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Towards a novel framework of barriers and drivers for digital transformation in industrial supply chains

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Abstract—

Businesses across all sectors are facing the complexity of an increasingly digital economy. Digital transformation offers vast opportunities to businesses and entire supply chains. While many investments are targeted at the organization level, the supply chain perspective can lead to even greater impacts on business performance. However, as supply chains involve interconnections between multiple actors, comprehensive digitalization initiatives at this level are very complex. Several strategic factors affect decision-making around digital investments. For this reason, a framework that categorizes all these factors is needed in order to help managers build digitalization strategies for their supply chains.

In this paper, based on a review of existing literature, we give indications for a framework encompassing barriers to and drivers for digital transformation in the context of industrial supply chains. Our framework preliminarily allocates these factors by using two dimensions. The first one classifies them using several categories: financial, knowledge and skills, regulatory, technological, market, organizational, and cultural. The second dimension classifies determinants at the level on which actions can be made, i.e. market, supply chain, or organization. The framework can support organizations to exploit the opportunities provided by digitalization of supply chains and will help managers understand the complexity involved.

I. INTRODUCTION

Digital transformation offers tremendous opportunities to companies of all sectors and supply chains. Digital transformation is defined as “the use of new digital technologies (social media, mobile, analytics or embedded devices) to enable *major business improvements* (such as enhancing customer experience, streamlining operations or creating new business models)” [1].

As companies participate in extended supply chains, the model for creating business value has dramatically changed. In this context, operational efficiency and greater profitability are the result of improved visibility and greater collaboration between the actors of the supply chain. Moreover, authors acknowledge that competitiveness is nowadays being played more and more at a system level, rather than that of a single company [2]. Digitalization is a means to achieve greater levels of cooperation and the associated benefits [2]. Focusing on the supply chain perspective, Bowersox, Closs, & Drayer [2] claim that “true supply chain excellence will only come from making

a digital business transformation”. A transformation exploits all that technology has to offer, facilitates supply chain collaboration, and leads to new levels of operational excellence. More recently, Bughin, LaBerge, & Mellbye [3] have shown that the digitalization of supply chains can deeply boost revenues and EBIT growth. In their study, the authors claim that full digitalization of supply chains contributes to two-thirds of the total revenue growth and more than 75% to the annual EBIT [3]. However, so far only few supply chains have taken full advantage of the potential of digital technologies [4]. In fact, only 2% of companies report to focus their digital strategies on the whole supply chain [3]. The slow adoption of digitalization across supply chains possibly leads to two main conclusions: Firstly, there are some barriers preventing companies from implementing digitalization strategies throughout the whole supply chain. Secondly, some facilitating elements might help supply chains and companies in the future towards their digital transformation. Because of the low adoption of digital technologies in supply chains, it is essential for managers to be aware of barriers and facilitators of digitalization. The supply chain perspective includes the interaction of multiple actors which causes a high level of complexity. Thus, the present study aims at contributing to the academic discussion by taking first steps towards a novel framework describing a set of barriers and drivers of digital transformation for the context of supply chains. The framework aims to contribute by helping managers understand the level of complexity related to the implementation of digital transformation strategies throughout the supply chain. Indeed, the influenceability of the complexity that businesses face depends on where barriers and drivers are located. For example, if the lack of a suitable infrastructure is considered as a barrier, businesses may find hard to exercise any influence. Specifically, if the cause of complexity is not influenceable, employing strategies that handle the complexity could be the best response. On the other hand, businesses can apply strategies to reduce the complexity when it is influenceable in the short term, and strategies to avoid complexity in the future when it is influenceable in the long run [5].

The remainder of the paper is structured as follows: In the next section, we provide a description of the methodology that has been applied. Then, we offer a preliminary description of the resulting framework and present its categories. After that, we provide a validation of the framework by assessing it against related previous efforts in literature. Finally, we discuss the findings and close the paper by looking at potential activities that may follow this research.

II. METHODOLOGY

The goal of the research is to define a framework in which barriers and drivers of digital transformation in a supply chain context can be clustered. The main purpose of listing the factors preventing organizations to digitally transform is to understand whether companies can take any actions to lower barriers or exploit drivers. The framework we aim to produce is comprised of two dimensions (see Table I), one related to the level of origin where factors can reside, and the other related to the organizational category they can belong to. In order to define the first dimension (level of origin), we have used the model employed by Heilig, Lalla-Ruiz, & Voß [6], which is derived from Game Theory principles [7]). Since digitalization is an innovative and transformative process involving multiple strategies and players, it can be modelled by using the organizational level in which different interactions occur. These levels can be distinguished in intra-level, inter-level, and meta-level. Intra-level interactions occur within the frame of the organization. Inter-level interactions involve other organizations that can be either competitors or collaborators. For the study purpose, this level represents the supply chain dimension. Finally, meta-level interactions are high-level and they include policy-makers and governments [6].

		Level of origin		
		Intra-level	Inter-level	Meta-level
Organizational Categories	Category A			
	Category B			
	Category C			
	Category D			

TABLE I. FRAMEWORK TEMPLATE

The second dimension (organizational categories) has been defined through a methodology that consists of three steps (see Figure I). In Step 1, we perform a systematic literature review to identify the studies focusing on barriers and drivers in digital transformation and innovation contexts. We have encompassed in our research either studies categorizing the factors in a more (or less) structured framework, mentioned in a list, or even just described throughout the text. The results provided by the methodology have been filtered according to the research scope. Thus, only those related to digital transformation and applicable to the supply chain context have been considered as relevant (Step 2). By analyzing these studies, we extracted the categories in which the authors have framed barriers and drivers (Step 3).

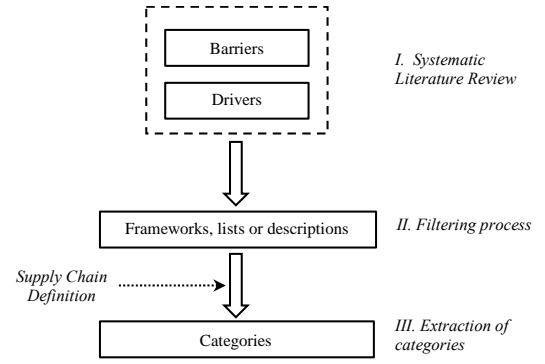


FIGURE I. THREE STEPS METHODOLOGY

STEP 1. Literature Review

In order to identify the factors that prevent or facilitate organizations and supply chains to digitally transform, a literature review has been applied following the methodology suggested by Levy & Ellis [8]. To query quality scholarly literature, the database employed is SCOPUS®. In the context of this study, *barrier* is defined as an *obstacle* preventing access and driver is defined as a *facilitator*, i.e. a factor that *enables* groups and organizations to work more effectively [10]. In general, the study investigates the *determinants* of digital transformation, defined as factors that decisively affect the nature or outcome of something. The keywords used have been derived from the definitions of barriers, drivers and determinants and they are displayed in Table II. The results have been filtered by source type – article or proceedings – and by subject area – computer science, business, and engineering.

Keywords			
Barriers	Barriers Digital Transformation	OR	Barriers Digital Transformation Supply Chain
	Barriers Digital Innovation		Barriers Digital Innovation Supply Chain
	Barriers ICT		Barriers ICT Supply Chain
	Obstacles Digital Transformation		Obstacles Digital Transformation Supply Chain
	Obstacles Digital Innovation		Obstacles Digital Innovation Supply Chain
	Obstacles ICT		Obstacles ICT Supply Chain
	Facilitator Digital Transformation		Facilitator Digital Transformation Supply Chain
Drivers	Facilitator Digital Innovation		Facilitator Digital Innovation Supply Chain
	Facilitator ICT		Facilitator ICT Supply Chain
	Enabling factors Digital Transformation		Enabling factors Digital Transformation Supply Chain
	Enabling factors Digital Innovation		Enabling factors Digital Innovation Supply Chain
	Enabling factors ICT		Enabling factors ICT Supply Chain
Determinants	Determinants Digital Transformation		Determinants Digital Transformation Supply Chain
	Determinants Digital Innovation		Determinants Digital Innovation Supply Chain
	Determinants ICT		Determinants ICT Supply Chain

TABLE II. KEYWORDS

STEP 2. Filtering process

In order to identify the set of relevant papers from the results provided by the literature, a filtering process has been applied. For each result we have analyzed title, abstract and body respectively to assess the relevancy. As a result, the set of results has been narrowed down to sources providing relevant information about *digital transformation in supply chain* contexts. Supply chain is defined as “a set of three or more companies directly linked by one or more of the upstream and downstream flows of products, services, finances, and information from a source to a customer” [9]. Because supply chains include different companies, the factors affecting the adoption of digital strategies within the company can also affect the adoption of these on a supply chain level. Many studies in the current literature have focused on barriers for the adoption of digital technologies in the company context. These studies have been considered as relevant to the research purposes, as the framework we aim to develop classifies determinants also by level of origin. This is included in the intra-level that refers to the organizational context. Finally, it is important to note that most of the results provided by the literature focus on specific industries or countries. However, the aim of the research is to provide a framework that is universally applicable. Therefore, it is necessary to define categories in which barriers and drivers in any supply chain context can be identified.

STEP 3. Extraction of categories

The literature review provides results displayed in different formats. Those can be either lists, tables or detailed descriptions. From these we extracted and derived recurrent categories in which barriers and drivers can be grouped. While the categories are quite general (e.g. organizational, cultural, technological), some subcategories are specific to the research scope pursued in the paper and they are not applicable to all contexts. As the research aims to be universally applicable, only categories that are universally applicable have been considered.

III. Results

The following section discusses the results by illustrating first aggregated outcomes generated by the application of the methodology, and then describing the categories that have been identified.

METHODOLOGY OUTCOMES

The methodology provided 2061 results. After the filtering process outlines in STEP 2 above, 59 have been considered as relevant for the study purpose (17 conference papers and 42 journal articles). The keywords that provided the largest number of results are ‘barrier’ (27 results) and ‘determinants’ (15 results).

CATEGORIES

As mentioned earlier, barriers and drivers can be clustered by category and level of origin. While the different levels have been defined already (intra-level, inter-level and meta-level), the categories have been identified through the application of the methodology described above. Together, these two dimensions allow clustering barriers and drivers of digital transformation in

supply chain contexts. The categories are illustrated in Table III and presented below.

		Level of origin		
		Intra-level	Inter-level	Meta-level
Categories	Financial			
	Knowledge & skills			
	Regulatory			
	Technological			
	Environmental			
	Organizational			
	Cultural			

TABLE III. PRELIMINARY FRAMEWORK

a. Financial

Some of the most recurrent barriers and drivers throughout the literature are represented by financial factors. In this category, the most cited barrier at the intra-level is the high cost of system improvements. This generally refers to the high costs of innovation [10] and investment costs [11] [12], but it also includes high costs of digital tools, of setting up equipment [13] and implementation [14]. All these factors refer to the costs associated with the implementation of digital technologies being deemed by companies as too high.

Another common issue companies face is the lack of funding, either internal (intra-level) or external (meta-level). The lack of internal funding refers to the insufficient budget for digital innovation [14] [13], that also includes team training and R&D [13]. On the other hand, the lack of external funding includes both lack of public funds and assistance, and lack of venture capital [10]. Accordingly, the availability of external funding, including government support, has been mentioned as a facilitator. A supportive national environment for the diffusion of new technologies has a positive effect on companies [15]. Finally, another financial category relates to the return on investment. In some cases, cost-benefits analyses are difficult to formulate [12] and these uncertainties are due to the lack of demonstrated business cases justifying the investment [16]. In some other cases, the problem is not related to the uncertainty of the return on investment. However, the short-term economic and financial policies [10] or the need for immediate return [14] represent an obstacle.

b. Knowledge and skills

Another recurrent barrier throughout the literature is represented by the lack of skills and knowledge. Companies are not able to find personnel with the right skills either within the company (intra-level) or on the market (meta-level). The personnel are inadequate to implement digital innovation [14], as roles such as data scientist and other IT figures are often not available in the company [12].

On the other hand, sometimes talents and capabilities are missing from the market [16] or the complexity brought by new technologies requires new skills [14]. The competition for IT talents is very high and recruiting qualified staff is difficult [12].

Similarly, a recurrent facilitator is represented by skills and previous knowledge within the organization (intra-level). Human resources are one of the assets that influence the effectiveness of ICT the most [17]. This both refers to managerial knowledge and mindset [18] [19] [20] and workers' skills and educational background [21]. As a result, computer skills, commitment to ICT and enjoyment of learning positively influence the adoption of new technologies [11], while previous knowledge can generate know-how that facilitates to overcome the barriers that companies face [17].

In general, technology competence, comprising the organization's internal technology resources as well as technology infrastructure and IT skills [15], is considered an important driver of digital transformation. In fact, IT infrastructure and IT skills are complementary dimensions leading to greater effectiveness in value-chain activities. The infrastructure provides the base on which digital technologies can be implemented through the necessary skills [22].

c. Regulatory

The regulatory environment can represent an important external obstacle at meta-level in some cases. The lack of standards and frameworks [23] [24] as well as regulatory limitations due to hindering policies and regulations [10] [25] can be a consistent external barrier.

On the other hand, governments' actions can also be a driver for digital transformation in the form of support to the deployment of innovation through incentives that facilitate the adoption of digital technologies [26] for different purposes.

d. Technological

One of the most common technological barriers at meta-level is represented by privacy and security concerns around digital technologies and lack of infrastructure. Security issues include concerns on confidentiality [13], fear of fraud [14], security and privacy [23] [16]. Similarly, the lack of IT infrastructure [11] or the lack of the technology needed [10] [13] have been found to be very common throughout the studies. In other cases, the issue is not represented by the lack of the technology, rather by its maturity level and limitations [13] [12] [24].

e. Environmental

From the businesses' external environment, the most important barrier for the supply chain perspective (intra-level) is the lack of collaboration and cooperation between actors. Digital technologies allow supply chains to achieve higher levels of collaboration with the associated benefits [2]. However, studies have mentioned the lack of collaboration and cooperation between the supply chain actors as a barrier to the implementation of digital transformation [25] [10] [13].

Integrating with vendors' and suppliers' systems throughout the supply chain is essential to unlock the full potential provided by the digitalization of the whole supply chain.

Another common factor arising from the meta-level that pushes organizations to adopt new technologies is competitive pressure. This refers to the pressure from the market on using new technologies, and can be represented by competitors that have already adopted digital technologies [15].

A supply chain context (inter-level) involves interconnected relations of multiple actors that introduce specific facilitating factors. Specifically, organizations may be pushed by other actors in the supply chain to adopt technologies, or may be the first adopters. The first case is the result of external pressures, which are similar to competitive pressures, but quite specific to the supply chain context: this includes pressures from the buyer or the supplier, or trading partners [27]. The second case occurs when a company wants to adopt a new IT system and has to face the issues arising by the inter-relations of the supply chain. In this case, two possible situations can facilitate the uptake of new technologies: the first one is the partner readiness, i.e. the degree to which system used by trading partners, up and down the value chain, can integrate with the company's one [15]. In this sense, cooperation and collaboration between partners is an essential component for the innovation uptake [25]. The second one is to overcome the issues derived by the interconnections with multiple actors by employing a system that is discrete and does not require any integration [26]: this can be possible by using systems that support an information exchange standard facilitating the communication between multiple ICT systems while providing independence to each of them [11].

f. Organizational

In order to make decisions that involve the transformation of business process within the organization, the perception of relative advantage is fundamental. This is defined by Zhu, Dong, Xu, & Kraemer [15] as 'the degree to which an innovation can bring benefits to an organisation' by reducing costs and increasing sales.

Strategic factors have been considered among organizational aspects, as the strategy is strictly related to the organizational structure and processes. Weak innovation strategies are often considered a barrier to the efficient development of digital transformation processes [16] [10] [13]. On the other hand, as organizations are characterized by specific processes, practices and value systems, the degree to which new technologies are compatible with them play a significant role in the uptake of new technologies [15] [27].

Finally, another recurrent organizational aspect emerging from the literature is the lack of time within the organization (intra-level). This could be either the lack of time spent on specific activities such as planning [14], or general time constraints to innovation initiatives [10].

g. Cultural

In order to address the changes needed to implement digital transformation, innovation culture [12] and an environment

allowing for open discussion [11] within the companies (intra-level) play a significant role. An unsupportive organizational culture can represent an obstacle when introducing innovation [10]. This can be further divided into specific cultural aspects such as poor organizational attitude towards innovation, insufficient team commitment and adversarial relationship among the staff [13]. Another important factor contributing to unsupportive organizational culture originates from the managerial staff and the lack of leadership in driving digital transformation. This can be due either to the lack of support of managerial staff, or the lack of managers to supervise digital innovation [13]. In both cases, the result is a lack of or insufficient time spent on planning and coordination [24] [14] creating an obstacle to digital innovation.

Two other recurrent components mentioned as cultural barriers at intra-level are organizational inertia and lack of interest. These can be seen also as psychological barriers characterizing the culture of an organization. Organizational inertia – defined as fear of or resistance to change – can create a significant obstacle to digital transformation, that by definition involves changes within the organization processes [1]. Fear of change can also involve many aspects including fear of work, product, process or marketing changes [13]. On the other hand, lack of interest in innovation [11] and in the knowledge of digital technology represents a different issue, as it arises from the individual value orientation, that can also develop in a persistent and negative attitude toward innovation [14].

IV. DISCUSSION AND OUTLOOK

The need for a framework that classifies barriers and drivers arises from the fact that the available studies in the current literature mainly focus on the organizational context. However, as businesses are part of extended supply chains, the way they create value has changed. Visibility, integration and collaboration between partners allow obtaining real operational efficiency and financial improvements. Digital transformation is the means to achieve true supply chain excellence [2].

Despite the big potential of supply chain digitalization, very few companies (only 2%) report to adopt this perspective [3]. Since a comprehensive framework classifying barriers and drivers for digital transformation does not yet exist, this study aims at helping managers develop more effective strategies addressing the complexity arising from supply chains. It offers a contribution in more clearly understanding both barriers and drivers and in indicating these factors are located. As a result, strategies can indeed be formulated more precisely and managers may know whether to handle, reduce or avoid the complexity generated by the interaction of barriers and drivers [5].

The framework provided by this study has been defined using theoretical bases. Future research can aim to verify the results by conducting an empirical study that address the factors preventing or facilitating businesses to focus their digital strategies on supply chains.

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