Hub Innovazione Trentino
Fondazione Piazza Manci, 17-38123 Povo (Trento)-IT

BEST PRACTICE FOR THE DIGITALIZATION OF THE WOOD AND AGRIFOOD SUPPLY CHAINS OF SMES - DRAFT REPORT

Smart SME's
Co-financed by the European Parliament through
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Prepared by	RINA Team
Controlled by	-
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TABLE OF CONTENTS

LIST OF ABBREVIATIONS

AFSC	Agrifood Supply Chain
AGVs	Automated Guided Vehicles
AI	Artificial Intelligence
BI	Business Intelligence
BIS	Business Intelligence System
EU	European Union
EUSALP	EU Strategy for the Alpine Region
GFAR	Global Forum on Agricultural Research and Innovation
GNSS	Global Navigation Satellite System
GODAN	Global Open Data for Agriculture and Nutrition
GPS	Global Positioning System
ICT	Information and Communication Technology
IoT	Internet of Things
I4	Industry 4.0
LPIS	Land Parcel Identification System
ML	Machine learning
R&D	Research and Development
RFID	Radio-Frequency Identification
RPA	Robotic Process Automation
SCM	Supply Chain Management
SMEs	Small and Medium sized Enterprises
T&A	Textile and apparel

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

The report aims to address the issue of the digital gap of the value chain, focusing on the use cases wood and agrifood, for the part consisting of SMEs in the Alpine chain.

It will indicate good practice, including European or global reference, to identify actors, roles and specific tools, in order to make the best use of the funds available to accelerate the digital transformation, not only based on machines but above all on adequate levels of skills available in the supply chains themselves.

2 EXECUTIVE SUMMARY

Based on the experience of the team coordinated by RINA Consulting Centro Sviluppo Materiali, the report is designed to cover the following topics:

1	A general overview of the digital maturity of production chains and the state of the art
2	Level of digital maturity of the two supply chains, specifically wood and agrifood, (scouting and state of the art)
3	Comparison of the digital maturity level of the two value chains with that of an ideal or highly digitized chain (best practice, e.g., manufacturing)
4	Governance and organizational models of the two value chains, concerning the most significant part of the individual supply chain (e.g., for wood: cutting, transport, and first use), rather than the single company in the supply chain
5	Public or private funds to support the digitalization of the two supply chains
6	Innovation projects funded by EU programs related to the digitalization of value chains

Table 1: Summary of the contents

3 TECHNICAL TOPICS

3.1 THE SUPPLY CHAINS AND CASE STUDIES ON WOOD AND AGRIFOOD: CHARACTERISTICS AND SUGGESTIONS FOR IMPROVEMENT

3.1.1 Supply Chain 4.0: Overview

Supply chain management (SCM) is an integrated and complex network concept that refers to the sum of all the processes starting from the procurement of the raw material from the manufacturer/producer and ending with the delivery of the end-product to the consumer. The increasing interdependency of supply chain stakeholders is the result of many business trends that have emerged in the last three decades, including process and product specialization, outsourcing, off-shoring, just-in-time production, and consumer-driven production. These trends have increased the complexity of supply chains. This complexity is evident at various levels:

1. network complexity, caused by the increase in the number of parties in the chain and the links between them;
2. process complexity, due to the increased number of processes and faster product development cycles;
3. product complexity, owing to the higher number of components and shorter product life cycles;
4. demand complexity, due to increased demand volatility and fragmentation;
5. organizational complexity, due to the increasing number of entities involved and the tendency to work in silos.

With the design, production, and distribution processes scattered among a variety of firms and parties, companies no longer compete in isolation, but rather as participants in interconnected supply chains.

The sharing of information among supply chain networks allows the drivers to work together with the goal of integrated and coordinated supply chains for their effective management. Information also enhances performance and reduces the risks of supply chains because it provides visible processes executed transactions. It creates an opportunity for decision-makers when they need it, and in the format they need it. This is where ICT (Information and Communication Technology) comes into the role and becomes a strategic factor in integrating suppliers, manufactures, distributors, and customers to satisfy the quantity and quality of products. Organizations can gather vital information along the entire supply chain and react quickly to any predictable market changes, thereby gaining competitive advantage by effectively utilizing SCM.

ICT systems features such as data integrity check, real-time availability, visibility, processing capability of information and standardization of business processes are expected to facilitate the better matching of supply and demand between supply chain members and to create an excellent backdrop for embarking on integration with external partners in the supply chain. Such benefits can only be captured if all supply chain stakeholders are aligned and coordinated in their efforts towards digitally transforming the system. If this occurs, economic gains can be obtained not only for the actors that participate in a supply chain but also for the countries in which they operate.

The I4 (Industry 4.0) transformation of the supply chain is driven by the combined undertakings of many stakeholders, including technology developers, logistics service providers, large manufacturers, small and medium-sized manufacturers, tier 1 and 2 suppliers, infrastructure and gateway operators, carriers and governments, who exercise their influence through public policies and regulations. An integrated and comprehensive framework depicts the multiple stakeholders involved in the I4 transformation of the supply chain (Figure 1).

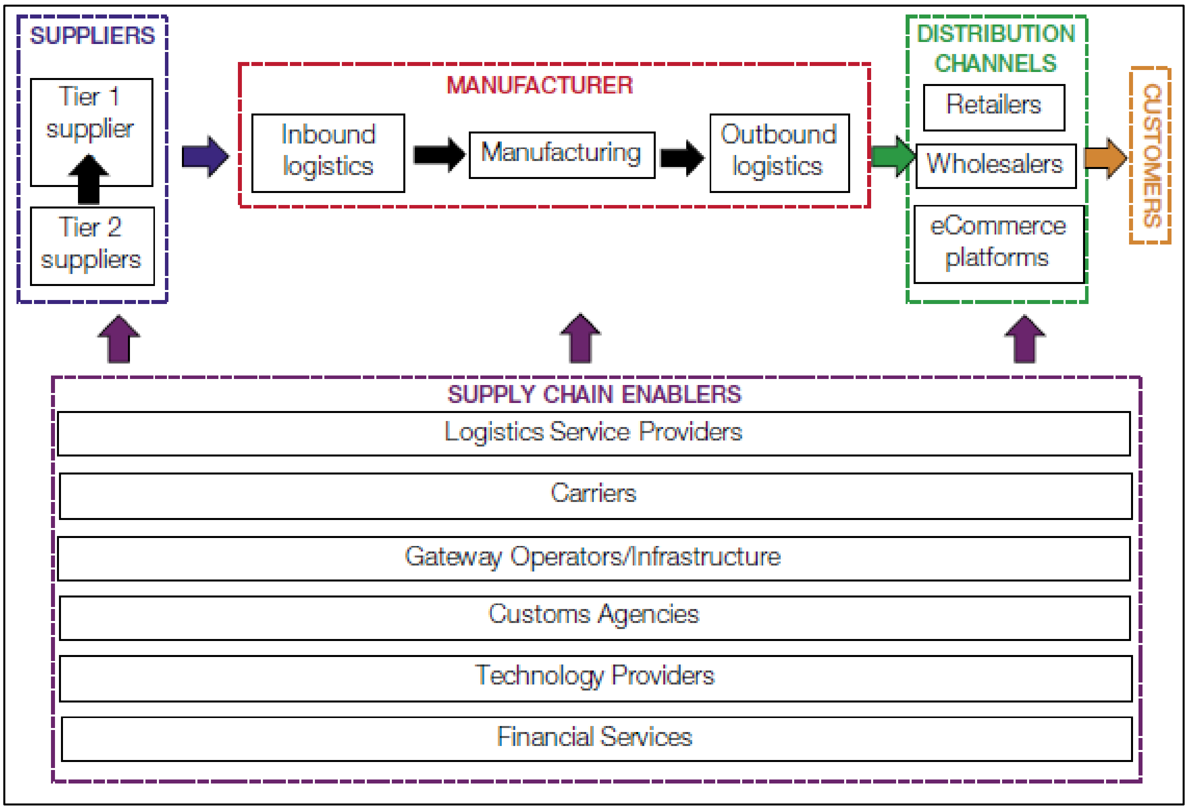

Figure 1: Framework of the multiple stakeholders involved in the I4 transformation of the Supply Chain
Source: prepared by the Authors

A brief list and description of the essential I4 tools applicable to SCM is reported in Annex1.

Due to process fragmentation and the multistakeholder nature of the supply chain, its full I4 transformation requires a high level of collaboration. Such transformation needs to be addressed systemically, tackling technological and economic barriers, and providing incentives for each group of stakeholders to take part in the change. The misalignment of stakeholder efforts to drive the I4 transformation of the supply chain causes a coordination failure. Public policy interventions can address this failure by putting in place mechanisms that help stakeholders to align. As an example, common IoT strategies and data standards, endorsed by all stakeholders, both public and private, facilitate connectivity and the flow of information among manufacturers, logistics service providers, and customs agencies, and enable real-time monitoring of supply materials and spare parts.

The digitalization of the "value chain" will allow companies to face new customer needs, supply-side challenges, and remaining expectations in terms of improving efficiency. Digitalization determines a Supply Chain 4.0, which will be:

FASTER

New approaches to product distribution reduce delivery times to a few hours. The basis of these services is built on advanced forecasting approaches, e.g.:

- predictive analysis of internal (e.g., demand) and external (e.g., market trends, weather conditions, school holidays, construction indices) data
- availability of data for monitoring and forecasting of the state of the machines and systems for optimization of spare parts management.

Forecasts are not carried out monthly, but weekly and for fast-moving products also every day. In the future, we will see the "predictive shipment" for which Amazon holds a patent: the products are shipped before the customer places an order. The customer's request is subsequently combined with a shipment already present in the logistics network (which is transported to the customer area), and the consignment is redirected to the exact destination.

MORE FLEXIBLE

Ad hoc and real-time planning allow a flexible reaction to changing situations of supply or demand. Planning cycles are reduced to a minimum, and planning becomes a continuous process capable of reacting dynamically to changing needs or constraints (e.g., feedback on production capacity in real-time from machines). Once products are shipped, more flexibility in delivery processes allows customers to redirect shipments to the most convenient destination.

New business models, such as "Supply Chain as a Service" for supply chain planning or transportation management functions, increase flexibility in supply chain organization. The supply chain can be purchased as a service and paid for based on usage rather than having internal resources and capabilities. The specialization and focus of the service providers allow them to create economies of scale, as well as economies of purpose and also attractive outsourcing opportunities. For example, we will see an "urbanization" of transport: flexible and flexible transport capacity, which will lead to a significant increase in agility in distribution networks.

MORE CUSTOMIZED

Customer demand for more personalized products is continuously increasing. This gives a strong push to micro-segmentation and mass customization ideas will finally be implemented. Customers are managed in much more granular clusters, and a broad spectrum of suitable products will be offered. This allows customers to select one of the many "logistics menus" that precisely fit their needs.

New transportation concepts, such as drone delivery, allow companies to manage the last mile efficiently for dense single and high-value packages.

MORE ACCURATE

The next generation of performance management systems offers real-time end-to-end transparency throughout the supply chain. The scope of information ranges from summarized top-level KPIs, such as the overall service level, to highly detailed process data, such as the exact location of trucks in the network. The integration of data from suppliers, service providers, etc. in a "supply chain cloud" ensures that all stakeholders govern and decide on the same facts. To maintain the level of service even in the event of a supply chain interruption, the systems will automatically adapt the objectives that can no longer be achieved to a realistic level of aspiration. We will be able to work with performance management systems that "learn" to automatically identify risks or exceptions and will change supply chain parameters into a closed-loop learning approach to mitigate them. The goal will be to manage a wide spectrum of limitations without human involvement and to exploit only the human planner for disruptive events / new events - with this, a supply chain is continuously developing towards its efficient frontier.

MORE EFFICIENT

Supply chain efficiency is enhanced by the automation of both physical activities and planning. The robots manage the material (pallets/boxes and single pieces) completely automatically along the warehouse process, from reception/unloading to storage for collection, packaging, and shipping. Autonomous trucks transport products within the network. To optimize the use of trucks and increase transport flexibility, transport optimization between companies is applied to share capacities between companies. The configuration of the network itself is continuously optimized to ensure optimal adaptation to business needs.

Figure 2 below well represents the "Vision" described.

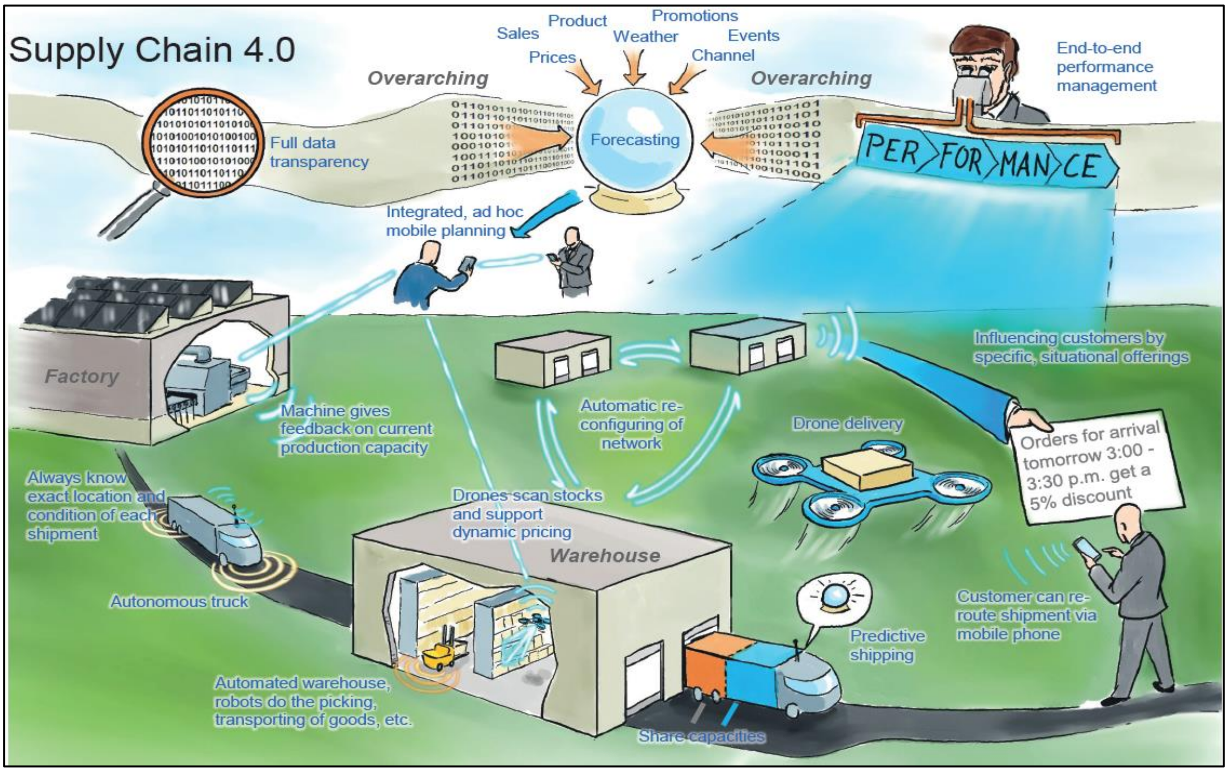

Figure 2: The Vision of the Supply Chain 4.0
Source: https://www.mckinsey.com/business-functions/operations/our-insights/supply-chain-40--the-next-generation-digital-supply-chain#

3.1.2 Barriers and risks to the Supply Chain 4.0

Some critical obstacles standing in the way to Supply Chain 4.0 transformation are summarized as follows:

1. Many new technologies are used or starting to be used. However, the level of implementation in Europe is still shallow compared to other regions in the world, such as the US, mainly due to the lack of workforce digital skills[1].
2. Primary requirements to enable most of the new technologies, broadband coverage, and good internet connection are not evenly distributed within Europe, especially in remote rural areas[2].
3. Small and medium sized enterprises seek cost-effectiveness and reliability on new technologies[3]. Resistance to change and to the introduction of new technologies in wood and agrifood might be due to the knowledge gap by new technologies providers. Independently of age or sectors, wood and agrifood stakeholders appear equally sensitive to technologies and their implementation. Their main objective is to gain benefits and reduce costs of labour without disrupting the way they work and negatively impacting their priorities.
4. Small and medium sized have difficulties with investment capabilities[4]. Investments in new technologies are expensive and it is difficult for SMEs to follow all the technological trends. Insurance schemes are also not sufficient at this stage to protect and cover the risks of technological investments. Funding through the private-public partnership is therefore developed to address this challenge.
5. Proper governance for 'fair' distribution of information is one of the key challenges for digitalizing food-chains[5]. It is more likely that upstream players in the food-chain adopt new technologies faster and more effectively. Food-chain partners recognize new opportunities for better alignment of supply and demand, improving food quality, reducing food waste, utilizing efficient logistics, etc. However, this could become a challenge if information asymmetry is created because some players in the value chain have broader access to valuable data and can strengthen their (market) position at the cost of other, less informed, parties.
6. In general, the process of digitalization is accompanied by uncertainty of the return and fear by employees, and sometimes by employer too. Although benefits of digitalization for a company are clear, sometimes they are not correctly presented to individual employees and teams: this often results in fear in those being impacted (job changes / losses, being faced with learning new skills, new technology or new ways of working). This may be particularly critical for SMEs involved in SCM, which have not the financial resources to cope with the inertia in involving staff in change: this in fact means not only digital training, or better, training on digital matters, but implementation of change paths that are recognized as opportunities by employees.

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[1] Cedefop (2018). Insights into skill shortages and skill mismatch: learning from Cedefop's European skills and jobs survey. Luxembourg: Publications Office. Cedefop reference series; No 106. https://www.cedefop.europa.eu/files/3075_en.pdf

[2] European Commission. DESI 2020 Thematic Chapters-Connectivity

[3] https://www.alphabrown.com/product-page/agriculture-iot-solutions-market-potential

[4] FAO. 2016. Public–private partnerships for agribusiness development – A review of international experiences, by Rankin, M., Gálvez Nogales, E., Santacoloma, P., Mhlanga, N. & Rizzo, C. Rome, Italy

[5] FAO. 2020. Realizing the potential of digitalization to improve the agri-food system: Proposing a new International Digital Council for Food and Agriculture. A concept note. Rome

The NIMBY syndrome applies also in digitalization processes inside the enterprises, at each level, form the owners down to the last basic worker. This situation is demonstrated by the fact that most of employers and employees make use, for example, of all social app, but they resist to use similar apps for working.SMEs are involved in supply chain processes along the chain, from sourcing to manufacturing, transportation, and distribution. As the trend towards digital technology adoption is accelerating among large manufacturers and tier 1 suppliers, the SME lag is resulting in a "dual economy" effect, where everybody might lose. The risk for SMEs is to be left behind and outside the new digital economy, with undesired effects for governments in terms of employment and economic growth. In turn, the risk for large companies is to indirectly rely on supply chain partners that, due to a low level of implementation, prevent them from fully grasping the benefits of the digitalization.

3.1.3 Best practices in advanced economies

A review of the focus and experience of advanced economies to enable Supply Chain 4.0 providing valuable lessons and best practices is summarized as follows:

Initiative	Example	Impact on the Supply Chain
4.0 Centers focused on SMEs	Italy: Fabbrica Intelligente, Digital Innovation Hub / Competence Centers	Cooperation of the public sector, Industry Associations, private companies, and Academia for the promotion of digital manufacturing platforms
	United States: Manufacturing USA, Manufacturing Extension Partnership	A policy that focuses on cross-cutting technology initiatives in the fields of additive manufacturing, robotics, energy, and biomanufacturing The development of innovative methodologies and practices to integrate technology in the supply chain
	Japan: Industrial Value Chain Initiative	A collaborative forum promoting the development and adoption of "smart manufacturing" solutions, by bringing large and small enterprises together to develop a combination of manufacturing and ICT technologies to improve industrial operations The supply of advanced manufacturing IoT kits for SMEs
	Spain: Federación Española de Centros Tecnológicos	Centers that provide SMEs with R&D project assistance, technical assessment and advice, technology diffusion, standards and quality certification, training and international cooperation
SME advisory services	France: Advisory Programme - Industrie du Futur	Tools that assess SME digital transformation maturity Free consulting from SME peers
Use case development	Germany: Plattform Industrie 4.0	A database of over 300 use cases of opportunities for digitalization production processes, 10 of which focus on the supply chain

Table 2: 4.0 Initiatives with Impact on the Supply Chain (1/2)
Source: World Economic Forum

Initiative	Example	Impact on the Supply Chain
4.0 Maturity indices	United States: Digital Compass (Digital Manufacturing Design and Innovation Institute)	A "Digital Compass" diagnostic tool to guide companies in their adoption of Industry 4.0 and evaluate the actual returns they realize from digital manufacturing implementations
	Germany: Industrie 4.0 Maturity Index	An index that charts the evolution of firm capabilities, from simple digitalization (adopting computers and connecting them online) to collecting data, to conducting diagnostics in real-time on the factory floor, to anticipating and predicting changes in demand, equipment maintenance, and other operational variables, to self-optimizing factories
	Singapore: Smart Industry Readiness Index	A comprehensive tool for all companies regardless of size or the industry they are operating in that covers all three core elements of Industry 4.0 (technology, process, and organization) A specific pillar of the index that addresses the key components of Supply Chain 4.0
	Spain: Industria Conectada 4.0 Maturity Toolkit	A toolkit aimed at auto-evaluating a company's state of maturity in terms of its migration towards digital transformation; 16 pillars associated with enabling technologies
Data standards development	United States: MT Connect	A free, open standard that enables manufacturing equipment to provide structured, contextualized data with no proprietary format, used by manufacturers in the United States, Europe, Brazil, and China
	Japan: e-F@ctory, Industry 4.1	A data standard providing a flexible approach to the interoperability of smart manufacturing equipment
	South Korea: Private-sector and KATS standards development	Interoperability standards defined by private companies within a sector (e.g., automotive companies define data standards for their sector

Table 3: 4.0 Initiatives with Impact on the Supply Chain (2/2)
Source: World Economic Forum

3.1.4 The Digital Economy & Society Maturity Level

Some figures on the International digital economy and society maturity level will show the current state of the art, with focus on the Business Technology Integration and Supply Chain Management.

The DESI Index

The European Commission has been monitoring Member States' digital progress through the **Digital Economy and Society Index (DESI) reports since 2014**. The DESI country reports combine quantitative evidence from the DESI indicators across the five dimensions of the index with country-specific policy insights and best practices. As regards the thematic chapters, the DESI 2020 report includes a European-level analysis of broadband connectivity, digital skills, use of the Internet, digitalization of businesses, digital public services, emerging technologies, cybersecurity, the ICT sector and its R&D spending and Member States' use of Horizon 2020 funds. As the Figure 3 below refers to 2019, the United Kingdom is still included in the 2020 DESI, and EU averages are calculated for 28 Member States[6].

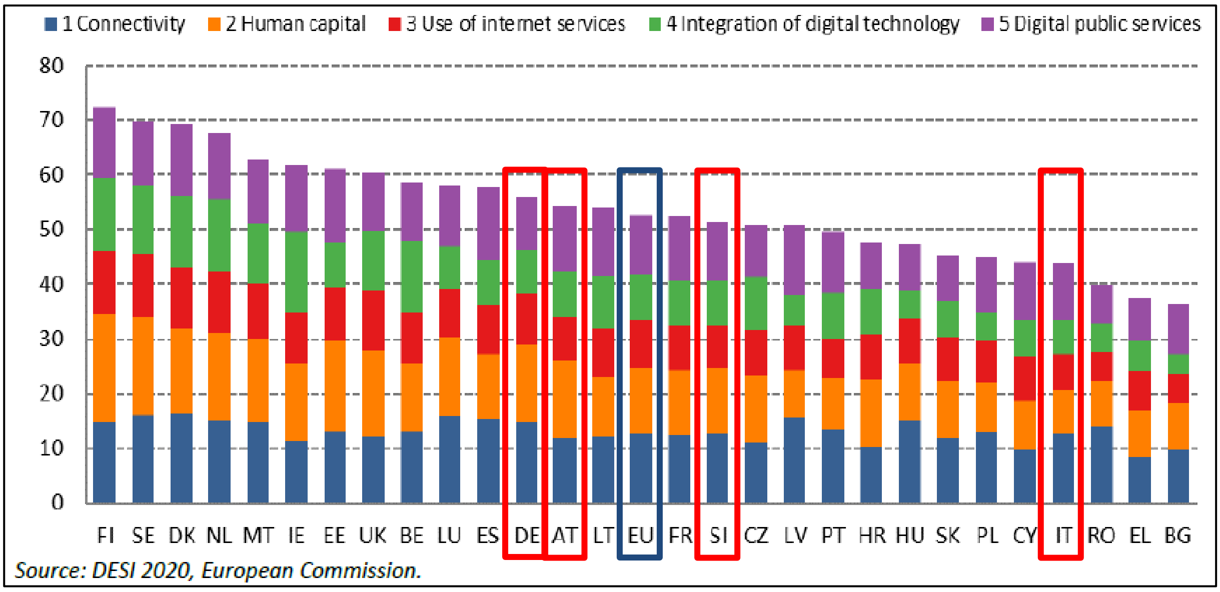

Figure 3: Digital Economy and Society Index (DESI) 2020 Ranking

Some comments on Germany (DE), Austria (AT), Slovenia (SI), and Italy (IT), the Alpine countries red marked in the previous Figure 3, are as follows.

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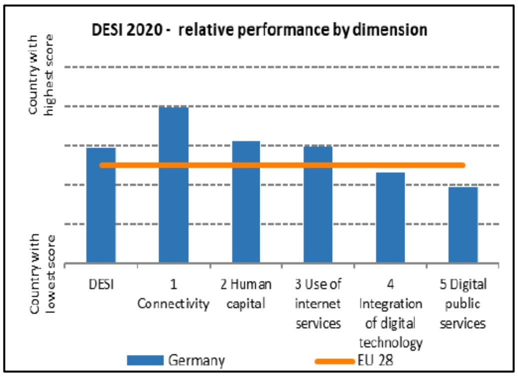
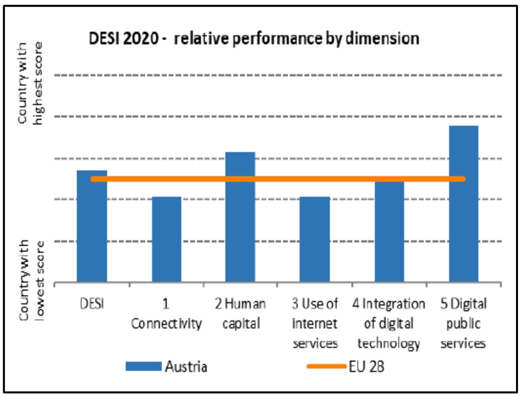
[6] European Commission. DESI 2020 Thematic Chapters-Full European Analysis

Based on data prior to the pandemic, **Germany** performs well in most DESI dimensions, except in digital public services. On the Connectivity dimension, Germany leads the EU on 5G readiness and has a high take-up of overall fixed broadband. The country performs well on the Human capital dimension, ranking fifth both for at least basic digital skills and for at least basic software skills. German companies have increased their use of social media but have not made progress in the level of Integration of digital technologies.

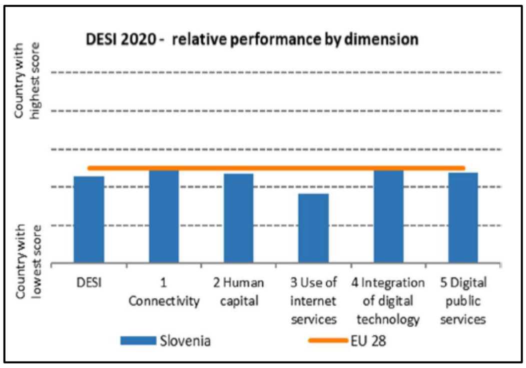


Austria is above average in two of the DESI dimensions, and below in three.

Compared to last years' DESI, Austria's ranking remained relatively stable. While Austria remains slightly above the EU average, the distance to the best performing countries has increased. Austria is an above average performer in every indicator of the Human Capital dimension of the DESI (digital skills, software skills, ICT graduates and specialists). It performs below average in Connectivity and Integration of digital technologies.



Slovenia has improved its score in all five dimensions, but advanced in ranking only in the integration of digital technology dimension. Connectivity, Human capital, Integration of digital technology and Digital public services are in line with EU average.



Italy has a good ranking in terms of 5G preparedness, as all the pioneer bands were assigned, and the first commercial services were launched. There are significant gaps as regards Human Capital. Compared to the EU average, Italy records very low levels of basic and advanced digital skills. Although the country ranks relatively high in its offer of e-government services, public take-up remains low. Similarly, Italian enterprises lag behind in the use of technologies such as cloud and big data, as well as in the uptake of e-commerce.

More details of Italy ranking versus EU28 in <u>Annex2</u>.

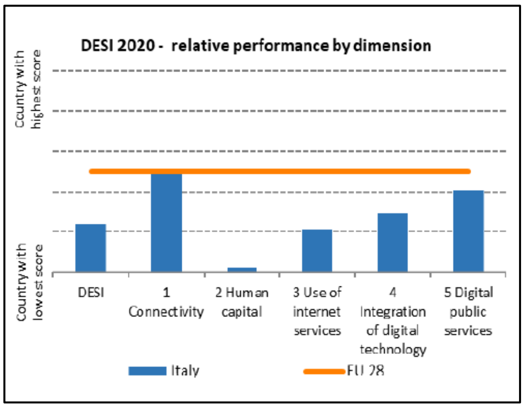


Figure 4: DESI 2020 scores: Germany, Austria, Slovenia, and Italy

The I-DESI Index 2018[7]

The International Digital Economy and Society Index (I-DESI) 2018 measures the digital economy performance of the EU28 Member States and the EU as a whole in comparison with 17 non-EU countries, using a similar methodology to the EU DESI index. I-DESI combines 24 indicators and uses a weighting system to rank each country based on its digital performance to benchmark the development of the digital economy and society. It measures performance in five dimensions or policy areas: connectivity, human capital (digital skills), use of the Internet by citizens, integration of technology, and digital public services.

The 2018 I-DESI has three key objectives:

1. General performance assessment - to obtain a characterization of the performance of non-EU countries that mirrors DESI by calculating overall index scores and scores for the main index dimensions of a selected group of 17 non-EU countries;

2. Comparative analysis - to undertake comparative trend analysis over a four-year time period – *2013 to 2016* - of the performance within and between a selected group of 17 non-EU countries and 28 EU Member States;

3. Zooming-in - to pinpoint areas where EU28 Member State performance is competitive in comparison with non-EU countries and to identify areas where performance needs to improve to better match a comparison group of 17 selected non-EU countries.

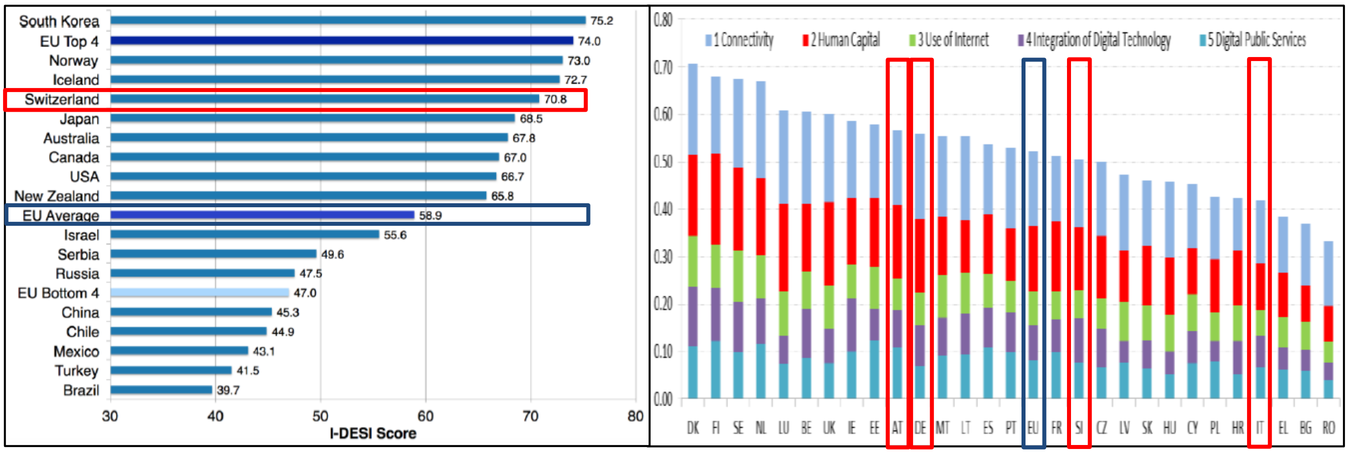


Figure 5: Non-EU countries normalized performance scores for I-DESI vs DESI EU28 (ref. the year 2016)

In Figure 5 above the I-DESI performance scores and DESI EU28 (based on same reference year and related data), are compared, to complete the scenario of Alpine countries, which is the main focus of this report, with Switzerland positioned on the top of the ranking, above EU average (normalized Switzerland 70,8 vs EU average 58,9) and over the best performer (Austria and Germany are 4-5 points better than EU average according to DESI EU28 2016).

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[7] European Commission. International Digital Economy and Society Index 2018

The Gartner Supply Chain Top 25 2020

The Gartner Supply Chain Top 25 for 2020 ranking reveals that supply chain leaders exhibit adaptability and resiliency, especially during times of disruption. Amazon, Apple, McDonald's, P&G, and Unilever continue to demonstrate advanced lessons for the supply chain community. Along with the master's category, the Supply Chain Top 25 offers a platform for insights, lessons, debates, and contributions to the rising influence of supply chain practices on the global economy (see table 4 below).

Rank	Company	Peer opinion[1] (151 voters) (25%)	Gartner opinion[1] (44 voters) (25%)	3-year weighted ROPA[2] (20%)	Inventory turns[3] (5%)	3-year weighted revenue growth[4] (10%)	ESG Component Score[5] (15%)	Composite Score[6]
1	Cisco Systems	470	574	300.7%	12.5	2.9%	10.00	**6.25**
2	Colgate-Palmolive	1113	532	68.8%	4.7	1.0%	10.00	**5.37**
3	Johnson & Johnson	885	454	77.6%	3.0	3.6%	8.00	**4.65**
4	Schneider Electric	567	453	63.0%	5.4	4.2%	10.00	**4.48**
5	Nestlé	1084	350	40.0%	4.8	1.2%	10.00	**4.44**
6	PepsiCo	857	385	47.9%	8.2	2.7%	10.00	**4.42**
7	Alibaba	991	316	106.7%	23.9	54.0%	0.00	**4.39**
8	Intel	583	488	37.4%	3.5	5.8%	8.00	**4.12**
9	Inditex	737	351	34.7%	4.6	6.8%	10.00	**4.11**
10	L'Oréal	677	252	71.1%	2.8	7.4%	10.00	**4.01**
11	Walmart	1333	324	13.2%	8.5	2.4%	7.00	**4.00**
12	HP Inc.	296	389	51.1%	8.5	5.5%	10.00	**3.87**
13	Coca-Cola	1195	207	75.4%	4.4	0.0%	6.00	**3.74**
14	Diageo	403	280	41.4%	0.9	6.2%	10.00	**3.49**
15	Lenovo	397	307	16.9%	11.2	7.0%	10.00	**3.44**
16	Nike	768	265	47.2%	4.0	6.7%	6.00	**3.35**
17	AbbVie	128	30	262.4%	4.1	7.6%	5.00	**3.20**
18	BMW	575	182	24.8%	3.9	4.2%	10.00	**3.17**
19	Starbucks	799	202	52.6%	13.0	7.7%	4.00	**2.99**
20	H&M	412	161	22.4%	2.8	7.7%	10.00	**2.95**
21	British American Tobacco	154	56	85.6%	0.7	18.1%	9.00	**2.90**
22	3M	624	207	54.1%	3.9	1.1%	6.00	**2.90**
23	Reckitt Benckiser	265	14	99.0%	3.8	8.2%	9.00	**2.79**
24	Biogen	79	27	152.2%	2.5	7.8%	7.00	**2.78**
25	Kimberly-Clark	534	80	34.6%	6.6	0.2%	10.00	**2.76**

Table 4: The Gartner Supply Chain Top 25 for 2020

In the current environment, the natural tendency of many companies is to pull back spending, including money tied to transformational programs. Advanced supply chains are pressing forward and, in some cases, accelerating investments in real-time visibility, planning and agile supply chain execution capabilities, well-suited for supporting uncertain demand mixes and volumes. *Leading companies in the Supply Chain Top 25 are early and frequent adopters of digital technologies.* Gartner's most recent Supply Chain User Wants and Needs Study shows advanced analytics and big data applications voted as the most important and frequently adopted (~70% of the population) digital capabilities. Other important and commonly adopted technologies include robotic process automation (RPA), artificial intelligence (AI) and/or machine learning (ML), and the Internet of Things (IoT) applications. Robots have also proliferated on the floors of factories and warehouses, often paired with automated guided vehicles (AGVs) to shuttle materials and finished items between stations and out the door.

3.1.5 Analysis of the Digitalization Level Indicators

There is no official global scale to measure the digitalization of SMEs, nor are there any global indicators for digitalization specified. The Alpine countries (Switzerland, Germany, Austria, Slovenia, and Italy) adopted different but comparable and overlapped schemes and approaches to measure the digitalization process of business and society.

Switzerland. In 2016 a joint publication from PwC Switzerland, Google Switzerland GmbH and digitalswitzerland reported a survey[8] of people representing more than 300 organizations. It took the form of a self-assessment, with participants asked to rate their own organization on a scale of 1 to 4 in the categories processes and infrastructure, digital sales, customer involvement and digital culture. Each organization's degree of digitalization (DoD) was calculated by averaging these scores. The average degree of digitalization was high (Figure 6), scoring 2,05 out of 2,5, with process/infrastructures and people/culture on the top levels; digital sales and customer involvement were recorded in the improvement areas.

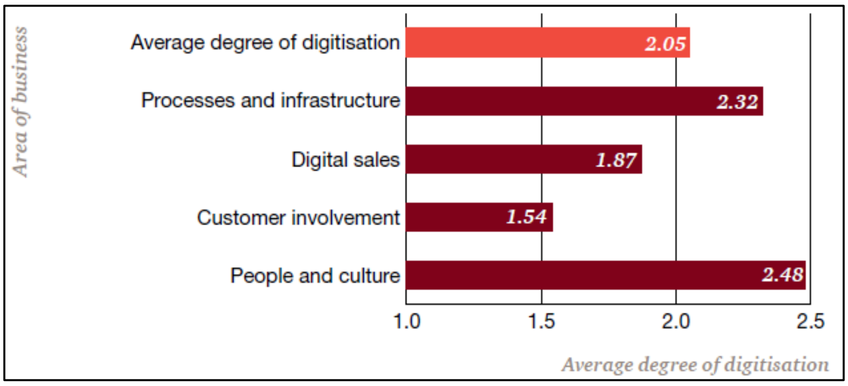

Figure 6: Swiss average and breakdown degree of digitalization (survey of around 300 Swiss SMEs)

Germany uses the Digital Economic Index (DEI)[9], that provides a number to show the level of digitalisation in the German economy. It is based on a survey of high-ranking decision-makers from 1,061 businesses. Three aspects are incorporated in the economy index: the use of digital devices, the state of internal company digitalization, and the effect of digitalization on the company commercial success.

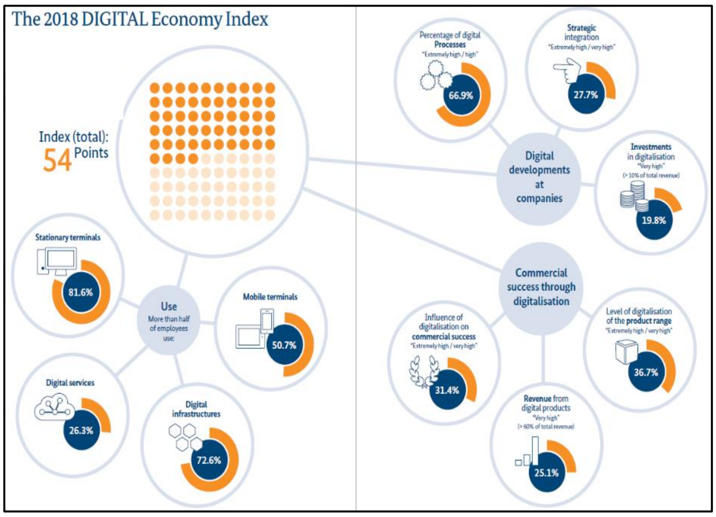

Figure 7: Germany Digital Economic Index 2018

Austria does not have any specific measurements.

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[8] PwC Switzerland, Google Switzerland GmbH and digitalswitzerland. Digital transformation: How mature are Swiss SMEs? 2016

[9] Federal Ministry for Economic Affairs and Energy Public Relations Department. DIGITAL Economy Monitoring Report 2018

Slovenia uses the Digital Intensity Index (DII)[10], a micro based index that measures the availability at firm level of 12 different digital technologies: internet for at least 50 % of employed persons, recourse to ICT specialists, fast broadband (30 Mbps or above), mobile internet devices for at least 20 % of employed persons, a website with sophisticated functions, social media, paying for advertising on the internet; the purchase of advanced cloud computing services; sending e-Invoices, e-Commerce turnover accounting for over 1 % of total turnover and business to consumer (B2C) web sales of over 10 % of total web sales. The value for the index therefore ranges from 0 to 12.

Such index (DII) was adopted by European Commission to measure the Integration of Digital Technology at EU level (Figure 8).

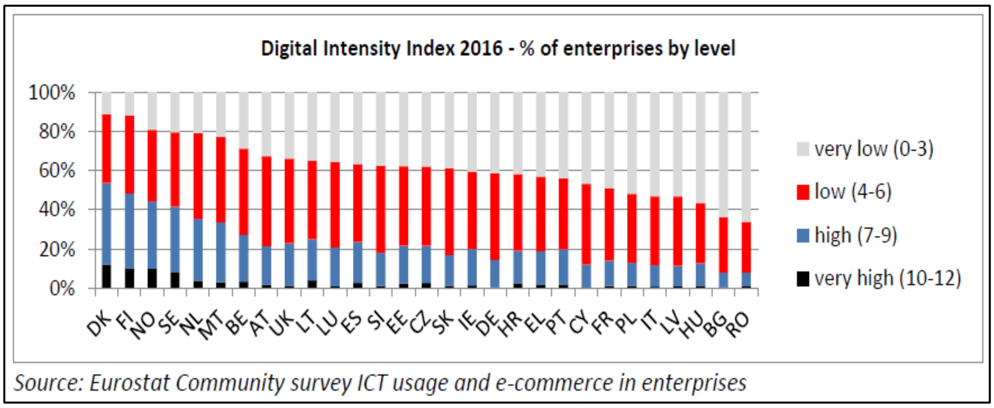

Figure 8: Digital Intensity Index 2016- % of enterprises by level

Denmark is the only country in the EU where the percentage of firms with an extremely high DII (i.e. possessing at least 10 out of the 12 monitored digital technologies) is close to 10%. By contrast, in some countries such as Bulgaria, Romania, Latvia, Italy, Greece, Hungary and France, the majority of businesses (more than 50%) have not yet invested heavily in digital technologies (i.e. have a very low DII).

Moreover, the digitalization of economic sectors is progressing at different speeds, according to their own specific needs and starting points, according to Figure 9. The different segments of the ICT sector (from "Telecoms" to the "Manufacture of computers"), as well as "Travel agencies" and "Repairs of computers and communication", tend to be the most digitalized sectors of the economy. Some sectors are still impervious to digital changes: for example, in the construction sector only 7.7 % of the enterprises have a high or extremely high DII. _Wood, textile and agrifood manufacturing are low down (10-16%), meaning that they have a slow absorption rate of digital technologies._

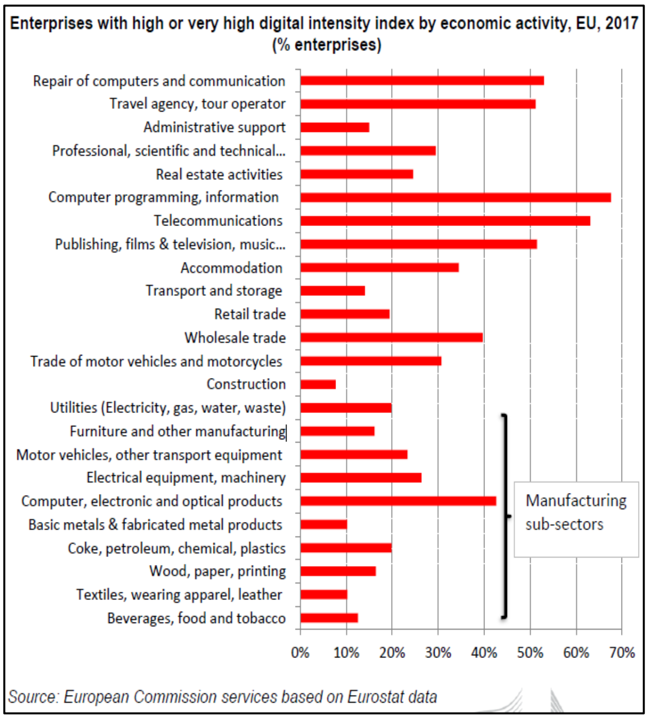

Figure 9: Percentage of EU enterprises with high (>6) Digital Intensity Index (2016)

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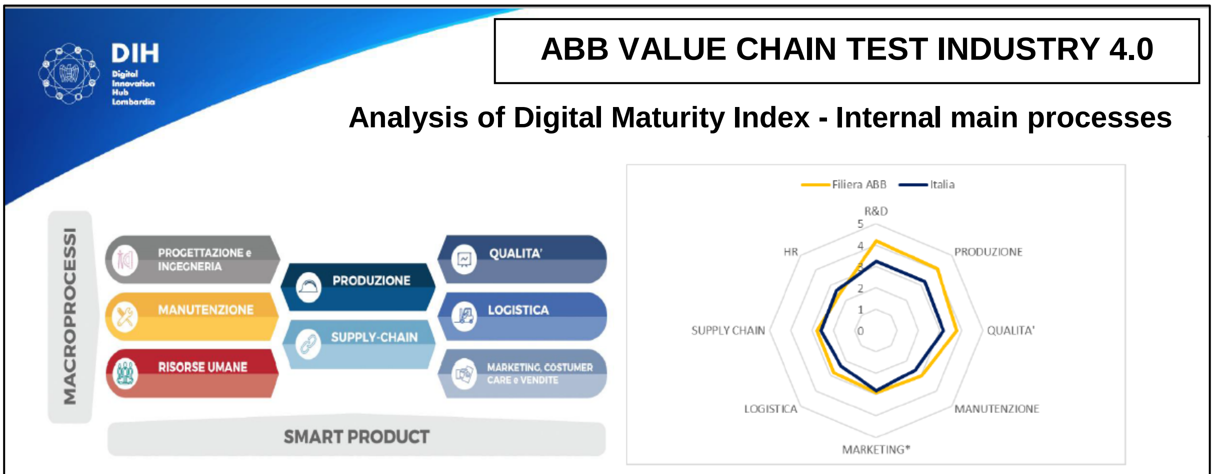
[10] European Commission. Europe's Digital Progress Report 2017

Italy approach is based on Digital Maturity Index (DMI), which provides SMEs with an assessment of their digital maturity by analyzing their business processes (R&D, Production, Quality, Maintenance, Marketing, Logistics, Supply Chain, and Human Resources). The stated processes are evaluated with respect to four dimensions of analysis, such as Monitoring and Control, Technologies, Execution and Organization, across the main company processes.

The slides attached below are extracted from a Digital Innovation HUB Lombardia report[11], performed on ABB company value chain, compared to the national average of 713 industries. This is one of the best practices from Italy in terms of assessment of the Digital Maturity Index (DMI).

The assessment revealed an inhomogeneous level of digital maturity across the main company processes, with R&D, Production and Quality which scored a higher level than Maintenance, Marketing, Supply Chain and Human Resources. The Supply Chain DMI of ABB value chain was measured 2,78 out of 5, slightly better than the national average (2,58 out of 5).



	R&D	Production	Quality	Maintenance	Marketing	Logistic	Supply Chain	Human Resource
Filiera ABB	4,19	4,08	3,78	2,99	2,90	2,79	2,78	2,43
Italia**	3,22	3,23	3,15	2,60	2,83	2,33	2,58	2,62

**= campione di 713 imprese che hanno effettuato la valutazione della maturità digitale con lo strumento «test 4.0» tramite la rete nazionale dei DIH di Confindustria

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Figure 10: The Digital Maturity Index of ABB Value Chain

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11 http://preparatialfuturo.confindustria.it/wp-content/uploads/2020/07/SHORT_Finale_ABB.pdf

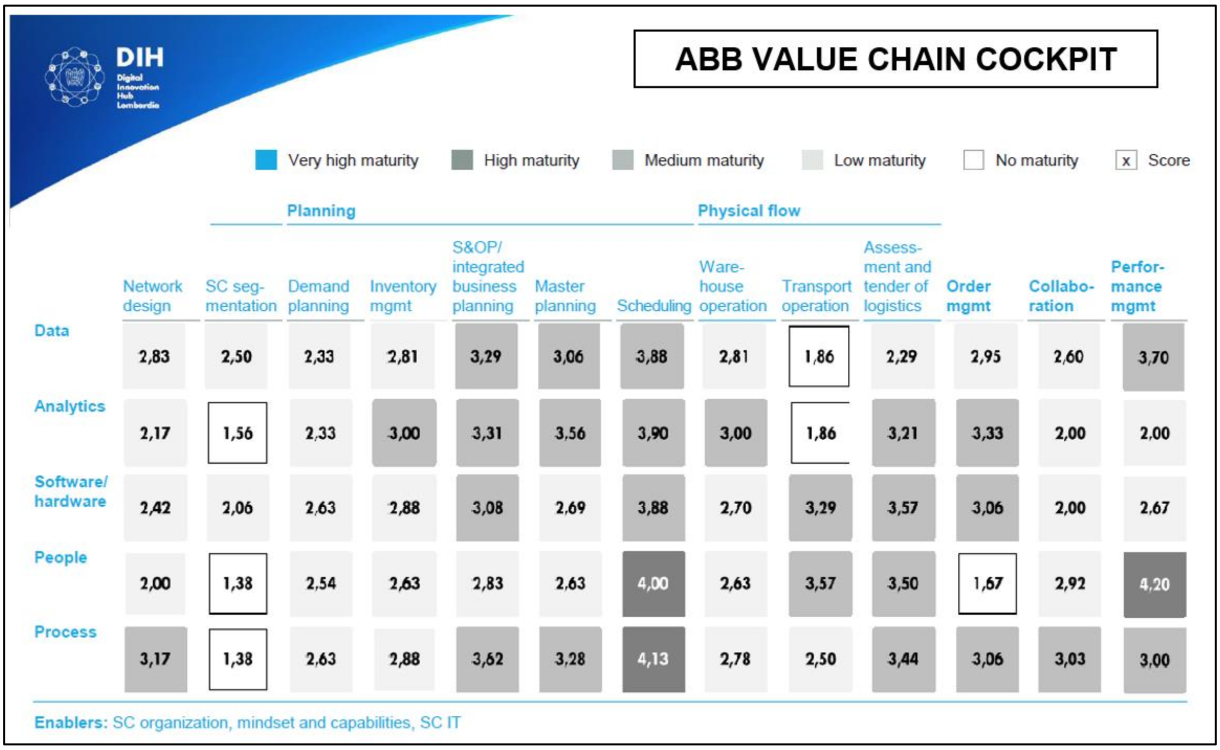

Figure 11: The ABB Value Chain Cockpit

The cockpit from ABB Value Chain evaluation reveals a high level of digital maturity in many fields of Physical Flow, as well as the Master planning and Scheduling. By contrast, Demand planning, Inventory management and SC segmentation, which are strategical factors of Supply Chain Management 4.0, are the strongest improvement areas. *Data analysis and exploitation, which were assessed as "low maturity" in 70% of all fields, shall be one of the most crucial point to accelerate SCM transformation.*

Sharing SCM information electronically[12]

Digitalization of the economy has also meant a change in the way enterprises engage with their customers, suppliers, and the wider public in general.

The uptake of electronic business is a phenomenon that needs to be monitored further and along the following lines:

- *% of enterprises sharing supply chain management information electronically;*
- % of enterprises sending and/or receiving e-Invoices;
- % of enterprises having a website with e-Commerce functions;
- % of enterprises using social media by purpose.

Source: Eurostat

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[12] E-business integration-Eurostat, June 2018

The adoption of e-business technologies varies among enterprise size classes. The gap between small and large enterprises is considerably bigger for those using more advanced ICT applications than for those with a website. The percentage of enterprises with a website ranged from 74 % for small enterprises to 94 % for largen enterprises, but from 28 % to 76 % respectively for those using enterprise resource planning (ERP).

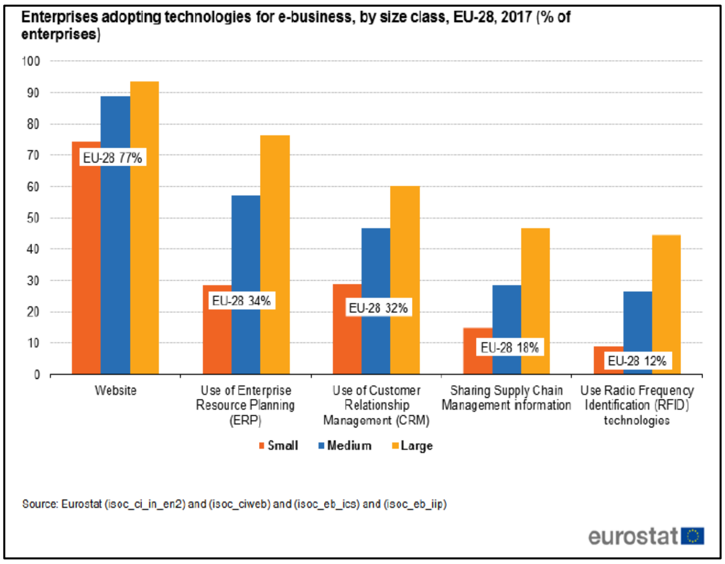

Figure 12: Enterprises adopting technologies for e-business, by size class, EU-28, 2017 (% of enterprises)

Sharing Supply Chain Management information strongly depends on economic sector. This information shared may concern, for example, inventory levels, production plans, demand and supply forecasts or progress of deliveries. Accordingly, the use of SCM software applications aims to effectively coordinate the availability and delivery of products to final consumers, in the right quantity, at the right time, into the right hands at optimal cost. SCM actively involves all resources - business functions - concerned with planning and forecasting, purchasing, product assembly, logistics, sales, and customer service.

The extent to which SCM information is shared varies among economic sectors. As shown in Figure 13, some 28 % of enterprises in the wholesale and retail trade - the highest among enterprises in all economic sectors - shared SCM information with their suppliers or customers, whereas slightly more than 10% did so in the Administrative and support service activities or the construction sector.

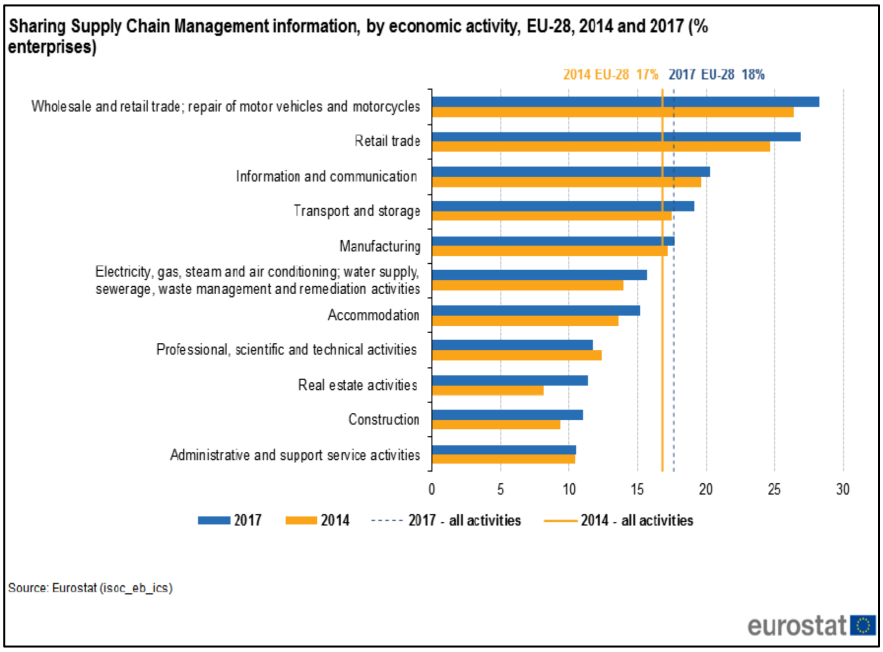

Figure 13: Sharing Supply Chain Management information, by economic activity

Finally, the digital maturity of wood, agrifood and textile supply chains were not yet deeply investigated nor measured, concerning the digital indicators listed so far.

3.1.6 Use case 1: Wood

Wood framework

The EU accounts for approximately 5 % of the world's forests and, contrary to what is happening in many other parts of the world, the forested area of the EU is slowly increasing. Apart from the forests' ecological value, their role as an essential element in European landscape and their importance for some non-economic uses, such as recreation, forests are also an economic resource[13].

Primary wood products

The total roundwood production in the EU continues to increase. In 2018, it reached an estimated 490 million m^3; i.e. almost 36 million m^3 (8 %) more than the peak output recorded in 2007, when the industry had to process greater numbers of trees that were felled by severe storms, and 21 % more than at the beginning of the millennium. With the exception of five Member States, all EU-27 countries recorded an increase in roundwood production in the period of 2000 - 2018. The largest relative increase in the amount of harvested wood took place in the Netherlands (ca 200 %) and Slovenia (124 %). In 2018, Sweden was the largest producer of roundwood in EU-27 (75 million m^3), followed by Germany, Finland and France (each producing between 48 and 72 million m^3).

Roundwood production, 2018

	Roundwood production (1 000 m^3 under bark)		
	Total	Fuelwood	Industrial roundwood
EU-27 (¹)	*489 783*	*111 089*	*378 694*
Belgium	:	:	:
Bulgaria	6 529	2 849	3 680
Czechia	25 689	4 246	21 443
Denmark	:	:	:
Germany	*71 802*	*21 874*	*49 928*
Estonia	12 034	4 681	7 353
Ireland	3 541	211	3 330
Greece	:	:	:
Spain	17 360	*1 903*	15 457
France	48 154	22 433	25 721
Croatia	5 390	2 175	3 214
Italy	*6 054*	*3 841*	*2 213*
Cyprus	11	9	2
Latvia	:	:	:
Lithuania	6 982	1 749	5 233
Luxembourg	*448*	*85*	*363*
Hungary	5 856	2 818	3 038
Malta	:	:	:
Netherlands	3 144	2 378	766
Austria	19 192	5 243	13 949
Poland	46 720	5 352	41 368
Portugal	13 945	1 178	12 767
Romania	15 989	5 553	10 436
Slovenia	5 039	1 118	3 921
Slovakia	9 603	524	9 079
Finland	68 289	7 759	60 530
Sweden	75 100	6 800	68 300
United Kingdom	11 267	2 478	8 788
Liechtenstein	12	4	8
Norway	12 822	*1 795*	10 836
Switzerland	4 975	1 736	3 239

(:) not available

(¹) EU estimate produced using latest available data if a country did not report for 2018
Source: Eurostat (online data codes: for_remov)

eurostat

Figure 14: Roundwood production, 2018

The total output of sawnwood across the EU-27 was approximately 100 million m^3 per year from 2010 to 2018, reaching 109 million m^3 in 2018. Germany and Sweden were the EU's leading sawnwood producers in 2018, accounting for approximately 21 % and 17 % of the EU-27 total sawnwood output, respectively (Figure 15).

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[13] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Wood_products_-_production_and_trade#Primary_wood_products

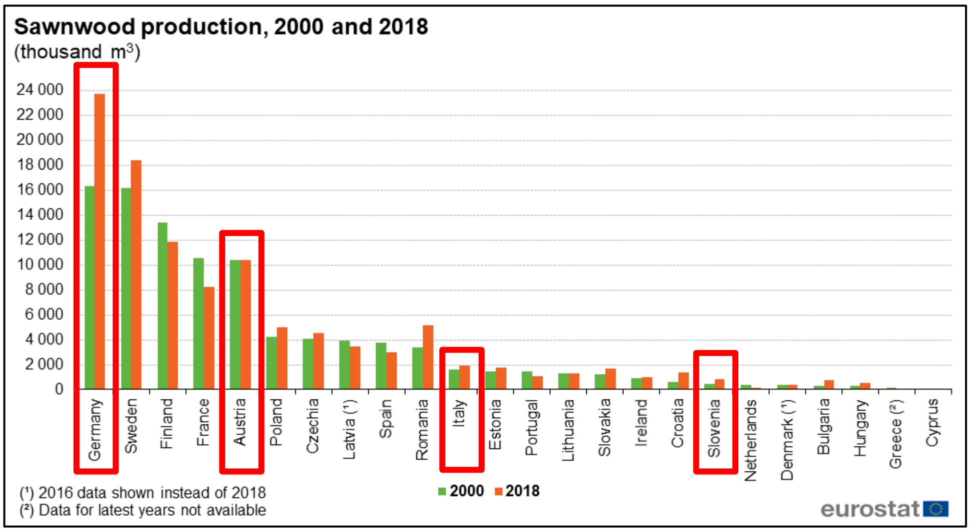

Figure 15: Sawnwood production, 2000 and 2018 (1.000 m3)

Wood-based industries

The EU's wood-based industries cover a range of downstream activities, including woodworking industries, large parts of the furniture industry, pulp and paper manufacturing and converting industries, and the printing industry. Together, some 401 000 enterprises were active in wood-based industries across the EU-27 in 2018; they represented one in five (20.0 %) manufacturing enterprises across the EU-27, highlighting that - with the exception of pulp and paper manufacturing that is characterized by economies of scale - many wood-based industries had a relatively high number of small or medium-sized enterprises.

The economic importance of an industry can be measured by the share of its gross value added (GVA) in the economy. In 2017, the GVA of wood-based industries in the EU-27 was EUR 129 billion or 7.1 % of the total manufacturing industry. The distribution of GVA across each of the four wood-based activities in 2017 is presented in Figure 16. Within the EU-27's wood-based industries, the largest GVA was recorded for pulp, paper and paper products manufacturing (34 % or EUR 44 billion). Regarding the other three sectors, printing and service activities related to printing amounted to 19 % of the GVA of wood-based industries, while the manufacture of furniture and manufacturing of wood and wood products each made up between 23 % and 24 %.

Main economic indicators for wood-based industries, EU-27, 2018

Activity (NACE Rev. 2)	Number of enterprises (1 000)	Gross value added at factor cost (billion EUR)	Number of persons employed (1 000)
	2018	2017	2018
Manufacturing (NACE C)	2 014 p	*1 826* de	29 148 p
Wood-based industries (NACE C 16+17+18.1+31)	401	129	3 060
Manufacture of wood and wood products (16)	163 p	31	920 p
Manufacture of pulp, paper and paper products (17)	18 p	44	*610* dep
Printing and service activities related to printing (18.1)	100 dpu	24	580 p
Manufacture of furniture (31)	120 dpu	*30*	*950* dep

'd' : definition differs, see metadata.
'e': estimated
'p': provisional
'u' : low reliability.

Source: Eurostat (online data code: sbs_na_ind_r2)

eurostat

Figure 16: Main economic indicators for wood-based industries, EU-27, 2018

The wood-based industries employed 3.1 million persons across the EU-27 in 2018 or 10.5 % of the manufacturing total. There were more than 900 000 persons employed within both the manufacture of wood and wood products and the manufacture of furniture, whereas an employment of 580 000 persons was recorded for printing and service activities related to printing, representing the lowest employment of the four activities.

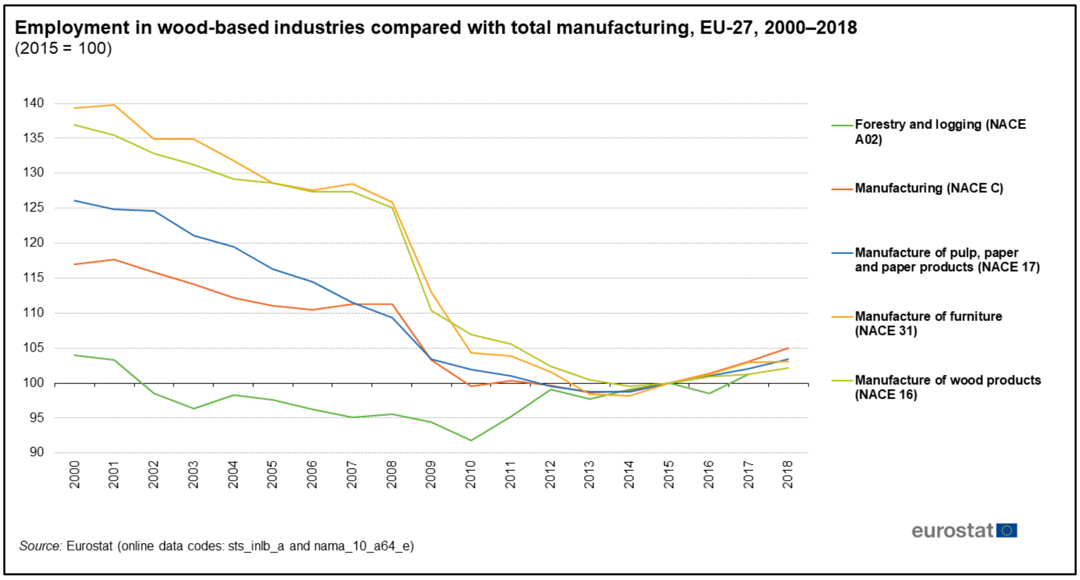

Figure 17: Employment in wood-based industries compared with total manufacturing, EU-27, 2000–2018

A longer time series and more recent data are available for employment for three of the four wood-based industries. Across the EU-27, manufacturing employment fell by 10% between 2000 and 2018, while the largest losses among the three wood-based industries shown in Figure 17 were recorded for furniture manufacturing (26 % fewer persons employed). Pulp, paper, and paper products was less affected (18 % reduction in employment during the 2000–2018 period), while employment in manufacturing of wood products dropped by 25 % between 2000 and 2018. In comparison, the forestry and logging industry had a decrease in employment of less than 3 % from 2000 to 2017.

Wood Supply Chain description

The wood supply chain describes the process steps starting with harvest planning and ending with logistics and sales. We define the following five main process steps as part of the wood supply chain:

Harvest planning

The objective of the technical planning is to prepare a forest stand for harvesting operations and vice versa. The main process steps of harvest planning are determining harvesting sequence and time, marking trees and on-road transportation lines (e.g. skid trails) and landings if necessary, defining harvesting method, defining timber assortments planned and estimating volume of work.

Harvest organization and control

This process step contains all organizational tasks around the time of the actual harvest, including instruction of the harvesting operators, quality control during the harvest, problem solving and ad hoc support as well as the documentation of execution.

Harvest operations

For cut-to-length timber harvesting, operations in the stand can be divided into two main sub-processes, which are generally carried out by different machinery: felling and processing as well as extraction. Felling and processing consists of the process steps of finding a tree, positioning of the harvester, heading towards the tree, felling the tree in the right direction, transferring the tree to the work area (skid trail), delimbing, measuring and bucking, piling logs if possible by assortment close to the skid trail. Extraction consists of the process steps of finding the wood piles, sorting (if necessary) and collecting the logs, transporting the logs to the forest road and finally piling logs at the road or at the landing zone.

Timber transport and logistics

The management of the transport and logistics process is the final step in the forest as well as the interface to the sawmills. Besides timber inventory, transport organization and scheduling, route optimization, truck operations (localization, navigation, loading, transportation of logs) as well as quality control and documentation of execution are necessary process steps.

Timber sales: Timber sales can be planned upfront or after the harvest is executed, which is very much dependent upon national standards, timber assortments and best practices of the single organization. Besides financial arrangements, the main task of sales operations is the most effective allocation of the harvested timber.

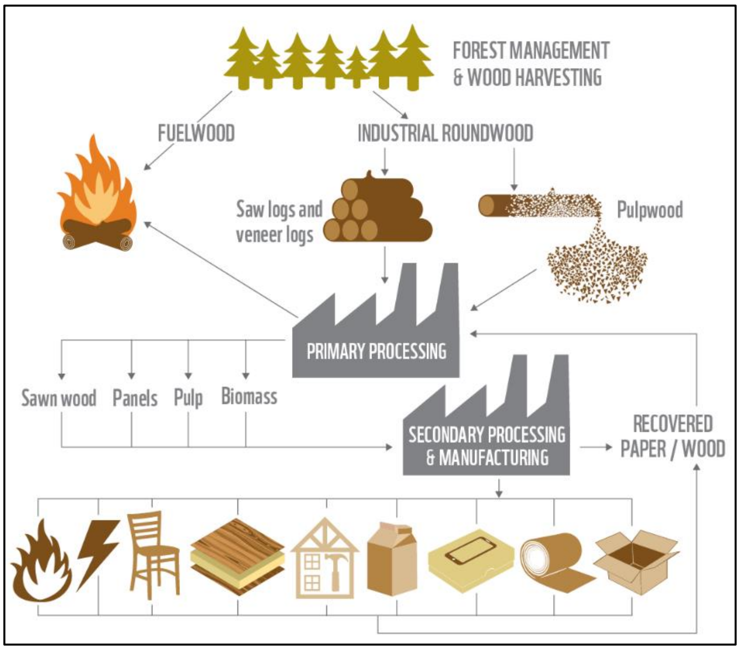

Figure 18: The Wood Supply Chain
Source: https://wwf.panda.org/?207367/Industry-key-to-conserving-forests-as-demand-for-wood-projected-to-triple-by-2050

Within the Wood supply chain description, it was considered relevant to point out the following studies which will be briefly presented.

Wood Chain Manager

Researchers from the Slovenian Forestry Institute developed the website Wood Chain Manager that offers different interactive tools suitable for the organization and optimization of forestry works.[14]

Web portal Wood Chain Manager offers different interactive tools suitable for the organization and optimization of forestry works:

· Creation of interactive transparent descriptions of forestry wood chains
· Creation of transparent calculations of forestry mechanization costs
· Stipulation of forestry production norms
· Converting between volume, weight, and energy units

Tools

- Wood flows and price
- Wood fuel price
- Wood supply chain stakeholders map
- Wood supply chain
- Calculate norms
- Cost calculations
- Unit converter

FPInnovations' Forestry 4.0

Initiative is developed by FPInnovations that is a private not-for-profit organization that specializes in the creation of solutions in support of the Canadian forest sector's global competitiveness.[15]

FPInnovations is launching the Forestry 4.0 initiative aimed at bringing the upstream part of the forest value chain to fully leverage the agility and power of Industry 4.0. One of the key goals of the initiative is to help make the supply chain component of the forest sector value chain more reactive and more resilient by implementing connected solutions.

To fulfill the mandate, four research themes regarding specific digital tools have been defined which, through their distinct functions, will help establish the upstream foundations of a new "connected" value chain for the forest sector. They are reported in Annex1.

Digitalization in wood supply – A review on how Industry 4.0 will change the forest value chain[16]

This study consolidates existing research, as well as examples in the practical use of I 4.0, which might change the forest value chain in the future. Therefore, this study seeks to answer the following research questions:

- **What are general trends in research and practice towards I 4.0 in the wood supply?**
- **What are concrete I 4.0 application examples in the wood supply chain on the process level?**

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[14] http://wcm.gozdis.si/en/

[15] https://www.youtube.com/watch?v=r4vhLQ8OEP0

http://cofe.org/files/2017_Proceedings/FPInnovations%20Gingras%20Charette%20Forestry%204.0%20for%20COFE%202017.pdf

[16] Computers and Electronics in Agriculture, Volume 162, July 2019, Pages 206-218, Fabian Müller, Dirk Jaeger, Marc Hanewinkel https://www.sciencedirect.com/science/article/pii/S0168169918305325

The concept of a virtual forest trees

Cyber-physical systems in a smart factory provide a digital image of, e.g. assembly lines. In terms of a smart wood supply chain, a digital image from the forest stand must be generated. As sum of individual trees, topography and soil conditions, available infrastructure and other information, this image can be called the virtual forest.

Sensing data is still a key challenge on the way to the virtual forest. Advanced analytics (AA) and artificial intelligence (AI) techniques solve this problem by translating data from remote sensing into forest attributes.

Tree species classification, yield estimations, diameter at breast height (DBH) and height estimation on single tree level are important examples in this field.

The technologies for generating a virtual forest are remote sensing and advanced modelling techniques, which can be summed up under the fields of advanced analytics and artificial intelligence. Airborne as well as terrestrial LiDAR technology is still a niche application in forest practice but, as research shows, has the potential to be the enabling technology for the development of a virtual forest. Developments in remote sensing show that processing remote support systems for commercial forestry, which are based on virtual forest models. Current developments in practice show that this is already ongoing (Institute of Forest Ecosystem Reserach Ltd., Jílové u Prahy, Czech Republic, 2018; Treemetrics Ltd., Cork, Ireland, 2018).

Harvest planning

With a virtual forest as digital copy of the existing forest stands, harvest planning efficiency and accuracy can be significantly improved.

Depending on the trafficability of the stands to be harvested, harvest time and sequence can be defined. Grigolato et al. (2014) demonstrate that the accessibility of stands to be harvested can be determined based on airborne laser scanning data including terrain, infrastructure and stand inventory information, depending on the type of harvesting systems selected.

Pichler et al. (2017) assess efficiency and costs for marking potential harvest trees by using terrestrial LiDAR data collected by drones. The trees of interest are marked with RFID-tags for location within the stand. However, both costs and efficiency are still not on a sufficient level for this application. Fransson et al. (2017) give an example of the model-aided determination of potential harvest trees. The trees are selected within a virtual forest and their positions are then transferred to the machine operators for optimal thinning efficiency.

On the infrastructure side, the project BesTWay of Andersson et al. (2017) gives an example of how to virtually plan skid trails with a scenario approach, including digital data of terrain, wet areas and stand volumes. Simulations can be used to determine costs and volumes of assortments harvested upfront for public tendering, negotiations with contractors or sales activities.

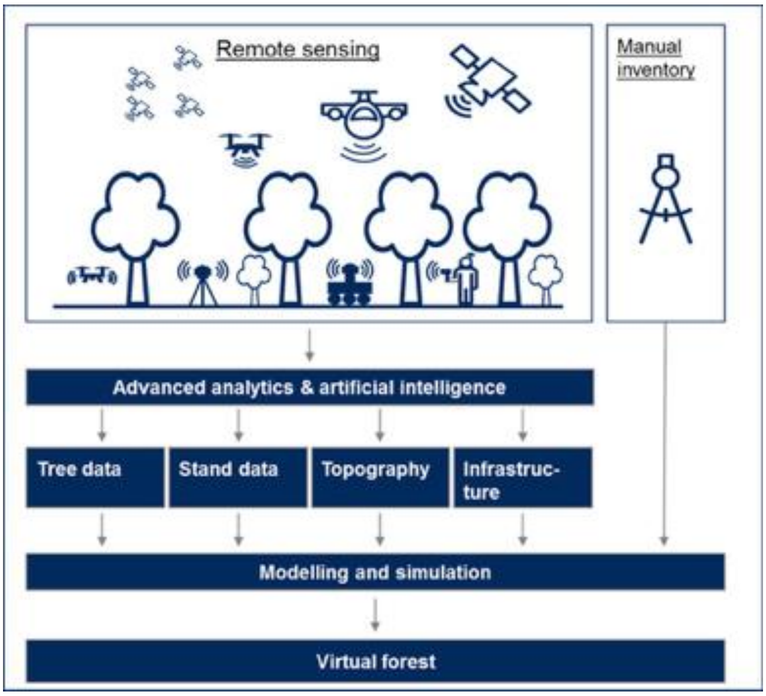

Figure 19: Step towards a virtual forest
Source: https://www.sciencedirect.com/science/article/pii/S0168169918305325

Harvesting operations

Different topics arise in I 4.0 harvesting operations.

Orientation and navigation of machine within the forest stand

Determining the position of the machine or parts of the machine like the harvester head is a key challenge for real-time connectivity of harvesters and forwarders. Collecting data about the position of the machine or machine parts is investigated by using a real-time kinematic GNSS. However, GNSS is technically limited in terms of accuracy under increasing dense canopy. The machine can navigate by matching data collected by various sensors (GPS, LiDAR, odometry) with the virtual forest in the cloud. Hussein et al. (2015) tested another application like the approach of Rossmann et al. (2009). They localize the position of the machine based on the match of a 3D LiDAR picture of the surrounding stand to another stem map from aerial orthoimagery.

Combined with additional sensors (e.g. 2D laser scanners or encoders on crane joints) for determining the harvester's head position, the precise position of the trees felled can be detected.

Machine as data collector

Harvesting machines can collect data about operational performance like productivity, reliability, utilization and process times. They can collect data about the harvested wood due to the automated bucking system in the harvester. These data include harvested volume (in total, per species and assortment), volume by log, diameter and length distribution as well as damage frequency of the trees.

Wireless communication of machine with others

The value of the data collected by harvest machinery becomes apparent with the close to real-time transmission of these data. This means that for I4.0 in the wood supply chain, connecting the harvesting machines as main production factor with each other and with decision makers outside the machines is important. Human machine interaction and level of automation: Different levels of automation can be achieved in timber harvesting operations, ranging from operator assistance to simplified control (automation level 1) to fully autonomous machinery (level 5). Some process steps have already been improved towards level 1 automation.

Human machine interaction and level of automation

Some process steps have already been improved towards level 1 automation. Examples introduced by Lindroos et al. (2017) are cranes with motion sensors and improved motion control, crane steering with boom-tip control and active suspension for improved comfort. Further examples are decision support for thinning operations giving the operator continuous feedback about the thinning intensity in the harvest area based on real-time harvester data (Moeller et al., 2017), advanced decision support for timber bucking, e.g. via acoustic sensors (Walsh et al., 2014) or geolocation matching (Lindroos et al., 2015). Another application which was recently tested by Palonen et al. (2017) is augmented reality technology for crane steering support. This application would also be useful for identifying marked trees in the stand

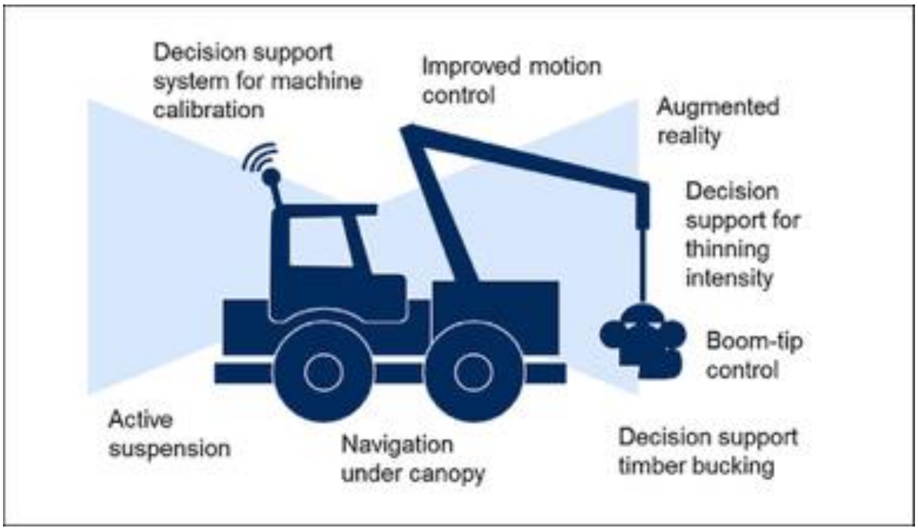

Figure 20: Examples for harvesting machine innovations at automation level 1
Source: https://www.sciencedirect.com/science/article/pii/S0168169918305325

Harvest organization and control

Real-time connectivity within the whole production process as promoted with I 4.0 would improve the organization and control process in several respects.

Operator instruction is easier as detailed digital data of the stand, trees harvested etc. is available in real time.

Managers do not necessarily have to be on site in person for progress and quality control.

Data collecting harvesting machines enable management to perform extended data analysis and comparison of performance indicators for benchmarking. Inefficiencies can be eliminated via ad hoc support.

Problem solving can be initiated before problems arise with advanced predictive analytics, e.g. predictive maintenance or yield predictions for truck and mill planning and operations.

Post-harvest documentation is easier as all stand and harvesting related data such as yield, assortments harvested, area harvested etc. is documented by harvest machinery and stored in the cloud for practical uses such as sales arrangements and contractor pay, as well as for documentation and quality assessment. Post-quality control of the remaining stand or the technical trafficability of the skid trails can be supported by remote sensing technology and unmanned sensing platforms.

Transport and logistics

The first step of the logistic chain is timber inventory. Photo-optical wood pile measurement is one I 4.0 application in transport and logistics, which can help to increase measurement's efficiency and collect data without media interruptions.

As the transport of timber is the most expensive part of the wood supply value chain, it is essential to optimize the timber transport by improved organization, scheduling, and routing. Flisberg et al. (2017) give a practical example in the form of a case study about optimal truck routing. Digital data about factors like travel time and road quality, but also safety relevant attributes of the roads, are combined to determine the safest and most efficient route for log trucks. This route finder is already in practical use, generating measurable savings for over 100 Swedish companies every year.

The traceability of logs has been discussed in forestry for many years, recently dominated by the suggestion of using radiofrequency identification (RFID) for tagging trees i.e. logs. One application in this context is to attach RFIDs to the logs by the harvester head once they are bucked. The RFID- tags then could contain information collected by the harvester about the tree's attributes and the log's attributes like the name of the assortment, the location of the stand or even the tree itself. The advantages of individual log identification and traceability are vast. Björk et al. (2011) introduce the use of RFID for improved stock management in sawmills with significant savings of up to 70%. Traceability of the logs would also improve feedback circles from the mills to the foresters about quality and attributes of the sawnwood. If the attributes could be directly and automatically linked to the log and its position, discussions about the wood quality of a stand could be started. Big data analyses could help to find new patterns of the stand and the sawn timber quality. However, until today RFID technology is rarely used in commercial forestry practice although its reliability increased while costs decreased. However, one reason might be that RFID technology has to be implemented in different organizations like the mills, the contractors' machines, and the forestry administration with high efforts for coordination and alignment.

Sales

In the future the virtual forest can be the basis of modelling techniques for optimized timber allocation to bring "the right log to the right product". Alam et al. (2014) demonstrate in their simulation that, with increasing the certainty of the information about the wood quality, the gross profit gain of a merchandizing yard can be increased by up to 50%.

Wood utilization and production efficiency can be improved by matching harvested timber with customer requirements using the transparency created by a virtual forest. Cloud technology enables connecting sawmills and timber suppliers in real time, which would allow timber suppliers to react immediately to changing markets and ensure efficient timber supply. From a process perspective, this approach would mean changing timber supply from a push to a pull principle of supply.

Smart wood supply chain – A process flow chart

To conclude the findings of this review, a process flow chart was designed visualizing the main results of the thematic analysis. The visualization shows the smart wood supply chain consisting of interlinked cyber-physical systems.

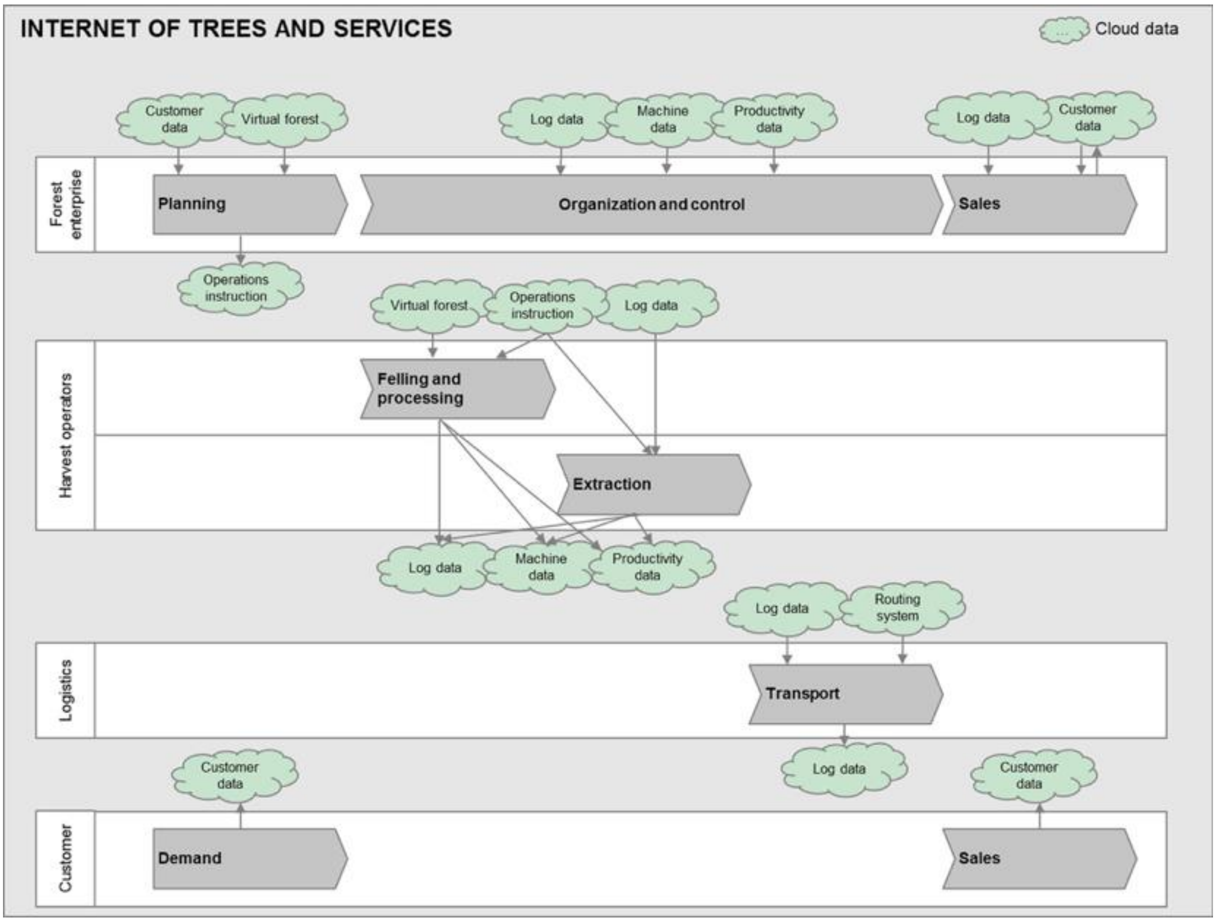

Figure 21: The wood supply chain within the internet of trees and services
Source: https://www.sciencedirect.com/science/article/pii/S0168169918305325

Reasons for selection of Case Studies

The case studies were chosen in such a way as to represent all the phases of the wood supply chain (harvest planning, harvest operations, harvest organization and control, transport, and logistics). In addition, priority was given to cases with high technological content and recently developed.

CASE STUDY 1

Harvest planning

Lasers and drones create virtual forests at TERN sites[17]

Description

3D-FOREST is a three-year project funded by the Belgian Federal Science Policy Office and led by Dr Kim Calders and Prof Hans Verbeeck from Ghent University, partnering with Dr Harm Bartholomeus and Prof Martin Herold from Wageningen University.

The 3D-FOREST team and their Australian government and university partners recently conducted surveys at three TERN tropical forest observing sites in Queensland and the Northern Territory. The team used a combination of on ground and airborne LiDAR to quantify aboveground biomass and forest structure.

Impacts on wood value chain

The concept of the project is to capture data to create 'virtual forests' with high-level detail.

The combination of 'bottom-up' terrestrial laser scanning (TLS) and 'top-down' UAV LiDAR data improves biomass estimates and knowledge on how we can upscale plot-based measurements to the landscape level.

Quantitative structure models (QSM) digitally weigh individual trees by calculating their volume and converting this to carbon mass.

The 3D structural metrics and biomass estimates it allows to scale-up the spatial patterns of tree structure and evenness from the 1ha plot scale to entire forests.

This information is crucial for more efficient forest management, but also for better understanding of the spatial variation of forest structure in ecosystem models.

Value-added by the digitalization

'3D-FOREST' project aims to overcome such challenges by developing novel on-ground remote sensing techniques to measure biomass and forest structure and validate global-scale satellite measurements.

The project aims to create the virtual forest which is the first milestone for the formulation of I4.0 in the wood sector

Implementation of the case study: **R&D phase**

The realization of the case study is obtained through the combination of Lidar data with those recorded on the ground. The processing of this data leads to the formulation of the virtual forest which is the basis of the planning of the cuts.

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[17] https://www.tern.org.au/harvesting-virtual-forests/

CASE STUDY 2
Harvest planning
LIDAR / GIS
LIDAR ITALIA – Hardware & Software branded GreenValley International[18]

Summary of the case study

LIDAR ITALIA was born from the union of the Italian companies Gter and JP Droni that for years have been operating in the 3D survey sector with the use of drones.

Together they bring the products of GreenValley International (GVI), a Californian company with a scientific background from the University of Berkeley, to Italy, which supplies LIDAR drone and ground instruments as well as a wide range of software for 3D data processing.

Impacts on wood value chain

The LiAIR, together with the LiBackPack and relative dedicated SW module, represent a complete package that allows you to approach the 3D survey in the forest area independently.

The main objectives of this type of activity mainly concern the planning of forest maintenance activities, the calculation of biomass, the safety of the territory

The added value of LIDAR Italia in this field is given by the integration and integration between LiAIR and LiBackPack. In fact, the two product lines are born with the aim of being able to create a complete 3D survey even in difficult areas, where most of the 3D model is made by drone flight, but where it is not possible to "penetrate" from the too thick vegetation can be integrated with a LiBackPack relief.

Value-added by the digitalization

In forestry applications, LIDAR finds a typical field of application as one of the main strengths of the technology lies in the fact that it is possible to carry out a survey of large areas, from above, allowing to “pierce” the vegetation and therefore managing to detect the ground below.

It is possible to edit individual trees, classify the entire cloud by performing an accurate segmentation that provides a three-dimensional model in which each individual plant is separated from the others. This operation, particularly important, allows then to carry out all subsequent analyzes by identifying the dimensions of the stems, diameter and volume of the crown and all the geometric characteristics of the individual plants.

Implementation of the case study: Fully operational

LIDAR Italia offers a special software tool, LIDAR360 - Forestry, specifically designed for the analysis of wooded areas.

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[18] https://www.lidar-italia.it/applicazioni/

CASE STUDY 3
Harvesting operation
Realization of highly accurate mobile robot system for multipurpose precision forestry application[19]

Summary of the case study

In this case study are used methods of mobile robotics to derive highly accurate position information of a wood harvester's cabin as well as of its harvesting head.

Impacts on wood value chain

The introduced single tree navigator for example allows optimized logging operations on wider areas as well as on very small-sized ones. It supports the machine operator identifying the next tree to cut and enables a correct accounting for the tree owner.

Value-added by the digitalization

Localization, navigation and identification of characteristics of the environment are of high importance in mobile robotic. In the last decade techniques of automation revolutionized processes in forestry. Wood harvesters were developed to enable faster logging operations on wider areas and with less manpower. On the one hand, this leads to lower costs and better price performance ratio of the logging operations. On the other hand, it is still impossible to create or to execute logging orders with precise information of single tree positions.

Implementation of the case study: Fully operational

Considering the results of the presented applications, localization of a wood harvester and identification of single trees now are possible. Based on this sensor framework new applications and algorithms were implemented.

CASE STUDY 4
Transport and Logistics

Automated volumetric measurement of truckloads through multi-view photogrammetry and 3D image processing software[20]

Summary of the case study

In this case study, multi-view Structure from Motion (SfM) photogrammetry and commercial 3D image processing software was tested as an innovative and alternative method for automated volumetric measurement of truckloads.

Impacts on wood value chain

The levels of accuracy obtained with SfM photogrammetry and 3D reconstruction in this study were quite similar to the ones reported in previous studies with laser scanning systems for truckloads with pulp-logs of similar species. These results confirm the great potential for multi-view SfM photogrammetric and 3D reconstruction methods to be used as a cost-effective tool to aid in the determination of the solid volume of logs on trucks.

Value-added by the digitalization

Since wood represents an important proportion of the delivered cost, it is important to embrace and implement correct measurement procedures and technologies that provide better wood volume estimates of logs on trucks.

Implementation of the case study: R&D phase

Structure from Motion with Multi-View Stereo photogrammetry (SfM) is being increasingly utilised by forestry practitioners as a cost-effective method of rapidly acquiring high resolution topographic and forest resource data across a range of scales and landscapes but has not been tested to determine the solid volume of logs on trucks

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[19] Rossmann, J. & Schluse, Michael & Schlette, Christian & Bücken, Arno & Krahwinkler, P. & Emde, Markus. (2009). Realization of a highly accurate mobile robot system for multi purpose precision forestry applications. 2009 International Conference on Advanced Robotics, ICAR 2009. 1 - 6.

[20] Acuna, Mauricio & Sosa, Amanda. (2019). Automated Volumetric Measurements of Truckloads through Multi-View Photogrammetry and 3D Reconstruction Software. Croatian Journal of Forest Engineering. 40. 151-162.

accurately. Implementing innovative technology and correct measurement procedures of truckloads will impact the contractual business relationships between haulage contractors and forest companies positively and will enable the correct implementation of commercial payment mechanisms along the supply chain based on volumetric measurements of truckloads.

CASE STUDY 5

12/IT-01-01 THE FIRST BUSINESS NETWORK IN ITALY CONNECTING THE WOOD TO THE MARKET[21]

Summary of the case study

Samuele Giacometti with his enterprise Sadilegno thanks to the "Analysis, plan and draft of the first business Network connecting the wood to the market in the high part of Carnia (UD)" create the first business network connecting the wood to the market in Italy developing a model of the business network 12-to-many.

Impacts on wood value chain

The impacts from this project are:

- improve the quality of the product in terms of technical characteristics that influence the expected quality according to the Quality Function Deployment (QFD);

- quantify the traditional value of the product and its benefits using a scientific method certified by Enea, based on the QFD and used for the Business Network;

- quantify the environmental impact of the production and logistics process that connects wood to the market with a scientific method certified by Enea and based on the Life Cycle Assessment (LCA)

Value-added by the digitalization

In the very fragmented context of companies in the wood sector, this network of companies aims to offer the Italian and international market wood products and services with a high economic, social and low environmental impact

Implementation of the case study: fully operational

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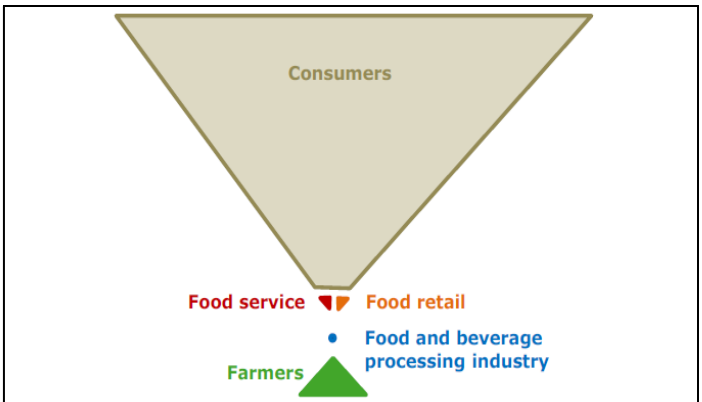
[21] https://www.12tomany.net/en/

3.1.7 Use case 2: Agrifood

Agrifood framework

In the EU, around 11 million farms produce agricultural products for processing by about 300.000 enterprises in the food and drink industry. The food processors sell their products through the 2.8 million enterprises within the food distribution and food service industry, which deliver food to the EU's 500 million consumers[22].



Source: DG Agriculture and Rural development based on Eurostat; the number of holdings/enterprises per food chain stage and number of consumers are represented by the size of each shape.

Figure 22: Synthetic and approximate representation of the food chain in the EU by actors involved

Furthermore, primary production together with food processing, food retail and food services make up a sector providing nearly 44 million jobs in the EU. Food production alone (agriculture, fisheries and the food processing industry) provides for 10% of total employment in the EU and the EU food supply chain provides a gross value added of more than €707 billion, which represented 5 % of EU's total value added in 2015. Europe's food and drink industry directly employs some 4.57 million people and has a turnover of €1.1 trillion; this makes it the largest manufacturing industry in the EU. In half of the EU's 28 Member States, the food and drink industry is the biggest employer within manufacturing[23].

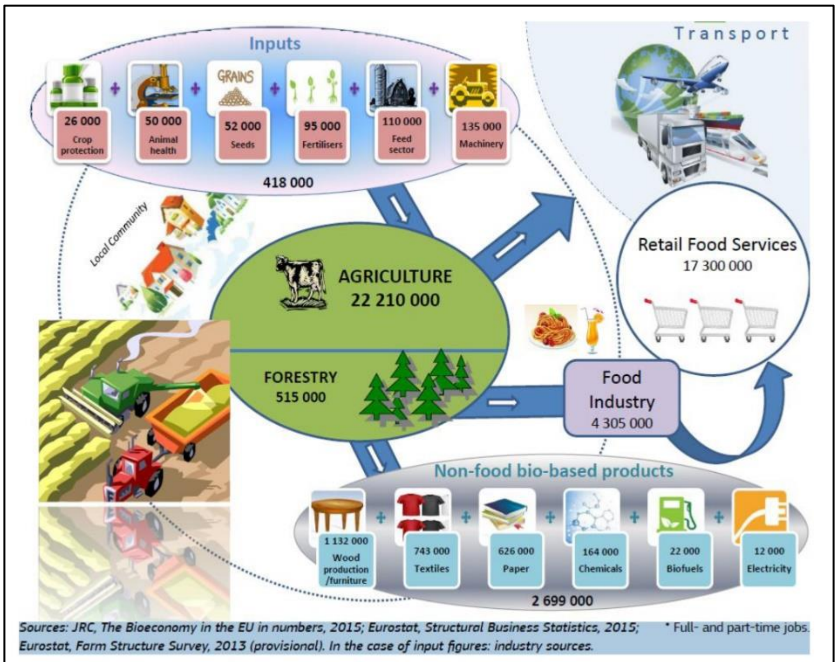


Figure 23: Number of persons employed in farming, forestry, and related industries

The majority of the over 15 million holdings/enterprises in the food chain are small or medium sized enterprises. The small and medium enterprises in the EU food processing industry represent more than 99% of all companies in the sector and 48% of its turnover.

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[22] https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/factsheet-food-supply-chain_march2017_en.pdf

[23] https://www.fooddrinkeurope.eu/uploads/publications_documents/FoodDrinkEurope_Data_and_Trends_2018_FINAL.pdf

Agrifood Supply Chain description

In general, an AFSC (Agrifood Supply Chain) is comprised of a set of activities in a "farm-to-fork" sequence including farming (i.e. land cultivation and production of crops), processing/production, testing, packaging, warehousing, transportation, distribution, and marketing. These operational areas are supported by logistical, financial, and technical services, whereas they themselves support five flow types:

- ✓ physical material and product flows
- ✓ financial flows
- ✓ information flows
- ✓ process flows
- ✓ energy and natural resources' flows.

These activities, services, and flows are integrated into a dynamic production-supply-consumption cluster of research institutions, industries, producers/farmers, agricultural cooperatives, intermediaries, manufacturers/processors, transporters, traders (exporters/importers), wholesalers, retailers, and consumers[24].

A conceptual configuration of AFSCs is depicted in Figure 24.

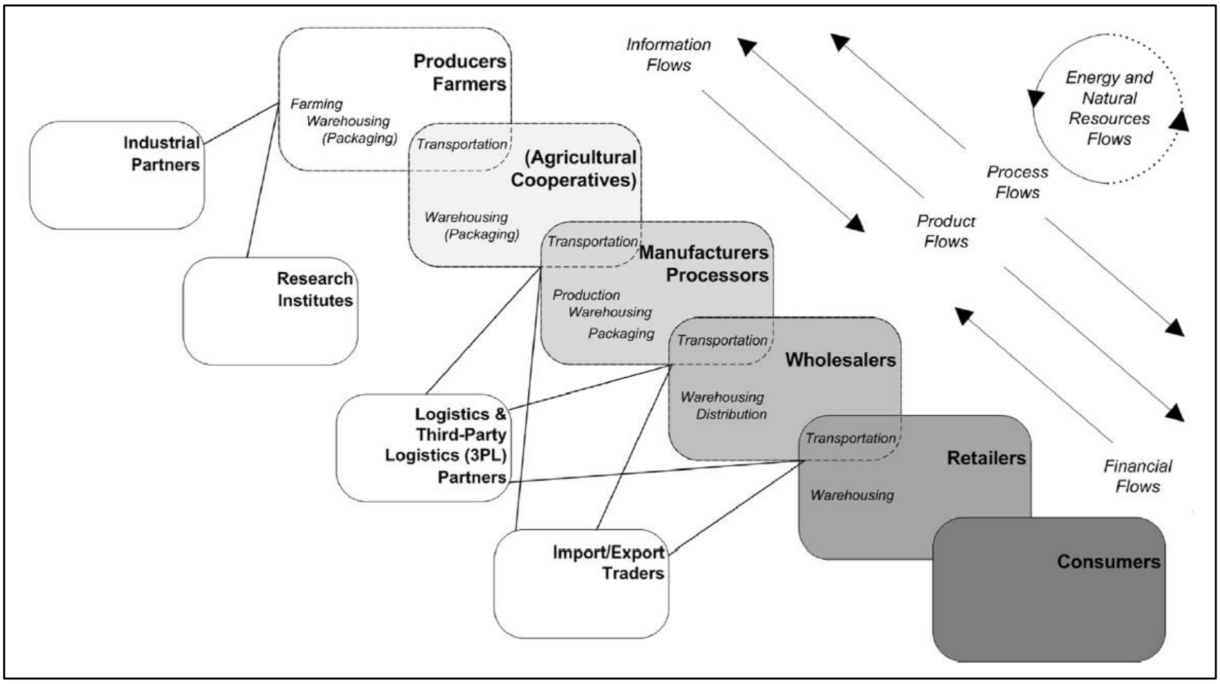

Figure 24: Agrifood supply chains: A conceptual system
Source: https://www.sciencedirect.com/science/article/abs/pii/S1537511013001748

The actors involved in the AFSC system can be generally partitioned into public authorities and private stakeholders. In addition, AFSCs exhibit a set of unique characteristics that differentiate them from classical supply networks and raise the need for special managerial capabilities[25], such as:

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[24] Jaffee, S., Siegel, P., & Andrews, C. (2010). Rapid agricultural supply chain risk assessment: A conceptual framework (Agriculture and Rural Development Discussion Paper 47). Washington D.C., US: The World Bank.

[25] Van der Vorst, J. G. A. J. (2000). Effective food supply chains-generating, modelling and evaluating supply chain scenarios. Wageningen, The Netherlands: Wageningen University (Ph.D.-thesis).

1. unique nature of the products as in most cases they refer to short life-cycle goods
2. high product differentiation
3. seasonality in harvesting and production operations
4. variability of quality and quantity on farm inputs and processing yields
5. specific requirements regarding transportation, storage conditions, quality, and material recycling
6. need to comply with national/international legislation, regulations, and directives regarding food safety and public health, as well as environmental issues (e.g. carbon and water footprints)
7. need for specialized attributes, such as traceability and visibility
8. need for high efficiency and productivity of the expensive technical equipment, despite the long production times
9. increased complexity of operations, and
10. the existence of significant capacity constraints.

The digitalization of AFSC complex framework shall bring benefits to all the actors as well as to the final end-user, the consumers. One event was representative of such awareness: '**Turning Data into Decisions in Agrifood' hosted in the UK by the Society of Chemical Industry (SCI) and the Knowledge Transfer Network (KTN) on 22 November 2017.**

This event gathered over 70 representatives from crop and livestock agri-businesses, farm and agronomy advisers, precision agriculture companies, machinery, and equipment manufacturers, companies developing and using sensors, input manufacturers, food and feed manufacturers, producer organizations, agricultural traders, retail, analytical and measurement services, data analysts, modelers, software engineers, robotics experts, insurance providers, academics, researchers, research councils and government departments. The event covered the following themes:

- ✓ Why we need data and how to make it meaningful
- ✓ Examples of data collected from sensors and connected devices and software applications for data analysis and integration
- ✓ Data analysis, integration, and the role of machine learning
- ✓ Use of data for financial models and models related to the environment and climate
- ✓ Using data for decision-making. e.g., development of software for customer interface and integrating data with agrifood practice
- ✓ Data sharing platforms and standards
- ✓ Governance around data ownership, privacy, and security

At the end of the Conference, the conclusions were as follows.

Data could drive decision-making in food growing and production to meet end-customers specifications and satisfaction. Some examples of the use of data follow:

1. Improving efficiency
2. Use of data to support automation and use of robotics in livestock production
3. Food provenance and safety
4. **Development of shorter supply chains and new operating models**
   Digitalization is enabling all farmers and food companies, whether small or larger scale to understand consumer needs and target higher-value markets. Digital technologies could facilitate the development of online trading platforms or virtual online coops. These online trading platforms may also help to open up the food market to smaller farms and food producers, allowing them to sell direct and bypass the main existing distribution channels. Differences in purchasing behavior between different consumer segments may be significant and require special attention to guide business planning, marketing, and new product

development. Data collected from retailers via consumer membership cards may elucidate factors such as geo-demographics, retail channels, and consumer lifestyles.

5. Managing risks and uncertainties in food production

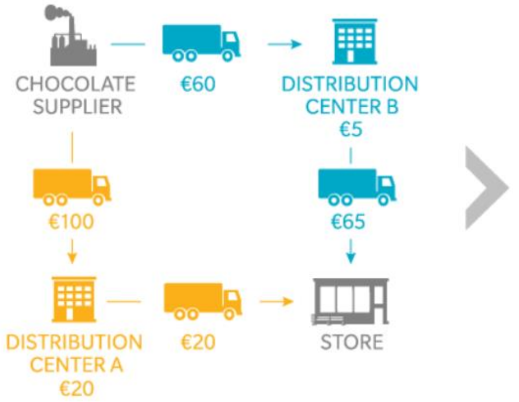
The "Turning Data into Decisions in Agrifood" meeting in November 2017 had a UK focus, but the problems and solutions are common to other countries. The European Commission is providing a framework for developing actionable plans to support digitalization in industry, such as the Digitalizing European Industry initiative (DEI), which produced sector-specific plans for how digitalization could add value in various industry sectors, including one for agrifood.

DEIs vision for the future is one of increased connectivity and interoperability between platforms, whereby more services could be provided through gathering and combining information from a wide range of smaller platforms gathering data from sensors, machinery, and animals. This would increase resilience within Farming, e.g., to manage resource efficiency, health, and welfare of animals, and it could also be used to decrease bureaucracy for farmers. Examples of other international initiatives include those led by Wageningen University and Research (Netherlands), INRA (France), Agroknow (Greece and Belgium), and AgGateway (USA). International organizations and initiatives supporting the digitalization of the agrifood sector include GODAN, CGIAR, and FAO (with a dedicated Interest Group on Agricultural Data).

Reasons for selection of Case Studies

Digital supply chains enable retailers to reduce logistics cost due to real-time, business case-based distribution configuration. For example, using a traditional supply-chain model, a supermarket always orders chocolate from the nearest distributor. But when numerous stores order at the same time, the nearest distributor suffers capacity overloads, which leads to additional warehouse costs and delayed deliveries. Total delivery cost: €140 per store.

With a digital supply chain, the distribution planning system has full transparency over available space in all distribution centers, all store orders, and delivery times and costs from the two distribution centers to the store. The business cases show that delivery from the second closest distributor is more cost-efficient, as there is a short-term available cross-docking slot that can be used, thus considerably reducing warehouse cost. Total delivery cost: €130.



ROUTING COST	A	B
TRANSPORT TO DC	€100	€60
WAREHOUSE COST	€20	€5
TRANSPORT TO STORE	€20	€65
TOTAL	€140	€130

Figure 25: Dynamic Distribution Configuration and Costs
Source: https://www.oliverwyman.com/our-expertise/insights/2017/nov/add-digital-to-your-supply-chain.html

For a medium-sized retailer with a few thousand stores, saving 10€ per delivery translates to an annual savings in the double-digit, million-euro range.

Four agrifood case studies were selected with regard to value-added created by digitalization and its impact on the value chain.

CASE STUDY 1
Use of Blockchain technology for the traceability of goods and animals
France

Description

Carrefour is one of the world's largest retailers and a leading food distributor, operating more than 12,150 stores and e-commerce sites in more than 30 countries. In 2018 the company launched Europe's first food Blockchain for free-range and plans to extend the technology to eight more product lines before the end of 2018.

Impacts on agrifood value chain

The impact would be perceived by breeders, resellers and consumers. It will unlock numerous benefits to the food sector: breeders will be able to showcase their products and expertise, gaining more visibility. Carrefour will be able to use a secured database and guarantee a higher level of food safety, which will increase consumer trust and most likely increase customer numbers and their loyalty.

Value-added by digitalization

Carrefour is looking to lead food transition in Europe, and thus quality, safety and showing where food comes from have become key concerns. Making use of Blockchain technology is a step towards achieving this goal.

Level of implementation: Widely adopted and fully operational by 2020.

To implement this technological solution, each product's label will feature a QR Code. Consumers will be able to scan the code using their smartphones. The scanned QR Code will provide them with detailed and reliable information about the value chain and the process their scanned product followed. For example, for chickens, consumers can find out where and how each animal was reared, the name of the farmer, what feed was used, what treatments were used (antibiotic-free, etc.), where the meat was processed and on which shelves of the store the chicken was stored.

CASE STUDY 2
BioSCO (Bioresources Supply Chain Optimizer)
France

Description

BioSCO targets the global market of bioresources logistics optimization. Today, agrilogistics is at best only manually supervised and uses outdated practices, resulting in high costs and a significant carbon footprint. **BioSCO's RonGO (Decision Support System) SaaS system has been developed to address the specific problems affecting agrilogistics**, including near-to-infinite variable combinations, short crop periods and 'live' commodity and weather constraints. RonGO, as a Decision Support System, delivers real-time logistics optimization (based on innovative applications of largescale operational research) and leads to cost savings. Moreover, RonGO substantially reduces carbon footprints by optimizing storage building management, as well as lowering mileage and petrol use.

Impacts on agrifood value chain

The innovation introduced by RonGO positively impacts logistics and storage in terms of optimization. Still, it also improves the internal processes, reducing the number of meetings and the amount of time required to define a non-optimized storage plan. It also helps to create cost-efficient logistics and storage in agribusiness, reducing transportation requirements, costs, and improving the life cycle of goods.

Value-added by digitalization

The cost of logistics (i.e., maintenance, transportation, and storage) accounts for up to 50% of the crop value. Storage organizations are also undergoing major reorganizations, including mergers between different players, increasing storage on the farm and precision in allotment strategies. For all these reasons, storage planning is becoming more strategic and complex. For example, an average agricooperative must choose the best solution from 10,800 different storage plans, which defies human analytical capability. Using algorithms RonGO will model the whole organization and its operational constraints (flows, costs, capacities, opening hours, etc.), presenting the cheapest and most operational solution. The solution will include storage planning, transportation planning and monitoring via Key Performance Indicators.

Level of implementation: R&D testing

BioSCO developed the RonGO product over for years of R&D. A live test was conducted with two points of contact in agri-cooperatives, which shared their data and know-how.

CASE STUDY 3
The "Control Tower" project
Ferrero Italy

Description

An integrated and collaborative Supply Chain is a powerful business lever for consumer goods companies, especially for an international company such as Ferrero. For the food giant of Alba (CN), the optimization of logistical activities is a critical success factor given the numbers involved. Just think that its products - Nutella and Kinder are recognized brands all over the world - pass through about 400 warehouses distributed in the five continents. Generally, multibrand and multichannel storage centers, almost always managed by external third parties. Amazon has raised the bar for the speed and traceability of logistics flows, and this new model is rapidly spreading even outside the e-commerce sector. In Ferrero, they are already gearing up. With **Control Tower**, the company aims to experience the benefits of integrated dashboards and, in the future, of Big Data, IoT, and Artificial Intelligence to manage in an optimized way all the flows involving logistic partners. The starting idea is to improve visibility on the transport and storage processes to experience then proactive and real-time management of the entire supply chain.

Impacts on agrifood value chain

This initiative completely changes the relationship with all logistics and supply chain partners.

Value-added by digitalization

They are the 3PL (Third Party Logistic Service Provider) who manage the deliveries to GDO and retailers through integrated warehouse and transport services, ensuring that products arrive on time and in perfect condition on the shelves. But delays and missed deliveries can happen. And when these problems occur, Ferrero must be able to trace the causes that generated them. Therefore, the need arises for a **Control Tower**, *a control system capable of guaranteeing detailed visibility on logistical events, through a closer IT collaboration with logistic partners. Ferrero has orders of 24 or 48 hours, and with such a short supply chain, they cannot afford delays or errors, which cost a lot in terms of missing slots and out of stock.*

Level of implementation: Pilot project

Pilot projects started in Germany and Iberica (Spain and Portugal - ed), two quite different logistics networks. Germany because it has a robust industrial sector and the largest production site and 5 integrated secondary logistics partners, as well as numerous transport operators. In the Iberian Peninsula, on the contrary, Ferrero have no factories and Ferrero products are distributed by only one partner. By 2021 the Control Tower will also be implemented in Italy, where Ferrero have 25 warehouses between platforms and transit points in France, Benelux, Poland and the United Kingdom. BY 2023 Ferrero should also be able to track & trace container shipments to all trans-oceanic destinations from Europe.

The success of the initiative is measured by the willingness of the partners to exchange information on when they send order and when the order arrives.

Today, Ferrero is in the transition phase from a reactive approach to a proactive approach, that is, from the situation in which we take action upon customer reporting to the immediate and autonomous interception of the problem to make the best decisions to manage it. The second phase of the Control Tower project, on the other hand, will allow to reason from a predictive perspective, so they will be able to know in advance if the delivery will not arrive on time by the customer and we will be able to pre-alert him, to create the least inconvenience for him.

To get to these results, Ferrero will have to be able to trace all the flows at least for discrete events. The goal is to create an Intelligent Supply Chain and reason from a prescriptive perspective, anticipating long-term problems as much as possible. To do this, they must track all the flows in real-time and for this they must equip themselves with IoT systems, Advanced Analytics and Deep Learning. Only in this way Ferrero will be able to understand what they can do to avoid late delivery by considering all the possible variables. This means doing a huge job at the Big Data level to manage, integrate, and above all, operate them.

The true digital revolution of the Supply Chain, however, will take place when the Control Tower communicates directly with the telematics of the vehicles or the products themselves equipped with appropriate sensors.

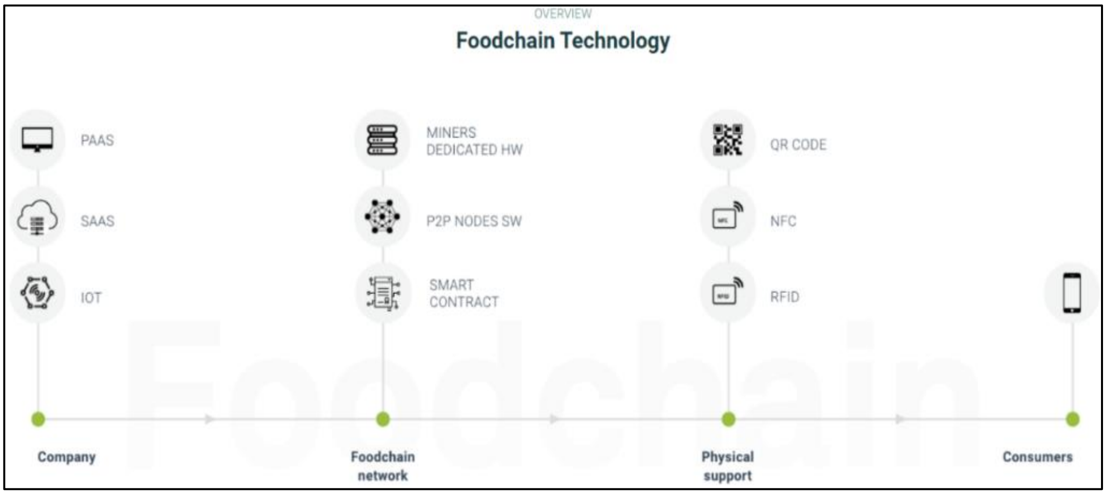
CASE STUDY 4
Foodchain Italy

Description

Foodchain Spa is an appealing case of Italian Blockchain. This Startup born in 2016 wants to make transparency an essential asset for any supply chain actor to guarantee the provenance, quality, and value of the food, supporting producers, and protecting consumers.

Impacts on agrifood value chain

Thanks to Quadrans blockchain, an open ecosystem has been created to track and trace materials and companies along supply chains. Blockchain is the bridging system that joins all supply chain flows, improving management efficiency, and quality control.



Source: https://food-chain.it/public/business/

Value-added by digitalization

Foodchain revolutionizes the organization of the food supply chain, making it smart and interactive. Every company is identified in a sound and univocal manner to prevent unauthorized entities to tamper with data, supporting the authenticity of the information, and preventing counterfeiting.

Level of implementation: Partially adopted.

The protection of the Italian gastronomic heritage is one of the objectives of Foodchain Spa and for this reason, is extremely important to support its presence in the Autonomous Province of Trento. Thanks to the Operative Program 2014-2020 FESR, the territory has chosen to give such an important issue to Foodchain, who has broad experience in providing innovative services and solutions. The program has the objective of investing in the growth and employment within the territory, to develop the regional circular economy. The territory has chosen Foodchain as a partner to collaborate on the implementation of the technologies that become available in the last years and is committed to the development of new ones for the protection of the local food heritage. The object of the activities of this call is the development of a new electronic board with a series of FPGA processors (reprogrammable processors) capable of the process any type of algorithm or computational operation, and the development of a new algorithm in collaboration with the Department of Mathematics and Cryptography of the University of Trento. This electronic board will empower the machines that process the new security algorithm with superior features compared to the ones currently in use and set them up for the future development of any type of algorithm.

Initiative realized under the ERDF Operational Program 2014-2020 of the Autonomous Province of Trento, with the co-financing of the European Union - European Regional Development Fund, the Italian State and the Autonomous Province of Trento.

3.1.8 Use case 3: Textile

Textile framework

The textile and clothing industry covers a range of activities from the transformation of natural (cotton, flax, wool, etc.) or synthetic (polyester, polyamide, etc.) fibers into yarns and fabrics, to the production of a wide variety of products such as hi-tech synthetic yarns, bed-linens, industrial filters, and clothing. The textile and clothing sector is an important part of the European manufacturing industry, playing a crucial role in the economy and social well-being in many regions of Europe, with 185.000 companies in the industry employing 1,7 million people and generating a turnover of €166 billion.

The sector accounts for a 3% share of value-added and a 6% share of employment in total manufacturing in Europe. The sector in the EU is based around small businesses. Companies with less than 50 employees account for more than 90% of the workforce and produce almost 60% of the value-added. The biggest producers in the industry are Italy, France, Germany, and Spain. Together, they account for about 3 quarters of EU production. Southern countries such as Italy, Greece, and Portugal; some of the new EU countries such as Romania, Bulgaria, and Poland; and, to a lesser extent, Spain and France, contribute more to total clothing production. On the other hand, northern countries such as Germany, Belgium, the Netherlands, Austria, and Sweden contribute more to textile production, notably technical textiles (Figure 26). With regard to external trade performance, about 20% of EU production is sold outside the EU despite limited access to many non-EU markets.

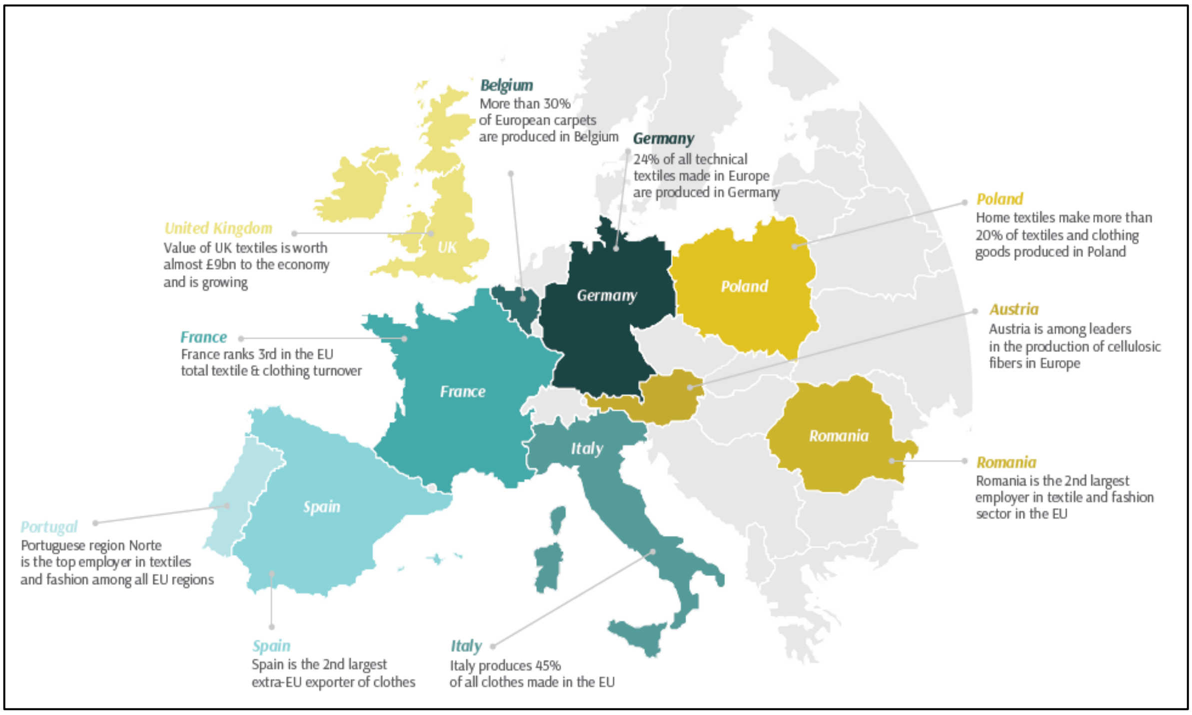


Figure 26: Top10 EU producers of fashion and textile goods
Source: https://euratex.eu/wp-content/uploads/EURATEX-Prospering-in-the-Circular-Economy-2020.pdf

Textile Supply Chain description

This graphic shows the different elements of the supply chain in the textile sector. The chain starts with the production of the raw material. It goes to the different steps of production processes until the end product is finished. This product will run through the different types of trade by reaching the customer.

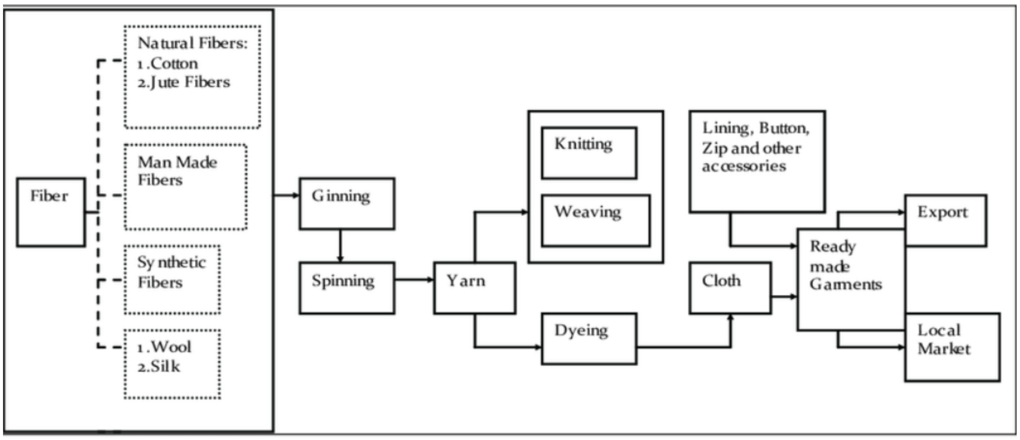


Figure 27: The Textile and Clothing Supply Chain
Source: https://www.researchgate.net/figure/Nine-Stages-of-Supply-Chain-for-Textile-and-Readymade-Garments-Industry-Dhaka_fig3_241685986

The digitalization of the supply chain may imply the use of new technologies such as RFID to improve transparency and, at the same time, responsiveness, innovation, and increasingly faster implementation. For textile and industrial providers, the digitalization of their processes will help them streamline their administrative expenses; it will give them increased control over the production process and their day-to-day capacity, and it will allow them to make quick operational adjustments. Digital innovation is the key to supply chain efficiency, and it translates into improved acquisition costs and better opportunities in sourcing. Finally, a complete SC digitalization dashboard in Figure 28 presents how to transform SC through real-time data visualization.

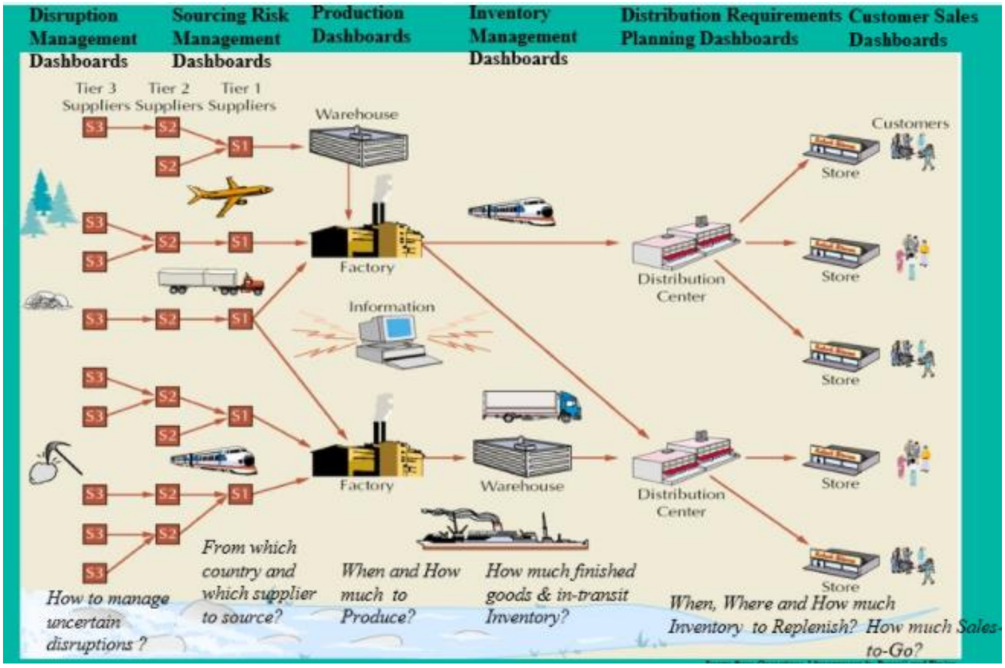


Figure 28: Supply Chain Digitalization Dashboard
Source: https://supplychaindigitization.com/2017/01/15/real-time-dashboards-for-effective-global-supply-chain-decision-making/

Reason for selection of Case Study

Textile and apparel (T&A) companies are adopting advanced technologies to achieve competitive edge. The research below investigated the role of Business Intelligence System (BIS) adoption and its capability to solve issues in T&A companies with Industry 4.0 technologies. [26]

Description

All players of the T&A industry are facing the same challenges, such as shortened order lead time and rising material and labor costs with reduced profit margins. The advent of fast fashion interrupted the industry by demands for quick production and frequent changes in product orders. T&A industry tried hard to harmonize with logistics warehouses, inventories of stores, and supply chains according to customer demand as well as with manufacturing/production plans.

Sometimes, companies face a shortage of products or surplus because of unexpected differences between sales periods and lead times. As a result, T&A products are manufactured in a broad range of sizes, colors, and designs according to the customers' preferences and needs. Demand and availability are a great issue in the T&A industry compared to other manufacturing industries with more stable products, such as home and office appliances. Along these lines, T&A companies can bear a notable loss in revenues because of outdated apparel stocks due to rapid, seasonal changes. In other words, the life cycle of new T&A products is very short for every season. This is why sales forecasting of products is very difficult in any given period.

The shipment of products from the production point to consumption point is another important issue in terms of quantity and timing, which should be determined in advance. To avoid excessive stock or shortage of inventory, the logistics of shipping products to warehouses and outlets is an important factor for effective sustainability in T&A industry.

To cope with these challenges, traditional T&A companies are prone to integrating advanced technologies for manufacturing/production, management, and operational processes. These advanced technologies are part of the Industry 4.0, such as big data, cloud technology, Internet of Things (IoT), RFID, and mobile computing. These digital solutions/systems raised new challenges as well as opportunities for T&A industry. All these advanced developments discard not only conventional production, manufacturing, and management paradigms by restructuring business processes, but also generate huge volumes of data, which are known as big data. *The utilization of big data for decision-making, supply chain management, inventory management at stores and warehouses, shipments to customers, and logistics is a major challenge in T&A industry. BIS with Industry 4.0 concept have a positive role in resolving sustainability issues in organizations.*

A qualitative research approach was applied with 14 semi-structured in-depth interviews from 12 of the world's high-end T&A companies adopting or starting to adopt BIS with I4.0 technologies. The combination of a snowball sampling strategy and purposeful sampling strategy was adopted for this exploratory research because it was very difficult to find and approach the potential participants with information-rich cases for the most effective use of limited resources. Both these strategies are helpful in selecting, identifying, and approaching the experienced and knowledgeable participants with the phenomenon of interest. The selection of informants was based on following criteria: (1) occupy position/designation as chief executive officer, IT manager, or strategic managers/owner, etc.; (2) have proper awareness about BIS and advanced technologies.

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[26] Ahmad, S.; Miskon, S.; Alabdan, R.; Tlili, I. Towards Sustainable Textile and Apparel Industry: Exploring the Role of Business Intelligence Systems in the Era of Industry 4.0. *Sustainability* **2020**, *12*, 2632.

Table 5 shows BI solutions for textile and apparel companies, Table 6 reports the main informants' data, while Table 7 describes Companies' profiles.

Names	Description
TradeGecko	TradeGecko offers cloud-based BI solutions for inventory management. TradeGecko solutions enable organizations to improve online retail and wholesale processes. Pink Boutique, Cloth & Co., and Zara are benefiting by TradeGecko.
Oracle	Role-based intuitive intelligence is supported by complete Oracle built-in BI solutions across the enterprise. Oracle cloud-based BIS offer scalable, efficient reporting solutions for distributed complex environment. Its central architecture empowers organizations for statistical and predictive analytics with mobile functionality.
MicroStrategy	Companies are integrating MicroStrategy analytics as the front end of BIS. It empowers companies to consolidate various independent data warehouses into one single platform running on HANA in-memory database. MicroStrategy provides faster aggregation analysis with greater computational power. Company D and Adidas are using MicroStrategy.
Dematic	Dematic BI solutions empower companies to enhance supply chains and provide a competitive edge to organizations. The supply chain management of Adidas, Gap, and Next is benefiting from Dematic BI solutions.
Tableau	Tableau BI solutions enable the company to identify the key matrices to confirm the right product availability before it is ordered and shipped. Abercrombie and Fitch are benefiting from Tableau solutions for improvement of their merchandising operations.
TIBCO Spotfire	Marks & Spencer and H&M are using TIBCO Spotfire. The TIBCO solutions empower the analysts of the companies to integrate all data sources, such as Hadoop databases and data warehouses, without an information technology (IT) specialist. Executives and employees can also analyze complicated data without IT expertise.
SAP HANA in memory database	SAP HANA in-memory database is based on an independent data warehouse. Third party databases, sensors, and Hadoop can be integrated into a single platform by SAP solutions. Cloud-based SAP has the ability to process high volumes of data for data modeling at high speed. Company B and Adidas have implemented SAP solutions.
Birst	Birst BI is built with machine learning patented automation technologies. This approach connects applications and teams across the organizations.
Qlik	Qlik BI solutions are complete enterprise solutions that provide quick analysis of vast amounts of data sourcing from retailers. Tantex textile industry uses Qlik solutions.

Table 5: Business intelligence (BI) solutions for textile and apparel (T&A) companies

Company Name	Company	Country	Interviewee Designation	Mode
Company A	Textile and Apparel	Pakistan	IT Executive	On-site
Company B	Clothing Brand	Pakistan	Retail Manager	On-site
Company C	Textile and Apparel	Malaysia	(2) Owner and IT Manager	On-site
Company D	Apparel	Spain	IT Manager	On Skype
Company E	Textile and Apparel	Pakistan	CEO (IT)	On-site
Company F	Clothing Brand	KSA	Regional Manager	On-site
Company G	Apparel	USA	(2) Senior Managers	On Skype
Company H	Textile and Apparel	India	CEO	On imo
Company I	Apparel Brand	UK	Manager	On Skype
Company J	Textile	USA	Area Manager	On Skype
Company K	Apparel Brand	Sweden	CEO	On Skype
Company L	Clothing Chain	China	General Manager	On imo

Table 6: Informants' data

Cases	Companies	Description
Case 1	Company A	Company A is a large, renowned T&A industry in Pakistan. It was founded in 1930 with group of factories comprising eight textile factories in different cities of Pakistan. The company has vertically integrated major processes: ginning, knitting, dying, printing fabric, and finished apparel products.
Case 2	Company B	Company B is one of the markets most famous high-end fashion retailer in Pakistan with nearly 5000 employees. It was founded in 1984. Company B has established 90 outlets across the country and in other countries, including the United Arab Emirates, United Kingdom, Malaysia, and India.
Case 3	Company C	Company C is another large T&A company of Malaysia with more than 16,000 employees. It is vertical integrated manufacturing yarn, cotton, fabric and produces apparel products. It exports its products to 35 countries all around the world.
Case 4	Company D	Company D is a German multinational corporation founded in 1949. The company designs and manufactures apparel products such as clothing and shoes. It is the largest manufacturer of sportswear in Europe and the second in the world with 57,016 employees.
Case 5	Company E	Company E has vertically integrated manufacturing, spinning, weaving, dying, and stitching processes. The company also runs one of the top Pakistani apparel brands. It has established more than 72 shops in Pakistan and in other countries such as Dubai, Abu Dhabi, Saudi Arabia, and Canada, with online stores as well. It has a continual supplier relationship with top international brands such as Ocean garments, Levi, Crate & Barrel, Hugo Boss, Gap, John Lewis, Next, and some others.
Case 6	Company F	Company F is a Spanish retailer of apparel products. The famous retail brand has 1770 retail stores in 86 countries across the world. It specializes in fast fashion. It launches generally 20 apparel collections in a year. It is famous as one of the most innovative retailers around the globe.
Case 7	Company G	The company G is a famous American apparel retail brand that operates with two other brands. It is known as a lifestyle retailer of men, women, and kids' accessories. It also operates with 1049 outlets with three brands across the world.
Case 8	Company H	Company H is an Indian-based big, vertically- and horizontally-integrated fabric manufacturer and woolen fabric maker textile company. It shares over 60% of the suiting market in India with 637 retail shops including 4000 multi-brand outlets in 150 cities across India. It also exports its products to over 55 countries including the Middle East, Japan, Europe, Canada, and the USA.
Case 9	Company I	Company I is a major British multinational clothing brand. It was established in 1884 in Leeds. It has opened 959 outlets all over the country and 1463 stores across the world.
Case 10	Company J	Company J is the world's leading commercial textiles manufacturer in North America. It has operated across the United States for a decade.
Case 11	Company K	Company K is a Swedish multinational clothing retail company. It operates multiple brands online and has established 5000 stores in 74 countries with 126,000 locations across the world. It is the second largest international clothing retailer in the world.
Case 12	Company L	Company L is a Chinese clothing chain. It was founded in 1980. Currently, the company is a multi-brand specialty retailer offering different labels with 700 outlets in the region including China, Vietnam, Taiwan, Malaysia, Philippines, Singapore, Thailand, Macau, Cambodia, Indonesia, Jordan, Qatar, Bahrain, the United Arab Emirates, and Saudi Arabia.

Table 7: Companies' profiles

Impacts on T&A value chain

See results from Table 8.

Value-added by BIS with I.4 Technologies and Implementation level

See results from Table 8.

Significant value creation processes are short lead time, efficient supply chain, fast delivery of products, fast merchandising, fast customer insights, quick order fulfilment, customer loyalty, and inventory management

Company	Sustainability Issues of Case Companies	Value Creation Improved Processes	BI Solutions	Industry 4.0 Technologies
A	Supply short lead time, supply chain management, marketing, customer satisfaction	Working on project for BIS adoption	BI project in process	
B	Uncertain apparel output, inventory management, shorter lead time	Financial and retailing operations, production forecasting, supplier, retailer collaboration	Business objects (BOBJ) on SAP	
C	Short delivery time, production inconsistency, supply management and inventory management	Production, delivery orders, production output, inventory operation and supply chain processes	Oracle BI solutions	RFID, Cloud technology
D	For customer insights, customer satisfaction	Fast delivery of customer insights, optimize customer experience, loyalty, acquisition and engagement financial reports	MicroStrategy BI solutions based on SAP HANNA	Cloud technology, Big dataRobotics, 3D printing, Virtual mirrors
E	Financial analysis, internal and external data integration, supply, retailing operations	Improved partnership with suppliers, retailers and customers, reducing overhead cost, competitor analysis, financial analysis, vertical and horizontal analysis for loss and profit, environmental analysis, ratio analysis, market analysis, and strategic policy	Oracle and SAP BI solutions	Cloud technology, Big data
F	Replenishment control, and designing replenishment plans, Inventory management, Supply chain management, distribution management, size/colour management	Reduction in product delivery lead time, improved the inventory management and reduced the logistics cost of supply chain across its international stores	TradeGecko BI solutions	Robotics, Augmented reality, RFID, Big data, Mobile technology, Cloud technology
G	Designing replenishment plans, distribution management, size/color management, supply chain management, and inventory management	Replenishment control, fast customer insights improved demand and ship processes	Tableau BI solution	Cloud technology, Mobile technology

Table 8: Overview of BIS adoption with the Industry 4.0 technologies in T&A companies (1/2)

Company	Sustainability Issues of Case Companies	Value Creation Improved Processes	BI Solutions	Industry 4.0 Technologies
H	Inventory management, demand forecasts with limited visibility over inventory, stock losses, excess inventory, costly supply chain, coordination with fragmented vendors and suppliers	Automate order taking and enhance the focus on merchandising, collection, and business development, offer best choices to customers with best service and with minimum inventory	AI powered sales-tech platform on SaaS model	Artificial Intelligence, Cloud, RFID, Big data
I	Scalable data-driven decisions across the business for better customer insights	Improved e-commerce, finance, and marketing processes by leveraging analytics	Hadoop-based data analytics, Qlik BI solutions	BI, Big data, Cloud technology
J	Limited functionality with disparate data sources, slow decision-making, low employee productivity	Improve customer service and satisfaction, production quality, reduction in lead time, better informed and fast decisions	Birst BI Solutions	BIS, Self-service, Machine Learning
K,L	Customer insights, loyalty, and engagement	Customize merchandising, better customer insights, evaluate robust potential business partners	Informatica PowerCenter, Cognos, SAS Tableau, Power BI	Big data, Artificial Intelligence, BI solutions

Table 9: Overview of BIS adoption with the Industry 4.0 technologies in T&A companies (2/2)

It is a fact that T&A companies are enjoying the benefits of BIS and Industry 4.0, but the informants also observed some barriers that might affect their adoption decisions. The main barriers are:

1. Cost and complexity
2. Top management support
3. Technical skills and expertise
4. Integration with existing systems
5. Change management

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Conclusions

The current exploratory study is one of the first studies conducted to explore the sustainability issues of T&A in the era of Industry 4.0, companies' integration of BIS with emerging technologies such as RFID, big data, robotics, cloud technology, augmented reality, virtual mirrors, artificial intelligence, machine learning, and 3D printing technology, and how BIS resolve the sustainability issues with Industry 4.0 technologies. All technologies make significant contributions to enhancing the sustainability in T&A by improving supply chain management, inventory management, marketing, fast merchandising, quick shipments, retailing, and distribution processes which result in optimization of a company's business, customer satisfaction, cost saving, and generating high revenues. A major improvement was observed in retail business with fast insights and well-informed decision-making. The main objective of all case companies was customer satisfaction.

Another important finding was that high-end apparel companies from advanced countries are more prone to adopt the Industry 4.0 technologies. As a result, they are enjoying market leadership with less employees and investments, rather than those companies that belong to developing countries, despite having a complete value chain of textiles and apparels with huge investments and a large number of employees.

All companies integrated advanced proprietary BI solutions such as BOBJ on SAP, Oracle BI solutions, MicroStrategy BI solutions based on SAP HANNA, Birst BI solutions, Informatica Powerceter, Cognos, SAS, Oracle, SAP BI solutions, TradeGecko BI solutions, AI powered sales-tech platform, and Tableau BI solutions. No case company adopted any non-proprietary or open source software/technology.

Eight case companies are using BIS with big data techniques for decision-making and they are benefiting more compared to the other four companies that are just using a single analytical system. Company C, Company D, Company F, Company G, and Company H are equipped with RFID technology for manufacturing, production, and tracking items in inventory management across international stores which has resulted in a reduction of energy material waste logistics and cost of supply chain. Company D and Company F integrated robotics and augmented reality only. Company F also uses click and collect, and augmented reality apps. Only Company H is using BIS with artificial intelligence techniques and company J built BIS on machine learning.

Results of this study show that retail companies are more ready to enter the fourth industrial revolution rather than only textile companies. Furthermore, major barriers such as cost and complexity, vendor support, top management support, technical skills and expertise, integration with existing systems, and change management also emerged.

3.2 GOVERNANCE AND ORGANISATIONAL MODELS

3.2.1 Use case 1: Wood

Within the forest-wood system, traditionally, a harvesting phase is carried out by forestry companies, a first transformation which includes the sawmills (production of beams and boards), companies in the sector of wood-based panels and the paper industry and finally a second process substantially formed by the furniture industry, artisan and industrial carpenters and other wood products.

The industrial sectors related to woodworking are numerous and highly differentiated, in terms of techniques used and outlet markets, and remain linked to each other through intense intersectoral exchanges which do not, however, involve all the phases of the supply chain, which indeed denounces a certain disconnect between the finding the resource and its transformation.

The concomitance of certain factors (economic crisis, delocalization of production processes) with the inadequate relationship between demand from the processing industries and the local wood supply, has generated critical issues within this integrated system.

Among the numerous best practice models, it was decided to describe a case of excellence represented by IKEA, which was able to remain a market leader by using digital technology and management of supply chain. In the next paragraph we will analyze and try to understand how it succeeded, because we believe it will help to identify the mechanisms on which the success of a digitalization process depends.

IKEA SUPPLY CHAIN

The world's largest home furnishing retailer has 355 stores in 29 countries. What are the best-kept secrets behind IKEA's supply chain management processes?

It ranks Number 40 on Forbes' esteemed World's Most Valuable Brands[27] list and took in $39.3 Billion in sales in 2017. IKEA has certainly come a long way in its 65 years of business since its 1943 founding in Sweden.

This organization impresses not just its consumers with affordable, high-quality furniture, but also competitors and companies around the world – especially with its unique supply chain and inventory management techniques.

Each IKEA store is huge and holds more than 9,500 products! How in the world does IKEA offer so much at such a low price while always being able to keep items in stock?

IKEA's vision: supported by efficient supply chain management

To start off, IKEA has a clear vision – to provide well designed, functional home furnishings at prices so low that as many people as possible will be able to afford them. Its various functions (supply chain operations and inventory management[28] included) work together to support its distinctive value proposition.

IKEA is distinctive in committing to a catalog of products that will be stocked for a year at a guaranteed price.

Cost savings in furniture design

IKEA stock incurs low manufacturing costs while meeting strict requirements for function, efficient distribution, quality, and impact on the environment.

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[27] https://www.forbes.com/companies/ikea/#c1b5fb32ad0e

[28] https://www.tradegecko.com/inventory-management?_ga=2.106229827.1550094665.1586145031-313224491.1586145031

According to a case study produced by The Times of London[29], more than 50% of the products are made from sustainable or recycled products. IKEA seeks to use as few materials as possible to make the furniture, without compromising on quality or durability. By using fewer materials, the company cuts down on transportation costs because it uses less fuel and manpower to receive materials and ship products.

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[29] https://businesscasestudies.co.uk/building-a-sustainable-supply-chain/#axzz2uijcsMD8

Sustainable relationships with suppliers

A key part of IKEA’s success is credited to its communications and relationship management with materials suppliers and manufacturers to get good prices on what it procures.

IKEA is a very high-volume retailer – it buys products from more than 1,800 suppliers in 50 countries and uses 42 trading service offices around the world to manage supplier relationships. They negotiate prices with suppliers, check the quality of materials, and keep an eye on social and working conditions.

Although IKEA fosters competition among suppliers to ensure it attains the best prices and materials, the company also makes longstanding commitments to suppliers by signing long-term contracts, thus lowering prices of products further.

For example, IKEA has a code of conduct called the IKEA Way of Purchasing Home Furnishing Products (IWAY), containing minimum rules and guidelines that help manufacturers reduce the impact of their activities on the environment. The requirements within IWAY raise standards by developing sustainable business activities and leaving positive impacts on the business environment in which the suppliers operate.

This also underlines IKEA's commitment to the 'low price but not at any price' vision. Although IKEA wants its customers to enjoy low prices, this should not happen at the expense of its business principles.

Do-It-Yourself assembly lowers packaging costs

Most IKEA furniture is designed and sold in pieces for the customer to assemble. The pieces are placed into convenient and efficient, flat packages for low-cost transport because they take up less room in trucks, maximizing the number of products that can be shipped and minimizing order fulfillment costs.

The unique packaging also takes up less space in warehouse bins and reserve racks, allowing for more room to stock additional items for order fulfillment. What the company saves in fuel and holding costs is passed on to customers.

Streamlining the IKEA supply chain

Every IKEA store has a warehouse on the premises. On the main showroom floor, customers can browse for items. They then obtain the products themselves from the floor pallet location with racking as high as the typical person could reach, where furniture can be purchased and taken home. Additional products are stored in reserve racks above these locations.

IKEA stock is let down to the lower slots at night (forklifts and pallet jacks are not used during store hours for safety reasons). About one-third of the lower level is comprised of a warehouse off limits to customers. This space contains items too bulky for customers to load without help from the staff. Since IKEA wants as much self-service as possible, it works to minimize the number of items in this bulk storage area.

Cost-per-touch inventory tactic

Having customers select the furniture and retrieve the packages themselves is an inventory management tactic called ‘cost-per-touch’. As a rule of thumb, companies find that the more hands touch the product, the more costs are associated with it.

For example, imagine when someone selects a piece of furniture to buy. The item is then ordered, shipped from the manufacturer, moved from the delivery truck into storage in the warehouse, moved from the warehouse to the customer’s vehicle or delivered by the furniture retailer to the customer’s home. Every time the product is shipped, moved, and loaded; it costs money. The fewer times someone moves or touches the item, the fewer costs are associated with it. IKEA saves costs with this guiding principle to minimize touches because it does not have to pay the customer to retrieve the furniture and take it home.

In-store logistics

IKEA also relies on something rare and unique concerning its logistical management of reordering products – it employs in-store logistics personnel to handle inventory management at its stores. According to the ARC Advisory Group (professionals and consultants on logistical and supply chain operations), there is an in-store logistics manager responsible for the ordering process and a store goods manager responsible for material handling logistics at all IKEA stores.

The duties of the logistics personnel are to monitor and record deliveries, carefully check delivery notices, sort and separate the goods, and get them off to the correct sales area or designated overstock locations. Overall, they ensure an efficient flow of goods within IKEA stores, which is essential to maintaining high sales and enhancing customer loyalty.

Maximum/minimum settings as a proprietary system

The in-store logistics managers use an inventory replenishment management process developed by IKEA called 'minimum/maximum settings' to respond to store-level inventory reorder points and reorder products.

Minimum settings: The minimum number of products available before reordering.

Maximum settings: The maximum amount of a product to order at one time.

Since all IKEA inventory is only stocked at night after opening hours, the logic of its min/max settings is based on the number of products that will be sold from the reserve stack of the bin in a single day or two-day period. The process meets customer demand while minimizing ordering too few or too many products.

This strategy also ensures that IKEA has inventory ready to meet customers' demands, lowering the cost of lost sales.

Using IKEA's proprietary inventory system, logistics managers know what is sold through point-of-sale (POS) data and how much inventory comes into the store through direct shipping, and from distribution centers through warehouse management system data. Using this data, they can forecast sales for the next couple of days and order in the suitable number of products to meet that demand.

If the sales data does not match the projected number of items that should have been sold that day, the logistics manager goes directly to the pallet and bin to do a manual stock take.

IKEA believes its process and system allows for the right goods to be in the store with greater certainty, and at a lower cost, than the traditional retail forecasting and replenishment process.

Usage of high-flow & low-flow warehouse facilities

IKEA's store operations are supported by high-flow facilities (focused on the 20% of SKUs that account for 80% of the volume) and low-flow warehouses that are more manual. In its high-flow warehouses, IKEA employs automatic storage and retrieval systems to drive down its costs-per-touch. Products stocked in a low-flow facility are not in high demand, and operations rely on manual processes since workers will not be shifting and moving inventory around too much.

These strategies have made IKEA the world's most successful furniture retailer with low operating costs and high product demand. This allows the company to stay competitive in the industry as it continually seeks more advanced methods to streamline supply chain management.

IKEA has a clear vision supported by complementary cross-functional logic. This not only differentiates IKEA from its peers, but also provides it with a competitive advantage that is difficult to duplicate at other organizations.

3.2.2 Use case 2: Agrifood

The agrifood chain is a very flexible structure considering the different presence of stakeholders, intermediaries, mediators, and concerning the type of product. For this reason, the supply chain can also acquire the connotation of a short or long supply chain with evident differences from an economic, environmental, and social point of view. On the subject side, the supply chain can identify internal actors, which characterize the individual phases and (external) economic actors who, although not belonging to the agrifood supply chain, maintain economic relations with it that profoundly affect the development of the supply chain and the formation of prices. By summarizing the agrifood supply chain, we can substantially divide it into 5 phases:

Phase 1

It is the phase characterized by the production of raw materials, such as agricultural production, breeding, and fishing. In this context, it is necessary to consider the interactions of the production of raw materials with the production of capital goods that allow and facilitate the exercise of primary activity (e.g. agricultural machinery).

Phase 2

After the production of raw materials that can concern fruit and vegetables, milk, meat, fish, the agrifood chain is characterized by the processing industry. In this phase, the product is processed and transformed according to the technical specifications and any approved specifications.

Phase 3

The next step is made up of the companies that deal with the packaging, labeling, and packaging of the processed product or the same primary product before it is placed on the market.

Phase 4

It is the distribution phase that allows the product to reach the fruit and vegetable, fish markets, or the various and different points of sale on the national territory.

Phase 5

Commercial phase to be understood as a set of multiple actors including wholesale and retail trade (distinguished between a traditional distribution and free service, of which Modern Distribution is a component) and the catering channel (collective, restaurants, catering, etc.).

A merely lexical definition traditionally identifies the agrifood chain with the sequence of steps that an agrifood product performs from production to distribution up to consumption. Sometimes, on the contrary, the concept is limited to the production system only, *excluding the ring of consumption*: "chain of production steps that precede the arrival of the goods on the store shelf (for example, in the dry pasta sector, the production chain it includes the production of wheat, milling, pasta production, the sector of packaging with film, inks, adhesives, etc., the storage of the finished product, the transport up to the sale in the distribution points) ".

But the concept that most effectively lends itself to describing today's complexity of the supply chains and interconnections that pass through them is that of the **agrifood ecosystem**. **A system of multidimensional relationships as they exist between individuals, individuals and collectives, between territories, between production processes, between geographical, cultural, landscape, geopolitical, economic and environmental contexts.**

Actors who are at the same level of the chain perceive themselves mainly as competitors and tend to remain distinct. Furthermore, they only accept union-representative forms (trade union protection) or consortium type, in order to better manage the power relationships with the upstream or downstream rings. The mere verticality tends to weaken the individual rings, increasingly with the decrease in the degree of transformation of the goods and materials: the producers of the raw materials are or risk being so with maximum intensity.

A similar approach turns out to be even more deleterious in the case of supply chains such as the Italian ones, which have specific characteristics we would call genetic, or rather deeply rooted, somewhat generalized:

• the *minuscule, if not microscopic, the average size of agrifood SMEs* and other economic operators in general (eg the professional firms that assist them);

• the *low propensity for innovation and innovative planning*, or at least the lack of structural research and development, as an integral part of the production process;

• *the structural, strategic and design fragmentation of SMEs;*

• mistrust towards actors and instruments that could prove to be useful complementary allies but often perceived as enemies of the agrifood and cultural tradition (two examples among many others: private finance and the world of digital communication).

The global food system, therefore, needs to set up an urgent transition. Among the most relevant methodological indications, within the framework of the extensive study and coordination effort promoted by the FAO (Food and Agriculture Organization), there are the active promotion of local food systems based on family farming as well as the adoption of suitable production methods to preserve and promote Biodiversity, traditional knowledge, and healthy diets. **The International Forum Relevant Territories for Sustainable Food Systems (FISAS),** which took place in Portugal in July 2019, deserves mention. This plural space hosted numerous events, concerning innovation for rural development (World Innovation Forum rural), the creation of bio-regions (World Eco-Congress / **Bio-districts**), local public policies (Laboratory on local public strategies for food sustainability) and agricultural heritage (International Seminar on World Agricultural Heritage). A **Bio-district** (or eco-regions as it is called abroad) is a geographical area where farmers, citizens, tour operators, associations and public administrations establish an agreement for the sustainable management of local resources, starting from the organic production model and consumption: short supply chain, buying groups, organic public canteens. *In the Bio-district, the promotion of natural products is mutually linked to the promotion of the territory and its peculiarities, to achieve the full development of economic, social, and cultural potential.*

In Italy, the first Bio-district was activated in 2004 in an area that is part of the Cilento, Vallo di Diano, and Alburni National Park. From the original experience, which sees in AIAB the Italian Association for Organic Agriculture, one of the protagonists, many others have flourished in different territories, up to the establishment of the **International Network of Eco Regions (IN.N.E.R.).** Today there are 32 bio-districts in Italy, but several others were born in France, Austria, Spain, Portugal. China, Brazil, Japan, and some African countries are also developing a similar model of sustainable land management, based on organic agriculture and agroecology.

As already said, the Italian entrepreneurial economic system is 92% made up of small and medium-sized enterprises (SMEs). *This is a category that tends to be more reluctant to aggregation;* it is mainly a cultural issue: minor and - in some cases - medium-sized enterprises tend to be family businesses, linked to their own business and, if allowed, "jealous" of the same, of their ideas and initiatives. Each aggregation form, therefore, is understood as a limit to one's effort and, in hindsight, this framework is further aggravated if one takes into consideration that most forms of aggregation entail serious limitations of the scope of action of the individual entrepreneur in favor of centralized management, often concentrated in the hands of larger companies.

Furthermore, the agrifood supply chain is often faced with the cumbersome presence of a subject who, compared to other entrepreneurs, is in a dominant position: *large retailers.* This is an imbalance situation often organized through the so-called vertical integrations, contractual agreements under which the large distributor undertakes to purchase from the small producer as long as the asset is made according to specific criteria dictated by the former.

A comparative analysis of aggregative forms: advantages and disadvantages

The aggregation can certainly be characterized by the presence of positive and negative aspects, especially if we consider that the success of a network depends on the characteristics of the companies, on the type of activity that is intended to be carried out as well as on the method of control and governance of the relationships. Among the advantages of network relationships, therefore, must be mentioned:

- ✓ the reduction of costs
- ✓ the possibility of attacking new markets through the sharing of information and the achievement of larger volumes
- ✓ sharing of R&D activities
- ✓ easier access to bank credit.

The disadvantages, however, can be summed up in a loss, even if partial, of autonomy. This is an aspect that can be limited but cannot be avoided and on which it is essential to act in the constitution and definition phases of the governance of the combination. Even before signing the aggregate agreement, it is necessary to establish relationships of trust between entrepreneurs, communicate their respective interests and, later, agree on specific "rules of conduct". The governance model of the aggregation, then, it will be particularly useful to avoid both a strong predominance of some companies over others (based on aspects such as economic potential, the know-how possessed and the degree of penetration of the reference market) and the conflict between the different interests or, to put it better, lateral interests.

The **district** has its peculiar elements in interpersonal relationships and, therefore, in the extreme informality, in the deep link with the territory and the specialization of the production process, characteristics that tend to be found in the other aggregative forms but which certainly in these are not are essential. Moreover, precisely from the character of the informality of the district form derives an inaccurate identification of the purposes of the aggregation which, instead, characterizes the other forms, however, based on a well-defined contractual relationship.

The **consortium**, on the other hand, distinguishes itself from the other models for the pursuit of objectives entirely falling within the activities already carried out by the member companies and never further than these, as instead typically happens, for example, in business networks. With this contractual form, companies collaborate and join together to carry out activities or carry out projects functional to the growth of innovative and competitive capacities, also acting outside the individual businesses and, in any case, aiming to extend the field of action in other areas and markets. With the consortium contract, several entrepreneurs set up a common organization for the discipline or for carrying out certain phases of the respective companies". Therefore, it is already possible to highlight a characterizing element of the form of aggregation of the consortium: *the companies establish a common organization for the discipline or for carrying out certain phases of the respective companies.*

The **cooperatives** have been an essential part of the history of Italian supply chains for well over a century. The cooperative movement represents more than 50% of the entire agrifood chain and constitutes one of the most valid and advanced answers to the problems of our country's agrifood sector. The numbers confirm this: the turnover of the agrifood cooperation exceeds 35 billion €, 5,900 active companies with over 950 thousand members and more than 94 thousand employees. At the end of 2015, 46% of the cooperatives active in Italy were located in the South, 35% in the North, and 19% in the Center. The region with the most unions is Sicily with just under 12 thousand businesses, ahead of Lombardy with 11 thousand and 200, followed at a distance by Lazio with only under 8 thousand and 600 coops.

Business networks. The business network contract represents a crucial legislative innovation which, introduced in 2009, then underwent a rapid evolution driven by a deeper reflection on the Italian economic system and its growth opportunities. Today there are 5,135 business networks in Italy and involve 31,405 companies with growth in 2018 compared to 2017, of +817 network contracts. This development is mainly justified by the need for SMEs *to cooperate to achieve services that are not part of the core business of the enterprises, but which are complementary to it*. Business networks, both those with legal subjectivity and those without legal subjectivity, in most cases, to pursue what outlined within the network program, need to make investments.

there are two possibilities in this regard:

1) on the one hand, networks can participate in - also - European calls;

2) on the other hand, companies can share the investment.

Whatever it may be the organizational model and governance, *through the aggregation, small and medium sized enterprises can carry out activities and dynamics that, otherwise, would be reserved for large companies only.* These are, in hindsight, those activities suitable for repositioning entire production chains, which were mentioned at the beginning of this paragraph: reduction of costs, exchange of information - also through inter-company learning - increase in efficiency and market power.

3.3 PUBLIC AND PRIVATE FUNDS AVAILABLE FOR THE DIGITALIZATION OF THE SUPPLY CHAINS

Logistics in general and Supply Chain Management (SCM) in particular, have become of interest in the EU R&D Framework Programs early 00', although digital transformation was, of course, out of the scope.

The Alliance for Logistics Innovation through Collaboration in Europe has set up its Technology Platform, ETP – Alice, to "develop a comprehensive strategy for research, innovation and market deployment of logistics and supply chain management innovation in Europe" (etp-logistics.eu).

ALICE is based on the recognition of the need for an overarching view on logistics and supply chain planning and control, in which shippers and logistics service providers closely collaborate to reach efficient logistics and supply chain operations.

In December 2016 ETP-Alice has proposed its Recommendations to H2020 Work Programs 2018-2020:

Work Program – *Sections* to which recommendations are directed	**Acronym***
Smart, Green and Integrated Transport - *Logistics, Urban Mobility, ITS, Infrastructure, socio-economic and behavioural research*	MG
Secure societies	SEC
Climate Action, Environment, Resource Efficiency and Raw Materials/Waste	CIRC
Nanotechnologies, Advanced Materials, Advanced Manufacturing and Processing, and Biotechnology - *INNOVATIVE AND RESPONSIBLE GOVERNANCE OF NEW AND CONVERGING ENABLING TECHNOLOGIES*	NMBP
Information and Communication Technologies – Big Data, Robotics and Autonomous Systems	ICT
Internet of Things PPP	IoT
Factories of the Future PPP	FoF

Most of the recommendations are, of course now, on thematics related to digital matters.

It is possible to become member of ETP-Alice, by means of the filling of an application form and the payment of a fee, which depends on the characteristics of the organization.

After membership is confirmed, the new member can ask for participating in the chosen Thematic Groups:

- **TG1. Sustainable logistic supply chains.**
- **TG2. Corridors, hubs and synchromodality.**
- **TG3. Systems & Technologies for Interconnected Logistics.**
- **TG4. Global Supply Network Coordination and Collaboration.**
- **TG5. Urban Logistics.**

SKIN, Short Supply Chain Knowledge and Innovation Network is focused on short food supply chain (SFSC), "*which aims to systematize the existing knowledge, fostering demand-driven innovation, building long-term collaboration among European farmers and cooperatives, facilitate stakeholders engagement and promote innovation through demand-driven research in the short food supply chain domain*" (http://www.shortfoodchain.eu/the-project/the-project.kl).

In this case it is possible to register to stay updated with good practices, news etc.

For what concerns the supply chain management platform development, it can be seen, as an example, the funding of 20M€ provided by the European Investment Bank to the German start up Forto (formerly FreightHub) to support software development and market expansion. The financing is provided under Investment Plan for Europe (https://www.eib.org/en/press/all/2020-165-european-investment-bank-provides-funding-of-eur20-million-to-forto-for-supply-chain-management-platform).

EIB seems to have depicted a clear scenario about barriers and possible solutions for digitalization of SMEs (25).

The DIVA project, fully named "Boosting innovative Digitech Value chains for Agrofood, forestry and environment" is a European initiative funded and supported by H2020.

DIVA "*aims to provide support to the emergence and development of new industrial digitech value chains with applications to the agro-food, forestry and environment sectors*" (projectdiva.eu).

Innovation actions proposed by SMEs can be funded by DIVA (max 60k€), included in Agrifood, Forestry and ICT and all surrounding sectors as robotics, automatics, electronics, machinery, etc..

DIVA edits a six-monthly Newsletter, which can be subscribed. There are National Contact Points for France, Greece, Ireland, Italy, Portugal and Spain, for both ICT domain and Agrifood, Forestry and Environment domains.

Summarizing, at the EU level there are two main channels available to promote digitalization of supply chains:

- The R&D programs, such as H2020, and the single projects, platforms, networks, initiatives
- The EIB, with its own funding programs.

Running from 2014 but closing by 2020, there is also COSME, the EU program for the Competitiveness of Enterprises and SMEs.

It must be underlined that following the specific sectors under study, agrifood and forestry of the ALPS, SMEs are possibly main target companies for digitalization of their supply chains. This is because before to digitize the supply chains, the single rings of the chains should already be digitized.

This means that all the funding tools available for SMEs can be exploited for digitizing the relevant supply chains.

3.4 PROJECTS FUNDED BY EU PROGRAMMES FOR THE DIGITALIZATION OF VALUE CHAINS

As said in the previous chapter, even though value chains have entered the EU R&D Programs in early '00, most projects were and are focused on logistics, i.e. transport of goods and the management of supply chains (SCM).
The topic of digitalization, at a large, of supply chains, agri-food and forestry in particular, has entered EU R&D programs driven by Industry 4.0 concepts, i.e. around 2017.
The Working Group 2 Digital Industrial Platforms of the Digitizing European Industry, under the framework of H2020 in august 2017 published a report on the mastering of digital value chains [26]. Among others is included a specific chapter on Smart agriculture, focusing on:

- Current landscape of activities
- visions of the future
- implementing the Vision
- contributions from PPPs
- contributions from the Member States
- Recommendations.

At the end, a list of running project is included, and here below is presented the list for smart agriculture:

Smart agriculture				
IoT Large-scale Pilots	IOF2020[viii] - cloud services - AGRI co-financing	Build a platform of cloud based App-like services for agriculture industry	Telco providers, electronics, user industry	30 M€
Big Data Value PPP	DATABIO[ix] - satellite data in agriculture	Optimise production with data analytics in agriculture, forestry and fishery/aquaculture	Communication and IT services, user from bio-economy (farming, fishing, forestry)	Tbd
Future Internet PPP	FIspace[x] - cloud services	Predecessor of IOF2020		13 M€

The links to the web pages of the three projects are the following:

- https://www.iof2020.eu/
- https://www.databio.eu/en/
- https://www.fispace.eu/.

The first event organized by InvestEUresearch and H2020 was November 2017 (https://ec.europa.eu/programmes/horizon2020/en/news/digitising-agriculture-and-food-value-chains), with parallel session dedicated on scenarios, technologies, examples of digital applications, roles of public and private organisms etc..

The most important running projects on supply chains evolution are:

- https://www.opendei.eu/
- https://nextnetproject.eu/
- https://www.etp-logistics.eu/

The project open dei is focused on Aligning Reference Architectures, Open Platforms and Large-Scale Pilots in Digitizing European Industry. It is focused on 4 sectors and the third is specific to agri-food. Such domain is leaded by an Italian nonprofit research organization, Tecnoalimenti.

OPEN DEI cover these Agri-food Projects:

- https://h2020-demeter.eu/, about empowering farmers
- https://www.atlas-h2020.eu/, about agricultural interoperability and analysis system
- https://agrobofood.eu/, about connecting robotic technologies with the agrifood secotr
- https://www.iof2020.eu/, about internet of food & farm
- https://smartagrihubs.eu/, about unleashing the innovation potential for the digital transformation of the European Agrifood Sector, with open call for proposals.

DT-ICT-09 rural economies (cross-domain) Starting in November 2020.

For nextnet, into the web site it is possible to have a look at:

- Next-Net Project Flyer
- Trends and Key Factors
- Future Scenario Generation
- Scenario Integration and Assessment
- Specific Challenges for SCs of the future
- Technology Mapping and Scouting
- Technology Mapping on Future Scenarios
- The Project Repository Journal |Challenges for the supply chains of the future
- Strategic Research & Innovation Agenda (SRIA)
- The Project Repository Journal | Strategic Research and Innovation Agenda

ETP-Logistics is Alice, already presented in the previous chapter as funding provider.

3.5 CONCLUSIONS

According to the scope of this paper, the authors collected the best initiatives and practices at European and Global level with impact on the supply value chains, and also highlight the barriers and risks to SC 4.0 which shall be overcome, here below summarized:

1. The level of implementation in Europe and Alpine countries is still shallow compared to other regions in the world, such as the US, Korea, Switzerland, Japan, mainly due to the lack of workforce digital skills.
2. Primary requirements to enable most of the new technologies, broadband coverage, and good internet connection are not evenly distributed within Europe, especially in remote rural areas.
3. Small and medium sized farmers seek cost-effectiveness and reliability on new technologies.
4. Small and medium sized farmers have difficulties with investment capabilities.
5. Proper governance for ‘fair’ distribution of information is one of the key challenges for digitalizing food-chains.

More generally, entry barriers and the cost of digitalization can imply a competitiveness gap between big and smaller actors in the supply chain who remain at a relatively basic stage of technology usage. The size and diversity of agrifood businesses in Europe constrain the uniform adoption of digitalization across the chain. The need for an integrated approach, involving the entire chain has been raised. Adapted digital solutions need to be developed considering the size and the needs of existing operators. *Ensuring a level-playing field and knowledge transfer for SMEs is a milestone for the successful digitalization of the food supply chain as a whole.*

Furthermore, some indicators developed over the last years to assess the digital maturity of SMEs, though different across the Alpine countries, but comparable, have generally proved a low level of implementation and adsorption of digital technologies, especially in the wood, agrifood and textile sectors within EU and the Alpine nations. *The deep measure assessment of the digital level of wood, agrifood, and textile value chains shall be the primary step to perform*. The Italian best practice of ABB value chain assessment could be considered regarding the methodology, in order to prepare the roadmap of the specific businesses, keeping in mind that the share and electronic exchange of data, as well as the analysis and exploitation of big data generated by I4.0 sensors, machines and latest equipment, is the crucial point to SC transformation towards a framework which will be faster, more efficient, more accurate and more customized.

As a lesson learned from this research, the digitalization of the value chain is successfully performed through the engagement of one or more leaders inside the chain. The masters of Gartner Top 25 report, as well as Ikea, represent the best practices of how leaders, strongly engaged and focused on their businesses, exploited their digital capabilities in creating efficient value chains worldwide, with good margins and high level of customer satisfaction. For wood, agrifood, and textile, the leadership of a single enterprise can be successfully replaced by the aggregation of SMEs into clusters, districts, or cooperatives, that can carry out activities and dynamics otherwise reserved for large companies only. *Once more, encouraging clusters of companies to support knowledge transfer and share innovative digital best practices among operators is crucial and should be pursued by any policy at EU level.*

Finally, two local facts are having long term global impact on the EU value chains, including wood and agrifood:

- Pandemic Sars-COVID19
- Final decision of UK to exit the EU (the so-called Brexit).

About the last, in July 2020 Innovate UK has announced the Digital Supply Chain competition for technology and manufacturing firms that develop innovative digital technologies aimed at potentially transforming supply chains, in order to help the UK manufacturing sector become more efficient, productive, flexible, and resilient. The focus is to rethink and restructure the way manufacturers design and operate supply chains, by means of innovative digital technologies.

About the impact of the first, it cannot be discarded that far suppliers, blocked during lockdown, with stopped transport and closed borders also among EU Member States, has put the problem of re-thinking the length and the distance of the supply chain for any manufacturing or service company. Wood and agrifood value chains in the EU are impacted too, and one solution is the digital evolution.

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3.8 ANNEX 1. THE DIGITAL TOOLS APPLICABLE TO SCM

WOOD

The Real Environment

LiDAR 3D point clouds, drones, WorldView-3 satellite system (o detect any short-term changes about the forest environment over large areas), data collected from machines, production monitoring systems (onboard data loggers, onboard computers), detailed roadside inventory information on volumes and quality can be a vital piece for transportation planning and optimal dispatching of trucks to minimize waiting times and wasted travel time. Similarly, additional information about the road infrastructure can become helpful building blocks around planning the whole transportation system.

The Internet of Forest (IoF)

Communications' systems: vehicle-to-vehicle and machine-to-machine (**V2V/M2M**), vehicle and machine-to-infrastructure (**V2I/M2I**), operations-to-cellular and Internet networks, real-time communications in remote operations.

NextGen Fiber Supply Chain

Unlike agricultural fields or mines, the forest presents some significant challenges to automation and robotics because of the highly variable terrain conditions (from flat, soft ground to steep slopes to boulder fields) and the ever-changing forest stand structures, even in managed natural forests (except for plantations).

Remote control or teleoperation systems are also starting to appear.

This project will be pursued along two main fronts: (1) evaluation of enabling technology around automation, sensors, machine learning, robotics and augmented reality, and (2) development of autonomous vehicles specific to the forest sector.

Data Analytics

The main data streams being generated in forest operation are related to the forest inventory, the machine data (from on-board computers), and the transported volume of wood (from scale or manual measurement). Most of the time, these data sets are not centralized nor widely accessible.

Gradually, the objective is to shift from passive data used to monitor operations to active data used for managing processes and predicting behaviors through artificial intelligence and deep learning systems.

Cyber-physical systems (CPS)

I 4.0 describes the merging of the physical with the virtual world. Thereby, the overarching goal is to create a digital image of reality that resembles it as closely as possible. The premise for this goal is that machines, objects and humans are integrated into the virtual world with the help of sensors which “collect physical data and by means of actuators influence physical procedures”. These smart machines, storage systems and production facilities (smart devices) relate to each other, building an embedded system, the CPS.

Localization and identification of objects

The basis for the network of CPS is that all objects within the network can be uniquely identified and located digitally as well as physically. There are several technologies that can be named in this context like barcodes or more advanced radio frequency identification (RFID), which will be better describer in further paragraphs. Other localization options are GNSS such as GPS, DGPS or internal GNSS which can be used inside factories.

WOOD/AGRIFOOD

Electronic Records Management

Paperless business transactions through Enterprises Resource Planning (ERP) Systems, Automatic Identification (Auto-ID), and Electronic Data Interchange (EDI) are collectively known as Electronic Records Management (ERM). The objective of ERM implementation in SCM is to ensure the accountability of process flow, which is fruitful to reduce cybercrime risks (e-risks) generate during the e-communication.

Bar code

Bar codes consist of ladder orientation (width lines in a horizontal order) or picket fence orientation (width lines in vertical order), where data is stored in magnetic or optical form as a part of the communication system. The organizations are using it in supply chain networks to automate tracings and tracking products and services at each process flow. It also provides the necessary accuracy and timeliness of information, which is useful to reduce errors because it is the representation of a number or code in a form suitable for reading by machines. This is commonly used in product identification, speeds data entry, enhances data accuracy, minimizes on-hand inventory, improves customer service, reduces product recall, verifies orders at receiving and shipping, reduces work-in-process idle time, monitors and controls shop floor activity, improves shop floor scheduling, optimizes floor space, improves product yield/reduces scrap.

Radio Frequency Identification (RFID)

Radio Frequency Identification (RFID) is a technology which is based on the use of tags that emit and receive the identity in the form unique serial number of an object through wireless using radio signals and on readers that collect the data transmitted by the tags and forward them into the company's information system for further evaluation and analysis. RFID and bar code are based on Auto ID technology but in bar code, the reading device scans a printed label with optical laser or imaging technology and in RFID the reading device scans a tag by using radio frequency signals. By adopting RFID technology, the supply chain can be enhanced by visibility into customer needs, efficient business process, reliable and accurate order forecasts, productivity improvement, operating cost reduction, better tracking, counterfeit identification, and theft predication.

Suppliers can manage product recalls and return of faulty and defective materials by using RFID through its Electronic Security Marker (ESM). RFID helps the organization to avoid duplication of items, as the tags are unique and authenticated. It can also reduce the chances of fraud generated by manipulation in the entry, authorization from the supplier to the customer. Cost and implementation constraints secure RFID tags and smart cards require specialized cryptographic implementations.

Internet of Things (IoT)

The Internet of Things (IoT) is a collection of interconnected physical devices that can monitor, report on, and send and exchange data. IoT devices are typically connected to computer systems via data or Wi-Fi networks. IoT devices use sensors to measure specific aspects of the world around them, including location, temperature, humidity, light levels, movement, handling, speed of movement, and other environmental factors. IoT devices come in many form factors including RFID chips, already detailed above, smart devices, and mobile sensors. In the supply chain, Internet of Things devices are an effective way to track and authenticate products and shipments using GPS and other technologies. They can also monitor the storage conditions of products which enhances quality management throughout the supply chain. IoT devices have revolutionized SCM. It is much easier to understand where goods are, how they are being stored and when they can be expected at a specific location. Tracking speed of movement and the traffic flow of products makes it much easier to predict how goods will move through the supply chain. Suppliers, manufacturers, and distribution centers can prepare to receive goods, which reduces handling times and ensures the efficient processing of materials. Some products like food and chemicals need to be stored in ideal conditions. Specialist IoT devices can monitor areas like temperature, humidity, exposure to an atmosphere, light intensity, and other environmental factors. These devices may even trigger an alarm if certain thresholds are breached. This makes it much easier to track the quality of goods through the supply chain and to reduce spoilage.

Goods tracking and route planning through IoT devices can identify where and when products are delayed in transit, allowing contingency planning and alternative routes to speed up the supply chain. Goods can remain tagged with IoT devices when they are in a distribution center. It would be much easier to find specific products within a large warehouse and ensures accurate identification and management of goods. Finally, verified tracking through IoT devices means that SCM can validate exactly when goods arrive. This can trigger other administrative tasks like supplier payments or onward shipping requests.

IoT devices are a significant benefit for all aspects of supply chain management:

- Reassurance that goods are located where stakeholders say they are, both at rest and in motion
- Early identification of issues with goods getting lost or delayed
- Real-time shipment and inventory visibility and tracking
- More straightforward supply and demand planning as stakeholders know when they can expect to receive goods
- Better quality management due to keeping raw materials and processed goods in optimal conditions
- Efficient storage and distribution of products due to the more accessible location of goods in warehouses

Electronic Data Interchange (EDI)

Electronic Data Interchange (EDI) is the computer to computer interchange of business documents and/or information in standard, structured, machine retrievable data format (the computer can process the information without human assistance) between trading partners and commonly referring specifically to the application of EDI communication standards. It is the replacement of the traditional forms of mail, courier, or fax. It is used for the paperless communication within supply chain network to share transactional data, order processing, inventory controlling, accounting, transportation, quick access to information, better customer service, increased productivity, improved tracing and expediting, cost efficiency, competitive advantage, and improved invoicing within the inbound and outbound supply chain. EDI is also tremendously beneficial in counteracting the Bullwhip effect, and supply chain organizations can overcome the distortions and exaggerations in supply and demand information by using technology to facilitate real-time sharing of actual demand and supply information.

Enterprise Resource Planning (ERP) Systems

Enterprise Resource Planning (ERP) is an organizational planning framework that includes administrative (finance, accounting), human resources (payroll, benefits), and Manufacturing Resources Planning (MRP) (procurement, production planning). It is a collective term for a cooperating software that manages and coordinates much of a company's resources, assets, and activities. ERP systems help organizations for automating and integrating their Supply Chain Management and business. In the new generation ERP, the whole supply chain management concept is incorporated extending the planning concept to trading partners where the complete visibility throughout the enterprise is possible and the concept of virtual enterprise is supported using electronic commerce.

Distribution Requirement Planning (DRP)

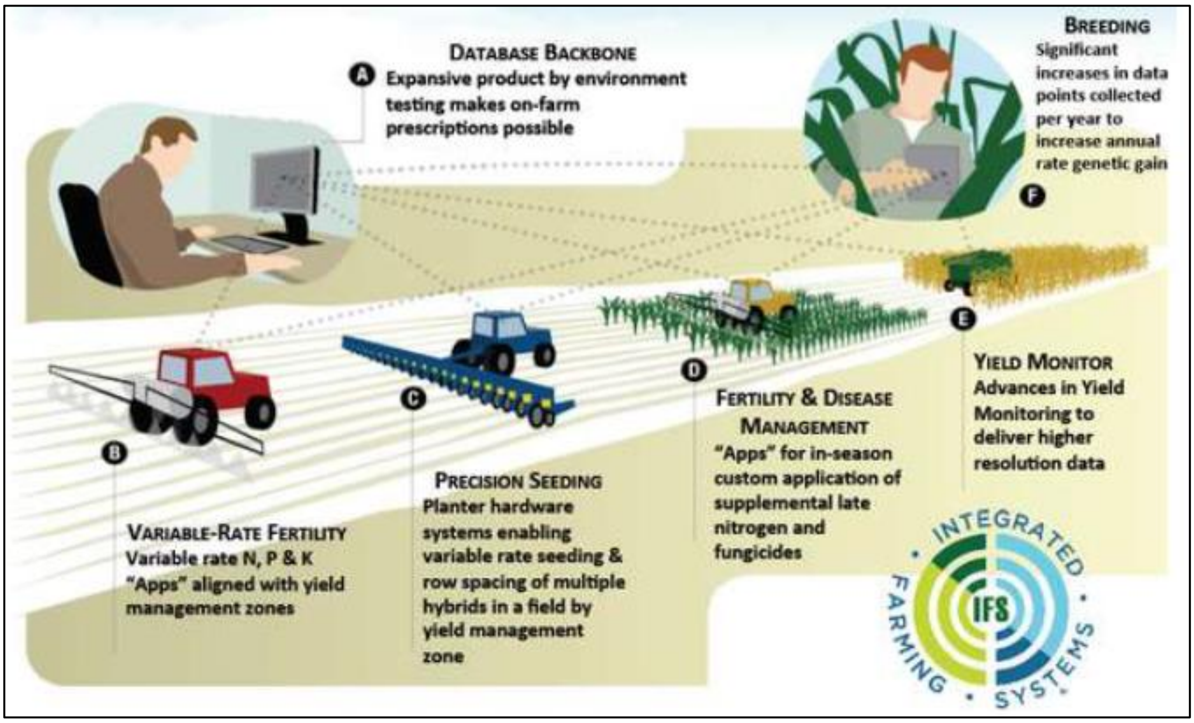
Distribution Requirement Planning (DRP) is a management process that provides a linkage between warehouse operations (store, distribution center, or warehouse that carries a product for sale) and transportation requirement that ensures that supply sources (third party supplier, a regional distribution point, or a factory) which be able to meet the demand.

Data Warehouse and Data Mining

Data Warehouse (DW), which provides a combination of many different databases across an entire enterprise, aids management in the decision-making process with specific characteristics as subject-oriented, integrated, nonvolatile time-variant, accessible and process-oriented. Data mining combines data analysis techniques such as statistical analysis and modeling to uncover hidden patterns and subtle relationships in data and to infer rules that allow for the prediction of future results. Data mining helps the organizations in defining business rules (alerts based on intuition and general experience), anomaly detection (alerts are defined based on events that represent a statistical deviation from normal or expected behavior), predictive models (statistical models which derived from event characteristics that are indicators of prior fraud incidents) and social network analysis (alerts are based on the level of association between the current event and individuals or accounts that are known or suspected of fraudulent behavior).

Big data

Big data are information assets with a high volume, velocity, and variety, making them difficult to manage with common tools. Data with many cases (rows) offer greater statistical power, while data with higher complexity (more attributes or columns) may lead to a higher false discovery rate. Big data challenges include capturing data, data storage, data analysis, search, sharing, transfer, visualization, querying, updating, information privacy and data source. Current usage of the term big data tends to refer to the use of predictive analytics, user behavior analytics, or certain other advanced data analytics methods that extract value from data, and seldom to a particular size of data set. Analysis of data sets can find new correlations to "spot business trends, prevent diseases, combat crime and so on. Scientists, business executives, practitioners of medicine, advertising and governments alike regularly meet difficulties with large data sets in areas including Internet searches, fintech, urban informatics, and business informatics. Data sets grow rapidly, to a certain extent because they are increasingly gathered by cheap and numerous information-sensing Internet of things devices such as mobile devices, aerial (remote sensing), software logs, cameras, microphones, radio-frequency identification (RFID) readers and wireless sensor networks. The world's technological per-capita capacity to store information has roughly doubled every 40 months since the 1980s; as of 2012, every day 2.5 exabytes (2.5×260 bytes) of data are generated. Based on an IDC report prediction, the global data volume was predicted to grow exponentially from 4.4 zettabytes to 44 zettabytes between 2013 and 2020. Relational database management systems, desktop statistics and software packages used to visualize data often have difficulty handling big data. The work may require massively parallel software running on tens, hundreds, or even thousands of servers. AgriFood chains become more technology/data-driven. Farms adopting technology based on big data/precision agriculture shall enjoy the benefits.



Source: Monsanto's Key Contributions to Precision Agriculture by Kaitlyn Nelson
https://slideplayer.com/slide/8453485/

Clouds

Cloud computing is already making a significant impact on the supply chain management application market, and adoption is expected to continue to grow. Companies that provide SCM software applications – including e-procurement, warehouse management systems, transportation management systems, supply chain planning, and business intelligence & analytics – are either already offering 'software as a service' (cloud-based) solutions or are articulating a clear strategy to move to such solutions as more customers demand it. As this happens, look for the following supply chain processes to become particularly prominent venues for cloud computing:

Planning and forecasting. Cloud-based tools are available for capturing itemized spend data, performing basic analytics, planning manufacturing runs, and executing statistical demand forecasts. Applications focused solely on the retail are also prevalent, with capabilities that include planning & allocation, assortment & space, pricing & promotion, and forecasting & replenishment. A primary reason is that planning and forecasting are rarely core components of companies' ERP systems.

Logistics. Cloud computing applications for functions such as network strategy, inventory management, warehousing, and transportation will appear with increasing regularity shortly. Processes such as global trade compliance, replenishment planning, order processing, and transportation load building, fleet management, and transportation route planning are likely candidates. Some basic warehouse and transportation-management applications are already available online.

Sourcing and Procurement. Cloud computing represents a great opportunity to reduce the 'total cost of ownership', the most cited success metric in sourcing and procurement. A key reason is that cloud-based tools are inherently collaborative and accessible – a significant boon to companies that may deal routinely with thousands of suppliers. Take contract management: cloud-based collaboration allows multiple parties to jointly develop supplier contracts.

Blockchain

Blockchain is one of the innovative technologies revolutionizing digital supply chain management. As supply chains grow and become tangled, involve diverse stakeholders, and mainly rely on many external intermediaries, Blockchain emerged as a strong contender for de-tangling all the data/documents/communication exchanges happening within the supply chain ecosystem.

Let us recall the four most distinctive features of Blockchain that make it highly applicable for the supply chain managers:

Transparent and controlled transactions. Blockchain has no intermediary (e.g., a bank). It results in faster and more transparent settlements, as the ledger is updated automatically. Payment conditions can be pre-programmed automatically, including the visibility of a transaction, so that it can only be visible to the authorized participants.

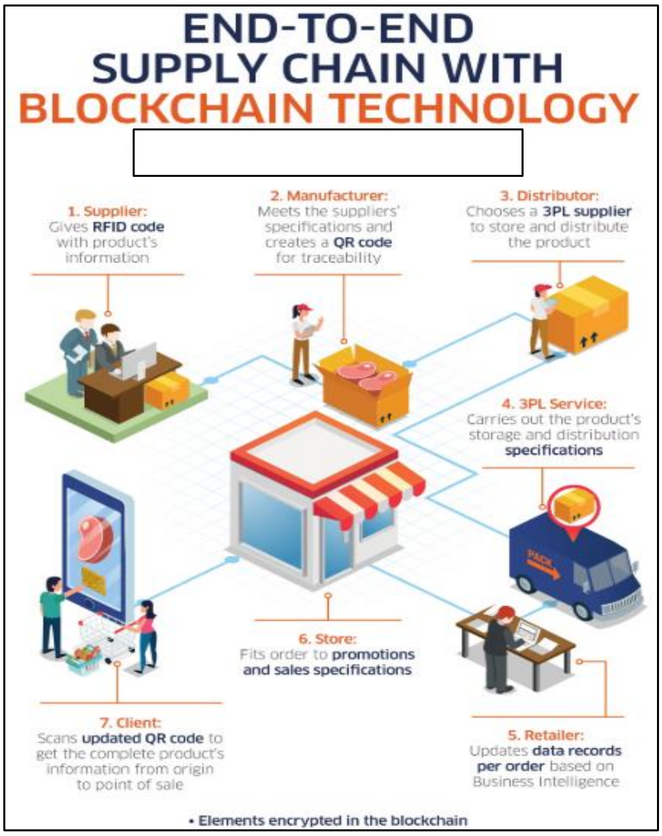
Preapproved transaction fees. When making cross-border payments with Swift, the commission for the transaction is deducted only after the transaction completion — or, to be more exact, upon running through a whole number of the intermediary banks, which have been executing this transaction. In the case of Blockchain, you know the fees beforehand.

Auditability. All the transactions are immediately visible to authorized parties, meaning no one can tamper, delete, or conceal any information added to the Blockchain.

Reliable. Due to its distributed nature, Blockchain does not have a single point of failure. Besides, all the transactions processed on the Blockchain are immutable and irrevocable, further eliminating the risks of fraud.

While blockchain supply chain use cases are still emerging, several successful pilots suggest that managers can realize big benefits from Blockchain, ranging from cost-savings and increased efficiencies to new operational models, specifically in the following areas of supply chain management:

- ✓ Procurement
- ✓ Provenance and traceability
- ✓ Digital payments and contracts
- ✓ Logistics
- ✓ Manufacturing



Source: https://blog.solistica.com/en/blockchain-in-supply-chain-infographics

Cybersecurity

Due to outsourcing, customization, time to market, and pricing pressure have compelled enterprises to adopt efficient and effective supply chain management. To survive, companies will find that their conventional supply chain integration will have to be expanded beyond their boundaries to integrate all stakeholders. The adoption of the latest ICT digital technologies is vital for such efforts. Unfortunately, technology is always a double-edged sword and cyber-security is a must to overcome e-risks e fight cyber-criminals.

Here is how the **Infosec Institute** explains the concept: "*Cybersecurity in the supply chain is a subset of supply chain security and is focused on the management of cybersecurity requirements for information technology systems, software, and networks, which are driven by threats such as cyber-terrorism, malware, data theft and the Advanced Persistent Threat (APT)".* Supply chain organizations often fall victim to supply chain cybersecurity incidents since in most cases, they are simply unaware of potential threats and they do not have the proper protection measures in place. Attackers are well aware of this reality and spend a lot of their time and energy to find a vendor's weak points so they can infiltrate. So, here is how companies can protect their business from potential supply chain cybersecurity risks.

Always vet company vendors before starting any partnership. According to the Ponemon report, organizations do have the power to reduce the incident of a breach by 20%. More precisely, all it takes is to evaluate the security and privacy policies of all suppliers and the likelihood of a data breach will decrease from 66% to 46.

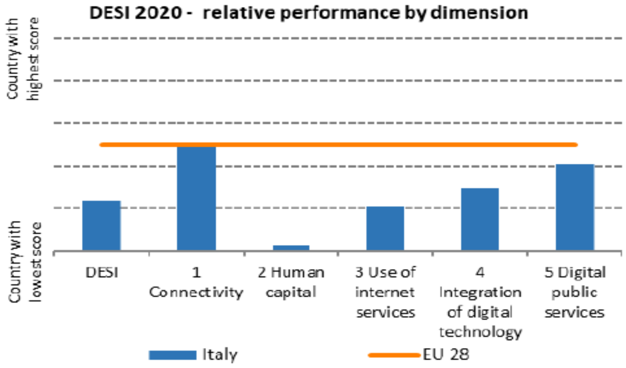
Continuously monitor data access. The first step when it comes to protecting the company's data is to know exactly who has access to what, from both the organization's side and the vendors.

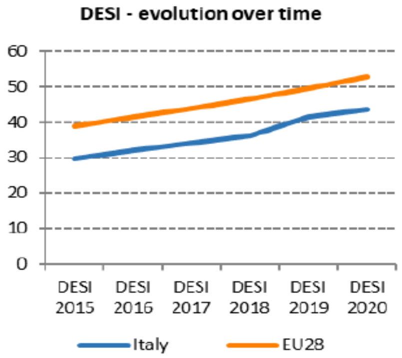
Train the company team and know for sure the vendors educate their employees too. Cyber-security awareness training is crucial, and it certainly makes up a strong layer of defense for both the organization and the vendor.

Safeguard the organization using multiple layers of protection. Of course, securing the endpoints and networks is an essential step to prevent attacks. But other aspects, like having proper patch management in place, effectively managing admin rights in the organization, and securing email from different angles (preventing spam and more advanced email threats) are equally important.

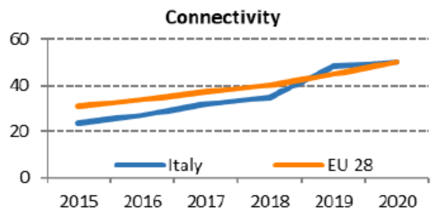
Organizations of all sizes, as well as their vendors and partners, can easily become victims of supply chain cybersecurity attacks if they do not apply at least some basic protection measures. All companies must understand the risks that can live inside their supply chain and foster a culture of organization-vendor cross-collaboration to be able to prevent and minimize the risks.

3.9 ANNEX 2. DESI 2020 RANKING - ITALY VS EU 28

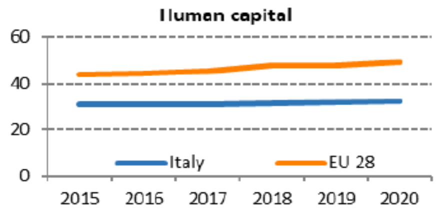




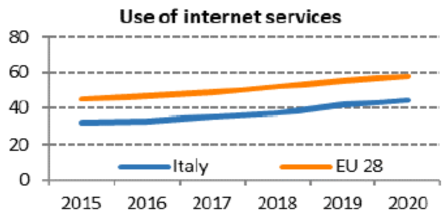
1 Connectivity	Italy rank	Italy score	EU score
DESI 2020	**17**	**50.0**	**50.1**
DESI 2019	12	48.2	44.7
DESI 2018	25	35.1	39.9



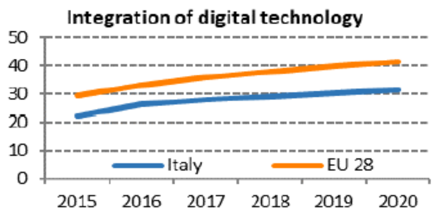
2 Human capital	Italy rank	Italy score	EU score
DESI 2020	**28**	**32.5**	**49.3**
DESI 2019	26	32.0	47.9
DESI 2018	27	31.6	47.6



3 Use of internet services	Italy rank	Italy score	EU score
DESI 2020	**26**	**44.5**	**58.0**
DESI 2019	26	41.7	55.0
DESI 2018	26	37.4	51.8



4 Integration of digital technology	Italy rank	Italy score	EU score
DESI 2020	**22**	**31.2**	**41.4**
DESI 2019	23	30.0	39.8
DESI 2018	22	29.1	37.8



5 Digital public services	Italy rank	Italy score	EU score
DESI 2020	**19**	**67.5**	**72.0**
DESI 2019	19	61.9	67.0
DESI 2018	22	54.1	61.8

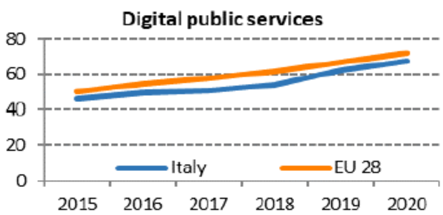


Figure 29: Digital Economy and Society Index (DESI) 2020 Ranking- Italy vs EU 28

Some figures about Italy Vs EU 28 within DESI 2020 ranking report.

In 2019, Italy dropped two places and now ranks last in the EU on the Human Capital dimension. Only 42% of people aged 16-74 years have at least basic digital skills (58% in the EU), and only 22% have above basic digital skills (33% in the EU). Although the percentage of ICT specialists in Italy increased to reach 2.8% of total employment, it is still below the EU average (3.9%). Italy's share of graduates holding an ICT degree remained stable compared to DESI 2019 (based on 2016 data). Only 1% of Italian graduates are ICT graduates (the lowest in the EU), while female ICT specialists are 1% of all female employees (slightly below the EU average of 1.4%). Measures to support advanced digital skills are included in the National Plan 'Enterprise 4.0'. Under this plan, the government activated the tax credit for 'Training 4.0' in 2018 and extended it to 2020. However, data on the first years of implementation shows that uptake of the tax credit was significantly lower than expected, because of regulatory constraints. The new plan 'Transition 4.0' extends the measure and simplifies its implementation to increase uptake.

Italy ranks 22nd in the EU on the Integration of digital technology. There has been almost no progress on the above indicators, except for the use of social media. The percentage of enterprises using social media increased to 22% (close to the EU average of 25%). The use of cloud services remained stable (used by 15% of Italian enterprises) and just below the EU average (18%). Despite a decrease between 2017 and 2019, the use of electronic information sharing remains higher among Italian enterprises than the EU average (35% of Italian enterprises, against the EU average of 34%). The gap between Italy and the EU is widening regarding e-commerce. Only 10% of Italian SMEs sell online (well below the EU average of 18%), 6% sell across border to other EU countries (8% in the EU), and they generate on average 8% of their turnover from online sales (11% in the EU).

The National Plan 'Enterprise 4.0' (i.e., Piano Nazionale Impresa 4.0), launched in 2016, has been a key instrument to support the digital transformation of Italian enterprises. Tax deductions for investment in capital goods (i.e., super- and hyper-depreciation) were among the most significant measures in the plan, and they have proved to be effective in stimulating investment. However, these measures were mainly used by medium and large enterprises, and especially for investment intangible (i.e., machinery) rather than intangible goods.

In 2019, the government launched two new national strategies, one on AI and another on Blockchain, with the support of groups of experts from industry, academia and social partners. The draft strategy on AI was opened for public consultation; it takes a comprehensive approach, including on aspects related to ethics, trust and education policies. Regarding Blockchain, the group of experts appointed by the government provided scientific and technical support on a number of aspects linked to Distributed Ledger Technologies and, at the end of 2019, delivered a draft that will form the basis for the future National Strategy on Blockchain. The government also announced several initiatives to support the development and uptake of key technologies, such as Artificial Intelligence, robotics and cybersecurity in its 'Italy 2025' strategy. Providing for a stable framework, refocusing incentives on SMEs, and increasing the effectiveness and outreach of support services are all steps in the right direction. A systemic approach over time, greater investment and involvement of all relevant players are all important elements to raise the level of digitalization of Italian SMEs and boost the digital economy of the country.

RINA Consulting - Centro Sviluppo Materiali S.p.A.
Società soggetta a direzione e coordinamento amministrativo e finanziario del socio unico RINA Consulting S.p.A.
Via di Castel Romano, 100 - 00128 Roma | P. +39 06 50551 | rinaconsulting@rinaconsulting.org | www.rinaconsulting.org
C.F. / R.I. Roma N. 00477510580 | P. IVA 00903541001 | Cap. Soc. € 1.050.000,00 i.v..