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**Challenges for a Digital Sustainable Supply Chain
in a Circular Economy Context**

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Abstract

The aim of this paper is to distinguish the main challenges Romanian companies face in implementing a sustainable digital supply chain. This issue is seen through the lens of the need to address the principles of the circular economy. In this regard, the paper also examines the extent to which managers are aware of the principles of the circular economy and the extent to which the organization aims to identify ways to make the transition from the linear economy to the circular economy. We start from the premise that today the implementation of a sustainable digital supply chain requires the ability to access, analyze, and manage large volumes of data with the support of a robust information architecture. We expect the results to prove that although the managers of the Romanian companies included in our study show a fairly high level of knowledge of the principles of the circular economy and want to address concrete steps in this direction, the implementation of a digital sustainable supply chain, necessary for this transition, brings economic, technical, and IT security challenges.

Keywords: digital supply chain, circular economy, sustainability, digitization.

JEL Classification: Q56, M11.

1. Introduction

The growing population of the planet, the booming global economies, and the visibly improved lifestyle of people have caused a dramatic increase in the volume of natural resources exploited. Studies have shown that the demand for most natural resources has grown steadily (Preston and Herron, 2016; Popescu et al., 2017). For these reasons, global organizations feel the pressure of serious operational challenges, especially at the strategic level. Obviously, this constant and growing

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demand for natural resources has led to shortages of certain material resources, which translates into higher costs for organizations to provide material resources, which further converge towards the realization of less sustainable products / services.

For the most part, we find organizations that rely solely on the traditional model of the linear economy, while the conventional approach to the reuse and recycling of used materials is neither cost-effective nor reduced in terms of reducing material resources (Kumar et al., 2021). Fang and Zhang (2018) pointed out that global supply chains, in particular, feel the pressure of regulatory institutions to increase the level of sustainability, especially on the operational side of the supply chain. At the same time, technology has become one of the most important drivers of a sustainable operational organization (Wamba, Queiroz, 2020). Therefore, organizations should closely monitor these technological developments in order to carry out their operational activities in accordance with environmental requirements, but also at a reasonable cost level.

Several previous studies have indicated that there are a number of links between technology and sustainable operational activities (Jabbour et al., 2020; Bag et al., 2020). However, we note that the level of analysis of barriers and challenges for sustainable operations in the context of the circular economy and the digitization of sustainable supply chains has not been pursued. Kumar et al. (2021) argues that most studies to date have examined separately the challenges of adopting the principles of the circular economy and the use of Industry 4.0 specific technologies, which we believe have the ability to form the basis for enabling digital sustainable supply chains. Today, the digitization of supply chains is a major strategic topic of interest for both the academic community and practitioners (Ageron et al., 2020), while certain organizational, technological, and strategic barriers stand in the way of this digitization. Therefore, our study aims to distinguish the main challenges Romanian companies face in implementing a sustainable digital supply chain in the era of circular economy, especially in the context in which a sustainable supply chain not only has the potential to contribute to the well-being of the population, but also manages to reduce costs, increase market performance both downstream and upstream, increase sales and profit margins of organizations, as some studies show (Younis et al., 2016; Cankaya, Sezen, 2018).

2. Setting the Context Based on the Literature Review

The age of Industry 4.0 and the circular economy pose a number of challenges for organizations in terms of their ability to take advantage of the opportunities that lie ahead to achieve, maintain, and develop a certain level of sustainability. Lack of skilled labour, inefficient regulations and legislation, and long-term investment objectives are just some of the challenges in implementing Industry 4.0, following the principles of the circular economy in terms of sustainability (Kumar et al., 2021). The problems that arise are both strategic and economically when it comes to the financing capacity of such initiatives.

2.1 Industry 4.0 and the Circular Economy

Both Industry 4.0 and the circular economy are two main topics of discussion when it comes to industrial research. On the one hand, Industry 4.0 involves a series of technologies that ultimately lead to success in digitizing the operational activities of organizations (Ghobakhloo, 2020). The Internet of Things (IoT) has made it easier for companies to collect and manage big data. However, there are a number of difficulties in maintaining a high level of operational sustainability due to a lack of an integrated approach to Industry 4.0 specific technologies and circular economy principles (Ozkan-Ozen et al., 2020). Implementing these technologies requires a skilled workforce with expertise (Vrchota et al., 2019). The circular economy starts from the premise that nothing is lost because the waste that the organization produces has the capacity to be used as a resource within the same organization or by others. Geissdoerfer et al. (2017) define the circular economy as a regenerative system in which material inputs, as well as waste, emission, and energy leakage, are aimed at being minimized by slowing, closing, and narrowing material and energy loops. Long-term design, maintenance, repair, reuse, remanufacturing, refurbishment, and recycling can all help.” By ensuring better transparency of information between supply chain parties, supply chain digitalization will assist in eliminating uncertainty. Furthermore, automation of the supply process can greatly reduce the time required for the supply cycle and contribute to resource optimization, enabling capacity growth to meet the needs of the circular economy (Bunea, 2021).

From a perspective of the benefits that can be brought to environmental elements, some studies (Manavalan, Jayakrishna, 2019) have indicated that the interdependence between the concept of circular economy and the sustainability of supply chains is beneficial. In addition, investing in technology means increased operational efficiency that supports a smoother transition to so-called circular supply chains. However, the main issue here remains the major investment required, which for young industries remains a challenge, but in the long run, from a strategic point of view, and not only can we witness enhanced sustainability. Government policies aimed at sustainability and encouraging the use of digital technologies are the main motivating factors for organizations in moving to the circular economy, in line with the standards and requirements of industry 4.0 (Manavalan, Jayakrishna, 2019).

2.2 Issues in the Digital Supply Chain

Supply chain-specific networks can be enabled by information technology, which ensures efficient collaboration by transmitting useful information within supply chains. However, an adverse effect may be that certain protection barriers specific to traditional supply chains are reduced or even removed (Zhang et al., 2019). The barriers we refer to have traditionally separated supply chains from what we call cyberattacks because they were not connected to the Internet and therefore exposed. The benefits of an Internet connection are well known but not without risks, as it allows for exposure to many external and internal risks in the systems used in the supply chain. In this way, potential cybercriminals can exploit these vulnerabilities.

Another issue of digitalization of supply chains may be issues related to trust between supply chain partners, but especially between these partners and other third parties (Niemann et al., 2019). Additionally, inefficient processing of data in supply chains, as well as their storage, raises certain risks because valuable information leaks can occur. Furthermore, Zhang et al. (2019) suggest that trust does not necessarily mean security in the supply chain and that security does not necessarily mean trust.

Regarding the process of transforming a traditional supply chain that involves the transition to sustainable supply chain management, we should be aware that the latter requires high initial investments for companies and also requires a strategic vision, so long-term in terms of sustainability and less of a short-term vision, which presupposes rather economic objectives (Hasanova, Romanovs, 2020). This causes some problems, especially when the organization's strategy is one that focuses on the idea of cost leadership. Some studies (Pereseina et al., 2014) have shown that focusing on reducing production costs creates the main problems in the implementation of expensive technologies. However, we believe that the low-cost strategy is not a cheap strategy, and as long as the implementation of some technologies increases the operational efficiency of the organization, it can assume higher costs in the short term, and companies will benefit from these investments in the long run without changing the strategic positioning. For example, the implementation of an environmental management system involves a significant initial cost, but the long-term benefits will outweigh the installation costs (Hasanova, Romanovs, 2020).

Furthermore, some studies (Sajjad et al., 2015) indicate that the level of openness of managers about the adoption of sustainable technologies is an influencing factor in terms of commitment to their implementation. From this point of view, the level of openness of the organization's management regarding the digitization of supply chains and adherence to the principles of the circular economy is, in fact, the trigger for such an effort, especially at the strategic level.

Therefore, the premise from which we started this study is that previous studies have shown how the digital supply chain positively influences the sustainability of the organization and facilitates the transition to the circular economy, but the approach is not without challenges. Therefore, we chose to contribute to the literature by studying the main challenges of Romanian companies in this regard.

3. Methodology

The purpose of this research is to identify the major obstacles Romanian businesses face in developing a digitally sustainable supply chain. This problem is viewed through the prism of the necessity to engage in the principles of the circular economy. In this regard, the article investigates whether managers are aware of the circular economy's concepts and whether the organization is attempting to develop strategies to make the transition from a linear to a circular economy.

To achieve our goal, we used the survey as a research method and the questionnaire as a research tool. The population for the survey was based only on

large companies from Romania. According to the European Commission (2015), a large company is defined as having more than 50 million EUR as annual turnover and also more than 250 employees. We opted to study only large companies because we considered that their stage of development and available resources will allow those companies to engage in the implementation of sustainable digital supply chain procedures while considering the idea of circular economy. The questionnaire was distributed to managers of organizations operating in Romania via email addresses as part of a larger research approach. In this way we managed to obtain 85 valid answers, which was the sample of this research with a response rate of 18,24% which is to be considered acceptable due to COVID-19 pandemic restrictions and because the companies were part of various fields of activity.

To get an idea of the composition of the research sample, we can say that most of the managers surveyed had the function of production manager, financial manager, respectively, sales manager. Also, the main fields of activity of the organizations they are part of were: (i) retail sale of parts and accessories for motor vehicles; (ii) furniture production; (iii) fabrication of other plastic products; (iv) fabrication of milling products.

The variables used for this research, whose results are presented in this article, are shown in Table 1.

Table 1. Description of variables with references

Variable	Content	References
Technical Challenges	Lack of Internet; Information storage capacity; Technical expertise.	Jabbour et al., 2020; Kumar et al., 2021; Vrchota et al., 2019.
Security Challenges	Confidentiality of sensitive business data; Exposure to cyber-attacks.	Jabbour et al., 2020; Zhang et al., 2019; Niemann et al., 2019.
Economic Challenges	Cost of investment; Long payback time; Government law and regulation.	Jabbour et al., 2020; Hasanova, Romanovs, 2020.
Circular Economy Openness	The extent to which managers are aware of the principles of the circular economy; The extent to which the organization aims to identify ways to make the transition from a "linear economy" to a "circular economy"	Sajjad et al., 2015; Ștefănică et al., 2020; Elia et al. (2017).

Source: Authors based on research.

4. Results and Discussion

The results obtained from the application of the questionnaire indicated that, at the level of the entire research sample, the main challenges in implementing a sustainable and digitized supply chain, which involves the ability to access, analyse and manage large volumes of data through a robust information architecture, are technical challenges, security challenges, and economic challenges.

In terms of technical challenges, the results of the investigation indicated that the lack of the Internet is not a problem, as all the organizations surveyed have stable and fast internet connections. Also, the storage capacity of the information was not a problem. All respondents indicated that lack of technical expertise is the main technical barrier to implementing a sustainable digital supply chain, which should consider the principles of the circular economy. These results are similar to those of the study by Vrchota et al. (2019), whose results suggested that the implementation of these technologies, specific to Industry 4.0, requires a skilled workforce with experience.

Regarding security challenges, 40% of the respondents believe that an important barrier is the confidentiality of sensitive business data. Managers are afraid to share valuable internal information with other members of the supply chain, especially with third parties. These results support the study by Niemann et al. (2019), which identified that another issue of supply chain digitization may be related to trust issues between supply chain partners, but especially between these partners and other third parties. In a proportion of more than 60%, the managers surveyed consider that exposure to cyber-attacks is a danger, as the internet connection significantly increases the exposure of supply chains to such attacks. This result reinforces the argument of Zhang et al. (2019), namely that certain security barriers specific to traditional supply chains are reduced or even removed with their internet connection, thus becoming more vulnerable to cyberattacks.

When it comes to economic challenges, 20% of the respondents consider the costs of implementing and supporting such a supply chain to be too high, while 80% of the managers surveyed consider the return on investment to be too long for the financial possibilities of the organization. This result reinforces the argument of the study by Hasanova, Romanovs (2020), which suggests that in terms of the process of transforming a traditional supply chain involving the transition to sustainable supply chain management, we should be aware that the latter requires a high initial investment for companies.

Regarding the level of openness of managers in terms of the circular economy, we analysed the extent to which managers are aware of the principles of the circular economy and the extent to which the organization aims to identify ways to make the transition from "linear economy" to "circular economy". The results indicated that the managers surveyed are aware of the principles of the circular economy and to some extent want to make the transition from the linear to the circular economy, as indicated by the Likert scale used with values from 1 to 5, where 1 – to a very small extent and 5 – to a very large extent, the results obtained being 3.2 and 2.8 respectively. Sajjad et al. (2015) indicated that the level of openness of managers regarding the adoption of sustainable technologies is a factor of influence in terms of commitment to their implementation.

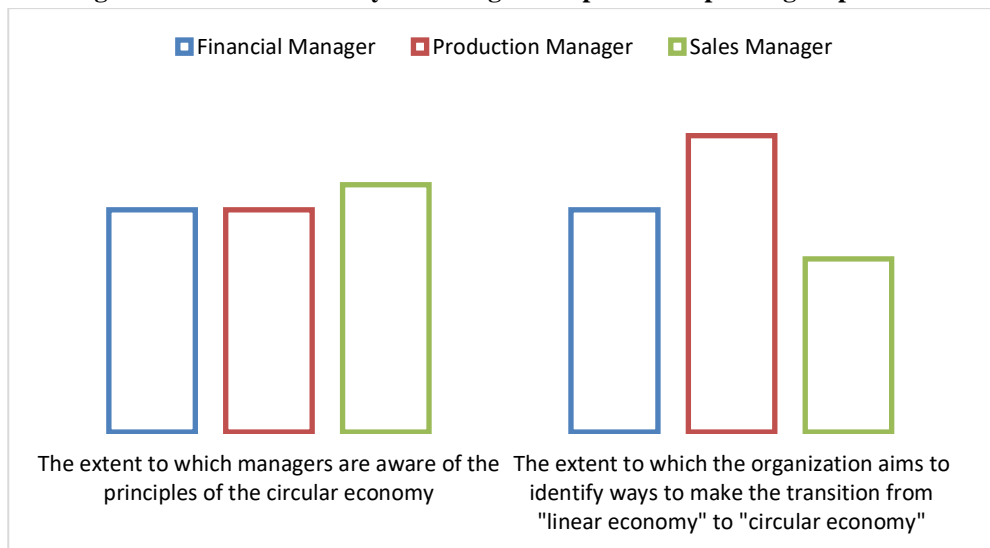
Going by this premise through the answers of our respondents, we can see that managers show a rather high level of openness towards sustainable circular economy principles and have a fairly high commitment to their implementation. However, technical, security, and economic barriers seem to be the ones that still stand in the

way of this transition, and that is why our efforts should focus on identifying ways to overcome them. Kirchherr et al. (2018), however, identified other barriers regarding circular economy at the level of the European Union, such as cultural barriers and lack of interest and awareness on the customer side. Therefore, future studies should also embrace these perspectives besides technical, security, and economic challenges.

Figure 1 illustrates the results of the extent to which managers are aware of the principles of the circular economy and the extent to which the organization aims to identify ways to make the transition from a "linear economy" to a "circular economy" by position. Thus, we can observe that, in terms of the level of awareness in terms of the principles of the circular economy, both the financial manager, production manager and sales manager recorded similar scores, with the mention that sales managers recorded a slightly higher score.

When it comes to their perception of the organization's goals and desire to move from the classic to the circular business model, there are significant differences. The highest score is recorded by production managers, followed by financial managers, and then sales managers with the lowest score. Perhaps production managers are the ones who better understand and perceive the benefits of this type of transition, while financial and sales managers may face pressure from shareholders to keep costs low, respectively, from customers who demand lower prices and flexible offers.

Figure 1. Circular economy knowledge and openness depending on position



Source: Authors based on research results.

In this way, our work contributes to the enrichment of the existing literature by making available for comparison results from Romania. We believe that these results are particularly valuable in terms of a future aggregate analysis of the European

Union member states in terms of the barriers and challenges facing organizations in the transition to digital sustainable supply chains and the circular economy.

5. Conclusions

The objective of the paper was to distinguish the main challenges Romanian companies face in implementing a sustainable digital supply chain in the era of circular economy. We believe that this has been achieved by identifying the main barriers that were of a technical, security, and economic nature, namely: lack of technical expertise, confidentiality of sensitive commercial data, exposure to cyber-attacks, costs of implementing and supporting such a supply chain that are perceived as too high, as well as the duration of the return on investment. Thus, by identifying these challenges, we will formulate in the following paragraphs a series of recommendations for managers, and we will mention a series of policy implications that can support such a transition.

In terms of recommendations with managerial implications, we believe that training programs are needed to gain the technical expertise needed to digitize the supply chain. Managers can also use partnerships with other members of the supply chain to acquire this know-how, based on a relational attitude and not just a simple transactional relationship. This involves integrating processes and fostering a culture of mutual trust, which would reduce the lack of trust in the risk of leaking information that is considered confidential and create closed-loop systems to protect from cyber-attacks. Furthermore, we believe that the costs of implementing and supporting the digitization of supply chains in a sustainable economic context should be seen as short-term effects with long-term benefits through a coherent strategic vision of these benefits of a sustainable economy. The investment effort is also significant, so supply chain partners could support each other, as the digitalization of the supply chain and its sustainability will benefit all members in the sense of better communication, better management, and more efficient stocks, which will bring long-term cost and waste reductions.

In terms of policy implications, we recommend that governments design programs to support corporate finance to converge with national and global environmental objectives, whether we are talking about national funds or, for example, EU-funded grants. Governments could also help reduce the risk of cyberattack by creating structures to identify and sanction such behaviour.

Therefore, this article opens the way for researchers to analyse in detail ways to overcome identified challenges on the five levels resulting from this research: lack of technical expertise, confidentiality of sensitive commercial data, exposure to cyber-attacks, costs of implementing and supporting such supply chain perceived as too high, and the long payback time. Moreover, another future research idea resulting from this paper is to analyse in an aggregated way the main barriers and challenges facing organizations in the member states of the European Union regarding the sustainable digital supply chain in the context of the circular economy. In this way, we can identify the contributions that each member state can make to achieve the common sustainability goals.

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