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Identifying the opportunities for enhancing the digital readiness level of the supply chain

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Abstract. Assessing the digital readiness of companies is becoming crucial to undertake a successful journey towards the digitalization of industry. Recently, the attention of both scholars and practitioners has turned to an extension of the assessment to the whole Supply Chain (SC). Given the importance of reaching a high level of integration and digital readiness in all the various actors that collaborate in the SC, some Digital Supply Chain (DSC) assessment models have been proposed mainly in the consulting field. However, to fully exploit the benefits of measuring the digital readiness of a SC, companies need also to be supported in the identification and prioritization of the most relevant opportunities triggered by the deployment of DSC projects. To this purpose, this paper presents a framework that links the potentials of DSC implementations with the SC operation processes, highlighting the most suitable technologies to deploy them. The framework has been conceived starting from a literature review and aims at providing a valuable tool to all the stakeholders involved in the transformation towards Digital Supply Chains.

Keywords: Digital Supply Chain, Readiness Assessment, Digital Transformation

1 Introduction

The business landscape has been heavily broken out by the emergence of the COVID-19 pandemia which is affecting all the societies and economies at the global level, changing promptly and profoundly the lifestyle of people, altering the market dynamics, disrupting dramatically the operations of companies and, at a large extent, of the supply chains. These extreme and severe changes have further fueled some needs and opportunities which were already nurturing in the last years, regarding in particular the digital transformation of the organizations to enable smart working of white collars, on-line controlling and monitoring of production systems, remote assistance of machines, thus mitigating the downfall effects triggered by reduced mobility of people,

workers and goods. However, the appropriate adoption and use of these new technologies are not immediate, but require a deep understanding and companies must be prepared for them [1].

One of the main requirements is the achievement of a certain level of digital readiness and this clearly makes it extremely important to identify a valid and reliable model for measuring it. Several digital readiness assessment and maturity models have been developed, mainly in the consulting and academic contexts [2]. Nevertheless, they tend to focus on the single firm and not on the value chains in which it operates. This is the reason why the attention has been shifting to an extension of the analysis at a supply chain (SC) level, encompassing the upstream and downstream sides of a focal company.

This new vision stems from the idea that significant advantages, such as an additional increase in efficiency, competitiveness and mitigation of risks, can only be achieved with a high level of integration and digital readiness of all the various actors collaborating in the SC.

This paper devotes its focus on the phase after Digital Readiness Assessment (DRA), that is when companies are required to define the main improvement areas in the SC. After briefly defining the basic concepts of Digital Supply Chain (DSC) and readiness assessment (Section 2), the paper presents a framework, which merges the technological perspective with the operational one, providing a tool for practitioners that want to enhance the digital readiness of their SC (Section 3). Some limitations and further improvements of the conducted research are finally discussed (Section 4).

2 Background

2.1 Digital supply chain

Industry 4.0 is a new industrial trend in which process integration and product connectivity allow to increase performance [3]. After e-commerce, which has completely changed the way people buy and sell products all over the world, the SC is evolving towards DSC, that in literature is considered according to two main definitions.

The first definition concerns the digital product ecosystem, or the chain of companies interested in providing digital products that were originally physical, such as eBooks and MP3s. The physical product must pass through the SC to reach the consumer; in the same way, the digital products must pass processing phases before the final consumer can use them [4]. This definition focuses more on the product: in fact, its digital nature contributes to the creation of “digital supply chains”; consequently, their construction derives from the needs and characteristics of the product.

In the second definition, instead, the digital nature is not in the product, but in the process of designing, producing and supplying goods. Aliche et al. [5] define the DSC as the next-generation SC which relies at the field level on interconnected systems, automatization of plants, collaborative digital platforms.

For these reasons, the second definition of DSC represents an integration between the traditional concepts of SC and the digital transformation, as enabling technologies

generate new opportunities and trigger new managerial SC models and processes. In literature, it has been shown that the use of technologies is positively correlated to the joint performance of the supplier and the focal company; familiarity with new digital trends allows companies' openness to share core information with their suppliers, and vice versa [6].

In a nutshell, the digital transformation of the SC is based on new innovative approaches and new features, such as:

- Speed, which allows the delivery of goods in useful times and faster movements in internal and external logistics, and in the long term even to possible "predictive shipment" (patented by Amazon) [5].
- Global connectivity, i.e. the creation of effective global hubs to provide goods and services locally, supporting integration [7], collaboration [8] and coordination [9].
- Intelligence, which allows converting digital data into useful information (automated execution, actionable insights and accelerated innovation) [10, 11].
- Flexibility, which consists in using the information to react to problems or changes instantaneously; for example, planning becomes a continuous process that reacts dynamically to the constraints and requirements of evolution [5].
- Transparency, that allows anticipating disruptions thanks to a wide information visibility [10].
- Scalability and Granularity, that allows to adapt the capacity of the SC to the "peak and trough" volumes of market demand [5].
- Sustainability, supporting the compliance and responsibility with environmental and social norms [5].

2.2 DSC Readiness Assessment

To develop such a DSC, Büyüközkan et al. [11, p.168] proposed a framework considering three different steps that are "vital for organizational alignment". The first step for digitalization is the definition of a digital strategy that exactly indicates what the company wants to achieve in terms of DSC features. Depending on the goal and its vision, as a second step, the company formulates the implementation strategy that allows it to achieve its objective(s) [13]. It considers "how, where, when and who" for the realization of the objective(s). Different aspects of SCM are affected by digital transformation and need to be defined in this step (e.g., integration, processes, automation, and analytics). The technological infrastructure must support the company strategy. Defining the nature of the infrastructure means better understanding the technological priorities and requirements (step 3) [14].

In order to support companies in these steps, DRA represents a valuable tool to suggest both the digital strategy definition and implementation.

Readiness is defined as the state of "being both psychologically and behaviorally prepared to take action (i.e., willing and able)" [15] and is strictly connected to a change process. The systemic analysis of an organization's ability to cope with transformational process or change is defined as measuring or assessing readiness, since readiness assessment aims at identify the risks, the opportunities, and the potential challenges that

might arise when change processes (concerning new processes, procedures, organization, etc.) are implemented within an actual organizational context [16]. Changing readiness means having the right conditions and resources to support certain company initiatives, to have clear goals and visions of change and to have objectives and the motivation to face it. As a result, assessing the readiness is fundamental, as companies often do not know their position towards their competitors and changes in general. Moreover, readiness assessment models can be used for comparison and benchmarking.

In the Industry 4.0 context, both scholars and consultancy groups have proposed several readiness assessment tools or maturity models (e.g., [16, 17]). However, they often focus on a single enterprise, maybe with a distinction between SMEs and large companies. So far, few researches deal with the DSC readiness. The assessment developed by the Digital Supply Chain Institute [18] has been applied to some companies operating in the manufacturing and service industry. The objective of this assessment is to analyze the SC from an internal focus to a customer-supplier focus. The assessment is divided into four areas (Demand, People, Technology and Risk), each area containing three levels. The DSC assessment developed by the consulting group Tecsys [19] aims at analyzing the critical milestones for an end-to-end SC, i.e. Executive Buy-In, Financial Foundations, Infrastructure Essentials, SC Operations, Cross-Functional Collaboration and Strategic Momentum. These ones are used to develop a roadmap to support digital transformation. Other assessment tools have been provided by the other consulting groups as well, such as Gartner [20] and McKinsey [5].

All these DRA represent significant tools for companies to identify their current level of digital readiness, but they lack in providing a clear view of the improvements that companies need to implement to increase their readiness level. Given this gap, further reflections about the post-assessment phase are required. For this reason, in the next paragraph a framework for recognizing the most interesting opportunities offered by the new technologies to improve the digital supply chain readiness is proposed.

3 The DSC improvements framework

In the McKinsey assessment [5], a Compass map with a series of improvement levers classified in six categories (planning, strategy, collaboration, order management, performance management and physical flow) originating from the DSC is presented.

To conceive our framework, we took the Compass map as a starting point to identify the main improvement areas, merging this perspective with other two dimensions: the Industry 4.0 technologies and the SC processes as defined by the Supply Chain Operations Reference (SCOR) model [21]. Similar approaches have been used in literature to build systematic literature mapping [22]. In this way, the framework provides the company with an overview of the digital results that can be potentially reached, indicating at the same time the processes that would benefit it and the technological solutions necessary to implement them successfully.

The resulting framework (represented in Fig. 1) has been developed based on academic articles, conference proceedings, and the SCOR model (version 12.0).

		Plan	Source	Make	Deliver	Return								
Strategy	Micro segmentation	S19							T40		T41			
	Proactive customer service					S20,S21	T42		T43		T44			
Planning	Predictive analytics for scenario planning	S2, S3	S2	S2			T5	T6	T7, T46		T8		T9	
	Closed-loop planning	S4, S6	S5	S4		S4,S5	T10		T11		T12		T45	
Physical flow	Automation of warehousing		S16		S17		T33			T34	T35			T36
Order mgmt.	Digital payments and invoices		S11,S12					T24				T25		
	Fraud detection		S15						T30		T31	T32		
	Online order monitoring				S18		T38	T39						
Collaboration	Product and design process optimization			S1			T1	T2	T46				T3	T4
	End-to-end connectivity	S14	S13	S14	S14		T26	T27	T28			T29		
	Online transparency		S9		S9		T17	T18			T19			
Performance mgmt.	Digital performance management	S10	S10	S10	S10		T21		T22, T46		T23		T9	
	Automated root cause analysis			S7,S8			T13		T14	T15	T16			
							IoT	Cloud computing	Big data analytics	Augmented reality	Autonomous machines	Cyber security/Blockchain	Simulation	Additive manufacturing

Fig. 1. DSC improvements framework

It is composed by three dimensions:

- The digital achievements (in orange) represent the opportunities and possible implementations of DSC in different areas of business management. They have been identified from different sources such as the McKinsey's Compass discussed above, but also from academic articles (in particular the ones used to build the framework) in which results, practices and improvements brought by the digitalization of the SC are described. The digital achievements are briefly described in Table 1.
- The SC processes (in green) refers to the SCOR model and allow to easily identify which aspects of the supply chain and companies' operations are directly affected by digital changes. In the SCOR model, six processes are described, while in the framework only five are considered. In fact, the process named Enable has not been reported, since, referring to the management of company rules, performance, data, resources, structures, contracts, network and risks, it is strictly connected to every other process. For this reason, it is possible to assume that all the digital achievements that affect the first five processes, also contribute to an improvement in the Enable dynamics.
- The enabling technologies (in blue) are the most relevant innovative technologies of Industry 4.0, as described by [23], which support the realization of the SC digital achievements.

Table 1. Digital achievements description

Cate- gory	Digital Achievements	Description
Strategy	Micro segmentation	It refers to the monitoring and the data collection related to demand, behaviors and relevant information through which it is possible to identify smaller segments of customers to whom offering products, services and promotions with high personalization.
	Proactive customer service	It allows anticipating problems encountered by the consumer, for example, by creating products that are able to record data and information about their operation or utilization and communicate them to the suppliers in advance.
Planning	Predictive analytics for scenario planning	It consists in exploiting the potential of a large quantity of data to be able to predict possible future scenarios and act accordingly to obtain the best possible economic return or to reduce any losses.
	Closed-loop planning	It allows the transformation of planning activities into a continuous and dynamic process.
Physical Flow	Automation of warehousing	Automation technologies can increase the speed of picking operations, optimize the space and the layout of the warehouse and reduce human error in inventory operations, transforming the warehouse from a cost center to a source of competitive advantage.
Order mgmt.	Digital payments and invoices	They allow companies to capitalize on aspects such as repayments and discounts due to upfront payments, adequately manage their supplier base and reduce invoice processing and payment costs.
	Fraud detection	It deals with the identification of possible frauds such as failure by suppliers to comply with contractual conditions, billing of non-delivered material or even corruption, thanks to the availability and correct analysis of a huge quantity of data.
	Online order monitoring	It allows companies to improve the service offered to customers who are able to monitor at any time different types of information constantly updated on their orders.
Collaboration	Product and design process optimization	It refers to the potential of new technologies in increasing the coordination and cooperation both internally with company functions such as marketing and production, and externally by involving suppliers in the product development cycle.
	End-to-end connectivity	It allows that different actors at different levels of the supply chain can obtain data and visibility in real-time, enhancing communication and coordination of activities and processes.
	Online transparency	It concerns the sharing of information with the partners in the SC, referring to Key Performance Indicators (e.g., service level) or real-time data (e.g., the position of a truck carrying a specific order).
Performance mgmt.	Digital performance management	It refers to the use of models that automatically and continuously process data and detect real-time performances to analyze and improve inefficiencies.
	Automated root cause analysis	It refers to the implementation of machine learning techniques to automatically identify problems, their causal dependencies and their root causes.

Each cell of the framework is based (and therefore justified) on an academic contribution or, rarely, on a web article, which explain the correlation between the three elements described above. The sources that have been used are marked in the cells with

an acronym (letters S for SCOR or T for technologies and a sequential number) and can be consulted at the link: https://drive.google.com/open?id=1h9ZHJ7pqzcCzn_cTxRMNiPIT52ohvZEJ .

Observing the framework, it is possible to notice that the proposed digital achievements affect mainly four out of the five SCOR processes. The process Return can be improved introducing only IoT technologies and data analytics to obtain data from the products' lifecycle, enabling improved customer assistance and planning activities.

Actually, it is quite evident that IoT and Big Data analytics, along with Autonomous machines, are the technologies more relevant to the realization of almost all the digital achievements. Also Simulation seems to support several digital achievements and can affect notably the companies' planning activities, potentially increasing in a significant way the performances of all the SC. Conversely, technologies such as Augmented Reality or Additive manufacturing seem to have less application in the DSC.

4 Conclusion

The paper presents a framework on the adoption of digital solutions for the optimization of SC processes, showing the advantages that they would entail and the business processes that would be involved and would benefit from it. Some limitations and further development of this research can be envisioned. First, the framework is conceived as a tool to be used in a following phase respect to a DRA of the SC. To this purpose, the digital achievements could be enriched and reorganized according to specific assessments, refining the framework also according to different perspectives (e.g., suppliers, customers). Future research will test the validity of the framework, evaluating how it could be applied jointly with a readiness assessment. In a second instance, the framework can be improved merging financial aspects of the technology implementations, evaluating technical feasibility along with returns on investments.

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