

Levers and barriers to implementation of digital technologies in Supply Chains: A Survey of the Literature, EL GADROURI, R.¹

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Abstract:

Digital technologies, a concept whose appearance is not new. The reasons for this arrival are collective thanks to the application and acceleration of Industry 4.0, the expansion of high-tech tools and, in addition, the current characteristics of the competitive atmosphere, mainly in terms of improbability, difficulty and enduring changeable aspects.

The acceptance of digital technologies in supply chains, referred to by the authors as "Supply Chain Digital", is becoming a necessity for companies to secure their position in this situation, as it improves competitiveness, which translates into availability of goods, reduced expenses and improved field positions.

With this in mind, a number of important questions need to be asked: what are the definitions and evolution of the phenomenon, what are its characteristics and related technologies, and what are the levers and barriers to its adoption? In order to provide some answers to these questions, we have conducted a literature review of scientific works that have analyzed the adoption of supply chain technologies. In this respect, we have tried firstly to build up a corpus of developments in the phenomenon of supply chain digitization, and secondly to list the challenges and difficulties of implementing digital technologies in the supply chain.

The results show, via an analysis of the scientific literature, that the adoption of supply chain digitization is a phenomenon under investigation, which few studies have been able to address from the conceptualization of the digital supply chain, even if the latter also proposes a series of measures to promote the dissemination of information, stimulate responsiveness and collaboration, and even agility. On the other hand, this phenomenon also reveals major levers and obstacles that make the adoption of digital technologies in the Supply Chain more delicate.

Keywords: Supply Chain, Levers, Barriers, Digital technologies, Technology adoption.

Les Leviers et les obstacles de la mise en œuvre des technologies numériques dans les chaînes logistiques : Une revue de littérature

Résumé:

Les technologies numériques, un concept dont l'apparition ne date pas d'hier. Les raisons de cette arrivée sont collectives grâce à l'application et à l'accélération de l'industrie 4.0, à l'expansion des outils de haute technologie et, en outre, aux caractéristiques actuelles de l'atmosphère concurrentielle, principalement en termes d'improbabilité, de difficulté et d'aspects changeants durables.

L'acceptation des technologies numériques dans les chaînes d'approvisionnement, appelé par les auteurs « Supply Chain Digital » devient une nécessité pour les entreprises afin d'assurer leur position dans cette situation, car elle améliore la compétitivité, ce qui se traduit par la disponibilité des biens, la réduction des dépenses et l'amélioration des positions sur le terrain.

Dans cette vision, des questions importantes pourront être posé : qu'en est-il des définitions et l'évolution du phénomène, quels sont ses caractéristiques et les technologies y affèrent, ainsi les leviers et barrières de son adoption ? Afin d'apporter des éléments de réponse à ces questions, nous avons mené une revue de littérature des travaux scientifiques qui ont analysé l'adoption des technologies de la Supply Chain. À cet égard, nous avons essayé en premier lieu, d'élaborer un corpus d'évolution du phénomène de la digitalisation de la Supply Chain, et dans un deuxième lieu d'énumérer les challenges et les difficultés de la mise en application des technologies numériques dans la Supply Chain.

Les aboutissements exposent via l'analyse de la littérature scientifique, que l'adoption de la digitalisation de la Supply Chain est un phénomène enquête, que peu d'études ont pu adresser de la conceptualisation de la Supply Chain digital, même si ce dernier propose également une série de mesures pour favoriser la diffusion de l'information, stimuler la capacité de réaction et de collaboration, voire l'agilité. En contrepartie, ce phénomène révèle aussi à des leviers importants mais aussi à des obstacles majeurs qui rendent l'adoption des technologies numériques en Supply Chain plus délicate.

Mots-clés : Supply Chain, leviers, obstacles, technologies numériques, adoption des technologies.

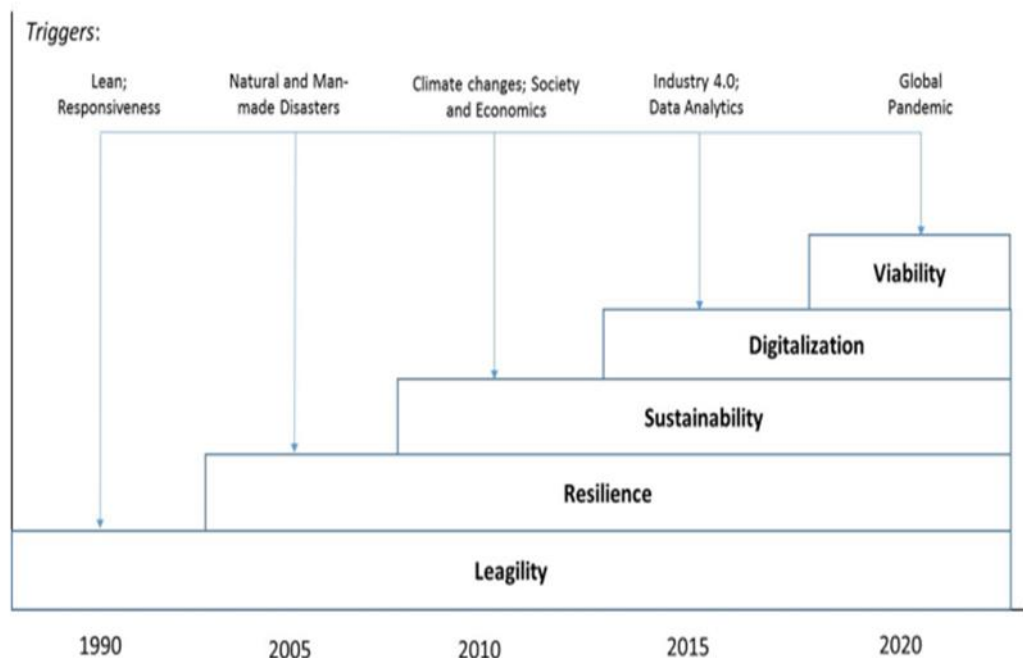
Introduction:

The recent technological progress illustrated by the emergence of a range of digital technological tools has fascinated the consideration of firms and scientific academics, because the use of these emerging technologies can present significant opportunities for the supply chain, particularly in improving the connection between information flows, goods flows, financial flows and also the flow of people (Ibarra et al., 2018), while creating a new mode of supply chain management. This phenomenon is called the Digital Supply Chain, also known as Supply Chain 4.0, which is unveiled as the use of digital technologies to the Internet of Things, advanced robotics, Big Data analysis in supply chain management while creating automated networks to significantly improve performance and customer satisfaction (Alicke et al., 2016). Otherwise, these technologies have the ability to reform supply chains into more agile and resilient networks because they improve performance in key supply chain qualities such as collaboration, transparency, flexibility, responsiveness and efficiency.

The Digital Supply Chain is an emerging concept resulting from a transformational methodology to supply chain management that uses disruptive Industry 4.0 technologies to restructure supply chain procedures, actions, and relationships to create major planned profits for all supply chain participants (Frederico et al., 2019a). Some see it as an ecosystem of mass and customized (digital and physical) products and services, through data mining and data trends, even predicting customer need lifecycles, adjusting their processes for quick and optimal responses (Garay-Rondero et al., 2019). However, other researchers argue that there are two aspects to this concept: the first relates to the implementation of innovative numerical technologies in supply chain processes that enable the creation of business relationships with suppliers and customers, while the second relates to the roles of these tools in changing supply chain abilities and operational performance (Ehie and Ferreira, 2019). Similarly, (Ernst and Young, 2016) have defined DSC as the advance of data structures and the implementation of new technologies that improve supply chain incorporation and agility, thereby improving customer service and sustainable organizational performance.

However, before this phenomenon quickly and widely aroused interest in theoretical and empirical research, it was the result of remarkable historical transformations (see Figure 1), depending on different global circumstances: historical, human, natural and societal (Ivanov, 2020a). This author has made clear, in this sense that the advent of digital technologies or the era of digitalization is even outdated, after this post-pandemic period that has been a real test for: sustainability, resilience, agility and integration of supply chains. He argues for a new reflection of a model called Viable supply chain.

Fig.1 Historical transformation of the main angles research on the supply chain adapted from (Ivanov, 2020a)



Source: (Ivanov, 2020a)

Moreover, the scientific literature on this subject is not limited to the conceptualization of the notion itself, but the theoretical and empirical research conducted has tried to demonstrate the relationships and intersections between digital technologies and supply chain management. Notably, (Queiroz and Telles, 2018) and (Queiroz et al., 2020) have respectively conducted empirical studies on the adoption of Big Data Analytics (BDA) in the supply chain and also on the relationship between the factors of Blockchain (BC) acceptance and supply chain performance; (Ghadge et al., 2020) studied the employment of Industry 4.0 technologies in the supply chain; (Kouhizadeh et al., 2021) theoretically explored the obstacles to approval of blockchain (BC) tools on sustainable supply chain; (Koh et al., 2019) clarified the disruptions of Industry 4.0 technologies on supply chain operations and management; (Ehie and Ferreira, 2019) developed a conceptual framework of the Digital Supply Chain; (Wang et al., 2020) established a conception of the supply chain activated by Blockchain (BC) technology.

Very recently the covid-19 pandemic has expanded the field of scientific research into other aspects of the supply chain, particularly resilience, sustainability, and agility (Ivanov, 2020b) while taking advantage of the circumstances of this ever-evolving sphere of digitalization; (Koh et al., 2019) disrupt the management of all phases of the supply chains (Korpela et al., 2017), for example the development of transactions and the conquest of new partners in the relationship: Buyers - Suppliers, while using digital technologies.

At the same time, the adoption of digital technologies will certainly face obstacles impacting the application of supply chain technologies due to various organizational, operational and financial

constraints. In view of the foregoing, our research problem is as follows: What is the state of development of scientific research into the phenomenon of implementing digital technologies in the supply chain?

In order to answer this question and gain a better understanding of the causes of the birth of this phenomenon, we have used a reference based on a thorough examination of the literature review to identify how authors have approached the birth of this phenomenon in all its aspects.

To prepare this work, we have attempted to set it out in three sections: firstly, we have given a theoretical and conceptual overview of the key concepts of our research; secondly, we have presented the levers for adopting digital technologies in the supply chain, as well as these barriers; and finally, we have analyzed and discussed the results obtained, and presented some avenues for future research.

1. Methodological approach and analysis model

The formulation of a literature review paper remains an important contribution for a researcher. The main aim of a literature review article is to develop a theory, offer a new conceptual framework or validate an existing theory. A literature review is considered to be the most classic form of review, including all relevant literature on a subject, but it does not necessarily require a systematic methodology or qualitative analysis of the articles selected for the review.

We used the Google Scholar search engine and the "Scopus" database to identify the relationship between the supply chain and digital technologies. The terms "Supply Chain", "Levers", "Barriers", "Digital technologies", "Technology adoption" were used as the main keywords. The search was extended to studies of a global context for a more comprehensive account. At the end of our literature review, we identified over 222 scientific articles for the period from 2000 to 2021. After an examination of the abstracts and full text of the documents based on our search criteria, we finally retained 96 scientific articles to conduct our literature review.

2. Literature review and background

2.1. Digital technologies of the supply chains

The proliferation of numerical technologies and their use will allow companies to create savings in production process costs, as well as create new types of jobs (Manyika et al., 2017). The era of digitalization has enabled the implementation of a range of digital technologies, which have impacted supply chain management, which has also led to the development of novel features of the supply chain.

The scientific literature on the subject (Büyüközkan feyzioğlu and Gocer, 2018); (Chick and Handfield, 2014); (Demetriou, 2011); (Dubey et al., 2020);(Frederico *et al.*, 2019);(Ivanov et al., 2019);(Koh et al., 2019);(Lohmer et al., 2020);(Queiroz et al., 2019);(Queiroz and Telles, 2018);(Wu et al., 2013) specifically cited technological tools that have the role of implementing a Digital Supply Chain (DSC) with respect to: Artificial Intelligence (AI), Cloud Computing (CC), Cyber

Security Systems (CPS), Big Data analytics (BDA), Blockchain (BC), Internet of Things (IoT), and Robotization (R). We have illustrated through (see Table 1.) some definitions from the literature on digital technologies in supply chain.

Table 1: Digital Technologies in supply chain

Tools	Sources	Description
Cyber Systems Security (CSS)	(Wang et al., 2016)	System structure by surrounded maneuvers (sensors) allowing self-management of physical processes and their feedback.
	(Hofmann and Rüscher, 2017)	Digital systems that control physical processes not only in one direction, but also linked to feedback loops with the system, while allowing real-time harmonization of information and physical flows.
Big Data Analytics (BDA)	(Wamba et al., 2015)	A global approach to procurement actionable information to generate a competitive advantage that differs from the business analysis approach in terms of 5V: volume, variety, speed, truthfulness and value.
	(Bahrin et al., 2016)	allows data to be collected from a variety of sources and fully analyzed, allowing real-time decision making based on the results of the data analysis.
	(Hu et al., 2014)	The process of using analysis algorithms to uncover potentials concealed in big data, such as hidden patterns or unknown correlations.
Artificial Intelligence (IA)	(Haenlein and Kaplan, 2019)	A set of theories and techniques used to create machines capable of simulating intelligence
	(Chung, 2018; Pei et al., 2019)	Artificial intelligence is the process of manufacturing enabled by machines which can imitate human activities as original.
	(Mishra et al., 2018, 2019)	Artificial intelligence includes every machine or equipment that uses computational abilities to work and perform like humans or replaces humans.
Internet of things (IoT)	(Okano, 2017)	An Internet-based technical infrastructure that enables the exchange of goods and services throughout the global supply chain network.
	(Majeed and Rupasinghe, 2017)	The Internet of Things provides solutions based on the integration of various information technologies, which includes hardware and software used to store, retrieve, and process information and communications technology which includes electronic systems used for communication between individuals or groups of devices.
	(Queiroz et al., 2019)	A set of objects to communicate with each other, without the need for human means.

Tools	Sources	Description
Blockchain (BC)	(Swan, 2015)	A ledger of transaction data recorded in a network of several members. Its transaction data is stored in blocks that are chronologically chained together.
	(Al-Saqaf and Seidler, 2017)	A distributed digital ledger in which all transactions are shared within a network whose transactions cannot be modified.
	(Wang, 2019)	Blockchain is an encoded digital ledger that is stored on multiple computers of a public or private network. It comprises data records, or 'blocks'. Once these blocks are combined in a 'chain', they cannot be changed or deleted by a single actor, and instead, are verified and managed using automation and shared governance protocols.
Robotisation (R)	(Ivančić et al., 2019)	A new technology that focuses on the automation of repetitive, routine, rule-based human tasks to bring benefits to organizations that decide to implement such a software solution.
	(Huang and Vasarhelyi, 2019)	Robotic Process Automation (RPA) is defined as "a preconfigured software instance that uses business rules and predefined activity choreography to complete the autonomous execution of a combination of processes, activities, transactions, and tasks in one or more unrelated software systems to deliver a result or service with human exception management".
	(Lacity et al., 2017)	RPA concerns tools "designed to be used by subject matter experts to automate tasks that use rules to process structured data, resulting in a single correct answer and deterministic outcome".
Cloud computing (CC)	(Badger et al., 2012; Mell and Grance, 2011)	Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.
	(Mitra et al., 2017)	Cloud computing is a computing technology. Cloud computing centers can store and compute a huge amount of data, therefore promoting the manufacturing and production and further bringing organizations higher performance and lower cost.
	(Aviles, 2015)	Cloud computing is turning Information's Technologies into utility computing accessible to all organizations for managing and delivering services over the internet.

Source: Author's elaboration

However, all its digital technologies play important roles in supply chain management, as an example, researchers (Gunasekaran et al., 2017) have analyzed the impact of the use of BDA in improving supply chain performance under different facets: visibility, robustness, resilience. (CC) also plays a role in developing the responsiveness and efficiency of supply chain processes (Jede and Teuteberg, 2015), while (IoT) facilitates supply chain coordination, planning, and control processes (Ben-Daya et al., 2019).

2.2. Characteristics of the digital technologies

In addition to the variety of digital tools used in supply chain management, this wave of digitalization also results in supply chains acquiring new properties and characteristics (Bechtold et al., 2014; Hanifan et al., 2014); (Schrauf and Berttram, 2016); (Schrauf and Berttram, 2016). Table 2. shows the main appearances of the digital technologies in supply chain from the scientific literature.

Table 2: The Features of the digital technologies in supply chain

Characteristics	Sources	Description
Intelligence	(Bechtold et al., 2014; Hanifan et al., 2014)	The DSC is characterized by intelligence that enables better autonomous decision making, automated execution, self-learning, and promotes innovation in supply chain operations due to the options offered by the adoption of digital technologies.
Scalability	(Bechtold et al., 2014; Hanifan et al., 2014)	The DSC goes beyond the problem of responding to changes in the size of supply chains, while making it possible to optimize processes and identify anomalies and errors.
Speed	(Hanifan et al., 2014; Raj and Sharma, 2014)	The SDC makes it possible to achieve the speed desired by organizations that are always looking for ways to achieve rapid delivery.
Transparency	(Schrauf and Berttram, 2016)	The DSC enables the scheduling of flows within the supply chain. It is, among other things, the modeling of the supply chain networks by the fact of mobilizing in real time to the changes.
Flexibility	(Hanifan et al., 2014; Schrauf and Berttram, 2016)	The SDC has the ability to ensure operational agility in the face of market volatility and changing circumstances. Otherwise, this digitalization allows supply chains to respond effectively and efficiently to its circumstances through the active use of collected and specified data.
Connectivity global	(Hanifan et al., 2014; Schrauf and Berttram, 2016)	The DSC is establishing a way, via digital technologies, to build efficient global centers to provide goods and services locally, rather than transporting them to around the world.
Innovation	(CUKIER and MAYER-SCHONBERGER, 2014)	Quality in DSC is a main characteristic to ensure that DSC are continually open to modification. The ecosphere is flooded with new technologies at a seemingly faster pace than ever before. DSC should always look for new ways to integrate these innovations into processes to remain competitive and ensure supply chain excellence.

Source: Author's elaboration

3. The levers of digital technologies Adoption in Supply Chain

While the emergence of digital technologies will offer strong advantages for supply chain management, at the same time their implementation also faces obstacles. We try to illustrate through the scientific literature on the subject the levers (table 3.) of the success of SCM as well as its barriers (table 4.) in the following paragraph.

Table 3: The levers of digital technologies Adoption in Supply Chain

Sources	Levers/ Description
(Oswald and Kleinemeier, 2017)	The rapid progress of digital technological tools.
	Change in the behavior, expectations and attitudes of individuals via easy access to the Internet.
	Low barriers to entry: the abundance of the Internet has enabled the development of investment in innovation.
	The emergence of the high risk capital factor: companies that are currently innovative, take significant risks in the search for new opportunities, especially in the digital economy developed by technological progress.
(Iddris, 2018)	Technologies: they offer advantages to logistics processes such as collaboration, visibility, availability, improvement of storage capacities.
	Integration: Integration enables organizations to share information in real time seamlessly, improve productivity, increase efficiency, and improve supply chain capacity to deliver goods and services quickly.
	Digitization: is the transformation of sociotechnical structures that were previously mediated by non-digital artifacts. This digitization puts an end to traditional supply chain management practices.
	Collaboration: the development of digital platforms calls for a need for inter- and intra-company collaboration.
	Coordination: it refers to the dissimilarity of activities related to the supply chain, which immediately implies coordination, especially with the integration of online activities as well as the sharing of data via computerized systems.
(Ghadge et al., 2020)	Technological: Transparency.
	Ethics/legal: Reduction of both monotony of work and environmental impact.
	Strategic: new business models; new value offers in the face of increased competitiveness.
	Organizational: improving efficiency, reducing costs, improving quality and agility.
(Mensah et al., 2015)	Supply chain strategy.
(Kassem et al., 2019)	Organizational flexibility.
(Gunasekaran et al., 2017; Kolding, 2018; Wamba et al., 2015)	Technology transfer.
	Skilled worker.

Source: Author's elaboration

As a complement, other authors have added other levers for the digitalization of supply chains including: supply chain strategy (Mensah et al., 2015), flexibility of organizations (Kassem et al., 2019; Makris et al., 2011) technology transfer and skilled worker (Gunasekaran et al., 2017; Kolding, 2018; Wamba et al., 2015). These levers can be used as a general guide for digital supply chain implementation.

4. The barriers of digital technologies Adoption in Supply Chain

The scope of implementation the digital technologies will allow for a complete change in supply chain management, while at the same time generating a scope and complexity of transformation of supply chain mechanisms, Table 4. provides an overview of the obstacles surrounding of digital technologies adoption in Supply Chain.

Table 4: The barriers of digital technologies Adoption in Supply Chain

Sources	Barriers / Description
(BÜYÜKÖZKAN FEYZİOĞLU and Gocer, 2018)	Lack of human resources awareness of digital media.
	Lack of competence among employees in the use of digital tools.
	Lack of agility and adequate flexibility for the adoption of digitalization.
	Lack of inter and intra company collaboration and planning for successful digitalization.
(Xu, 2014)	Difficulty in collecting all data from abundant sources.
	The challenge of accuracy of used data in the digitalization process.
	The challenge of the length of the supply chain involving internal and external members.
(Luthra and Mangla, 2018; Wang et al., 2016)	Insufficient research and development programs.
	Lack of infrastructure necessary for the digitalization of the supply chain.
	Lack of digital literacy and lack of trust from partners.
(Ghadge et al., 2020)	Organizational: financial constraints, resistance to change, lack of digital vision and strategy, lack of expertise and complex network systems.
	Strategic: the lack of policies and support from managers, the lack of research and development programs, the ambiguity of the economic benefits of digitalization and also the lack of digital literacy.
	Ethics/legal: legal constraints and also issues related to data security and confidentiality.
	Technological: the absence of digital infrastructures and also the poor management of data.

Source: Author's elaboration

As a result, further research is essential to overcome these barriers in order to meet the exact needs of customers, which is the ultimate goal of digital technologies adoption in Supply Chain (Büyüközkan feyzioglu and Gocer, 2018).

5. Results and discussion

After presenting existing research that addresses the adoption of digital technologies in the supply chain, including the emergence and evolution of this phenomenon, related technologies, characteristics, as well as levers and barriers to such adoption of digital technologies in the supply chain. We do not claim that similar frameworks have been worked on and treated rarely in the literature, but we argue that our study shows an integrated and holistic framework that provides a useful contribution to improve the understanding of the adoption of digital technologies in supply chain and to pave the way for the development of a roadmap to move from a classical to a digital supply chain. In addition, this study helps managers to broaden their perception of digital supply chain transformation beyond a technology implementation project.

This helps them to adopt a realistic approach to the possibility of reshaping it. This can be important because, in some cases, it is assumed that the introduction of several digital technologies into the supply chain would guarantee the exploitation of all the corresponding benefits and advantages.

But on the other hand, this could be a costly risk leading to wasted resources and inefficiency in these projects due to a lack of awareness of issues such as change management, trust management and partnership (Büyükoğlan feyzioglu and Gocer, 2018).

Moreover, what also explains why this field is in its infancy is the nature of the research, which remains limited to conceptual analyses. This may also require researchers to conduct empirical validation and confirmation studies.

By way of conclusion, the supply chain has recently entered a new phase of digitization, which differs from previous phases in terms of scope, responsiveness, transformative capability and complexity. The articles examined the peculiarities (Bechtold et al., 2014; Hanifan et al., 2014); (Schrauf and Bertram, 2016); (Schrauf and Bertram, 2016) that are likely to occur in any implementation of supply chain technologies, bearing in mind without any uncertainty that the ability to use its digital technologies has the power to pursue and better refine the criteria of supply chain management. On the other hand, the adoption of digital technologies in supply chains can certainly encounter obstacles (Ghadge et al., 2020) to overcome and conquer, thanks to the accurate capture of new technologies and their disruptions.

Conclusion and prospects:

Although this article presents relevant ideas, further research is needed to overcome the limitations associated with validating the proposed concepts. As the literature is still scarce and nascent, other concepts may be added in the future as understanding of the adoption of digital technologies in the supply chain evolves. In this sense, we can see that scientific research analyzing the levers and obstacles facing the adoption of digital technologies in the supply chain is still scarce, both theoretically and empirically. It is for this reason that we feel it is compelling to carry out in-depth work in this area, in order to ensure the success of this digitization, as well as to bring the benefits offered by these technologies to the supply chain.

Consequently, some of the research questions listed below may also encourage the development of new research programs linked to the adoption of digital technologies in the supply chain. These new research développements are essential for a deeper understanding of this phenomenon:

- What capabilities need to be developed prior to implementing adoption programs?
- What are the triggers for implementing an adoption strategy?
- How can supply chain members be aligned to develop an adoption programs?
- How can supply chain players gain competitive advantages by implementing joint adoption initiatives?
- What are the most useful technologies for making an impact on the supply chain?

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