efficiency and effectiveness of supply chain performance. It will describe the application of the selected technologies, the benefits, challenges and case studies where they are currently being applied. It will also include a section on future trends and recommendations for the adoption of these technologies. From the suppliers' point of view, an evaluation of the main suppliers of these technologies will also be performed. An outline of the reputational history of each of these vendors will be provided, as well as information on the size, number of customers and technological capabilities of each vendor. An effort will be made to include references and testimonials from users of the tools to provide guidance to other potential users.

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Executive summary

In a brief assessment, evolving global landscape marked by frequent disruptions, the resilience of supply chains has emerged as a critical capability for sustaining industrial competitiveness. Deliverable D2.2 of the RISE-SME project addresses this imperative by identifying, mapping, and evaluating a curated set of advanced digital technologies that can improve supply chain resilience across four key ecosystems: textile, agri-food, digital (Mobility-as-a-Service), and mobility (automotive).

This report presents a structured analysis of ten enabling technologies, AI, IoT, Digital Twins, Blockchain, Robotics, Data Spaces, Edge Computing, AR/VR, 5G Connectivity, and 3D Printing. These technologies have been chosen for their capacity to address ecosystem specific risks such as demand volatility, infrastructure breakdowns, labour shortages, and regulatory pressures.

In parallel, the deliverable conducts a detailed supplier mapping exercise, covering both EU and global providers, with a strong focus on identifying alternative and SME-driven solutions. Each supplier is evaluated using a common framework based on resilience capabilities (e.g., adaptability, visibility, efficiency) and barriers to adoption (e.g., cost, integration complexity, digital maturity).

Key findings indicate that digital technologies are essential not only for mitigating supply chain disruptions but also for enabling continuous innovation and responsiveness. While larger providers offer mature, high-performing solutions, SMEs frequently bring agility, customization, and regional autonomy, making them critical actors in the resilience landscape.

The outcome of this deliverable is a strategic technology-supplier portfolio that supports informed decision-making among stakeholders. It lays the foundation for further validation activities, technology adoption planning, and cross-ecosystem knowledge transfer throughout the remainder of the RISE-SME project.

Table of Contents

Executive summary	5
1 Introduction.....	9
1.1 Purpose and scope.....	9
1.2 Methodology	10
1.3 Structure of the deliverable	11
1.4 State of the art	11
1.4.1 Role of Digital Technologies in Supply Chain Resilience.....	11
1.4.2 Mapping Approaches and Evaluation Criteria	12
2 Technologies Mapping.....	13
2.1 Overview of Ecosystems and Resilience Needs	13
2.1.1 Supply chain Resilience Challenges.....	15
2.1.2 Role of Digital Technologies.....	20
2.2 Mapping of Advanced Technologies by Ecosystems.....	29
2.2.1 Artificial Intelligence (AI).....	30
2.2.2 Digital Twin	33
2.2.3 Internet of Things (IoT)	34
2.2.4 Blockchain	36
2.2.5 Data Spaces.....	39
2.2.6 5G Connectivity.....	41
2.2.7 Edge Computing.....	43
2.2.8 AR/VR.....	44
2.2.9 Robotic	46
2.2.10 3D Printing.....	48
2.3 Mapping Critical Factors to Technologies.....	49
3 Supplier Analysis	55
3.1 Methodology for identifying suppliers	56
3.1.1 Scope of technology domains.....	56
3.1.2 Evaluation framework and criteria.....	56
3.2 Scouting Alternate Suppliers.....	57
3.3 Supplier Reliability and Quality Evaluation.....	58
4 Conclusion	58
5 References	59

List of Tables

Table 1 : AI Technology Suppliers – Textile Ecosystem:	30
Table 2 : AI Technology Suppliers – Agri-food Ecosystem.....	30
Table 3 : AI Technology Suppliers – Digital Ecosystem.....	31
Table 4 : AI Technology Suppliers – Automotive Ecosystem.....	32
Table 5 : Digital Twin Suppliers – Digital Ecosystem.....	33
Table 6 : Digital Twin Suppliers – Automotive Ecosystem.....	33
Table 7 : IoT Technology Suppliers – Textile Ecosystem.....	34
Table 8 : IoT Technology Suppliers – Agri-food Ecosystem.....	35
Table 9 : IoT Technology Suppliers – Automotive Ecosystem.....	36
Table 10 : Blockchain Technology Suppliers – Textile Ecosystem.....	37
Table 11 : Blockchain Technology Suppliers – Agri-food Ecosystem.....	37
Table 12 : Blockchain Technology Suppliers – Digital Ecosystem.....	38
Table 13 : Blockchain Technology Suppliers – Automotive Ecosystem.....	39
Table 14 : Data Space Technology Suppliers – Textile Ecosystem.....	40
Table 15 : Data Space Technology Suppliers – Agri-food Ecosystem.....	40
Table 16 : Data Space Technology Suppliers – Digital Ecosystem.....	41
Table 17 : 5G Technology Suppliers – Digital Ecosystem.....	42
Table 18 : 5G Technology Suppliers – Automotive Ecosystem.....	42
Table 19 : Edge Computing Suppliers – Digital Ecosystem.....	43
Table 20 : Edge Computing Suppliers – Automotive Ecosystem.....	44
Table 21 : AR/VR Technology Suppliers – Textile Ecosystem.....	44
Table 22 : AR/VR Technology Suppliers – Digital Ecosystem	45
Table 23 : Robotics Suppliers – Textile Ecosystem	46
Table 24 : Robotics Suppliers – Automotive Ecosystem	47
Table 25 : 3D Printing Suppliers – Textile Ecosystem	48
Table 26 : 3D Printing Suppliers – Agri-food Ecosystem.....	48
Table 27 : Mapping of AI Technologies to Critical Factors in the Textile Ecosystem.....	50
Table 28: Mapping of IoT Solutions to Disruption Events in the Textile Ecosystem.....	51
Table 29: Mapping of Block Chain Solutions to Disruption Events in the Textile Ecosystem ..	51
Table 30: Mapping of Data Space Technologies to Critical Factors in the Textile Ecosystem	52
Table 31: Mapping of AR/VR Technologies to Critical Factors in the Textile Ecosystem	53
Table 32: Mapping of Robotic Technologies to Critical Factors in the Textile Ecosystem	54
Table 33: Mapping of 3D Printing Technologies to Critical Factors in the Textile Ecosystem	55

List of Figures

Figure 1: Flowchart of Methodology.....	10
Figure 2 : Ecosystems overview	14
Figure 3 : Key Advanced Digital Technologies for Supply Chain Resilience	21

List of Abbreviations and Acronyms	
AI	Artificial Intelligence
IoT	Internet of Things
SMEs	small and medium-sized enterprises
MaaS	Mobility-as-a-Service
AR	Augmented Reality
VR	Virtual Reality
5G	Fifth Generation

1 Introduction

In an era marked by increasingly frequent and complex disruptions, the resilience of supply chains has become a critical concern for industrial ecosystems. Digital technologies, when properly identified and adopted, offer a powerful means to improve readiness, improve responsiveness, and accelerate recovery during and after crises. This deliverable, D2.2 “Mapping of Advanced Technologies,” addresses this strategic need by identifying and evaluating key technologies that support supply chain resilience and adaptability across multiple sectors and ecosystems.

Building on the model-based insights developed in Task 2.3, these deliverable maps the advanced technologies that supply chain stakeholders rely on or can adopt to mitigate disruption risks and improve operational continuity. Special attention is given to technologies that enable better communication, visibility, automation, and collaboration ranging from IoT and Artificial Intelligence (AI) to Blockchain, Robotics, Digital Twins, and other enabling innovations.

In addition to identifying these critical technologies, the deliverable explores the current suppliers, both within the EU and globally, who provide these solutions. It includes a structured evaluation of supplier reliability and the potential for identifying alternative suppliers and technologies, especially from SMEs and emerging technology providers. The evaluation criteria consider factors such as resilience capability, support for specific risk scenarios, and barriers to adoption.

The outcome of this mapping exercise is not only a catalogue of relevant technologies and suppliers, but also a strategic tool for ecosystems to make informed decisions on technology adoption and supplier engagement. It supports the overarching objective of increasing supply chain resilience through a robust and diversified technological foundation.

1.1 Purpose and scope

The purpose of this deliverable is to identify, map, and assess critical advanced technologies that can improve the resilience of supply chains across multiple industrial ecosystems. These technologies are directly linked to actions for improving supply chain readiness, response, and recovery in the face of disruptions, as identified through the modelling work conducted in Task 2.3. This mapping exercise provides a comprehensive overview of innovative digital technologies such as the IoT, AI, Robotics, Blockchain, Digital Twins, Edge Computing, and others that support improved communication, automation, visibility, and collaboration within and across supply chains.

In addition to technological categorization, this deliverable aims to:

- Identify current and emerging technology suppliers, including both EU and non-EU providers.
- Classify between large providers and SMEs, highlighting the innovation potential of smaller actors.
- Evaluate supplier reliability and maturity, particularly regarding resilience support.

- Document adoption barriers that may hinder integration of advanced technologies across sectors.

The scope of the deliverable covers a cross-ecosystem analysis, integrating contributions from project partners and focusing on technologies with proven or high potential impact on supply chain resilience. The result is a curated and structured mapping that feeds into later tasks and other project activities related to technology validation, adoption strategies, and policy recommendations.

1.2 Methodology

This section defines the approach used to identify, classify, and evaluate critical advanced technologies supporting supply chain resilience. It describes the technologies and suppliers, the process of mapping them to ecosystems, and the evaluation framework applied. The methodology integrates expert inputs, literature review, and structured data collection.

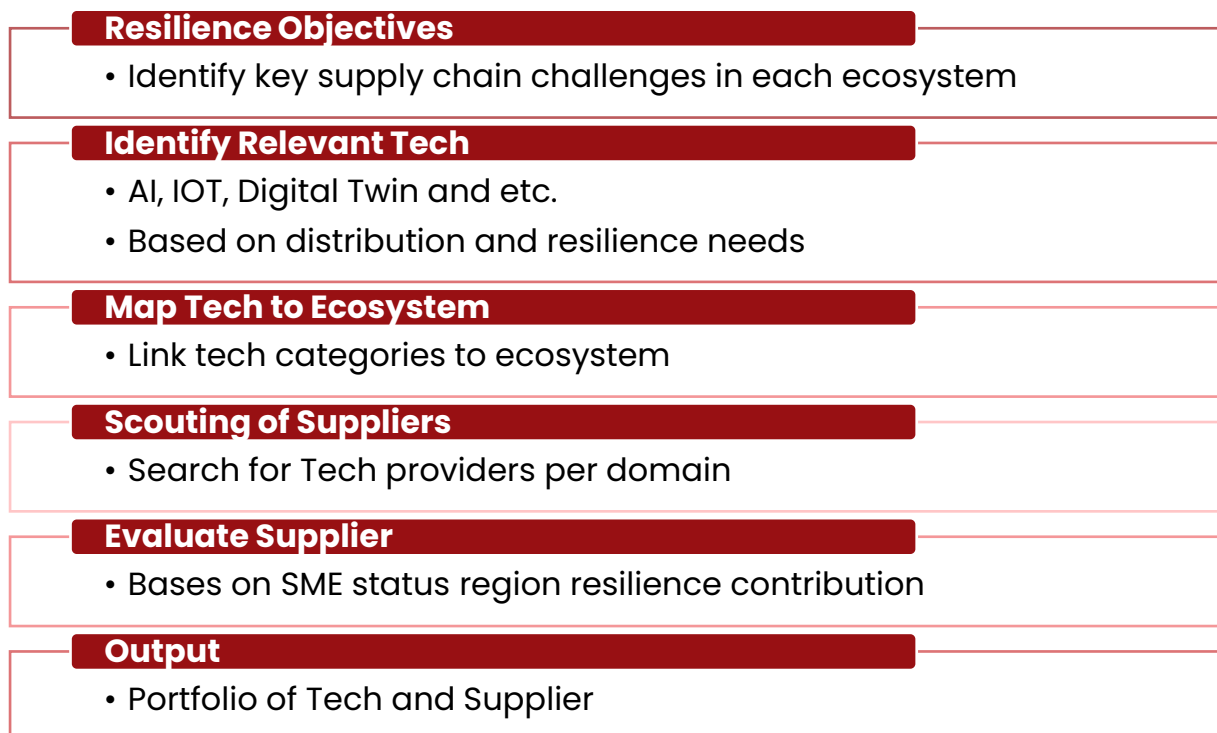


Figure 1: Flowchart of Methodology

The flowchart above summarizes the methodological approach followed in Task 2.3 to identify, map, and evaluate advanced technologies and their suppliers. It begins by defining resilience objectives for each ecosystem, identifying key supply chain challenges that technologies must address. Based on these needs, relevant technologies such as AI, IoT, and Digital Twin are selected and mapped to each ecosystem. This is followed by a scouting phase to identify suppliers within each technology domain, including mainstream and alternate providers. Each supplier is then evaluated based on criteria such as SME status, geographical location, and contribution to resilience capabilities. The

outcome is a structured portfolio of technologies and suppliers tailored to ecosystem-specific resilience requirements.

1.3 Structure of the deliverable

This deliverable presents a journey through digital technologies that shape the resilience of today's supply chains. It starts off with the Introduction, where the process set the stage by explaining the purpose and scope of the work, the methodology is followed, and a concise review of existing research and practices. Here, the document also introduce why resilience is essential for modern supply chains and how digital tools can become a strategic asset in times of disruption.

From there, this document dives into the core of Technology Mapping. In this section, the investigation explores ten advanced technologies, ranging from AI and IoT to Robotics and Blockchain, highlighting their relevance and practical value across four ecosystems: textile, agri-food, digital mobility (Mobility-as-a-Service (MaaS)), and automotive. This investigation examines how each technology addresses specific resilience challenges and identifies real-world suppliers providing these solutions, with special attention to innovative SMEs.

Building on this foundation, the Supplier Analysis takes us deeper into the selection and evaluation of technology providers. This section explains how suppliers were identified, how they were assessed using a common framework, and how alternate and emerging players especially those from within the EU can offer flexible and forward-thinking alternatives to traditional industry giants. The journey concludes with the Conclusions, where the document

reflect on what the findings mean for the future of supply chains, particularly for SMEs striving to become more robust, adaptive, and digitally empowered.

Together, these sections guide the reader from understanding the context and technologies, through concrete mappings and evaluations, and toward strategic insights that will inform the next steps of the RISE-SME project.

1.4 State of the art

1.4.1 Role of Digital Technologies in Supply Chain Resilience

Advanced digital technologies such as the Internet of Things, Artificial Intelligence, Blockchain, Robotics, and Digital Twins have been widely recognized for their potential to strengthen supply chains (Khan, 2022). These tools facilitate real-time tracking, predictive analytics, autonomous decision-making, and integrated communication systems, all of which are essential for dynamic risk mitigation and response. In a study, Oliveira (2023) examines the mediating effect of supply chain memory on the relationship between digital technologies and supply chain resilience and robustness. 257 supply chain managers were surveyed, and data was analysed using structural equation modelling. Results showed that experience, familiarity, and knowledge of disruptions partially mediate the relationship between digital technologies, resilience, and robustness. Memory is less efficient for maintaining acceptable performance during extreme disruptions like COVID-19. The study

contributes to understanding how to develop supply chain memory and the impact of digital technologies on disruption management. This paper examines the role of digital supply chain technologies in improving automotive supply chain resilience practices and supply chain performance objectives. The study, conducted using a questionnaire survey, found that digital supply chain technologies encourage firms' supply chain performance practices, supporting supply chain performance objectives. The study also found that digital supply chain technologies competency moderates the relationship between SCR and SC-Perf objectives, with a higher moderation effect in post-COVID-19 lockdown situations. The research provides practical insights for practitioners and academics on digital supply chain technologies in supply chain resilience practices and offers insights on implementing digital supply chain technologies across AP automotive firms (Balakrishnan & Ramanathan 2021).

1.4.2 Mapping Approaches and Evaluation Criteria

Contemporary research emphasizes structured methodologies for identifying and evaluating critical technologies. Multi-stakeholder consultations, literature reviews, and system-thinking approaches are often employed to assess technology fit and impact (Breen & Hannibal, 2020). In the context of the current project, such methods are integrated through expert input, workshops, and interviews, ensuring alignment with the specific needs of industrial ecosystems. The study by Oliveira-Dias et al. (2022) study explores the role and implications of Industry 4.0 Information and Digital Technologies for Agile Supply Chain strategy through a systematic literature review of 123 papers. The research categorizes literature into mature, emerging, and generic approaches. Results show a strong relationship between different types of Information and Digital Technologies and Agile Supply Chain, improving market response and customer demands. The study also discusses gaps, presents an Agile Supply Chain 4.0 model, and proposes future research opportunities (Oliveira-Dias et al. ,2022).

Supplier evaluation has become an integral part of resilience planning, particularly considering increasing global disruptions such as the COVID-19 pandemic. A core part of this evaluation involves assessing suppliers on criteria like reliability, innovation capability, geographical diversification, and resilience maturity. These dimensions help organizations determine whether suppliers can withstand and recover from operational shocks. For example, Wang et al. (2019) proposed a decision support system using fuzzy logic to quantify supplier performance across resilience indicators. Their method allowed managers to identify weak and strong areas, supporting informed decision-making and continuous improvement (Wang et al., 2019). At the same time, small and medium-sized enterprises (SMEs) are increasingly recognized as vital contributors to supply chain innovation and adaptability. Despite having fewer resources, SMEs often demonstrate agility, niche specialization, and rapid innovation cycles, which are critical attributes during crises.

Mandal (2020) emphasizes that supplier innovativeness and top management support are crucial for building supply chain resilience, especially when underpinned by a supportive organizational culture. While larger firms often dominate traditional supply networks, the

inclusion of innovative SMEs as strategic partners can significantly boost resilience capacity (Mandal, 2020).

2 Technologies Mapping

In today's highly interconnected and rapidly evolving supply chains, mapping the landscape of advanced digital technologies and the networks of suppliers that deliver them is a critical first step toward enhancing organizational resilience. By systematically identifying key technologies such as IoT, sensors, blockchain platforms, AI driven analytics, or cloud-based orchestration tools, stakeholders gain visibility into both the capabilities and dependencies that underpin their flows of goods, data, and services.

2.1 Overview of Ecosystems and Resilience Needs

To carry out the mapping of the different technologies and their suppliers, we have focused individually on each of the four ecosystems within the scope of the RISE-SME project defined in Deliverable 1.1: textile, agri-food, digital, and mobility.

The **textile** ecosystem is a complex and globally distributed value chain that spans from raw material producers to high-end fashion brands. Each stage of this ecosystem, ranging from the cultivation of natural fibres or production of synthetic materials, through manufacturing and finishing processes, to transportation logistics, distribution, and retail, relies increasingly on digital technologies to ensure operational continuity, traceability, and responsiveness to market fluctuations.

Across the entire textile ecosystem, digital solutions are key enablers of resilience. They allow for better demand forecasting, faster responses to disruptions, and more agile supply chain configurations. Together, these technologies not only accelerate recovery from disruptions but also drive continuous improvement, enabling textile companies to innovate, scale responsively, and maintain competitive advantage.

The **agri-food** ecosystem encompasses a wide array of activities, from primary agriculture, farming, and fishing operations through processing, packaging, and distribution, to retail and end consumer engagement supported by a network of auxiliary suppliers providing inputs such as seeds, feed, fertilizers, and equipment.

At every node, the advanced technologies are analyzing in this deliverable not only improve operational efficiency but also fortify the agri-food supply chain's ability to absorb shocks whether climatic, logistical, or market-driven, ensuring continuity of supply and protection of both livelihoods and food security.

In the case of the **Digital** ecosystem are going to focus on MaaS. MaaS represents a convergence of digital platforms, urban transport operators, infrastructure providers, and end users in an integrated, on-demand mobility framework. At its core, disruptive technologies enable seamless trip planning, booking, and payment across multiple modes such as buses, metros, bike and scooter sharing, ride hailing, car rental, and even micro-mobility options, through unified mobile applications or web portals.

By weaving these technologies into the fabric of MaaS, stakeholders can detect and respond to disruptions, ranging from traffic congestion and vehicle breakdowns to cybersecurity threats, more rapidly and cohesively. The result of adopting the advanced

technologies we are studying in this delivery is a more flexible, user-centric mobility service that maintains continuity under stress, adapts to real-time conditions, and continuously evolves to meet emerging urban mobility challenges.

Finally, for the **mobility** ecosystem, are going to focus on the automotive industry. The automotive ecosystem spans a tightly interlinked network of vehicle production plants, tier-1 and tier-2 auxiliary suppliers, logistics providers, and dealer networks each playing a pivotal role in delivering finished vehicles to end customers.

Emerging technologies improve plant level flexibility, enabling manufacturers to quickly reconfigure production in response to parts shortages or demand shifts. Advanced technologies also support supply chain collaboration platforms, synchronize procurement, production scheduling, and inbound logistics, helping teams foresee and mitigate bottlenecks. Finally, digital retail tools empower dealer networks to maintain sales and after-sales services even amid showroom closures or delivery constraints. Collectively, these technologies bolster the automotive value chain's resilience by improving adaptability, accelerating decision-making, and safeguarding continuity across every stakeholder from plant floor to customer driveway.

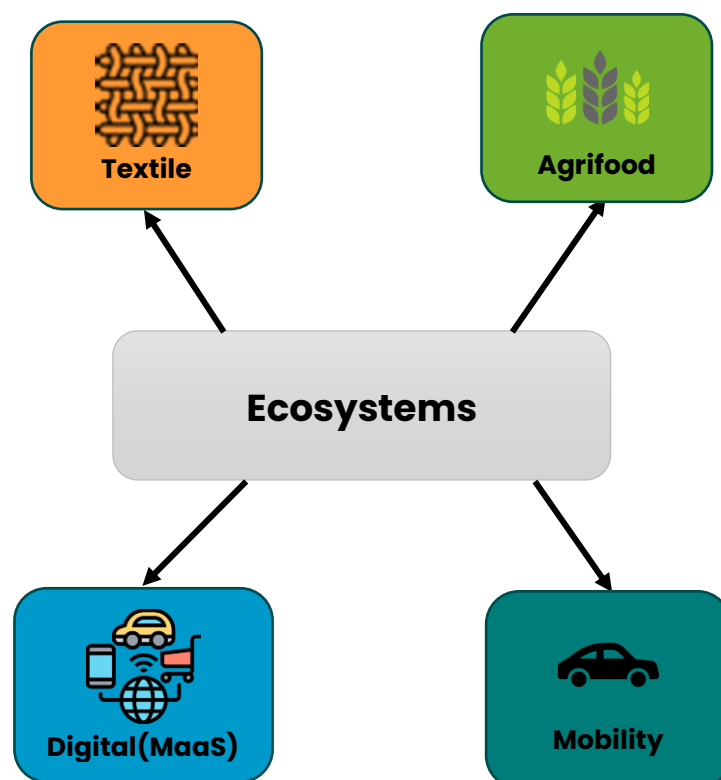


Figure 2 : Ecosystems overview

2.1.1 Supply chain Resilience Challenges

➤ TEXTILE

The textile sector faces a range of resilience challenges driven by volatile markets, shifting consumer behaviours, and strict sustainability demands (Abylaev, Pal, & Torstensson, 2014). Below is a summary of key difficulties and the digital technologies best positioned to mitigate them:

Rapid Changes in Demand and Production

The fast-fashion cycle and unpredictable seasonal shifts place immense pressure on planning and production.

- **AI-Driven Forecasting & Optimization:** Advanced machine-learning models ingest historical sales, social-media trends, and external data to generate highly accurate demand forecasts and recommend optimal production schedules.
- **IoT-Enabled Real-Time Analysis:** Networked sensors on factory floors and in warehouses feed continuous streams of performance and inventory data into analytics dashboards enabling immediate course corrections and “just-in-time” adjustments.
- **AR/VR powered Design Flexibility:** Virtual prototyping tools let designers iterate new styles in immersive 3D, shortening approval cycles and reducing physical sample waste (Kuts, Otto, Bondarenko, & Yu, 2020).
- **3D Printing for Customization:** Additive manufacturing supports small-batch, on-demand production of accessories and high-value garments, helping brands respond instantly to niche requests without tooling delays.

Need for Sustainable, High-Quality Products

As regulators and consumers demand proof of ethical sourcing and minimal environmental impact, traceability and material efficiency become indispensable (Chen, 2022).

- **Blockchain-Backed Traceability:** Distributed ledgers record every handoff from fiber origin to dye house, to final stitch; ensuring tamper proof certification of organic, fair trade, or recycled content (Chen, 2022).
- **Sustainable 3D Printing:** New biodegradable or recycled feedstocks in 3D printers enable localized, minimized waste production of complex components (e.g., buttons, embellishments).

Emerging Consumption Patterns (Online & On-Demand Shopping)

The rise of e-commerce and personalized ordering demands new ways to bridge the digital/physical spaces.

- **AR improved Shopping Experiences:** Virtual “try-on” apps allow customers to visualize garments on their own avatars or in real world settings, reducing return rates and improving satisfaction.
- **On-Demand 3D Printing:** By producing garments or accessories only after orders are placed, brands can eliminate overstock, shorten lead times, and offer highly personalized assortments.

Production Throughput and Labour Constraints

Legacy equipment and manual handling can create bottlenecks and quality inconsistencies, especially under labour shortages or safety restrictions.

- **Industrial Robotics & Cobots:** Automated sewing stations, pick-and-place robots, and collaborative robotic arms augment human operators boosting throughput, ensuring uniform stitching, and reallocating workers to higher-value tasks (Robinson, et al., 2023).

➤ AGRI-FOOD

The agri-food supply chain is inherently exposed to volatility, from weather conditions that affect production performance to shifting consumer demand and contending with perishable products and stringent safety regulations. Below is an outline of its principal resilience challenges, paired with the advanced digital technologies that help mitigate them:

Rapid Fluctuations in Demand & Production Conditions

Agricultural outputs and processing capacities must adapt quickly to unpredictable market signals and environmental variables (Betti, et al., 2024).

- **IoT & AI-Powered Analytics, Forecasting and Predictive Maintenance:** real-time IoT data from soil moisture, weather, and crop sensors to equipment telemetry to power AI models that both optimize agronomic decisions (planting, irrigation, harvesting) and trigger predictive maintenance alerts (Grieves & Vickers, 2017).
- **Blockchain for End-to-End Traceability:** Distributed ledgers record every step from field to fork, enabling rapid root-cause analysis when volumes surge or drop unexpectedly.

- 3D Printing for Rapid Adaptations & Repairs: On-site additive manufacturing of spare parts and bespoke tooling (e.g., pump fittings, nozzle heads) minimizes downtime during peak cycles (Song & Zhang, 2020).

Labour Shortages & Skill Gaps

Seasonal peaks and remote locations often leave farms and processing facilities understaffed with qualified personnel.

- IoT-Enabled Automation & AI-driven actions: By deploying networked sensors and actuators to automate repetitive tasks and layering AI-driven orchestration for workflow optimization and predictive maintenance, operations can run smoothly with fewer hands.
- Interactive dashboards coordinate the remaining human workforce and machines in real time, dynamically allocating resources to match fluctuating production demands.

Handling Fragile, Perishable Goods Under Strict Regulations

Maintaining product quality, safety, and compliance throughout transport and storage is critical to avoid spoilage and regulatory penalties (Chen, 2022).

- IoT Sensors for Condition Monitoring: Temperature, humidity, and shock detectors in cold-chain vehicles and warehouses trigger alerts and automated corrective actions when parameters drift.
- Blockchain & Event-Based NFTs for Provenance & Compliance: Immutable records and time-stamped tokens certify each handling event, streamlining audits and recalls (Betti, et al., 2024).
- Data Spaces for Transparent Quality Management: Shared platforms give regulators, logistics partners, and retailers real-time access to standardized safety and quality data.
- 3D-Printed, Custom Packaging Solutions: Tailor-made inserts and ventilated crates extend shelf life, cushion delicate items, and can be produced locally to reduce lead times.

➤ DIGITAL

The MaaS ecosystem must absorb frequent shifts in service mixes, network load, regulatory requirements, and user expectations, all in real time (Cisterna, et al., 2023). Below is its key resilience challenges paired with the digital enablers that address them:

Constant Changes in Service Offerings & Traffic Conditions

Integrating new mobility modes (e-scooters, autonomous shuttles) requires the ability to monitor and respond to constantly changing traffic congestion patterns through comprehensive scenario-based ('what-if') planning and real-time adjustments.

- **Digital Twins & AI-Assisted Simulation:** Virtual replicas of the urban transport network ingest real-time traffic, ridership, and incident data, while AI models test scenarios such as route diversions or fleet reallocations before they're deployed.
- **Edge Computing & 5G Connectivity:** Low-latency processing at network edges aggregates intermodal sensor feeds (vehicle telemetry, station occupancy) to enable instant rerouting and demand responsive dispatching (Singh, Beliatas, & Presser, 2024).
- **Data Spaces for Cross-Operator Integration:** Shared data architecture and standardized APIs allow public transit, micro mobility, and ride hailing services to exchange status and capacity information seamlessly (Singh, Beliatas, & Presser, 2024).

User Identification, Payment Reliability & Regulatory Compliance

Securely onboarding riders, guaranteeing fare integrity, and adhering to data privacy mandates are foundational for trust and uptime.

- **Blockchain Enabled APIs & Data Exchange:** Decentralized identity protocols authenticate users across multiple platforms, while immutable ledgers record trip data and regulatory attestations.
- **Smart Contracts & Blockchain Payments:** Automated fare-settlement contracts execute instantly upon service completion, reducing settlement disputes and ensuring operator liquidity (Alharby, Aldweesh, & van Moorsel, 2018).
- **5G Backed Service Continuity:** Ultrareliable networks sustain high throughput transaction volumes and encrypted communications, even under peak usage.

Onboarding & Loyalty of New Users

Simplifying the user experience and creating engaging touchpoints are critical to drive repeat usage and diversify revenue streams.

- **Augmented Reality Experiences:** AR wayfinding overlays real-world streetscapes with route guidance, promotional gamification, and contextual information making multimodal trips intuitive and entertaining.

➤ **MOBILITY**

The automotive value chain must absorb rapid advances in vehicle architectures, cope with evolving driving modalities, secure vast streams of data, and manage complex multi-tier supplier networks. Below is an outline of its chief resilience challenges and the enabling technologies that help overcome them (Lee et al., 2018):

Constant Evolution in Vehicle Designs & Production Processes

Manufacturers regularly introduce new models, materials, and assembly techniques requiring flexible, reconfigurable factories.

- **Digital Twins & Simulation:** Virtual replicas of production lines and vehicle designs allow engineers to optimize workflows, test “what-if” scenarios, and predict bottlenecks before physical changes are made (Grieves & Vickers, 2017).
- **IoT Enabled Plant Digitalization:** Networked sensors across machines and conveyors feed real-time dashboards, support device self-diagnosis, and expose open APIs for rapid integration of novel tools or sensors.
- **Flexible Robotics:** Adaptive cobots and modular robotic cells switch tasks on demand sewing interior panels one day, handling battery modules the next.
- **Edge Computing:** Localized data processing minimizes latency for control loops and analytics, ensuring real-time responsiveness to production variances.

Emergence of New Driving Technologies & In-Vehicle Experiences

The shift toward autonomy and improved human-machine interaction demands robust AI and immersive interfaces.

- **AI for Autonomous Driving Support:** Deep-learning models fuse camera, lidar, and radar feeds to detect hazards, plan trajectories, and support driver assist features (Grigorescu, et al., 2020).
- **AI-Driven & AR-improved Interiors:** Augmented reality HUDs and voice AI assistants deliver navigation, safety alerts, and personalized infotainment boosting user engagement and perceived value.

Security of Vehicle Generated Data & Transaction Integrity

Modern vehicles produce gigabytes of telemetry and participate in software updates, OTA payments, and e-commerce.

- Private Blockchains for Data Management: Permissioned ledgers authenticate vehicle identities, secure over-the-air updates, and maintain tamper proof logs of service history (Aldweesh, 2023).
- Smart Contracts & Edge-Backed Enforcement: Automated agreements govern software licensing, usage-based insurance, and charging sessions with edge nodes validating transactions close to the source.

Complexity of components Supply & Supplier Resilience

Automotive supply chains span thousands of components from global Tier-1 and Tier-2 vendors exposing OEMs to disruption from single-source constraints or geopolitical events.

- Blockchain-Enabled Traceability: Distributed ledgers record the provenance of critical parts (e.g., semiconductors, braking systems), enabling rapid recall management and supplier risk scoring (Chen, 2022).
- Real-Time Parts Tracking with IoT: Sensor tags monitor shipment location, temperature, and handling conditions while blockchain anchors these events in an immutable audit trail to ensure part authenticity and timely replenishment.

2.1.2 Role of Digital Technologies

Digital technologies are playing a crucial role in making supply chains more resilient and responsive (Ivanov & Dolgui, 2021). These tools enable real-time visibility, smarter decision-making, and faster adaptation to change. With data flowing in from factory floors, farms, delivery fleets, and smart devices, organizations can spot potential disruptions early and take proactive steps to manage them.

Advanced analytics and AI help translate raw data into actionable insights, improving forecasts, streamlining operations, and anticipating maintenance needs. Meanwhile, digital twins and simulations let companies test strategies and contingency plans without disrupting live systems. Secure digital architectures and technologies like blockchain build trust across partners by ensuring data integrity, and fast, low-latency networks support instant coordination across locations (Senthilraja, R et al., 2025; Owusu-Berko, 2025).

Together, these technologies form a flexible digital foundation, one that boosts agility, accelerates response times, and supports continuous improvement. In short, they're key to helping supply chains not only withstand disruption but thrive in the face of it.

Based on the resilience priorities of the target ecosystems for this deliverable, that will focus our technology mapping on a selected list of 10 specific technologies.

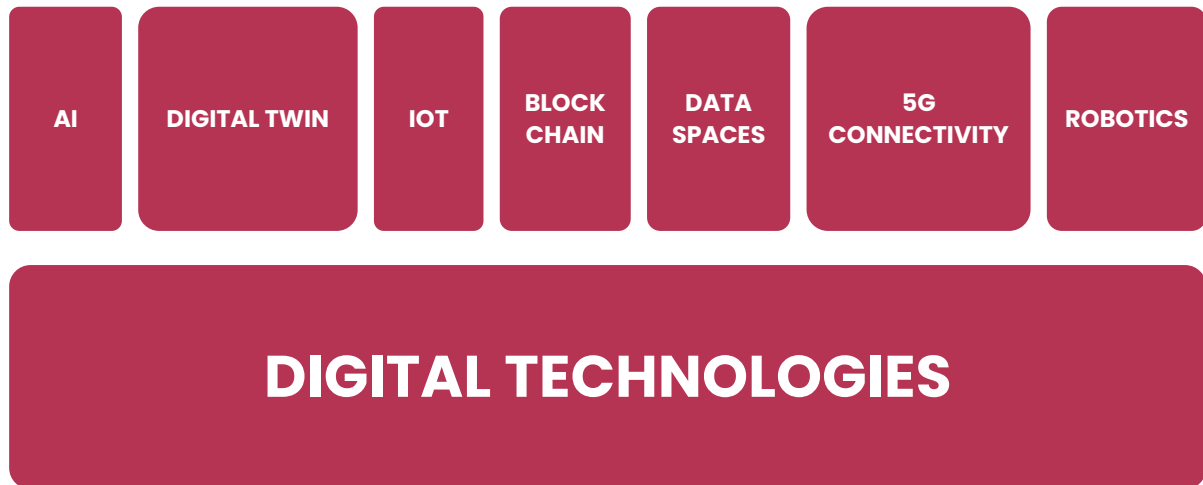


Figure 3 : Key Advanced Digital Technologies for Supply Chain Resilience

➤ **ARTIFICIAL INTELLIGENCE**

AI refers to a broad set of technologies and techniques that enable machines to perform tasks traditionally requiring human intelligence (Russell & Norvig, 2021). At its essence, AI involves algorithms that can learn from data, recognize patterns, and make decisions with minimal human intervention. From early rule-based expert systems to today's deep learning frameworks, AI has evolved into a versatile toolkit capable of powering everything from voice assistants and recommendation engines to complex scientific research.

Central to AI's power is its ability to process enormous volumes of structured and unstructured data like text, numbers, images, and sensor feeds and extract meaningful insights. By continuously refining its models as new data arrives, AI can improve its accuracy over time, uncovering subtle trends or anomalies that might elude even the most experienced human analyst. Due to this adaptive learning capability AI is proving indispensable in modern supply chains, offering predictive insights and automation in fields as diverse as healthcare, finance, autonomous vehicles, and manufacturing (Choi, Wallace, & Wang, 2018).

Moreover, AI is not working alone. It makes other technologies stronger and faster—those same technologies that are changing supply chains today.

Digital-twin platforms rely on AI for continuous calibration and scenario simulation, enabling teams to safely “stress-test” operations under hypothetical disruptions. Computer-vision systems powered by AI perform automated inspections on production lines and track inventory movements in real time. Even autonomous robots leverage reinforcement-learning algorithms to navigate busy warehouses and adapt to changing layouts without manual reprogramming (Parmar, 2022; Arcidiacono, F et al, 2023).

Based on the needs examined earlier, this research find that AI is crucial for a large variety of important tasks which give supply chain resilience. Advanced forecasting models use historical sales figures, promotional calendars, and external indicators such as weather or

economic data to predict demand more precisely. At the same time, AI-driven analytics sift through equipment telemetry and maintenance logs to anticipate mechanical wear and schedule interventions before failures occur minimizing downtime and trimming service costs (Choi, Wallace, & Wang, 2018).

➤ **DIGITAL TWIN**

Digital twins are virtual replicas of physical assets, processes, or systems that mirror their real-world counterparts in both structure and behaviour (Grieves & Vickers, 2017). By integrating data from sensors, CAD models, and operational systems, a digital twin continuously reflects the current state of its physical partner, capturing everything from geometry and configuration to performance metrics and environmental conditions. This living model can be as simple as a single machine component or as complex as an entire factory floor, city infrastructure, or even a whole supply chain network.

Originally pioneered in aerospace and manufacturing, digital twins have evolved alongside advances on the IoT, big data platforms, and cloud computing (Tao et al., 2018). Today, they serve multiple industries from healthcare (modelling patient physiology) to urban planning (simulating traffic flows) to energy (optimizing power grids). What unites these applications is the ability to bring physical and digital worlds into a continuous feedback loop: measurements feed the model, and the model's insights inform real-world actions.

One of the most powerful strengths of digital twins is their capacity for realistic simulation. By running "what-if" scenarios against the virtual model, organizations can explore the impact of changes: new process layouts, equipment upgrades, environmental shift without risking disruption to live operations. This allows teams to validate design decisions, uncover hidden bottlenecks, and fine-tune configurations under various conditions (Jones et al., 2022).

Beyond simulation, digital twins enable predictive insights. Machine-learning algorithms can analyse historical and real-time data within the twin to forecast future behaviour, such as throughput rates, energy consumption, or failure modes. Armed with these predictions, companies can proactively adjust maintenance schedules, balance workloads, or reconfigure workflows helping to prevent downtime, reduce costs, and maximize asset utilization.

Based on the needs and the examination earlier, the investigation find that digital twins are crucial for mentioned tasks such as immersive "what-if" testing, continuous performance monitoring, predictive analysis of system behaviour, and rapid scenario-based decision support. By integrating simulation, prediction, and real-time feedback into a single platform, digital twins empower organizations to both anticipate challenges and optimize operations with confidence.

➤ **INTERNET of THINGS (IoT)**

The IOT describes a network of interconnected physical devices ranging from simple sensors to complex machinery that collect, exchange, and act on data over the internet. At its foundation, IoT unites hardware (sensors, actuators, gateways) with software platforms

and communication protocols, enabling devices to “sense” their environment, communicate their status, and receive instructions without direct human intervention.

Over the past decade, rapid advances in low-power wireless connectivity, miniaturized electronics, and cloud computing have propelled IoT from a niche concept into a cornerstone of modern digital infrastructure. Today, IoT spans industries as varied as smart cities (monitoring traffic and air quality), agriculture (measuring soil moisture and crop health), healthcare (tracking patient vitals), and manufacturing (supervising equipment performance) (Centenaro, Costa, Granelli, Sacchi, & Vangelista, 2021). What ties these applications together is the ability to capture granular, real-time insights at scale.

One of IoT’s most valuable strengths is its capacity for real-time data analysis. By streaming continuous feeds of temperature, humidity, vibration, and other metrics from sensors placed throughout an operation, organizations gain fine-grained visibility into conditions that once went unmonitored. This digitalization of physical assets turns every device into a data source fuelling dashboards, alerts, and analytics engines that surface anomalies, detect inefficiencies, and support rapid decision-making.

Another key benefit is real-time tracking. Whether monitoring the location and status of goods in transit or following the utilization rates of machinery on the shop floor, IoT systems can pinpoint asset movements and conditions at any moment. Combined with geolocation services and telemetry data, this enables precise route optimization, loss prevention, and dynamic resource-allocation critical capabilities in today’s fast-paced, globalized operations (Sangaiah, et al., 2020).

Based on the examined earlier, the investigation finds that IoT is crucial for tasks such as continuous monitoring of environmental and operational parameters, seamless digitalization of assets, real-time tracking of goods and equipment, and feeding high-volume telemetry into advanced analytics platforms. By laying the sensory groundwork for other technologies like AI-driven analytics, digital twins, and predictive maintenance IoT forms the data foundation that makes resilient, adaptive supply chains possible.

➤ **BLOCKCHAIN**

Blockchain is a distributed ledger technology that records transactions across a network of computers in a way that ensures data immutability, transparency, and security. Instead of relying on a central authority to validate and store records, blockchain uses a consensus mechanism such as proof of work or proof of stake to agree on the contents of each new “block” of transactions. Once added, each block is cryptographically linked to the previous one, creating an auditable chain that is extremely difficult to tamper with or alter retrospectively.

Originally developed as the underlying technology for cryptocurrencies, blockchain has quickly expanded into many other sectors. Financial services use it for faster cross-border payments and streamlined clearing and settlement. Healthcare organizations explore blockchain for secure patient records and consent management. Even energy grids leverage it to track distributed generation and peer-to-peer energy trading (Casino, Dasaklis, & Patsakis, 2019). Across all these applications, the key attraction is a trust less

environment: participants can transact and share data without needing to know or fully trust every other party.

One of blockchain's standout strengths is traceability. Every asset or data point recorded on the chain carries a timestamped history of its origin and transformations. This makes it ideal for provenance tracking, whether tracing a diamond's journey from mine to market, verifying fair-trade coffee, or ensuring pharmaceutical authenticity. Immutable certificates and digital credentials can be issued and verified on chain, replacing paper records with tamper-proof digital proofs (Rahardja, et al., 2021).

Another powerful feature is smart contracts: self-executing code stored on the blockchain that automatically enforces agreed terms when predefined conditions are met. Smart contracts can handle payments, release goods, or trigger notifications without manual intervention, greatly reducing administrative overhead and error (Alharby, Aldweesh, & van Moorsel, 2018). Event-based non-fungible tokens (NFTs) also extend blockchain's capabilities, representing unique assets or rights such as shipment milestones, carbon credits, or service entitlements in a secure, programmable token (Regner, Urbach, & Schweizer, 2019).

Based on the examined earlier, the blockchain is crucial for tasks such as end-to-end traceability of goods and data, authentication of certificates and credentials, automated execution and settlement via smart contracts, event-driven tokenization with NFTs, and robust data security and participant authentication. By providing an immutable, transparent ledger and programmable transaction logic, blockchain lays the groundwork for trustworthy, automated collaboration across complex ecosystems.

➤ DATA SPACES

Data spaces are integrated, interoperable environments where organizations can securely share, access, and govern data according to common standards and policies. Unlike traditional data lakes or warehouses which centralize data in single repository data spaces enable a decentralized model: each participant retains control over its own data while making selected datasets available through well-defined interfaces. This federation approach facilitates collaboration without sacrificing data sovereignty or privacy.

Emerging from initiatives in smart manufacturing (e.g., Industry 4.0) and European data governance frameworks, data spaces leverage open standards, semantic models, and common protocols (such as IDS-Connectors and DCAT) to ensure that data exchanged between parties is understandable and usable out of the box (Andresel, et al. 2024). They often build on underlying technologies like APIs, metadata catalogues, and identity management systems to create a trusted data-sharing ecosystem.

One of the core strengths of data spaces is real-time, standardized access to distributed datasets. By adopting shared vocabularies and data schemas, participants eliminate time-consuming data-mapping efforts and reduce integration errors. As new data is generated, whether from ERP systems, IoT sensors, or partner applications, it becomes immediately discoverable and usable by authorized stakeholders across the network.

Data spaces also excel at cross-operation integration (Singh, Beliatas, & Presser, 2024). For example, in our case of MaaS, platforms use common API specifications to seamlessly coordinate vehicle bookings, payments, and real-time tracking across multiple transport providers, data-space APIs allow you to exchange production schedules with contract manufacturers, share quality metrics with logistics partners, or aggregate sustainability reports from diverse suppliers. With built-in governance controls enforcing privacy rules, licensing terms, and industry regulations, every data request and transfer happens under a unified framework so participants can collaborate confidently without compromising sensitive information.

All these features are crucial to addressing the challenges facing supply chains today. By creating a decentralized yet interoperable data layer, data spaces empower organizations to unlock new insights, streamline end-to-end workflows, and drive collective resilience.

➤ **5G CONNECTIVITY**

Fifth generation (5G) connectivity represents the latest evolution in cellular network technology, designed to deliver dramatically faster speeds, vastly increased capacity, and remarkably low latency compared to its predecessors. At its foundation, 5G leverages higher-frequency spectrum bands, advanced antenna technologies (such as massive MIMO), and sophisticated beam-forming techniques to support peak data rates of up to 20 Gbps and user-experienced speeds in the gigabit-per-second range. This leap in performance isn't just about faster downloads, it's about enabling entirely new classes of applications across industries (Navarro-Ortiz, et al., 2020).

Beyond raw speed, 5G introduces network slicing, which partitions the physical network into multiple virtual "slices" tailored to specific service requirements. Each slice can be configured with its own quality-of-service parameters guaranteeing, for example, ultra-reliable low-latency communications for critical control systems while simultaneously supporting high-bandwidth mobile broadband for user devices. Combined with native support for edge computing where data processing is pushed closer to the devices generating it, 5G creates a flexible, programmable infrastructure that adapts to diverse use cases on demand (Hassan, Yau, & Wu, 2019).

One of the most powerful strengths of 5G is its ultra-low latency, often under 1 ms in optimal conditions. This makes it possible to stream intermodal sensor feeds, from drones, autonomous vehicles, or smart machinery in real time, enabling instantaneous detection of anomalies and automated responses. Whether rerouting an AGV around an obstacle or adjusting conveyor speeds to prevent a bottleneck, 5G's responsiveness transforms reactive workflows into proactive, closed-loop control systems.

High capacity 5G networks also underpin robust infrastructures for real-time tracking and analytics. With thousands of IoT devices uploading telemetry from temperature and humidity to vibration and GPS coordinates, organizations gain continuous visibility over assets in transit or on the shop floor. This flood of high-resolution data can feed advanced analytics engines and AI models, driving dynamic route optimization, condition-based maintenance, and predictive demand management.

Based on the examined earlier, the 5G connectivity is crucial for tasks such as supporting intermodal sensor networks with millisecond-level responsiveness, enabling pervasive real-time tracking and telemetry, powering edge-based analytics and automation, and creating flexible network slices for diverse application demands. By delivering the bandwidth, reliability, and latency needed for next-generation digital services, 5G forms the vital communications backbone for resilient, adaptive ecosystems (Pham et al., 2020).

➤ **EDGE COMPUTING**

Edge computing is a distributed IT architecture that brings data processing and storage closer to the sources of data such as sensors, cameras, machinery, and other IoT devices rather than relying solely on centralized cloud data centres. By deploying compute resources “at the edge” of the network (for example, on gateways, factory floors, or even inside vehicles), edge computing reduces the physical and network distance between data generation and analysis. This shift enables faster insights, lowers bandwidth costs, and improves reliability in environments with intermittent connectivity (Shi, Cao, Zhang, Li, & Xu, 2016).

The rise of edge computing has been driven by several trends: the explosive growth of IoT devices generating massive data streams; the need for real-time decision making in critical applications; and the limitations of cloud only models when ultra-low latency or data sovereignty is required. Edge platforms often combine small-form-factor servers, specialized accelerators (like GPUs or TPUs), and containerized or virtualized software stacks to support a wide range of workloads from analytics and AI inference to real-time control and augmented reality (Pham et al., 2020).

One of edge computing’s standout benefits is its ultra-low latency. By processing data locally, edge nodes can execute analytics, trigger actions, or feed control loops in milliseconds rather than the tens or hundreds of milliseconds typical of round-trip cloud communications (Ren, Yu, He, & Li, 2019). This capability is critical for applications such as autonomous guided vehicles in warehouses, robotic arms on the production line, or collision-avoidance systems in logistics vehicles, any scenario where delays can compromise performance or safety (Pham et al., 2020).

Edge computing also enhances bandwidth efficiency and resilience. Instead of sending all raw data upstream, edge nodes can filter, aggregate, or preprocess information, transmitting only the most relevant insights or summaries to the cloud. This reduces network congestion and cloud storage costs, while ensuring mission-critical operations continue uninterrupted even if the upstream connection falters. In addition, localized compute resources can host containerized applications and AI models tailored to specific operational contexts, allowing for rapid updates and modular scalability (Hu, Shi, & Li, 2022). Based on examined earlier, that shows edge computing is crucial for tasks such as millisecond-level processing and response, real-time control loops and analytics on the production floor, bandwidth-optimized data filtering, and resilient operation in network-constrained environments. By decentralizing compute power and bringing intelligence to the points of action, edge computing lays the groundwork for responsive, efficient, and reliable industrial and logistical systems.

➤ **AR/VR**

Augmented Reality (AR) and Virtual Reality (VR) are immersive technologies that blend digital content with the physical world or create entirely simulated environments. AR overlays computer-generated graphics, data, or instructions into a user's real-world view typically via smart glasses or mobile devices, while VR fully transports users into a computer rendered, 3D space through head-mounted displays and haptic feedback systems. Together, they enable new ways to visualize, interact with, and manipulate digital information.

Since their early roots in gaming and entertainment, AR/VR platforms have matured into versatile tools for design, training, collaboration, and customer engagement. Advances in display resolution, motion tracking, and spatial audio have sharpened the realism of virtual scenes and the precision of overlay graphics. At the same time, lighter headsets, wireless connectivity, and cloud-powered rendering pipelines have made AR/VR more accessible on the factory floor, in warehouse aisles, and even in drivers' cabs (Eswaran & Bahubalendruni, 2022).

One of AR/VR's most compelling strengths is virtual prototyping. Designers and engineers can iterate on product concepts in a shared virtual space, scaling machinery models to life-size, examining them from any angle, and making real-time adjustments without cutting steel or 3D-printing parts. This accelerates development cycles, reduces material waste, and fosters better cross-discipline collaboration, since stakeholders can experience designs first hand rather than interpreting 2D drawings.

AR also excels at giving users immersive, context-aware guidance allowing them to complete tasks more accurately and efficiently. By overlaying clear visual cues and instructions directly onto their environment, it reduces the need to consult external documentation, minimizes errors, and accelerates learning curves. This seamless, in-context assistance boosts user confidence, enhances overall satisfaction, and enables people to engage with products and services more intuitively transforming complex workflows into straightforward, guided experiences (Kuts, Otto, Bondarenko, & Yu, 2020).

Based on the examined earlier, it showed that AR/VR is crucial for tasks such as virtual prototyping and design review, immersive training simulations, context-sensitive work instructions, and enhanced customer or driver experiences through live data overlays. By merging digital and physical realms, these technologies unlock new efficiencies and insights empowering teams to visualize the invisible, practice the complex, and interact more naturally with data wherever they operate.

➤ **ROBOTIC**

Robotics encompasses the design, construction, operation, and use of robots, programmable machines that can carry out a variety of tasks autonomously or under human supervision. At its foundation, robotics brings together mechanical engineering, electronics, control systems, and software to create systems that sense their environment, make decisions, and perform actions. From the earliest industrial arms that welded car

bodies to today's autonomous drones and service robots, the field has continuously pushed the boundaries of what machines can achieve.

Over time, robotics has evolved from single purpose, hard-wired machines into versatile platforms capable of adaptation and learning. Advances in sensors, motors, and artificial intelligence have enabled robots to perceive complex surroundings, navigate unstructured environments, and adjust their behaviour on the fly. Modern robots can process vision data, interpret human gestures or speech, and even collaborate directly with people blurring the line between automation and teamwork (Robinson, et al., 2023).

One of robotics core strengths lies in automating new and increasingly complex tasks. Robots excel at repetitive, high-precision operations such as assembly, welding, or pick-and-place that demand speed and accuracy. At the same time, more sophisticated robotic cells can handle variability: recognizing different part geometries, adapting to slight misalignments, and switching between workflows with minimal reprogramming. This capability reduces cycle times, improves product quality, and unlocks efficiencies that were previously unattainable.

Collaborative robots, or "cobots," take this flexibility one step further by working safely alongside humans. Lightweight and equipped with force-sensing technology, cobots can share workspaces without bulky safety cages, handing off parts, assisting with lifting, or guiding operators through complex procedures (Simões, et al., 2022). Their ease of deployment and intuitive programming interfaces make them ideal for small batch runs, rapid line changeovers, and tasks that require both human judgment and robotic precision. Based on the examined earlier, the investigation finds that robotics is crucial for tasks such as executing complex automated operations, enabling flexible task assignment across production lines, supporting human-robot collaboration through cobots, and scaling high-precision work at speed. By combining mechanical prowess with intelligent control, robotics offers a powerful toolkit for boosting productivity, ensuring consistent quality, and accelerating innovation across diverse environments.

➤ **3D PRINTING**

3D printing, also known as additive manufacturing, refers to a family of processes that create three-dimensional objects layer by layer from digital designs. Unlike traditional subtractive methods which cut or drill material away, 3D printers build parts by depositing materials such as plastics, metals, ceramics, or composites precisely where they're needed. This approach allows for intricate geometries, internal channels, and customized structures that would be difficult or impossible to achieve with conventional tooling.

Since its inception in the 1980s, 3D printing has evolved from a rapid-prototyping novelty into a versatile production technology used across industries. In aerospace and automotive, engineers leverage it for lightweight components with complex internal lattices. In healthcare, it enables patient-specific implants and anatomical models. Even in fashion and consumer goods, designers experiment with custom jewellery, footwear, and accessories all driven by digital models and flexible material options (Tuli, Khatun, & Rashid, 2024).

A defining advantage of 3D printing is its ability to produce parts directly from CAD files without expensive molds or dedicated tooling. This workflow accelerates design iterations, reduces lead times, and lowers up-front costs making it ideal for short runs, proof-of-concept models, and highly customized items. As a result, companies can respond quickly to changing specifications or market demands without the capital expense of retooling a production line.

Beyond prototyping, on-demand additive manufacturing opens new possibilities for distributed, localized production. Warehouses, service centres, and even remote sites can host compact printers to fabricate spare parts, repair tools, or custom fixtures on site. This capability not only slashes inventory carrying costs and obsolescence risks but also shortens downtime by eliminating long lead times for replacement components (Song & Zhang, 2020).

Based on the examined earlier, the 3D printing is crucial for tasks such as small-batch, on-demand production of accessories and high-value garments; on-site additive manufacturing of spare parts, jigs, and bespoke tooling; rapid design validation through prototypes; and flexible scaling of complex, low-volume components. By bridging the gap between digital design and physical output, 3D printing empowers organizations to innovate faster, reduce waste, and support agile, decentralized manufacturing.

2.2 Mapping of Advanced Technologies by Ecosystems

Information presented in this section is based on a combination of publicly available data sources, including technology provider websites, online market reports, and general web-based information, complemented by expert knowledge contributed by ITA and domain specialists involved in the project. The comparison table is structured to evaluate digital technology suppliers across several key dimensions. The first row indicates whether the supplier is classified as an SME (Small or Medium-sized Enterprise), providing insight into its scale and potential agility in innovation. The second row specifies whether the supplier is based in the European Union or outside it, which is relevant for regulatory alignment and funding considerations. The Application Field row highlights the focus areas or challenges the supplier addresses, such as digital transformation, infrastructure issues, or market dependencies. The Description section summarizes the supplier's core offerings and technological capabilities, particularly their contributions to modern mobility solutions like AI, MaaS platforms, and intermodal services. The Technology Resilience Support row explains how the supplier's technology helps improve the resilience of transport systems, such as by enabling flexibility or seamless travel. Resilience Capabilities identifies the specific operational strengths supported by the technology, like visibility, adaptability, or efficiency. Finally, the Adoption Barriers row outlines potential obstacles to implementing the supplier's solutions, including integration challenges, public acceptance, and concerns related to interoperability and data privacy.

2.2.1 Artificial Intelligence (AI)

Artificial Intelligence refers to systems capable of simulating human intelligence processes such as learning, reasoning, and self-correction. In supply chains, AI improves capabilities like demand forecasting, anomaly detection, predictive maintenance, inventory optimization, and decision automation. These capabilities are critical in helping ecosystems adapt to sudden market changes, resource constraints, and infrastructure disruptions.

Table 1: AI Technology Suppliers – Textile Ecosystem:

Textile				
list of potential suppliers	Blue Yonder	o9 Solution	Smartex	Robotextile
SME	No	No	YES	YES
EU/non-EU	Non-EU	Non-EU	EU	EU
Application Field	Demand Forecasting	Supply Chain Optimization	Low Digital Maturity	Skilled Labor Shortages
Description	*AI-Powered Demand Forecasting Helps Adjust Production Based on Market Trends. *Machine Learning for Quality Control Allows Dynamic Response to Quality Issues. Predictive Maintenance Ensures Quick Adaptation to Machinery Issues. *Supply Chain Optimization Tools Provide Real-Time Tracking and Transparency Across the Supply Chain. IOT And AI Integration Improves Data Visibility from Production to Delivery. *AI In Inventory Management Reduces Waste and Optimizes Stock Levels. Robotic Process Automation *Automates Routine Tasks, Increasing Operational Efficiency.			
Technology-Resilience Support	*AI-Powered Demand Forecasting. *Machine Learning for Quality Control. Predictive Maintenance with AI *Supply Chain Optimization Tools. IOT And Ai Integration			
Resilience Capabilities	*Adaptability & Flexibility *Visibility			
Adoption Barriers	High Implementation Cost, Data Privacy Concerns, Integration with Legacy Systems, Need for Skilled Personnel			

Table 2: AI Technology Suppliers – Agri-food Ecosystem

Agrifood				
list of potential suppliers	Blue River Technology	Prospera Technologies	CropX	CeresAI
SME	Yes	Yes	Yes	Yes

EU/non-EU	Non-EU	Non-EU	Non-EU	EU
Application Field	Demand Forecasting	Demand Forecasting	Demand Forecasting	Predictive Maintenance
Description	*AI-Driven Predictive Analytics Improves Demand Forecasting and Optimizes Supply Chains in Agriculture. *AI Solutions Enable Real-Time Analysis of Crop Performance and Demand Patterns. *AI-Based Soil Monitoring Tools Provide Data for Better Forecasting and Crop Management. *Supports Predictive Maintenance, Reducing Downtime and Increasing Equipment Efficiency. *Provides A Web-Based Operating System Empowering Farmer to Maximize Field Profitability Through Real-Time.			
Technology -Resilience Support	*Predictive Analytics, Machine Learning *Predictive Analytics, Crop Monitoring AI *Soil Data AI Analytics *Predictive Maintenance with AI *AI-Driven Analytics for Proactive Issue Detection and Resource Optimization			
Resilience Capabilities	Adaptability & Flexibility	Adaptability & Flexibility	Adaptability & Flexibility	Efficiency
Adoption Barriers	*Data Privacy, Infrastructure Costs, Skill Gaps *Integration Complexity, High Implementation Costs *High Costs of Deployment, Data Reliability Issues *Integration With Legacy Systems, Training Needs *Initial Setup Costs, Training Requirements for Effective Utilization			

Table 3 : AI Technology Suppliers – Digital Ecosystem

Digital		
list of potential suppliers	ioki	Siemens Mobility
SME	Yes	No
EU/non-EU	Eu	Eu
Application Field	Digital Maturity, Customer Overdependence	Technological Disruptions, Infrastructure Disruptions
Description	*Offers AI-Powered On-Demand Mobility Solutions and Ride-Pooling Platforms, Focusing on Integrating Autonomous Vehicles into Public Transport. *Provides Digital Maas Solutions That Integrate Public Transport and New, Shared Mobility Services, Offering Intermodal Route Planning and Ticketing.	

Technology -Resilience Support	*Improve Public Transportation by Providing Flexible, Demand-Responsive E-Mobility Services. *Facilitates Seamless Travel Experiences Through Integrated Digital Platforms	
Resilience Capabilities	Visibility, Efficiency	Adaptability, Efficiency
Adoption Barriers	*Adoption In Traditional Transport Networks, Public Acceptance *System Interoperability, Data Privacy Concerns.	

Table 4 : AI Technology Suppliers – Automotive Ecosystem

Automotive			
list of potential suppliers	NVIDIA	Mobileye	Impel
SME	No	Yes	Yes
EU/non-EU	Non-EU	Non-EU	Non-EU
Application Field	Technological Disruptions, Infrastructure Disruptions	Technological Disruptions, Low Digital Maturity	Customer Overdependencies, Low Digital Maturity
Description	*Provides AI-Powered Solutions for Autonomous Driving, Manufacturing Process Optimization, And In-Vehicle Experiences. *Provides AI-Driven Computer Vision Solutions for Automotive Manufacturing and Autonomous Vehicles. *Offers AI-Powered Customer Lifecycle Management Platforms for the Automotive Industry.		
Technology -Resilience Support	*Improves Vehicle Automation and Factory Efficiency Through Advanced AI Computing Platforms. *Supports Manufacturing Precision and Quality Inspections Through AI And Machine Learning. *Improves Customer Engagement and Sales Processes Through AI-Driven Insights and Automation.		
Resilience Capabilities	Adaptability, Efficiency	Adaptability, Efficiency	Visibility, Efficiency
Adoption Barriers	*High Implementation Costs, Integration Complexity *High Implementation Costs, Need for Specialized Expertise *Integration With Existing CRM Systems, Data Security Concerns		

The mapping table highlights the widespread application of AI across supply chains, with use cases ranging from predictive maintenance and demand forecasting to customer engagement and autonomous decision-making. EU-based SMEs demonstrate strong innovation capacity, especially in niche applications like textile inspection and agriculture monitoring. Barriers such as data privacy, integration complexity, and implementation cost

remain common across sectors, but resilience benefits in terms of adaptability, visibility, and efficiency are consistently reported.

2.2.2 Digital Twin

Digital Twin technology involves creating virtual replicas of physical systems that allow real-time monitoring, simulation, and optimization. In the context of supply chains and industrial ecosystems, Digital Twins are used to evaluate operational strategies, forecast the impact of disruptions, and improve infrastructure planning. This technology is especially impactful in mobility and automotive ecosystems, where system complexity, time-critical decisions, and high infrastructure costs demand simulation-based insights.

Table 5 : Digital Twin Suppliers – Digital Ecosystem

Digital			
list of potential suppliers	AnyLogic	Aimsun	PTV Group
SME	Yes	Yes	No
EU/non-EU	Non-EU	EU	EU
Application Field	Technological Disruptions, Infrastructure Disruptions		
Description	*Simulate Traffic Flow to Optimize Road Design and Planning. Visual Tools Highlight Congestion and Bottlenecks. Uses Real-Time Data and Scenario Analysis. *Unified City/Regional Mobility Modelling Platform Showing Multimodal Transport at Any Scale. *Simulates Traffic Patterns to Evaluate Transport Infrastructure and Reduce Congestion/Emissions.		
Technology -Resilience Support	*Improve Mobility Decision-Making		
Resilience Capabilities	Adaptability, Efficiency, Visibility	Adaptability, Efficiency, Visibility	Adaptability, Efficiency, Visibility
Adoption Barriers	*Standardization Challenges, Training Needs		

Table 6 : Digital Twin Suppliers – Automotive Ecosystem

Automotive			
list of potential suppliers	Siemens	Rockwell Automation	Royal HaskoningDHV
SME	No	No	No
EU/non-EU	Eu	Non-Eu	Eu

Application Field	*Process Optimization, Predictive Maintenance		
Description	* Simulates Machines, Lines, Or Full Factories in Real Time to Optimize Production Workflows Before Physical Implementation. *Emulates Production Lines, Supports Training in Virtual Environments, And Simulates Performance Changes. *Immersive 3D Models And “What-If” Simulations to Uncover Business Insights and Optimize Production.		
Technology -Resilience Support	* Process Optimization Through Digital Twin		
Resilience Capabilities	Adaptability, Efficiency, Visibility	Adaptability, Efficiency, Visibility	Adaptability, Efficiency, Visibility
Adoption Barriers	* Integration With Legacy Systems, Training Needs		

The suppliers mapped under Digital Twins demonstrate the technology’s role in enhancing decision making, predictive simulation, and system optimization. Applications span city wide mobility planning and factory level automation. EU providers dominate the landscape, especially in mobility Modelling, while adoption barriers primarily involve integration with legacy infrastructure and the need for workforce training. Nonetheless, digital twins show high alignment with resilience attributes such as adaptability, efficiency, and visibility.

2.2.3 Internet of Things (IoT)

Internet of Things technologies enable physical assets across the supply chain to communicate in real time through sensors, devices, and platforms. In manufacturing, logistics, and agriculture, IoT improves visibility, automates workflows, enables condition-based monitoring, and supports predictive decision-making. IoT is central to resilience strategies involving real-time traceability, resource optimization, and automated response to disruptions.

Table 7: IoT Technology Suppliers – Textile Ecosystem

Textile			
list of potential suppliers	Siemens AG	UBI Solutions	Datatex
SME	No	Yes	No
EU/non-EU	EU	EU	EU
Application Field	Low Digital Maturity, Infrastructure Disruptions	Low Digital Maturity, Environmental Crises	Skilled Labor Shortages, Low Digital Maturity
Description	*Smart Factory Integration with Edge-Enabled Real-Time Machine Health Monitoring		

	*RFID/BLE Tagging & Sensor Network for Full Traceability and Resource Tracking *ERP-Integrated Shop-Floor Sensors Feeding Real-Time Production Dashboards		
Technology-Resilience Support	Unified Visibility and Predictive-Maintenance Alerts	End-To-End Digitization of Workflows and Resource Monitoring	Automatic Metrics Capture for Planning and Quality Control
Resilience Capabilities	Adaptability, Efficiency	Visibility, Redundance, Market Strength	Efficiency, Respond
Adoption Barriers	*Legacy System Integration, High Implementation Cost *Connectivity Challenges, Supplier Participation Reluctance *ERP Integration Complexity, Scalability Constraints		

Table 8 : IoT Technology Suppliers – Agri-food Ecosystem

Agrifood				
list of potential suppliers	LIBELIUM	SENSEFARM	Plantae	Altim
SME	Yes	Yes	Yes	Yes
EU/non-EU	EU	EU	EU	EU
Application Field	Low Digital Maturity, Environmental Crises	Skilled Labor Shortages, Environmental Crises, Tech. Disruptions	Environmental Crises, Infrastructure Disruptions	Regulatory Compliance, Health Crises, Infrastructure Disruptions
Description	Dashboard-linked automation for input efficiency	Full automation of farm climate and irrigation systems	Tracking visibility in logistics using satellite	Real-time visibility and traceability through IoT & blockchain
Technology-Resilience Support	* Dashboard-linked automation for input efficiency *Full automation of farm climate and irrigation systems *Tracking visibility in logistics using satellite/cellular *Health monitoring and alerts via IoT platform *Real-time visibility and traceability through IoT & blockchain			
Resilience Capabilities	Efficiency, Adaptability	Efficiency, Adaptability, Respond	Visibility, Respond	Efficiency, Transform, Market Strength
Adoption Barriers	*Upfront cost, Connectivity *High CAPEX, Integration complexity, Maintenance Network coverage, Regulation *User resistance, Maintenance needs			

Agrifood	
	*Customization complexity, High upfront cost

Table 9 : IoT Technology Suppliers – Automotive Ecosystem

Automotive			
list of potential suppliers	Sisteplant	Impinj	Comau
SME	Yes	No	No
EU/non-EU	Eu	Non-Eu	Eu
Application Field	Low Digital Maturity, Infrastructure Disruptions, Skilled Labour Shortages	Low Digital Maturity, Customer Overdependencies	Skilled Labour Shortages, Technological Disruptions
Description	* MES With Lot Dashboards, Predictive Maintenance, Remote Work-Order Guidance *RAIN RFID For Real-Time Part Location & Rerouting *Lot-Connected Robotics with Self-Diagnosis and Plug-And-Play Architecture		
Technology-Resilience Support	Unified Production-Line Digitization & Automated Alerts	Real-Time Status Tracking of Components	Adaptive Robotics with Flexible Hardware/Software Integrations
Resilience Capabilities	Efficiency, Respond	Visibility, Efficiency, Redundance	Adaptability, Efficiency, Transform
Adoption Barriers	* Integration Complexity, Workforce Training Gap *Data Security Concerns *Legacy Equipment Compatibility, Cybersecurity Needs		

IoT solutions across ecosystems focus on real-time monitoring, traceability, and automation. Suppliers offer technologies ranging from sensor-based data collection to predictive analytics. The mapping reveals strong participation from EU-based SMEs, particularly in the agri-food and automotive sectors. Key resilience capabilities include visibility and operational efficiency, while adoption challenges relate to connectivity, data integration, and regulatory compliance.

2.2.4 Blockchain

Blockchain is a distributed ledger technology that enables secure, transparent, and tamper-proof data sharing across supply chains. In the context of supply chain resilience, it supports traceability, authenticity verification, automated compliance, and secure decentralized transactions. The technology's role is crucial for increasing visibility, ensuring

data integrity, and enabling efficient collaboration across ecosystems, particularly where trust and multi-stakeholder verification are need

Table 10 : Blockchain Technology Suppliers – Textile Ecosystem

Textile				
list of potential suppliers	Textile Genesis	Aura Blockchain Consortium	Provenance	icommunity
SME	Yes	No	Yes	Yes
EU/non-EU	Non-EU	Non-EU	Non-EU	EU
Application Field	Tech. Disruptions, Environmental Crises	Technology & Infrastructure. Disruptions	Regulatory Compliance, Environmental Crises	Low Digital Maturity, Tech. Disruptions
Description	Fiber Traceability and Cryptographic Verification for Premium Textiles	Full Lifecycle Authenticity & Compliance with Smart Contracts	Sustainability Claims Auditing and Tokenized Credentials	Plug-And-Play Blockchain-As-A-Service (Baas) For Fast Traceability
Technology-Resilience Support	* End-To-End Traceability, Verified Authenticity *Decentralized Transparency, Automated Compliance *Tokenized Sustainability, Real-Time Auditing *Multi-Chain Baas with Interoperability			
Resilience Capabilities	Visibility, Adaptability, Efficiency	Visibility, Market Strength, Transform	Visibility, Efficiency, Adaptability	Visibility, Efficiency, Transform
Adoption Barriers	*High Cost, Stakeholder Literacy *Interoperability, Regulation, Brand Reluctance *Data Privacy, Resistance to Change *Security Concerns			

Table 11 : Blockchain Technology Suppliers – Agri-food Ecosystem

Agrifood				
list of potential suppliers	OpenSC	AgriDigital	Llanthu	ORIGIN CHAIN networks
SME	Yes	Yes	Yes	Yes
EU/non-EU	Non-EU	Non-EU	Non-EU	EU
Application Field	Regulation, Environment, Infrastructure.	Low Digital Maturity, Infrastructure.	Regulatory Compliance, Infrastructure.	Tech., Environmental, Health Crises

Description	Verifies Ethical and Sustainable Sourcing Through Immutable Records	Grain Tracking with Tokenized Financing and Automated Workflows	Full Traceability + Secure Producer Payments Via Blockchain	Regenerative Farming Action Proof Through NFT Minting
Technology -Resilience Support	* Immutable Ledger + Smart Contracts + Analytics *Tokenized Inventory, Blockchain Workflows *Decentralized Traceability & Automated Micropayments *NFT Minting for Action-Proof Farming			
Resilience Capabilities	Visibility, Adaptability, Efficiency	Visibility, Efficiency	Visibility, Efficiency	Visibility, Adaptability, Transform
Adoption Barriers	*Digital Literacy, Offline Sync, Lot Cost *Stakeholder Resistance, Data Privacy *Literacy Gaps, Sync Issues *Platform Interoperability, Scalability			

Table 12: Blockchain Technology Suppliers – Digital Ecosystem

Digital				
list of potential suppliers	Transchain	IoMob	Nextrope	FISTA SOLUTIONS
SME	Yes	Yes	Yes	Yes
EU/non-EU	Eu	Eu	Eu	Non-Eu
Application Field	Digital Maturity, Regulation	Infrastructure, Low Digital Maturity	Low Digital Maturity	Low Digital Maturity, Tech. Disruptions
Description	Public Blockchain for Standardized Business Communication	Decentralized Mobility Marketplace with Blockchain Payments	Peer-To-Peer Smart Parking & DLT Applications	Decentralized Ride-Sharing Platforms Via Smart Contracts
Technology -Resilience Support	* Immutable B2B Traceability for Data Exchanges *Open Mobility Services, Decentralized Booking/Payments *P2P Services with Contract-Driven Operations *Smart Contracts Enabling Secure Automated Trust			
Resilience Capabilities	Visibility, Efficiency, Market Strength	Adaptability, Visibility, Transform	Respond, Financial Strength, Transform	Efficiency, Adaptability, Visibility
Adoption Barriers	*Interoperability, Legacy Resistance *Privacy Concerns, Regulatory Approvals			

*Customization Burden, Adoption Reluctance
*High Investment, IT/OT Integration Limits

Table 13 : Blockchain Technology Suppliers – Automotive Ecosystem

Automotive				
list of potential suppliers	Aetsoft	Nextrope	FISTA SOLUTIONS	Cellport
SME	Yes	Yes	Yes	Yes
EU/non-EU	Non-EU	EU	Non-EU	Non-EU
Application Field	Data Security, Tech., Infrastructure Disruptions	Data Security, Tech., Infrastructure	Infrastructure Disruptions	Data Security, Tech. Disruptions
Description	Real-Time Part Tracking, Recall Optimization, Secure Data Ledger	Supply Chain Monitoring and Immutable Automotive Db	Full Part/Component Traceability with Cryptographic Records	Telematics Security, Decentralized Identity & Transactions
Technology –Resilience Support	* Smart Contracts Recall Alerts + Private Blockchain *Smart Contract-Driven Tracking + Immutable Data *DLT-Based Provenance & Audit Trail *Blockchain-Based Secure Identity + Commerce			
Resilience Capabilities	Adaptability, Efficiency	Respond, Financial Strength, Transform	Efficiency, Adaptability, Transform	Visibility, Redundance, Respond
Adoption Barriers	* Integration With Legacy Automotive Systems, Regulation *Expertise Gap, Performance Bottlenecks, Customization *High Investment, Integration Limits *Compliance Certification, Legacy Hurdles			

The blockchain supplier mapping shows diverse applications, including traceability, compliance automation, sustainability verification, and decentralized identity management. While many providers are SMEs, EU and non-EU firms both contribute actively. Barriers such as interoperability, regulatory uncertainty, and digital literacy are prevalent, but the technology offers strong potential for transparency, adaptability, and transformation across all studied ecosystems.

2.2.5 Data Spaces

Data Spaces are federated digital environments that allow multiple stakeholders to share, access, and control data securely and transparently. In the context of supply chain resilience, Data Spaces enable real-time visibility, data-driven collaboration, and system

interoperability, which are essential for informed decision-making during disruptions. This section maps the key organizations and platforms supporting Data Space development and integration across the textile, agri-food, and digital mobility ecosystems.

Table 14 : Data Space Technology Suppliers – Textile Ecosystem

Textile	
list of potential suppliers	EURATEX
SME	No
EU/non-EU	Eu
Application Field	Low Digital Maturity
Description	Enables Standardized Data Sharing Across Textile Supply Chains
Technology-Resilience Support	Interoperable Digital Platforms
Resilience Capabilities	Visibility
Adoption Barriers	Integration With Legacy ERP Systems

Table 15 : Data Space Technology Suppliers – Agri-food Ecosystem

Agrifood		
list of potential suppliers	TraceGains	AgriDigital
SME	No	Yes
EU/non-EU	Non-EU	Non-EU
Application Field	Technological Disruptions	Infrastructure Disruptions
Description	Cloud-Based Network for Food Supply Chain Transparency and Compliance	Cloud Platform Supporting Grain Supply Chain Operations
Technology-Resilience Support	Real-Time Data Integration, Ingredient Management	Digital Contracts and Real-Time Data Sharing
Resilience Capabilities	Visibility, Compliance	Adaptability, Efficiency
Adoption Barriers	Complex Regulatory Alignment, System Onboarding	Low Connectivity Adoption Challenges

Table 16 : Data Space Technology Suppliers – Digital Ecosystem

Digital			
list of potential suppliers	Gaia-X	TNO	iShare (INNOPAY)
SME	No (Governance framework, not a technology supplier)	No	Yes
EU/non-EU	Eu	Eu	Eu
Application Field	Technological Disruptions	Customer Overdependencies	Low Digital Maturity
Description	Federated Data Infrastructure for Secure, Interoperable Maas Data	Public-Private Research for Open Mobility Data Ecosystems	Identity & Access Data Sharing Scheme for Logistics and Maas
Technology-Resilience Support	Open, Sovereign Data Spaces	Data Sharing Standards for Mobility	Interoperability Protocol for Maas Actors
Resilience Capabilities	Visibility, Adaptability	Efficiency, Visibility	Visibility
Adoption Barriers	Governance Complexity, Stakeholder Alignment	Platform Interoperability	Awareness, Standard Adoption Lag

The data space solutions identified provide the backbone for interoperable and secure data exchange across industries. While most are EU-based and tied to public private initiatives, several commercial platforms also serve niche use cases in agrifood and logistics. Resilience benefits include improved visibility, efficiency, and compliance. However, barriers such as legacy system compatibility and low standardization uptake must be addressed for broader impact.

2.2.6 5G Connectivity

5G Connectivity offers ultra-fast, low-latency, and high-bandwidth wireless communication that enables advanced supply chain applications. In digital mobility and automotive ecosystems, 5G is the foundation for real-time data exchange, autonomous operations, remote monitoring, and smart infrastructure control. The technology facilitates seamless integration of IoT devices, edge computing, and AI systems, contributing directly to resilience through adaptability, visibility, and operational efficiency.

Table 17: 5G Technology Suppliers – Digital Ecosystem

Digital				
list of potential suppliers	Nokia	Cellnex	BICS	Telit Cinterion
SME	No	No	No	Yes
EU/non-EU	Eu	Eu	Eu	Eu
Application Field	Low Digital Maturity	Infrastructure Disruptions	Customer Overdependencies	Political Conflicts & Security
Description	Network Slicing for Digital Transport and Ultra-Low Latency Use Cases	Infrastructure Sharing For 5G Mobility Applications	Seamless And Secure Connectivity for Maas Providers	Modules And 5G For Digital Transport Platforms
Technology –Resilience Support	* High-Efficiency Transport Networks with Slicing and Prioritization *Widespread Coverage Via 5G Tower Sharing *Secure Data Exchange Across Systems *Optimized & Secure Device Communication			
Resilience Capabilities	Efficiency	Redundance	Market Strength	Security, Stability
Adoption Barriers	*Rural Rollout Gaps, High Infra Requirements *Regulatory Approval Dependency *Data Privacy, Cross-Border Compliance *Cybersecurity, Geopolitical Risks			

Table 18 : 5G Technology Suppliers – Automotive Ecosystem

Automotive			
list of potential suppliers	Cellnex	Siemens	Nokia
SME	No	No	No
EU/non-EU	EU	EU	EU
Application Field	Infrastructure Disruptions	Infrastructure Disruptions	Low Digital Maturity
Description	5G Infra for Seamless Data Exchange in Automotive Logistics	Smart Factory Automation Via 5G Edge Computing And AI	Private 5G Networks for Process Optimization in Engine Production

Technology -Resilience Support	* Shared Infra for Real-Time Supply Tracking *5G-Powered AI Monitoring and Full-Line Digitization *Network Slicing For AI-Driven Logistics and Factory Automation		
Resilience Capabilities	Redundancy, Operational Efficiency	Resilience, Operational Efficiency	Efficiency, Market Strength
Adoption Barriers	*Multi-Country Rollout, Regulation *High Cost, Legacy Systems *Integration Issues in Traditional Plants		

The mapping of 5G providers illustrates their central role in enabling real-time operations in both mobility and automotive applications. Solutions focus on private networks, infrastructure sharing, and integration with IoT platforms. Despite significant potential for redundancy and operational efficiency, adoption is slowed by high deployment costs and the complexity of cross border or multi-site implementation.

2.2.7 Edge Computing

Edge computing refers to the practice of processing data near its source rather than relying solely on centralized cloud infrastructure. In the context of supply chain resilience, edge computing enables real-time decision-making, autonomous systems, and localized control, especially useful in mobility and automotive contexts. It reduces latency, improves security, and ensures continuous operations even in disconnected environments.

Table 19 : Edge Computing Suppliers – Digital Ecosystem

Digital		
list of potential suppliers	OnLogic	T-Systems
SME	Yes	No
EU/non-EU	Non-EU	EU
Application Field	Low Digital Maturity, Infrastructure Disruptions	Low Digital Maturity
Description	Offers Rugged Edge Computing Hardware for Transit and Real-Time Maas Use Cases	Provides Edge-Enabled Platforms for Multimodal Transport and Maas Integration
Technology-Resilience Support	Supports Decentralized Processing and Local Intelligence at the Edge	Real-Time Multimodal Service Delivery and Data Processing
Resilience Capabilities	Efficiency, Visibility	Visibility, Adaptability
Adoption Barriers	Customization And Support Needs	Complex System Deployment, Interoperability Issues

Table 20 : Edge Computing Suppliers – Automotive Ecosystem

Automotive		
list of potential suppliers	Cisco Systems	Rittal
SME	No	No
EU/non-EU	Non-EU	Non-EU
Application Field	Technological Disruptions, Infrastructure Disruptions	Technological Disruptions, Infrastructure Disruptions
Description	Distributed Edge Platforms for Secure, Real-Time Vehicle Manufacturing	Industrial Edge Data Centres Designed for Factory Automation and Data Processing
Technology-Resilience Support	Low-Latency, Secure Factory Data Handling, Supporting Real-Time Production Responsiveness	On-Site Analytics and IT Processing Close to Production Asset
Resilience Capabilities	Efficiency, Adaptability	Efficiency, Adaptability
Adoption Barriers	High Implementation Cost, Integration Complexity	Space Constraints, Integration with Existing Systems

Edge computing suppliers emphasize the value of local data processing to reduce latency and improve responsiveness. In both digital and automotive sectors, edge systems are shown to support real-time monitoring and decentralized control. Most suppliers are non-EU multinationals, though SMEs also play a role in mobility solutions. Key challenges include integration complexity and infrastructure needs.

2.2.8 AR/VR

Augmented Reality (AR) and Virtual Reality (VR) technologies enable immersive interaction with digital information in physical or simulated environments. In supply chains, AR/VR supports training, layout planning, remote assistance, product visualization, and user navigation. Their integration improves adaptability, efficiency, and transformational capabilities in customer engagement, operations, and workforce development.

Table 21 : AR/VR Technology Suppliers – Textile Ecosystem

Textile				
list of potential suppliers	Wearfits	Innowise	Vuzix	Hellmann
SME	Yes	No	No	No
EU/non-EU	Eu	Eu	Non-Eu	Eu
Application Field	Technological Disruptions			

Textile				
list of potential suppliers	Wearfits	Innowise	Vuzix	Hellmann
Description	AR And AI Platform for Virtual Clothing Try-Ons and Shopping Personalization	Immersive VR Exhibitions And AR-Based Retail Improvements	AR Smart Glasses for Warehousing and Remote Support	VR Software for Warehouse Layout Planning and Simulation
Technology-Resilience Support	* Real-Time AR And 3D Avatar Try-Ons *VR And AR To Improve Customer and Staff Interaction *Visual AR Guidance for Manufacturing and Logistics Tasks *Virtual Warehouse Planning with Scenario Testing			
Resilience Capabilities	Market Strength	Market Strength, Transform	Adaptability, Efficiency	Adaptability, Efficiency
Adoption Barriers	*Data Privacy, Legacy Integration *Infrastructure Costs *Acquisition Cost, Training Needs *Acquisition Cost, Training Needs			

Table 22 : AR/VR Technology Suppliers – Digital Ecosystem

Digital				
list of potential suppliers	Moovit	WayRay	arvision	Meta Reality Labs
SME	No	No	Yes	No
EU/non-EU	Non-EU	Non-EU	EU	Non-EU
Application Field	Technological Disruptions			
Description	AR-Based App to Help Users Locate Transit Stations Easily	In-Vehicle AR For Navigation, Entertainment, And Task Support	AR Apps for Public Transport to Inform and Guide Users	Immersive Mobility AR Co-Developed with BMW To Improves Driving UX
Technology-Resilience Support	* Real-Time AR Overlays for Public Transport Orientation *AR To Enrich and Secure Driver and Passenger Experiences *Mobile AR For Interactive User Engagement *Automotive AR For Navigation and Contextual Awareness			

Resilience Capabilities	Adaptability, Visibility	Market Strength, Transform	Adaptability, Efficiency	Market Strength, Transform
Adoption Barriers	*Limited AR/VR Integration *Hardware Cost, Regulatory Challenges *User Adoption Reluctance *High Development Cost, Data Privacy Risks			

AR/VR technologies provide immersive, interactive capabilities for customer engagement, training, and layout planning. The supplier landscape includes both global and EU-based SMEs, especially in the textile and digital mobility domains. While the resilience potential is strong particularly for adaptability and transformation adoption is limited by hardware costs, training requirements, and user acceptance.

2.2.9 Robotic

Robotic technologies improve manufacturing efficiency, safety, and flexibility by automating repetitive or hazardous tasks. In supply chains, robotics contributes to resilience by ensuring consistent performance, reducing labour dependency, and enabling faster recovery during disruptions. In the textile and automotive sectors, robotics supports processes like cutting, sewing, material handling, welding, and engine assembly, improving operational reliability and scalability.

Table 23: Robotics Suppliers – Textile Ecosystem

Textile				
list of potential suppliers	ABB Robotics	Robotextile	Yaskawa Robotics	Stäubli Robotics
SME	No	No	Yes	No
EU/non-EU	Eu	Eu	Eu	Eu
Application Field	Technological Disruptions, Skilled Labour Shortages	Low Digital Maturity, Environmental Crises	Skilled Labor Shortages, Customer Overdependencies	Technological Disruptions, Skilled Labor Shortages
Description	Robotic Systems for Cutting, Sewing, And Material Handling in Textile Manufacturing	AI-Driven Robotic Solutions for Sorting, Recycling, And Automation	High-Speed Robotic Arms for Fabric Manipulation and Stitching	Precision Robotics for Weaving, Cutting, And High-Volume Textile Operations
Technology –Resilience Support	* Robotic Automation for Textile Production Workflows *Ai-Integrated Robots for Production and Recycling Processes *Robotic Solutions to Replace Repetitive Labour			

	*Advanced Robotic Systems for Large-Scale, High-Precision Textile Processes			
Resilience Capabilities	Efficiency, Adaptability	Visibility, Efficiency	Operational Efficiency	Market Strength, Efficiency
Adoption Barriers	*High Investment, Workforce Retraining, System Integration *Integration Issues, Resistance in Legacy Factories *Job Displacement Concerns, Training Needs *Maintenance Costs, Workforce Training for Advanced Robotics			

Table 24 : Robotics Suppliers – Automotive Ecosystem

Automotive			
list of potential suppliers	Comau Robotics	Fanuc Robotics	Vuletech
SME	No	No	Yes
EU/non-EU	Eu	Non-Eu	Non-Eu
Application Field	Infrastructure Disruptions, Technological Disruptions	Skilled Labour Shortages, Customer Overdependencies	Skilled Labour Shortages, Technological Disruptions
Description	Robotic Machining, Assembly, And Testing for Car Engines and Components	Full Robotic Systems for Powertrain Manufacturing and Inspection	Custom Industrial Robots for Welding, Painting, And Assembly in Automotive Plants
Technology -Resilience Support	*AI-Enabled Robotic Production for Flexible Automotive Manufacturing *Precision Robotic Processes to Reduce Labour Demand *Robotic Automation to Enhance Safety and Reduce Operational Bottlenecks		
Resilience Capabilities	Operational Efficiency, Market Strength	Efficiency, Market Strength	Efficiency, Safety
Adoption Barriers	High Setup Cost, Complex Customization	Expensive Maintenance, Skilled Workforce Needed	Tech Integration Hurdles, Workforce Training Demands

Robotic systems across the textile and automotive industries improve production efficiency, quality control, and labour substitution. EU providers dominate the textile sector, while global leaders support complex automotive applications. Despite the benefits in operational efficiency and adaptability, barriers such as investment cost and workforce retraining pose persistent adoption challenges.

2.2.10 3D Printing

3D printing also known as additive manufacturing enables decentralized, rapid, and customizable production. In supply chain resilience, it reduces lead times, minimizes overproduction, and allows on demand manufacturing, particularly useful in textiles for personalized design and in agrifood for packaging, tooling, and even food preparation. 3D printing improves adaptability, innovation, and compliance with changing customer demands and regulatory environments.

Table 25 : 3D Printing Suppliers – Textile Ecosystem

Textile			
list of potential suppliers	VARIANT3D	Sculpteo	Stratasys
SME	Yes	Yes	No
EU/non-EU	Non-EU	EU	Non-EU
Application Field	Technological Disruptions, Environmental Crises	Low Digital Maturity, Customer Overdependencies	Technological Disruptions
Description	Zero-Waste, Hyperlocal 3D Knitting Via LOOP™ CAD/CAM Software	Custom 3D Printing for Textile Design and Rapid Prototyping	Industrial-Scale 3D Printing for Prototyping and Textile Fabrication
Technology -Resilience Support	Sustainable, Integrated Design-To-Production Loop	Flexible Material Uses and Online Service Integration	High-Precision, On-Demand Production
Resilience Capabilities	Adaptability, Efficiency	Flexibility, Innovation	Adaptability, Flexibility
Adoption Barriers	*Integration With Legacy Manufacturing, High Initial Cost *Material And Design Limitations *High Cost, Technical Expertise Required		

Table 26 : 3D Printing Suppliers – Agri-food Ecosystem

Agrifood			
list of potential suppliers	Oceanz	byFlow	Materialise
SME	Yes	Yes	No
EU/non-EU	EU	Non-EU	Non-EU
Application Field	Technological Disruptions,	Technological Disruptions, Skilled Labor Shortages	Tech. Disruptions, infrastructure. Disruptions, Low Digital Maturity

	Customer Overdependencies		
Description	Food-Safe 3D Printed Machine Parts, Prototypes, And Packaging	Portable 3D Food Printer for Chefs and Caterers	3D Printing of Packaging, Tooling, Fixtures for Food Production
Technology -Resilience Support	EC 1935/2004-Compliant Rapid Part Manufacturing	Customized Dish Design and Food Personalization	Efficient Tooling and Equipment Prototyping
Resilience Capabilities	Adaptability, Compliance	Customization, Technological Advancement	Adaptability, Efficiency, Visibility
Adoption Barriers	Compliance Certification, Material Limits	High Cost, Niche Applicability	Initial Investment, Tech Knowledge, Material Compatibility

The mapping of 3D printing suppliers shows strong use cases for flexible, localized, and sustainable manufacturing. Textile applications emphasize prototyping and custom design, while agri-food solutions target packaging, tooling, and even food printing. SMEs led innovation in this space, though material compatibility, regulatory approval, and equipment cost remain key barriers.

2.3 Mapping Critical Factors to Technologies

This section builds upon the conceptual groundwork established in Task 2.1 by translating identified critical factors and disruption events into a technology driven resilience strategy. By combining the structural insights from supply chain models with real-world scenarios, the process establishes clear connections between weaknesses and potential digital interventions. Each disruption identified in the T2.1 whether caused by material shortages, delays, or limited supplier flexibility is contextualized within its ecosystem and linked to specific technologies that can mitigate its effects.

To operationalize this mapping, we introduce a structured table that includes the main critical factor, the corresponding disruption event, and a curated list of potential technology suppliers. As a concrete case, some examples from the Textile ecosystem are represented here. Key disruptions such as unreliable upstream suppliers and fluctuating demand are mapped to enabling technologies like AI-based forecasting, blockchain traceability, and IoT-enabled monitoring. This approach supports the creation of a technology catalogue that is both ecosystem-specific and actionable, providing a foundation for resilience-oriented decision-making.

Table 27 :Mapping of AI Technologies to Critical Factors in the Textile Ecosystem

Artificial Intelligence (AI)				
Textile				
list of potential suppliers	Blue Yonder	o9 Solutions	Smartex	Robotextile
SME	Yes	Yes	No	Yes
EU/non-EU	EU	Non-EU	Non-EU	EU
Main Critical Factor	T.6 Supplier and customer concentration (overdependencies) T.7 Global and complex supply chains (decentralization of supply and demand)	T.4 Technological disruptions and low digital maturity T.5 Challenges in sustaining existing business model	T.7 Global and complex supply chains (decentralization of supply and demand) T.2 Environmental crises and natural disasters	T.4 Technological disruptions and low digital maturity
Distribution Event	T6.1. Lack of visibility and interactions; Lack of communication T.7.2. High dependency from suppliers located outside of EU for some of the most important materials and components (such as fibers, yarn, and fabric)	T.4.1. Time-consuming activities and outdated technologies no longer supported T4.2. Information systems not interconnected with each other T 5.1 Inflexible business model	T.7.1 Difficulties in controlling the environmental footprint and robustness of supply chains T.7.2 Lack of visibility and interactions; Lack of communication T.2.3 Damaged materials /final products	T.4.1 Time-consuming activities and outdated technologies no longer supported T.4.2 The old product design and the lack of innovation prospects

Table 28: Mapping of IoT Solutions to Disruption Events in the Textile Ecosystem

Internet of Things (IoT)			
Textile			
list of potential suppliers	Siemens AG	UBI Solutions	Datatex
SME	No	Yes	No
EU/non-EU	EU	EU	EU
Main Critical Factor	T.4 Technological disruptions and low digital maturity	T.2 Environmental crises and natural disasters T.4 Technological disruptions and low digital maturity T.7 Global and complex supply chains (decentralization of supply and demand)	T.8 Skills gaps T.3 Political conflicts and crises T.1 Health and pandemic disruptions
Distribution Event	T.4.1 Information systems not interconnected with each other T 4.2 Time-consuming activities and outdated technologies no longer supported T 4.3 Data sharing may raise regulatory compliance concerns.	T 2.1 Interruption along the Supply Network due to environmental crisis T 4.2 Information systems not interconnected with each other T 7.3 Lack of visibility and interactions (both upstream and downstream) T 7.4 Issues related to product traceability and origin.	T 8.1 Lack of specialized employees T 8.2 High turnover T 3.3 Staff availability issues (Strikes) T 1.4 Staff availability issues (Illness)

Table 29: Mapping of Block Chain Solutions to Disruption Events in the Textile Ecosystem

Block Chain				
Textile				
list of potential suppliers	Textile Genesis	Aura Blockchain Consortium	Provenance	community
SME	Yes	No	Yes	Yes
EU/non-EU	Non-EU	Non-EU	Non-EU	EU
Main Critical Factor	T.2 Environmental crises and natural disasters	T.7 Global and complex supply chains (decentralization)	T.9 Waste T. 10 Infrastructure	T.5 Challenges in sustaining existing

	T.4 Technological disruptions and low digital maturity T.7 Global and complex supply chains (decentralization of supply and demand)	n of supply and demand) T.4 Technological disruptions and low digital maturity T.9 Waste	and Logistics Disruptions	business model T.4 Technological disruptions and low digital maturity
Distribution Event	T 2.1 Interruption along the Supply Network due to environmental crisis T 4.2 Information systems not interconnected with each other T 7.3 Lack of visibility and interactions (both upstream and downstream) T 7.4 Issues related to product traceability and origin.	T 4.1 Information systems not interconnected between different actors of the Supply Network T 7.2 Lack of visibility and interactions (both upstream and downstream) T 9.3 Poor visibility in the tracking of the disposal phase	T 9.1 Poor visibility in the tracking of the disposal phase T 10.2 Environmental regulations T 10.3 Negative public perception (Greenwashing)	T 5.1 Difficulty in keeping up with new market demands T 5.2 Inflexible business model T 4.3 Time-consuming activities and outdated technologies no longer supported T 4.4 The old product design and the lack of innovation prospects

Table 30: Mapping of Data Space Technologies to Critical Factors in the Textile Ecosystem

Data Space	
Textile	
list of potential suppliers	EURATEX
SME	No
EU/non-EU	Eu
Main critical Factor	

Disruption Event	T.4 Technological disruptions and low digital maturity (T 4.1 Information systems not interconnected with each other) T.7 Global and complex supply chains (T 7.2 Difficulties to control the environmental footprint and robustness of supply chains)
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Table 3i: Mapping of AR/VR Technologies to Critical Factors in the Textile Ecosystem

AR/VR				
Textile				
list of potential suppliers	Wearfits	Innowise	Vuzix	Hellmann
SME	Yes	No	No	No
EU/non-EU	Eu	Eu	Non-Eu	Eu
Main Critical Factor	T.7 Global and complex supply chains (decentralization of supply and demand) T.5 Challenges in sustaining existing business model	T.7 Global and complex supply chains (decentralization of supply and demand) T.5 Challenges in sustaining existing business model T. 8 Skills Gaps	T. 8 Skills Gaps	T. 8 Skills Gaps T.10 Infrastructure and Logistics Disruptions
Distribution Event	T 7.1 Lack of visibility and interactions with the final customer T 7.2 Lack of personalized customer service results in poor public perception. T 5.3 Difficulty in keeping up with new market demands	T 7.1 Lack of visibility and interactions with the final customer T 7.2 Lack of personalized customer service results in poor public perception. T 5.3 Difficulty in keeping up with new market demands T 8.4 A shortage of specialized employees and difficulties in training new staff make workforce	T 8.1 Lack of specialized employee T 8.2 Time-consuming manual tasks with a high risk of error T 8.3 Limited access to shared information and procedures within the parent company is a critical factor impacting operational efficiency.	T 8.1 High number of accidents at work T 10.2 Fast Transports and DE located Suppliers T 10.3 Environmental regulations

	T 7.4 Difficult to forecast final demand	development challenging.	T 8.4 High number of accidents at work	
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Table 32: Mapping of Robotic Technologies to Critical Factors in the Textile Ecosystem

Robotic				
Textile				
list of potential suppliers	ABB Robotics	Robotextile	Yaskawa Robotics	Stäubli Robotics
SME	No	No	Yes	No
EU/non-EU	Eu	Eu	Eu	Eu
Main Critical Factor	T.1 Health and pandemic disruptions T.8 Skills gaps T.4 Technological disruptions and low digital maturity	T.9 Waste T.8 Skills gaps T.4 Technological disruptions and low digital maturity	T.1 Health and pandemic disruptions T.8 Skills gaps T.4 Technological disruptions and low digital maturity	T.1 Health and pandemic disruptions T.8 Skills gaps T.4 Technological disruptions and low digital maturity
Distribution Event	T.1.1 Staff availability issues (Illness) T.4.2 Time-consuming activities and outdated technologies no longer supported T 8.3 Lack of specialized employee T 8.4 Skill Shortage in Digital and Green Industry Transition	T.9.1 Difficulties in recycling specific types of products (e.g.: fibers because of the blended composition) T.4.2 Time-consuming activities and outdated technologies no longer supported T 8.3 Lack of specialized employee T 8.4 Skill Shortage in Digital and Green Industry Transition	T.1.1 Staff availability issues (Illness) T.4.2 Time-consuming activities and outdated technologies no longer supported T 8.3 Lack of specialized employee T 8.4 Skill Shortage in Digital and Green Industry Transition	T.1.1 Staff availability issues (Illness) T.4.2 Time-consuming activities and outdated technologies no longer supported T 8.3 Lack of specialized employee T 8.4 Skill Shortage in Digital and Green Industry Transition

Table 33: Mapping of 3D Printing Technologies to Critical Factors in the Textile Ecosystem

3D Printing			
Textile			
list of potential suppliers	VARIANT3D	Sculpteo	Stratasys
SME	Yes	Yes	No
EU/non-EU	Non-EU	EU	Non-EU
Main Critical Factor	T.9 Waste T. 10 Infrastructure and Logistics Disruptions	T.6 Supplier and customer concentration (overdependencies) T.7 Global and complex supply chains (decentralization of supply and demand) T.10 Infrastructure and Logistics Disruptions	T.7 Global and complex supply chains (decentralization of supply and demand) T.8 Skills gaps T.9 Waste
Distribution Event	T 9.1 Poor visibility in the tracking of the disposal phase T 10.2 Environmental regulations T 10.3 Negative public perception (Greenwashing) T 10.4 Difficulties in recycling specific types of products (e.g.: fibers because of the blended composition)	T 6.1 High dependency from suppliers located outside of EU for some of the most important material and components (such as fibers, yarn, and fabric) T 10.2 Negative public perception (Greenwashing) T 7.3 Lack of visibility and interactions (both upstream and downstream); Lack of communication	7.1 Lack of visibility and interactions (both upstream and downstream); Lack of communication T 8.2 Lack of specialized employees T 9.3 High levels of waste generated during production

3 Supplier Analysis

This section presents the structured methodology used to identify, evaluate, and compare technology providers relevant to the resilience needs of supply chains. The goal of this analysis is not only to map existing providers but to also scout alternative suppliers and assess their reliability and quality, enabling ecosystem actors to make informed adoption decisions.

3.1 Methodology for identifying suppliers

To ensure a robust and comprehensive supplier mapping, the process adopted a multi-phase methodology based on research, expert consultation, and cross-validation with technology use cases derived from the models developed in Work Package 2.2.

3.1.1 Scope of technology domains

Ten key technology domains were defined by the project consortium based on their relevance to supply chain resilience, digital transformation, and strategic autonomy:

- AI
- Digital Twin
- IoT
- Blockchain
- Data Spaces
- 5G Connectivity
- Edge Computing
- Augmented/Virtual Reality (AR/VR)
- Robotics
- 3D Printing

These domains were selected based on their potential to mitigate key vulnerabilities (e.g., demand shocks, infrastructure disruptions, skilled labour shortages, low digital maturity), and their demonstrated role in improving visibility, adaptability, flexibility, and efficiency across supply chains.

The supplier identification process considered both EU-based and international providers, with a special emphasis on SMEs offering cutting-edge. Inclusion was guided by technological relevance, operational readiness, and alignment with the resilience gaps mapped in each ecosystem (textile, agri-food, digital mobility, automotive).

3.1.2 Evaluation framework and criteria

Suppliers were assessed using a unified evaluation template to ensure comparability across sectors and technology domains. Each entry was filled with data from official websites, whitepapers, public registries, and where available, case studies or deployment examples. The evaluation criteria included:

- SME Status: Whether the supplier qualifies as a Small or Medium-sized Enterprise under EU definitions.
- Geographical Location: EU vs. non-EU location, to support strategic considerations around supply control and regional sourcing.
- Critical Factors Addressed: Disruption types the technology addresses (e.g., infrastructure failure, low digital maturity, customer dependency, environmental or regulatory risks).

- **Solution Description:** A short summary of the technology's purpose, deployment scope, and innovation level.
- **Technology Resilience Support:** Specific resilience mechanisms enabled by the solution (e.g., real-time visibility, predictive capabilities, system redundancy, autonomous operation).
- **Resilience Capabilities Mapping:** Classification under one or more categories:
 - ✓ Adaptability
 - ✓ Efficiency
 - ✓ Visibility
 - ✓ Redundancy
 - ✓ Respond
 - ✓ Transform
 - ✓ Market Strength
 - ✓ Compliance
 - ✓ Security & Stability
- **Adoption Barriers:** Key limitations or risks associated with technology adoption, such as:
 - ✓ High initial costs
 - ✓ Integration with legacy systems
 - ✓ Workforce retraining
 - ✓ Regulatory or cybersecurity concerns
 - ✓ Supplier lock-in or lack of interoperability

This approach enables stakeholders to weigh not only the functionality of each technology, but also its fit within their operational, regulatory, and financial constraints.

3.2 Scouting Alternate Suppliers

To improve supply chain resilience and strategic autonomy, Task 2.3 placed strong emphasis on scouting alternate suppliers across all 10 technology domains. These are providers that are not necessarily global leaders, but offer innovative, regionally available, or disruptive solutions.

The scouting process prioritized SMEs, EU-based innovators, and providers with specialized capabilities in calling areas such as textile robotics, IoT-enabled Agri-tech, or portable 3D printing.

Across categories, SMEs like Robotextile (textile automation), Vuletech (automotive robotics), and byFlow (3D food printing) illustrate the potential of alternate suppliers to deliver flexible and sustainable solutions. While these companies may not yet be mainstream, they offer valuable backup options that reduce dependency on large multinational vendors and improve resilience in procurement planning. So, the scouting effort prioritized:

- Disruptive capabilities
- Regional presence in underserved areas

- Alignment with EU values around green transition, digital sovereignty, and social responsibility

Alternative suppliers were particularly highlighted in tables with the SME flag, allowing users to filter for less conventional but potentially high-impact vendors.

3.3 Supplier Reliability and Quality Evaluation

As part of the mapping and scouting process under Task 2.3, a preliminary evaluation of supplier reliability and solution quality was performed to guide potential adoption and integration decisions by end users and stakeholders.

The assessment framework included both qualitative and background indicators, based on publicly available data. These indicators included:

- Deployment maturity: Verified use cases, industrial adoption, or pilot deployments
- Company profile: SME status, geographic presence (EU vs. non-EU), and specialization
- Compliance readiness: Presence of regulatory alignment
- Scalability: Whether the solution supports integration into existing digital infrastructures.
- Support availability: Access to documentation, APIs, training materials, and customer support services

Technologies offered by large, mature firms (e.g., Siemens, PTC, ABB) were typically associated with higher reliability, but also higher adoption barriers, particularly around integration costs, complexity, and vendor lock-in. In contrast, SME and alternate suppliers (e.g., Innoarea, Oceanz, Altim) often provided more agile, customizable, and cost-effective solutions, but presented potential risks in terms of long-term support, product maturity, or compliance documentation.

Where possible, indicators like resilience support (e.g., adaptability, visibility), identified in each supplier table, were used to benchmark quality and fitness for deployment in resilient supply chain contexts.

4 Conclusion

This deliverable has provided a comprehensive mapping of critical advanced technologies that improve supply chain resilience across four key industrial ecosystems: textile, agri-food, digital (MaaS), and mobility (automotive). Through structured evaluation and supplier analysis, this investigation identified ten high-impact technology domains such as AI, IoT, Digital Twins, Blockchain, and 3D Printing and assessed their relevance, availability, and barriers to adoption.

Our findings highlight the critical role that digital technologies play in strengthening adaptability, visibility, and responsiveness throughout supply chains. Advanced tools enable real-time monitoring, predictive decision-making, and process automation

capabilities that are especially critical in the face of increasing disruptions driven by climate, geopolitical, and market instability.

The supplier mapping shows a diverse ecosystem of both EU and non-EU providers, with a significant presence of innovative SMEs offering active and customizable solutions. These SMEs are particularly significant for strategic autonomy and regional resilience. However, adoption barriers continue, including high implementation costs, integration complexity, and limited digital maturity among end users.

The deliverable also highlights the importance of considering supplier reliability, compliance readiness, and long-term support capabilities when selecting technology partners. These insights will serve as a foundation for later project tasks related to technology validation, ecosystem specific roadmaps, and policy recommendations aimed at improving digital application and resilience capacity in European SMEs.

The Textile ecosystem served as a detailed use case to illustrate how critical disruptions such as low visibility, supply chain complexity, outdated technologies, and waste can be directly mapped to enabling technologies like AI, IoT, Robotics, AR/VR, Blockchain, and 3D Printing. By analysing real-world suppliers and their resilience-enabling capabilities, the investigation demonstrated how targeted digital interventions can address specific vulnerabilities and disruption scenarios. The diversity of supplier profiles ranging from global corporations to agile European SMEs reinforces the importance of maintaining a balanced and resilient sourcing strategy. This approach not only supports operational continuity but also fosters innovation and sustainability in traditionally resource intensive sectors. The structured mapping methodology applied to the Textile sector can now be scaled and adapted to other ecosystems, forming a replicable framework for future digital transition and resilience planning activities.

Finally, this work supports the RISE-SME project's principal goal empowering industrial ecosystems with the tools, knowledge, and partnerships needed to create more resilient, responsive, and future proof supply chains.

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