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nextnet

Next generation Technologies for networked Europe

D2.4: Report on specific challenges for SCs of the future

WP:	*2 – Industrial Future Scenarios for Supply Chains*
Task:	*T2.4 – Specific challenges for SCs of the future*
Authors:	*Mustafa Cagri Gurbuz, Victoria Muerza (ZLC)*
Contributors:	*Ana Barros and Pedro Senna (INESC TEC), Sébastien Balech (PNO),Evanthia Thanou and Aristides Matopoulos (ASTON University), Markus Stüte and Saskia Sardesai (Fraunhofer IML), Rosanna Fornasiero, Andrea Zangiacomi and Irene Marchiori (CNR-STIIMA)*
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Executive summary

This report is the Deliverable 2.4 (D2.4) of the Next-net project. The aim of the project is to put in place a cross-sectoral and cross-technological initiative at European level to increase integration between production and distribution proposing research and innovation priorities for the future of supply chain. This report on task T2.4 focuses on the identification of challenges that will face supply chains in future scenarios. Work package 2 (WP2) aims to develop and assess future industry specific supply chain scenarios, which are shaped by various socio-economic, political and technological megatrends. The task 2.4 builds on the results from task 2.1, task 2.2 and task 2.3 as the projection about future state of factors affecting the design and operations of global SCs will reveal what challenges/ opportunities will arise. The challenges described in this deliverable aim to be related to SC processes, and to endogenous factors as a consequence of exogenous factors identified in previous deliverables.

The methodology used for the identification of challenges for supply chains consists of two stages: (1) Identification of challenges with the support of inputs from task 2.3 and task 3.1; (2) identification of challenges with support of Input from industry stakeholders.

This process allowed identifying several specific challenges based on the macro-scenarios defined in D2.2 and related supply chains in D2.3. The workshop with stakeholders enabled to consolidate the list and to specify the challenges taking into consideration the point of view of different actors in the supply chains (buyer, supplier, policy maker, and facilitator). After their identification, challenges have been aggregated according to cluster-specific topics in order to restrict the number to a reasonable amount and to help the process of identify research needs in T3.3. Of course the long list can be always consulted during activities in T3.3 in case it is necessary to have specific details. Technological challenges have been derived from D3.1 and a dedicated chapter is present in the deliverable. Recognized decisional dimensions like Behavioural, Operational, Legal, and Financial have been then used to categorize them.

The output of this analysis together with D2.3 results provide the basis for enabling the identification of Challenges faced by the future SC Industry in Europe and of related Research Priorities in T3.3.

In this report, we take into consideration the supply chain dimensions as defined in the consequence matrix (D2.3 NextNet project) for the identification of challenges. The developed methodology for the identification of challenges is described in Chapter 2.

After this brief introduction, Chapter 2 presents the methodology followed in this deliverable. Chapter 3 focuses on the first stage of the methodology developed, presenting the identification and prioritization of challenges for future supply chains. Chapter 4 deals with the second stage of the methodology and includes the feedback from industry stakeholders for the validation of challenges. In chapter 5, it is proposed a clusterization of the challenges derived from these 2 stages, while chapter 6 propose a categorization of the challenges as

a way to facilitate the process of putting in place dedicated actions to face them. Chapter 6 presents the conclusions. Annexes are provided to give more details on the detailed analysis held during the T2.4.

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1 Introduction

This report on task T2.4 focuses on the identification of challenges that supply chains will face in future scenarios. Work package 2 (WP2) aims to develop and assess future industry specific supply chain scenarios, which are shaped by various socio-economic, political and technological megatrends. The task 2.4 builds on the results from task 2.1, task 2.2 and task 2.3 as the projection about future state of factors affecting the design and operations of global SCs will reveal what challenges/ opportunities will arise. The methodology used for the identification of challenges is also included in the deliverable.

Some studies are already available in literature analysing specific challenges. But most of the time they focus on some specific application or domain. Sustainable logistics and supply chains are the engine for a more competitive and unified European market. To be able to comply with market demands, logistics must be highly efficient, reliable, safe, secure, environmentally friendly and cost-effective. Some key aspects include (Clausen et al., 2016):

(1) better utilisation of existing infrastructures;
(2) in Europe, increases in infrastructure capacity cannot always be (cost-effectively) facilitated by physical infrastructure expansion;
(3) anticipated shortages in manpower required for physically demanding tasks.

In addition, some challenges are related to the adequacy of measures to minimise advance logistics negative effects and include (Clausen et al., 2016): (1) reduction of the environmental impacts (e.g. carbon footprint, noise, un-safety and inadequate land use); (2) reduction of the demand for non-renewable resources; (3) improvement of external safety and labour conditions. Furthermore, the creation of megacities and people getting older suppose the appearance of challenges for society and the corporate world linked to risk behaviour, mobility and certainly consumer behaviour. With regard to logistics it is linked to the need to organize warehouses, transport operations and other workplace environments (Clausen et al., 2016). Megacities have been identified as a trend within the social dimension in the deliverable D2.1 of the Next-Net project, and it is projected into the urban living dimension in the deliverable D2.2.

Another challenge linked to the logistic sector is the challenge to “become environmentally sustainable, imposed by the increasing global awareness and commitment to preserve resources and reduce emissions” (Mason et al. 2007). Sustainability has also been addressed along NextNet, e.g. alternative energy generation, storage and usage projection (see deliverable D2.2),

The major challenges for manufacturing companies are “aligning corporate strategy with the right organizational model and matching that strategy to targeted customer segments—by size, footprint, vertical category and market. Leading logistics providers excel at understanding key customers’ needs and purchasing behaviours—and they know that

understanding is a key ingredient to build a solid strategy and defining the most efficient commercial approach and offerings"[1].

Van Breedam (2016) indicates that challenges can be structured along three elements: changing environment, changing customer behaviour, and changing logistics. Changing customer behaviour is linked to the followed challenges: on demand, omni-channel, product innovation, and speed of change in ICT technology. In the NextNet project these challenges have been identified as trends (see Deliverable 2.1 NextNet project) because they represent factors which are taking place independently from what a SC can decide and define. Specific challenges will be derived as a consequence of these trends. Other general challenges that the changing logistics faces include: supply chain as a competitive advantage, manufacturing and process innovation, labour force, capacity shortage, co-modality, hybrid distribution structures, big data and the physical internet. Some of these challenges have also been identified in Deliverable 3.1.

The identification of challenges in future scenarios goes a step beyond and takes advantage of the information regarding future projections already developed along the project. Six macro scenarios were identified (see deliverable D2.2): two optimistic (PrOCEEDINg, aSPIRANT), 2 pessimistic (UNEasE, ENDANGEr) and 2 intermediates (oFFsET, DiThER).

At the same time, Deliverable D2.3 of the NextNet project presents the "consequence-matrix" which describes the supply chain dimensions and their characteristics with regard to the six macro scenarios specific features e.g. the Inventory levels dimension includes low and constant levels of inventory (aSPIRANT scenario), low and personalized inventory, higher stocks (PrOCEEDINg scenario), high inventory levels, multi-level inventory, and shortage of some materials (oFFsET scenario), low levels of inventory, higher stocks (DiThER scenario), high inventory levels (UNEasE scenario), high inventory levels, low levels of inventory based on demand, avoid the use of scarce resources in production to stock (ENDANGEr scenario)).

In this report, we take into consideration the supply chain dimensions as defined in the consequence matrix (D2.3 NextNet project) for the identification of challenges. The developed methodology for the identification of challenges is described in Chapter 2.

After this brief introduction, Chapter 2 presents the methodology followed in this deliverable. Chapter 3 focuses on the first stage of the methodology developed, presenting the identification and prioritization of challenges for future supply chains. Chapter 4 deals with the second stage of the methodology and includes the feedback from industry stakeholders for the validation of challenges. In chapter 5, it is proposed a clusterization of the challenges derived from these 2 stages, while chapter 6 propose a categorization of the challenges as a way to facilitate the process of putting in place dedicated actions to face them. Chapter 6 presents the conclusions.

[1] https://www.bain.com/insights/challenges-and-winning-models-in-logistics

2 Methodology

This section describes the methodology applied and the results of the activities carried out in the T2.4 related to the identification of specific challenges for future supply chains. Input from T2.1, T2.2, and T2.3 are a requisite for the definition of the methodology.

The challenges have been identified and classified in two stages as described below and in Figure 1:

- Stage 1 (S1). Desk research: based on the definition of the Supply Chain (SC) dimension from the consequence matrix carried out in T2.3, identification of specific challenges for the 6 scenarios depicted in T2.2 is performed. The identification of challenges is based on brainstorming of each partner team with a two-fold perspective: (1) Input from T2.3; and (2) Input from T3.1 on technological challenges and gaps to have a different perspective on the enabling technologies identified in that deliverable. The challenges are clustered as well as categorized in several groups (i.e., Legal, Operational, Behavioural, Financial, and Technological) in order to serve later on as a basis for "recommendations to overcome them". The general categories of the SC dimension as defined in the consequence matrix and used for the identification of challenges include:
    - **Sourcing strategy:**
        - Local/Glocal/Global Sourcing.
        - Sourcing and Shoring Characteristics.
        - Localization.
        - SC Structure.
    - **Distribution:**
        - Inventory levels.
        - Distribution Characteristics.
        - Shipping Characteristics.
        - Structure Characteristics.
        - Transport Characteristics.
        - Environmental Impacts.
    - **Supply chain integration:**
        - Material flow integration.
        - Information flow integration and IT infrastructure.
        - Financial flow integration.
    - **Finance:**
        - Presence/absence of Intermediaries.
        - Currency Characteristics and Use.
        - Regulations.
        - Technologies.

- Stage 2 (S2). Input from industry stakeholders: a workshop has been carried out to gather the opinion of experts from the process industry, distribution logistics and discrete manufacturing. Challenges and opportunities have been identified. The information generated as a result of this workshop has been then used to confirm that most of the challenges the Next-Net Consortium partners come up with are indeed relevant for the industry stakeholders and are grounded in reality. Moreover, this stage also gave the possibility to integrate some additional challenges/opportunities proposed by the industry experts.

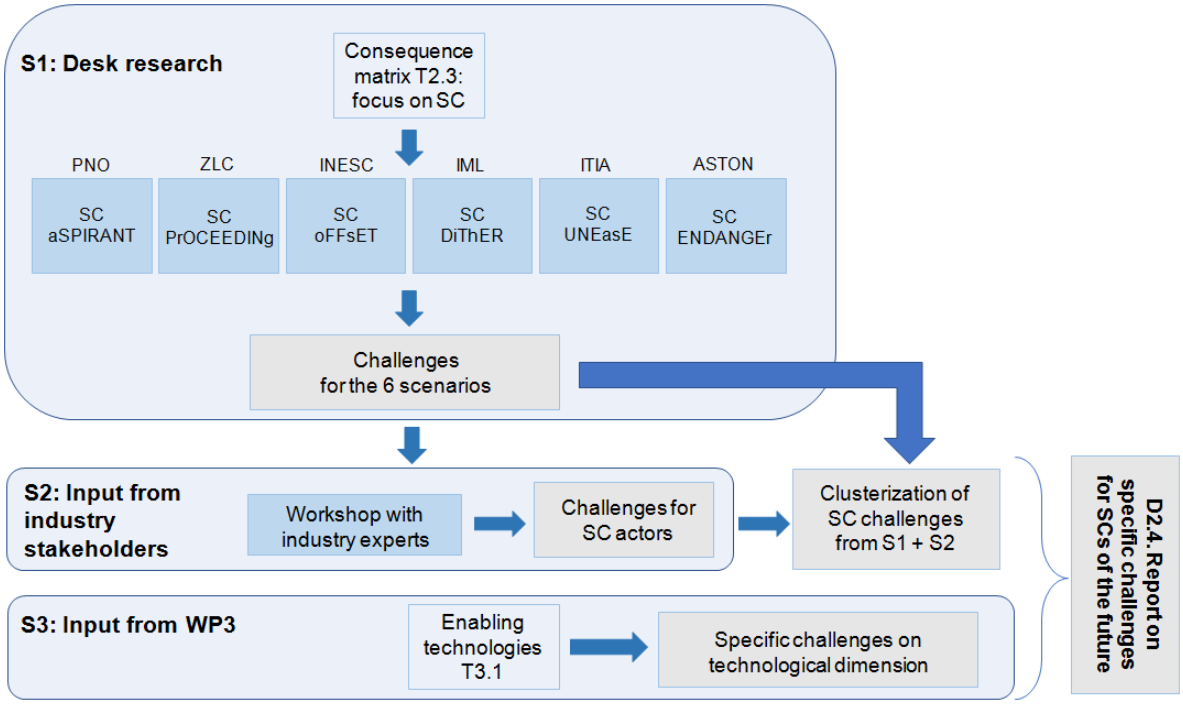

Figure 1. Methodology for the identification of challenges

3 Stage 1: Desk Research

3.1 Identification of SC specific Challenges from macro-scenarios

For the identification of the challenges, each partner has worked on a specific macro- scenario, considering the “actions/decisions” that supply chain managers have to perform/take under the given conditions as identified in T2.3. Some examples to such actions/decisions are “sourcing decisions (multiple/single, global/local, outsourcing/in- house), setting inventory levels, network design (e.g., centralized versus decentralized, facility location decisions), reverse logistics operations, distribution (e.g., long haul, last mile), information sharing and/or collaboration among supply chain partners”.

An initial list of 65 challenges was identified from all the scenarios.

It is interesting to underline that in several cases firms end up facing similar challenges in very distinct future scenarios. For instance, the operational challenges such as higher inventory levels and capital tied up associated with larger lead times seem to be a challenge when “protectionism” leads to shorter supply chains in general but requires companies to spend more time at border crossings and complete necessary import/export paperwork. By the same token, the same challenge appears to be relevant when global trade is facilitated without complicated paperwork, but lead times are still large as firms source from far away suppliers if it makes economic sense. Therefore, certain challenges are quite important regardless of how the future looks like and businesses need to come up with sound strategies mitigating risks stemming from such challenges. Most probably, “proactive” strategies must be designed for these as the likelihood of these scenarios being realized is significant. Contingency planning or a mix of proactive and contingency planning might be the appropriate choice for some other challenges that only appear in rare situations. Research needs in later stages of the Next-Net project could explore this mix of contingency plans (actions taken when an adverse event happens) and preventive/proactive (actions to minimize the probability and/or likelihood of these events happening) to manage the challenges identified in this task. During this preliminary part of the work, it was also observed that a large number of challenges are relevant for scenarios that are deemed to be “more positive (optimistic)” in the sense that countries across the globe keep cooperating, international trade grows under the presence of political stability and well established alliances (e.g., PrOCEEDINg and aSPIRANT). Although this might sound counter-intuitive at first sight, it also makes sense as the supply chains get larger and more complicated (due to the existence of heterogeneous systems most likely with decentralized decision making) when global operations become the norm. In other, more pessimistic, scenarios (e.g., protectionism), supply chains might become more local which creates its own challenges, however at the same time leads to “simpler” chains to manage in general.

3.2 Specific challenges on technological dimension

In addition to the set of challenges identified in the previous chapters, technological challenges have been identified in D3.1 of NextNet Project regarding 18 enabling technologies (Autonomous Transport Systems; Robots; Cloud Based Computer Systems; Internet of Things; Distributed Ledger/ Blockchain; Artificial Intelligence; Data Science; Mobile and Wearable Devices; Communication Infrastructure; Identification Technologies; Location Technologies; Visual Computing; Additive Manufacturing; Energy Infrastructure; Alternative Propulsion Systems; Renewable Energy Technologies for Production and Storage; Smart Materials; Nanotechnology). These challenges are transversally linked to the other challenges previously considered due to their interrelation with some specific aspects addressed in each of the cluster identified. In D3.1, technological challenges are classified into two main groups: (1) *Major technological gaps and challenges*, and (2) *Specific implementation challenges related to each technology* and during T2.4 they have been reorganized per "topic" and not per technology. The detailed work is summarized in Appendix A3 and is here shortly summarized in the following list:

- TCH #1 -LACK OF TECHNOLOGY MATURITY/ UNDERDEVELOPMENT OF TECHNOLOGY: this challenge is related to the necessity to further develop existing or create new technologies in areas such as positioning, algorithms, connectivity, solve unexpected systems failures, extension of data network, data processing, data analytics and data sharing.
- TCH #2 -IMPROVEMENT OF ENERGY SYSTEMS AND DEVELOPMENT OF NEW POWER SOURCES: This challenge is mainly related to the current short/ limited battery lifes to be used for different technologies (e.g. Mobile and wearable devices, alternative propulsion systems, technologies for visual computing, robots). In addition, new power sources will be decisive for robots, and power supply and endurance in drones.
- TCH #3 -HIGH COST OF DEVELOPMENT AND IMPLEMENTATION OF TECHNOLOGY: the high costs of devices are limiting the applicability of Location systems and IoT. Management cost is essential in Cloud Based Computer systems. High implementation costs are also affecting Artificial Intelligence an Additive Manufacturing systems (due to costs of 3D printing and smart materials).
- TCH #4 -ACCEPTANCE AND AWARENESS: It is necessary to increase the acceptance level and awareness of technology impact both on enterprises, culture and society. It is a preliminary step for the implementation of technology and at the same time a challenge.
- TCH #5 -LACK OF STANDARDIZATION: the lack of standardization and regulations is causing problems in artificial intelligence. The development of standards will be necessary/ decisive for the following technologies: autonomous transport systems, visual computing, artificial intelligence, distributed ledger/ blockchain, data science, alternative propulsion systems, location technologies robots, IoT, additive

manufacturing, and energy infrastructure.

- TCH #6 -SAFETY FOR USERS: safety is an important challenge in the implementation of technology such as robots and Autonomous Transport Systems (due to the consideration of humans in the surroundings).
- TCH #7 -DATA SECURITY AND INTELLECTUAL PROPERTY THREAT: data security, vulnerability and cybersecurity problems e.g. in smart contracts and cryptocurrency should be improved. Hacking can affect technologies such as data science, distributed ledger/ blockchain, visual computing, cloud based computer systems, artificial intelligence, and energy infrastructure.
- TCH #8 -SCARCE INTEROPERABILITY AND DIFFICULTIES IN INTEGRATION: interoperability has to be increased for devices and integrated into the business proceses (in IoT systems) and existing infrastructure, systems and production and supply chains (in smart materials and nanotechnology). For alternative propulsion systems this challenge is related to the limited existing models and refuelling infrastructure, workshop and service network.
- TCH #9 -NEED FOR SPECIALISED WORKFORCE: due to the continuous development of technologies, specialised workforce is needed for the effective implementation in areas such as Artificial Intelligence, blockchain technology (mainly related to IT and legislation), and smart materials (expertise in multiple disciplines for the conception and design of new solutions).
- TCH #10 -LIMITED PRODUCTION/ SCALABILITY: this challenge is mainly linked to the following technologies: mass production in nanotechnology, number of transactions in a distributed ledger/ blockchain, augmented reality (currently a predominately mobile-focused technology), business scalability in renewable energy technologies for production and storage, and cloud based computer systems.
- TCH #11 -LIMITED RELIABILITY: this is a challenge directly related with the implementation of some technologies. In fact, it should be improved in Cloud Based Computer Systems, IoT (sensor's reliability has to be increased), and Additive Manufacturing (printing of complex parts in 3D printing) between others.
- TCH #12 -TECHNOLOGY ACCURACY: different types of technologies need to improve its accuracy for implementation. For example, location technologies (location accuracy), mobile and wearable devices (data accuracy), visual computing technology, and identification technologies (RFID sensors sensitive to environmental conditions).
- TCH #13 -FEEDSTOCK SUPPLY: feedstock supply can be limited depending on raw materials. In addition, some rare and scarce materials are used as core elements in the development of alternative propulsions systems (e.g. lithium-ion batteries for electric vehicles). The use of rare materials also limits the implementation of smart materials.

In the table below there is a summary to show how each challenge correspond to the enabling technologies as from D3.1.

	TCH #1: Tech. maturity	TCH #2: Improvement energy systems	TCH #3: Costs	TCH #4: Acceptance and awareness	TCH #5: Lack of standardization	TCH #6: Safety for users	TCH #7: Security	CH #8: Scarce interoperability and difficulties in integration	TCH #9: Need for specialised workforce	TCH #10: Limited production/ scalability	TCH 11: Limited reliability	TCH #12: Accuracy	TCH #13: Feedstock supply
Autonomous Transport Systems	x	x		x	x	x	x	x					
Robots	x	x	x	x	x	x	x						
Cloud Based Computer Systems	x		x				x	x		x	x		
Internet of Things (IoT)	x		x	x	x	x	x	x			x	x	
Distributed Ledger/ Blockchain	x	x		x	x		x			x			
Artificial Intelligence (AI)	x		x	x	x		x		x			x	
Data Science	x						x		x		x		
Mobile and Wearable Devices	x	x		x			x			x		x	
Communication Infrastructure	x						x				x		
Identification Technologies	x		x		x							x	
Location Technologies	x	x	x		x		x			x		x	
Visual Computing	x	x		x	x	x	x		x	X		x	
Additive Manufacturing	x				x		x				x		
Energy Infrastructure	x	x			x		x						
Alternative Propulsion Systems	x		x		x			x					x
Renewable Energy Technologies for Production and Storage	x		x	x						x	x		
Smart Materials	x		x	x					x				x
Nanotechnology	x					x			x	x			

Table 1. Mapping of technological challenges on specific technologies

4 Second stage: validation and additional input from industry stakeholders

During the first stage of the analysis it has been observed that whether a certain trend creates a challenge or not very much depends on "what supply chain actor" one looks at. Future scenarios leading to more "local sourcing" due to protectionism might create a "challenge" for "buyers" of raw materials/products as there are few suppliers (only local) to choose from. This, however, might be an "opportunity" for "local suppliers" in the sense that they now would have more power (e.g., can charge higher prices) and even develop local networks. Consequently, for all the actors within a supply chain to survive in different future scenarios, a holistic view needs to be taken and win-win solutions for all actors in the supply chain need to be designed.

The identification of challenges for the Supply Chain in the six macro-scenarios has also been performed by 15 stakeholders in a workshop carried out at Zaragoza Logistics Center in Zaragoza, Spain. The group of experts involved has two different profiles: (1) Industry stakeholders: participants with relevant positions within companies from the process industry, distribution logistics and discrete manufacturing. More specifically the following industries were represented: steel, petrochemical, consultancy, engineering, and Fast-Moving Consumer Goods (FMCG); (2) academia: participants from academy or research areas within companies. The majority of the participants represented the industry perspective. The used methodology, consisting of three phases, is described below followed by the summary of the results obtained. We mainly report which challenges proposed by the Next Net Consortium partners have been validated and what additional challenges are considered during the workshop.

The three phases undertaken are:

- **Phase 1:** Ensuring that each participant works on "two different stations (i.e., macro-scenarios)". The matching between participants and the scenarios were made such that each participant works on scenarios that are as "dissimilar as possible". We ensured that each scenario has been visited by a team at least once during the workshop.
- **Phase 2:** In order to "facilitate" the process of identifying potential challenges, a setting where different participants assumed different roles has been chosen. Finally, in order to close the loop and remind the participants that the "reverse logistics" is as important, we have added a role called the "Circular Economy (CE) facilitator". These roles have been described to the participants before the workshop (reminding them that a particular entity (e.g., government) can assume all of the above roles in different supply chains). Once each participant contemplated on the challenges on her/his particular role, we asked them to discuss the "Supply Chain Coordination/Integration" issues as a "team". We observed that this "role" playing facilitated the discussion and interesting results emerged in the end. In summary, at

each station (scenario), the following roles were assumed by different participants in a given team: *Supplier, Buyer, Policy maker, Circular Economy (CE) Facilitator*. SC Coordination role was assumed by all participants together in a given team. Figure 2 was placed on each station to support the discussion. Following activities were performed by each team:

- "All participants as a group" would discuss the overall implications of the "scenario" (10 minutes) to make sure everyone is on the same page.
- "Each individual participant with the determined role" would contemplate what challenges/opportunities would arise under the particular scenario and place them on the board using post-its (10 minutes).
- "All participants as a group" would discuss together the SC issues (integration, links between different roles, etc. under the guidance of the SC Coordinator) and come up with SC related challenges/opportunities (10 minutes).
- "The team" would summarize the challenges/opportunities on a different sheet of paper (5 minutes).

- **Phase 3**: All the challenges from different scenarios are discussed by all participants at the end of the workshop.

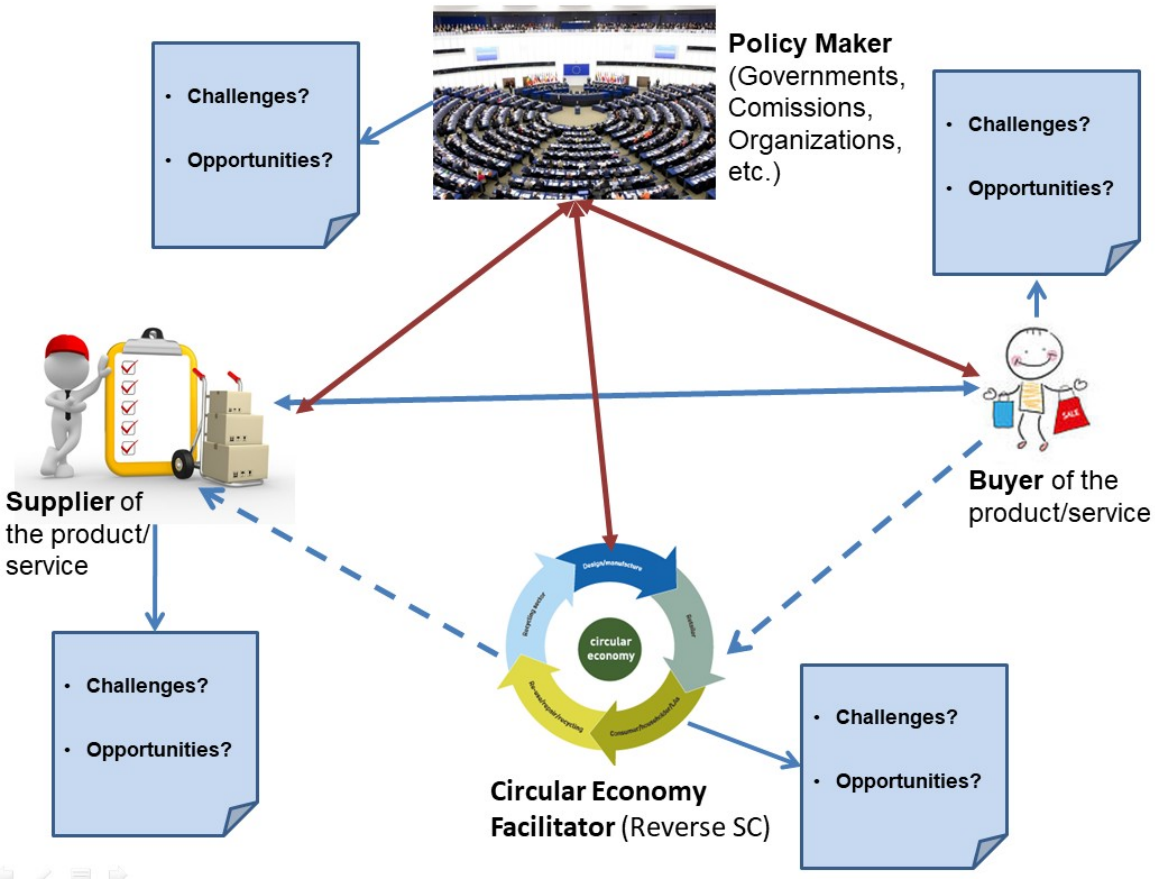

Figure 2. Interrelation within the stakeholders of the SC


Figure 3. Participants during the workshop

In what follows, we present the results and insights generated as a result of the workshop. The most **common** challenges were identified along the six scenarios:

- From the point of view of the supplier, the main challenge is how to be competitive to gain share market. One possible strategy is through differentiation, e.g. through technology or the use of new materials (linked to challenges #5 and 6).
- The main challenges for the buyer are the adaptation to new business models according to technology (linked to challenge #1). In addition, the existence of policies that promote sustainability.
- For the policy maker it is challenging to establish the suitable environmental laws, making use of the proper channels to share the information (linked to challenge #11).
- The facilitator faces the legislative pressure on the final disposal of goods. Different technologies can bring a detriment to the use of human labour thus driving to a loss of employment. In addition, digitalisation (in different levels) can be used for the circular economy coordination to create new jobs. This supposes a challenge due to data protection issues (linked to challenge #5).

A list of challenges for the Supplier, Buyer, Policy Maker and Facilitator identified during the workshop in every scenario was identified.

Thus, it can be concluded that the stakeholders participating in the workshop verify the information obtained by NextNet consortium partners during the first stage of this T2.4. Moreover, the following additional challenges have been identified and will be further clustered in the final table of challenges:

- CH #66: Exploit climate issues as a marketing opportunity.
- CH #67: Rigidity towards unexpected events.
- CH #68: Manage power differences to avoid inefficiencies along the SC.
- CH #69: Set Trade policies.
- CH #70: Deal with an informal (parallel) economy.
- CH #71: Difficulties in addressing market needs.
- CH #72: ease “SUPPLIER - BUYER” financial relationship.

- CH #73: Political uncertainty impacting investments.
- CH #74: Service assurance.
- CH #75: Loss of competiveness.
- CH #76: Application of flexible tax policies.
- CH #77: Set economic/ social policies for new markets.
- CH#78: Empowering public administration to regulate strong partnership agreements.
- CH #79: Lack of international rules.
- CH #80: Use of suitable channels to share information along the SC.
- CH#81: Consider how to take under control environmental damage due to increased pollution and waste.
- CH #82: Economic stagnation.
- CH #83: Alignment of legislation according with technology.
- CH #84: Integration of rural and urban areas.
- CH #85: Balance customization needs with shorter SCs.
- CH #86: Integrate distribution with proximity delivery points in urban areas.
- CH #87: Overcoming innovation inertia.
- CH #88: Target inclusive policies to contrast unemployment and social inequality.
- CH #89: Creativity in finding alternative supplying opportunities.

5 Clustering of challenges from stage 1 and 2

In this phase, challenges derived from the desk analysis and the workshop addressed respectively in stage 1 and 2 have been clustered in several groups (based on qualitative evaluation of the reason they have been mentioned by experts). The aim of this step is to help the supply chain managers through simplifying challenges by clustering them and discussing the causes so that the results serve as a starting point to overcome them. Consequently, the clusterization of the challenges would help managers in focusing their efforts on the major "common themes" although specificity of each challenges might differ. It is also important to note that the supply chains will be more robust when these "common themes" are addressed properly because if the business environment changes from one scenario to another in the medium term, the supply chain partners will be ready for the new setup. The clusterization of the challenges is based on the comparative analysis of the content provided by the respondents and grouping is based on similarities in the concepts expressed by each challenge (see Table 2). The research needs that will be identified later in T3.3 activities of the Next-Net project shall be based on the above classification.

Challenge #	*Definition*	*Reason*
SCH#1	**DEVELOPING NEW COLLABORATIVE SC MODELS** - Need for developing new business models to encourage coordination/collaboration maintaining information symmetry across different SC entities for end-to-end SC solutions with the ultimate goal of matching supply and demand and creating agile/responsive SCs - Lack of willingness to share information (CH #64) - Manage power differences to avoid inefficiencies along the SC (CH #68) - Ease supplier-buyer financial relationship (CH #72)	SCs getting longer and complex with limited coordination/collaboration between manufacturers/distributers/retailers/LSPs due to both lack of trust and cost effective technology (low penetration of digitalization) for smooth information sharing and collaboration. This leads to long order cycles, frequent stock outs, poor forecasting, and production planning because of decentralized and non-standard processes Simplified SC structure (proceeding) Need to relax the payment terms and provide financial support for smaller firms
SCH#2	**RESOURCE MANAGEMENT FOR A CIRCULAR ECONOMY** - Need for more efficient (and holistic) manufacturing, collection, recovery, disposal, recycle, reuse; - Ensuring quality of the goods produced with recycled materials; - Management (S&OP) of the "growing product portfolio" with the new (recycled) goods; - Design of new materials with longer lifecycle (to be used multiple times); - Industrial symbiosis for resource (new and old) sharing; - Incentives (rewards/penalties) by governments to make circular economy financially attractive - Management of the additional complexity dealing with additional regulations and incentives (penalty/reward) from each country (government) for more reuse/recycling (CH #29) - Creation of standard/harmonized waste management and environmental impact measurement processes (CH #30)	Resource scarcity and the need to reduce consumption through symbiosis or centralized planning; Different incentives from each country and lack of waste regulation in some countries; Collector-dependent commercial waste, inefficient flow of information between recyclers; Different regions having different capabilities collecting/managing waste (e.g., councils being unable to sustainably manage their waste) Different regulations because of global and local sourcing Differences between local regulations across different regions
SCH#3	**SOURCING COMPLEXITY MANAGEMENT** - Dealing with increased average lead time and uncertainty and complexity of managing suppliers - Managing a larger supplier base located in different parts of the world with different conditions, regulations, etc. (CH #12)	Protectionism (trade barriers); Underdeveloped transport infrastructure, long SCs (supplier and buyer far away); Complex distribution networks with little information sharing and collaboration leading to difficulties in managing suppliers far away

	- Finding the "right" locations: Limited choices for locations for manufacturing and sourcing, limited number of suppliers available (certified/high quality); single sourcing and disruption risk (CH #20) - Dealing with suppliers with more power (CH #41) - Knowledge building/development in the country and finding new local suppliers (CH #44) - Creativity in finding alternative supplying opportunities (CH#89) - Need to map potential supply chain actors in terms of value/market power –to have a SC observatory on the strength of the EU driven SC (CH@41)	Multiple sourcing for imports with complex regulations; The urge to reduce the potential risk of single sourcing and scarcity; Global sourcing Scarcity and Protectionism (Endanger); Collapse of alliances and fewer suppliers available in the manufacturing country (Dither) Lack of competition from international suppliers Onshoring due to local sourcing Scarcity of resources
SCH#4	**DEVELOPING ”LEANER” AND MORE FLEXIBLE SC** - Need to maintain high service level and quick response time (higher inventory levels); Striving to eliminate redundant resources and working capital and managing the risk of obsolescence (duplicate stock and assets) - Having a flexible responsive SC (via proactive procurement, JIT delivery/replenishment, on-demand forecasting) (CH #39) - Service assurance (CH74)	Longer lead times make it more difficult to respond quickly without high inventory levels; Many different/ decentralized hubs lead to redundant assets and working capital; Low penetration of digitalization might be leading to bullwhip effect leading to high inventories; More difficult to forecast in case of SKU proliferation Lack of adequate and timely information sharing; Centralized planning unable to respond to local market changes Increased transportation lost to remote locations
SCH#5	**PROMOTING EFFICIENT AND SUSTAINABLE LOGISTICS IN URBAN ENVIRONMENT** - Development of autonomous and environmentally friendly (e.g., electric vehicles for air and noise pollution) last mile logistics (transport/delivery/pickup) systems in urban environments (dealing with problems with wrong addresses, personalized shipping); - Use of location technologies and optimization of routes - Being able to manage "centralized" distribution centers in smart cities, in terms of lack of IT infrastructure, delivery costs, and risk management (CH #25) - Integration of rural and urban areas (CH #84) - Integrate distribution with proximity delivery points in urban areas (CH #86)	More people living in congested cities and the need to manage transport in short distances and the push to have more sustainable modes of transport Unequal distribution of ICT infrastructure between the central location and the external locations, increased costs of regional deliveries, inability to replenish from in-store inventory (everything is central) // risk of increased outbound transport costs and increased risk of centralization in case something goes wrong (offset)
SCH#6	**FACING CHANGES IN SC DUE TO PERSONALISED SHIPMENT** - Managing the growing cost of delivery/pickup and smart management of added packaging complexity due to personalized shipping (e.g., size, package, confidential information, lack of bundling opportunities); - The need to use smart materials for packaging design; - Change in SC structure due to disintermediation of some players in the SC	Increased B2C direct sales (home delivery and pick up) that might lead to some intermediaries disappearing (e.g., retailers, warehouses); Customers have increased demands in delivery options (e.g., packaging options, delivery time windows and location, etc.)
SCH#7	**ORGANIZING SC FOR VARIABLE AND CUSTOM DEMAND** - Understanding customer demand; need for developments in gathering huge volumes of data from customers, handling it, data science and AI; - Building an agile network to respond to this customer demand (deal with larger product variety, variability and customized products) - Need to get closer to the final customers by establishing manufactories, fablabs, hotspots and service centers and postpone "last" activities to these centers to deal with customization (CH #36) - Dealing with shrinking customer market (CH #42) - Dealing with larger price sensitivity (CH #48) - Ensuring sufficient amount of raw materials given long lead times to cope with increased demand (aspirant) (CH #49) - Problems in addressing market needs (CH #71)	Fragmented & dynamic demand; Dynamically changing consumer patterns; Larger number of SKUs to manage and different value these provide to consumers Lack of international customers Product commodization Increasing demand (aspirant) // shortage of materials -- resource scarcity (offset)

	- Balance customization needs with shorter SCs (CH #85)	
SCH#8	**ENSURING QUALITY ALONG THE SC** - Ensuring short delivery times, reliability, and quality (versus price) as they become much more important as competitive factors when consumers make purchasing decisions; - Difficulties in quality control and standardization in global SCs - Need to ensure quality standards to protect brand image and avoid financial penalties (CH #31)	Similar product specifications and price offered by many suppliers ; Issues with reliability in transport in the home/host countries Less consistency in product quality control // difficulty of standardization (quality) with global SCs
SCH#9	**IDENTIFYING TALENTS IN SC** - Finding skilled labour - Need for developing new skills for digitalization - Need to create new training methods and apply new technologies in training - Need to define an EU framework on SC competences - Need for specialised workforce (CH #I)	Shortage of talent & skill gaps
SCH#10	**ENERGY AND EMISSIONS MANAGEMENT** - Containing carbon emissions to stop increased pollution; - Managing the increased use of electric vehicles to better use depleting natural resources and reduced energy consumption finding alternative energy sources	Refuelling infrastructure (charging stations) for alternative energy vehicles not sufficiently developed yet; Not vehicles of all sizes can be electric at the moment; Legal issues; High production costs of electric vehicles and price of electricity (market balance between generators and users); Issues with battery recycling ; Range anxiety of electric vehicles; Increased demand for electricity; Procurement of expensive battery technology
SCH#11	**IT INTEGRATION AND INTEROPERABILITY** - Need to set up standardized data processes and integrated IT infrastructure; - Maintaining secure IT infrastructure; - Integration of heterogeneous devices and applications - Simplified SC administration and too much dependence on IT (CH #37)	To enable financial flow integration; To avoid information leakage and manage the scale of financial flow and avoid delays in transmitting changes Not everyone may have similar technology, some manual (in global SCs with proceeding)
SCH#12	**MANAGING IP PROTECTION ISSUES** - Dealing with IP Rights issues	Outsourcing for standardized products and digital B2B platforms; Dealing with suppliers that cannot be fully trusted; Global SCs
SCH#13	**DEALING WITH DIGITAL-DRIVEN ISSUES** - IT Platform Management; - Cyber Security Issues; - New Business Models Creation (such as centralized sourcing for multiple DIY manufacturers through an online platform) - Need for online and real-time track-and-trace solutions for smart materials management with multiple locations (even including the customers who become prosumers with the DIY) (CH #15) - High performance of automated logistics systems (CH #54) - Sustained support for new product development technologies, integrating them with legacy systems (CH #56)	Digital B2B Platforms; Decentralized&heterogeneous IT systems&technologies (e.g., ERP systems) Existence of decentralized DCs and manufacturing facilities; Difficulties with track and trace because of low digitalization Huge data volumes, quick response required, underdeveloped performance of automated logistics systems Complex programmability in additive manufacturing systems, reliance on the already existing ICT infrastructure and legacy systems
SCH#14	**HUMAN PERSPECTIVE IN DIGITAL TRANSFORMATION** - Technology development (automation) and Change Management (automation versus human); - Human centered approach in developing equipment (mobile apps, smart contracts, etc.) and more training environments for "digital transformation officers"	Resistance, workers' training, local differences in automation levels // resistance to schedules/plans generated completely by algorithms (proceeding)
SCH#15	**COPING WITH DIGITALIZATION AND GLOBALIZATION IN FINANCE** - Creation of blockchain technology to develop trust among SC partners and financial/bill settlement models in SCs; - Use of alternative currencies;	Lack of trust and the need for smooth transactions in SCs; Fluctuating exchange rates and varying import/export restrictions (e.g., trade tariffs and quotas) Multiple such providers, not enough standardization, some fintech providers at the risk of going out of business (dither) To overcome the difference of those less economic develop countries (problems in commercial transactions > same

	- Create profiles who can manage these complementary currencies and seamless payments with the customer data protected - Managing global supply agreements with multiple currencies with suppliers/customers in multiple countries (CH #18) - Having to use different fintech providers and platforms (endanger) // new business models for fintech collaboration (CH #21) - Regulate the competition between centralized banking systems and FinTech (CH #58)	currency but maybe different regulations which can affect some manufacturers, providers, etc
SCH#16	**ADDRESSING PROBLEMS AND LIMITATIONS OF REGULATORY FRAMEWORK** - Increased cost/resources (energy, fuel, logistics costs, etc.) because of trade barriers // barriers, new taxes and regulations make it harder to source from abroad (offset) (CH #19) - Creating the adequate legal and regulatory framework for financial flow integrations (endanger) // reduce the complexity of financial transactions and compliance costs with international regulations (aspirant) (CH #27) - Dealing with tax related additional workload and cost (CH #28) - Legal and compliance issues (CH #43) - Develop new laws to regulate and simplify the access to finance founds (CH #60) - Deal with an informal "parallel" economy due to lack / ambiguous regulations (CH #70) - Alignment of legislation according with technology (CH#83)	Protectionism and Scarcity Need for safer/standard transactions More complicated tax issues Outsourcing for standardized products (dither)

SCH#17	**FACING OUTSOURCING COMPLEXITY**
	- Dealing with loss of jobs (social) (CH #22)
	- Increased dependence of third party capacity (CH #23)
	- Dealing with the negative effect of outsourcing on R&D development at home country (CH #33)
	- Dealing with the risk of not being able to reduce costs via outsourcing (CH #50)
	- Coordinating outsourcing and nearshoring (CH #61)
		Outsourcing for standardized products (dither) // global sourcing (proceeding)
		Outsourcing for standardized products (dither) // outsourcing with global SCs (proceeding)
		Some activities are no longer done and over time may lead to lack of investment
		Outsourcing not being able to transform fixed costs into variable costs,
		decomposition of assets increasing switching costs due to low penetration of digitalization

SCH#18	**MANAGING OMNICHANNEL SC AND MULTIMODALITY** - Managing omnichannel supply chain strategies (CH #26) - Being able to efficiently use multimodal distribution ensuring product integrity and to reconfigure based on demand evolution (CH #34)	Multiple siloed organizational structures, price protection and enforcement in different channels, suboptimal collaboration mechanisms, inadequate segmentation of markets, more complex inventory and distribution and pricing decisions (aspirant) // difficult to reach new customer segments because of low penetration of digitalization (offset) // pricing for distribution or the product itself, on-time delivery especially for online channel is critical, allocation of capacity among different channels (proceeding) Lack of information about consignments, tracking and tracing, inefficient use of multimodal distribution assets and the network // even using humans in cities and real time communication with customers to update schedules (proceeding)
SCH#19	**MANAGING COMPLEX OR INCREASED INFORMATION FLOW** - Risk of confidential information leaking (CH #32) - Being able to control the quality of information from the extensive use of algorithms for distribution optimization (CH #35) - Less asset control and more data control for revenue streams (CH #38) - Making sure that "security" is ensured in the SC (CH #40) - Increase cyber-security of private data related to product personalization and customer profiling (CH #59)	More documentation requirements for border crossings Complex computations may result in poor control affecting operational performance (e.g., loading, forecasting, etc.). And fuzzy control of these algorithms may create operational risks in optimization (aspirant) // not factoring in the qualitative, human intelligence (knowledge about events, deals, etc.) in the algorithms, too much dependence on them (proceeding) Lack of control, information sharing and collaboration might lead to brand damage in case security breaches occur

	- Use of suitable channels to share information along the SC (CH #80)	
SCH#20	**DEALING WITH INDUSTRY CONCENTRATION AND COMPETITION** - Dealing with the negative impact of industry concentration on production growth, due to the higher level of market entry, product variety, and geographic concentration of production networks (CH #51) - Anti-trust risks arising from concentration of manufacturing competition in Europe and US (CH #52) - Competing for resources and infrastructure to establish presence in growing economies (CH #62) - Supporting SMEs to stay in the market (CH #63) - Dealing with more competitors and mapping them with observatory (CH #65) - Loss of competitiveness compared to Asia (CH #75) - Empowering public administration to regulate strong partnership agreements (CH# 78)	Increased supply chain integration and concentration of production facilities in Europe and US, creating agglomeration economies of production, leading to the geographic concentration of international tax competition Dominance of big global players. Need to have a systemic approach to the analysis of supply chains where public sector can support a comprehensive mapping of operations.
SCH#21	**MANAGING RISK AND DISRUPTION** - Risk management in global SCs (unethical activities such as child labor, disruptions, strikes, disasters, etc.) // helping suppliers get out of a disruption that are too far away (CH #24) - Being able to manage disruptions/disasters (CH #55) - Overcome rigidity and lack of reactivity towards unexpected events (CH #67)	More complicated as end-to-end SC solutions are harder to obtain and monitoring bottlenecks and problematic nodes is more complicated // global SCs (proceeding) Lack of preparations in the "centralized" distribution centers.
SCH#22	**FACING INVENTORY AND SHIPPING PROBLEMS** - Low variety of inventory in different hubs/DCs/Warehouses (CH #46) - Finding drivers (CH #47) - Dealing with the increased costs of shipping and risk of product stock outs (CH #53) - Need to centralize inventories and distribution, at least for the parts and components in urban areas (CH #57) - Need to use autonomous vehicles extensively and integrate those into the existing processes (CH #45)	Decentralized multiple hub structure Because it takes longer to transport (customs, border-crossings, longer SCs) -- both for endanger and dither Low and constant levels of inventory Because of the larger product variety, it is important to control for the increase in inventory levels of components/parts that go into assembly of these products Need to reduce costs in high-wage countries (dither)
SCH#23	**POLICIES** - Set trade policies (CH #69) - Political uncertainty impacting investments (CH #73) - Application of flexible tax policies (CH #76) - Set economic/ social policies for new markets (CH #77) - Consider how to take under control environmental damage due to increased pollution and waste (CH#81) - Overcoming innovation inertia (CH#87) - Target inclusive policies to contrast unemployment and social inequality (CH#88) - Need of an independent observatory on the role of EU in international SCs (CH#41).	Ensuring non- EU countries left aside and adaptability to different contexts Risk of large investments due to political uncertainty Identify the most influential countries to my economy and make a list of most sensitive import/ export commodities related to them to increase or decrease taxes in case politics turn more protective To promote emerging SC's with social or economic policies to enter in a new market

Table 2. The Supply Chain Specific Challenges from clustering of stage 1 and stage 2 results

6 Categorization of specific challenges

A careful analysis of the reasons why these challenges are relevant leads to the observation that while some are due to technological/infrastructure related, some others could be solely due to behavioural, legal issues, and so on. In certain cases for example, even though the actors within a specific supply chain "can" effectively and efficiently share information (i.e., ICT is sufficiently developed and the systems enabling efficient data/information transfer is well established), they end up withholding critical information from their supply chain partners. Of course this could be due to several reasons such as conflicting incentives, no legal requirement for such reporting or information sharing, the fear of releasing confidential information, or the risk of letting competition get their hands on such information (or even "create" own competition). It is important to know what the main underlying reason behind a certain challenge is, so that corrective actions can be taken to attack the root cause of the problem and avoid spending resources (time & capital) on the wrong issues. In what follows, we will discuss some of these issues. Please note that this is not a "formal" categorization of these challenges, but merely an attempt to classify them such that the efforts to combat them are focused properly because many of those challenges have a combination of operational, behavioural, technological, financial, and legal issues that are interlinked. "Operational and technological challenges" are rather straightforward as they become obvious immediately, but we also added the impact of "human decision making and interactions" (behavioural), "the policy maker's impact on how global supply chains function" (legal), and "the difficulties associated with setting up a business or the ultimate goal of any business, which is making money" (financial) challenges. In what follows, we briefly discuss these challenges within the aforementioned categories:

Behavioral issues: In decentralized systems where each entity in the supply chain strives for optimizing its own objectives (e.g., maximizing profits) in isolation without considering the impact of own decisions on the performance of the rest of the partners, it is known that the system efficiency (of the whole chain) deteriorates. In general, it is quite difficult to change such ***behavior*** and make people adapt a holistic view of the supply chain rather than their own firm/business unit in isolation. Initiatives to increase coordination and collaboration among supply chain partners are not always successful because of the lack of willingness to share information, coordinate actions, and collaborate when necessary, even if it is technically possible. Some collaborative business models such as the Collaborative Planning and Forecasting Review (CPFR) have been used and shown to benefit parties involved. Exploring the impact of consumption patterns on waste generation/recycling/reuse is one of the most promising future research directions, related to a number of challenges identified in T2.4 of the Next-Net Project. To sum it up, **challenges # 1, 2, 3, 7, 9, 10, 11, 12, 14, 15, 16, 17 and 21,** all have a behavioral component and require models that are "human-centric".

Operational issues: Longer and more complex/global supply chains with different technical and information infrastructures make supply chain management even more difficult. *Inventory planning*, *sourcing decisions*, *transport mode choice*, *last mile logistics in big cities*, *integrating forward and reverse supply chains to promote circular economy principles*, *demand forecasting*, *facility location, SC configuration, shoring strategies definition* decisions based on trends in costs, operational decisions in regards to management of *digital platforms*, *design of new materials and production techniques integration of robotics in manufacturing* considering the reaction from humans, and *tracking and tracing capabilities* to control the source and enable actions based on unexpected deviations from the plan are some major operational issues that supply chain managers regularly need to deal with. Most of the **challenges,** beside the political ones and other specific cases have an operational component in it. To sum it up, **challenges # 1, 2, 3, 4, 5, 6, 7, 11, 13, 17, 18, 19, 20, 21 and 22.** Therefore, significant research in improving the quality of such decisions must be carried out to be effectively and efficiently combat such challenges.

Legal issues: Regardless of whether a supply chain is local or global, there are certain legal obligations that each supply chain actors must comply with. Apparently, this becomes a herculean task for firms that do business with supply chain partners the world over. There are different and at times conflicting regulations in different parts of the world, and companies that are present globally need to develop effective strategies to ensure compliance. These challenges limit the options supply chain professionals have and determine the boundaries in which they can do business. **Challenges # 2, 3, 12, 13, 16, 19,, 20 and 23,** are relevant, although almost all challenges are impacted by legal issues one way or another.

Financial issues: A lot is happening recently in the field of supply chain finance that has the potential to change the way business manage the financial flows. Chief among these are the new sources of income (e.g., crowdfunding), new forms of payments and currencies (e.g., cashless payments, cryptocurrencies), technology enabling financial flow integration and settlements. As most of these developments are fairly recent, new research needs to be carried out to identify proper mechanisms/models to finance SMEs as well as big players (e.g., reverse factoring, crowd-funding, platforms enabling the allocation of costs/benefits through smart payments and smooth financial transactions), explore the impact of new currencies on global trade agreements, use of new technologies for financial flow integration and emergence of fintech providers (e.g., blockchain). **Challenges # 11, 15 and partially 1** are quite relevant to financial issues in global supply chains.

Technological issues have been considered in the specific list of technological challenges extracted from D3.1.

7 Conclusions and Future Work

This deliverable is focused on the identification of challenges for future supply chains. The identification of challenges has been carried out by the NextNet consortium partners and validated by industry stakeholders. The defined methodology can be seen in Chapter 2.

As a first step both in the first and second stage, challenges are identified along 6 macro-scenarios (two optimistic (PrOCEEDINg, aSPIRANT), 2 pessimistic (UNEasE, ENDANGEr) and 2 intermediates (oFFsET, DiThER)).

It was observed that in several cases firms end up facing similar challenges in very distinct future scenarios and for this reason after the workshop a list of clusterized challenges have been created merging in a reasoned way the long list initially collected. The list wants to give a support to launch activities in T3.3 with easy to ready challenges to act as incentive to think to research needs. The challenges represent a problem and the research needs in T3.3 should propose ideas to solve those problems. Since during challenges definition also legal and political issues arisen, they can be used also during T4.1 to support the definition of horizontal actions on i.e. standardization, or legal issues. Of course, during the work in T3.3 and T4.1 it can be always possible to go back to the long list of challenges for gaining more detail and to link the challenges to the macro-scenario features.

Regarding the technological point of view, major technological gaps and challenges were identified, and lack of maturity of technology or underdevelopment of technology, data security and intellectual property threat, and lack of standardization for the use of technology are the most common technological challenges to the enabling technologies defined in deliverable D3.1.

The workshop carried out with industry and academia participants served to validate the results obtained during the first stage of the methodology.

In a complementary manner, based on the categories, different research needs should be put in place. For instance behavioural challenges will be linked to the definition of models understanding human reaction, collaboration, trust building mechanisms, etc.

Operational challenges will be linked to recommendations technology-driven research needs improving flexibility, and resilience should be the focus. Legal challenges will need to be related to research need where regionally or globally sound regulations are in place.

A summary of the challenges identified and including both supply chain specific challenges (SCH#) and the transversal technological challenges (TCH#) is listed in Table 3.

During the analysis, not only operational but also political and systemic challenges have emerged with the need to define a shared mapping of the supply chains, their structure and the definition of a level of competitiveness. Here below the full list is provided.

Challenge #	Definition
SCH #1	Developing new collaborative SC models
SCH #2	Resource management for a circular economy
SCH #3	Sourcing complexity management
SCH #4	Developing ”leaner” and more flexible SC
SCH #5	Promoting efficient and sustainable logistics in urban environment
SCH #6	Facing changes in SC due to personalised shipment
SCH #7	Organizing SC for variable and custom demand
SCH #8	Ensuring quality along the SC
SCH #9	Identifying talents in SC
SCH #10	Energy and emissions management
SCH #11	IT integration and interoperability
SCH #12	Managing IP protection issues
SCH #13	Dealing with digital-driven issues
SCH #14	Human perspective in digital transformation
SCH #15	Coping with digitalization and globalization in finance
SCH #16	Addressing problems and limitations of regulatory framework
SCH #17	Facing outsourcing complexity
SCH #18	Managing omnichannel SC and multimodality
SCH #19	Managing complex or increased information flow
SCH #20	Dealing with industry concentration and competition
SCH #21	Managing risk and disruption
SCH #22	Facing inventory and shipping problems
SCH #23	Policies
TCH #1	Lack of technology maturity/ Underdevelopment of technology
TCH #2	Improvement of energy systems and development of new power sources
TCH #3	High cost of development and implementation of technology
TCH #4	Social acceptance and awareness
TCH #5	Lack of standardization for the use of technology
TCH #6	Safety for users
TCH #7	Data Security and intellectual property threat
TCH #8	Scarce Interoperability and difficulties in integration
TCH #9	Need for specialised workforce
TCH #10	Limited production/ scalability
TCH #11	Limited reliability in technologies
TCH #12	Technology accuracy
TCH #13	Feedstock supply due to dependence of raw materials

Table 3. List of challenges

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