Assessment of the Implementation of New Digital Technologies in Connection with the Level of Efficiency of Supply Chains in the Context of COVID-19

**KEYWORDS**

supply chain; information and communication technology; management; efficiency; COVID-19; pandemic; coping strategy; supply chain disruptions

**ABSTRACT**

**Introduction.** In the extreme conditions of the COVID-19 pandemic, the vitality of supply chains has come to the fore, that is, their ability to self-support and survival in a changing environment through restructuring and rescheduling of productivity with long-term consequences. An effective information system and governance can help not only improve customer service and control costs but also facilitate planning to achieve key sustainability indicators such as environmental, economic, and social development.

The purpose of this paper is to assess the impact of the widespread adoption of new digital technologies on the level of efficiency of supply chains in the face of disruption caused by the pandemic.

**Materials and Methods.** For this study, statistical data were collected for the period from 2010 to 2019. Sources: Organization for Economic Cooperation and Development; The World Bank; Institute for Global Entrepreneurship and Development, etc. A logical-heuristic algorithm was used to form a system of indicators for assessing the effectiveness of information and communication technology and logistics.

**Results.** It has been found that countries with a high level of economic development as evidenced by persistently high values of gross domestic product in the pre-crisis period show high indicators both in terms of the efficiency of logistics systems and in terms of digital transformation of the economy. At the same time, countries with low and below-average levels of economic development do not show high results in the context of logistics systems, but they also do not demonstrate a correlation between the level of economic development and the level of logistics efficiency and the level of digital life.

**Conclusion.** Thus, the study has shown that the role of information and communication technology in improving the efficiency of supply chains becomes significant in favorable economic conditions in the country, and in times of crisis, the role of information and communication technology significantly increases and contributes to the restoration of supply chains and the survival of business in general.

INTRODUCTION

Supply chains (SCs) are the backbone of the economy and society and interact to a large extent with nature. The interactions in these SC ecosystems are very complex and governed by mutual relationships and feedback between SCs, nature, society, and economy [26].

From time to time, companies have to transform their SCs in order to increase their profitability and competitiveness, while remaining green, technologically advanced, and withstanding major disruptions in global SCs [24].

One such disruption in global SCs was triggered by the COVID-19 pandemic, which hit global and local economies severely. According to Remko [28], from 81 to 94.9% of SCs have been affected by the pandemic. Many industries faced massive consumer panic, and factories and warehouses of the world’s largest companies appeared in the quarantine zone [28]. The food SC and food industry required the most significant transformation: from the product to the end-user [25].

In the extreme conditions of the COVID-19 pandemic and the global and local SC crisis, the vitality of SCs has come to the fore, that is, the ability of SCs to self-support and survival in a changing environment through restructuring and rescheduling of productivity with long-term consequences [26].

Competitiveness in modern conditions depends not only on the price but also on the quality of customer service and the speed of delivery. This is one of the reasons for the introduction of modern methods and technologies in logistics. An effective information system and governance can help not only improve customer service and control costs but also facilitate planning to achieve key sustainability indicators such as environmental, economic, and social development.

LITERATURE REVIEW

In the modern world, the use of information and communication technology (ICT) in management processes has become widespread. Therefore, the impact of ICT on the efficiency of SCs, especially in times of crisis, is an important issue of concern to practitioners and scientists. Yoon et al. [1] examine the impact of innovation leadership and innovation in the SC in terms of efficiency (a case study of a healthcare organization). Thongrawd concludes that external and internal green SC management methods implemented in SCs make it easier for firms to increase market share and profits only when they are jointly implemented, increasing environmental efficiency and minimizing environmental risks, which is also important during a downturn market in a pandemic [2]. Chorfi et al. present a balanced scorecard and model framework for developing an integrated performance measurement system for public health SC management. This system of indicators can be adapted to the goals and preferences of
the decision-maker, which makes it possible to include the most important indicators for the formation of an integrated assessment [3].

One of the central questions in the design of an SC is how to invest correctly [4]. This perspective in SC design requires an understanding of the relationships between costs, SC risk factors, including in the face of global crises, and investments in SC capabilities. In [4], a multipurpose stochastic model is proposed for designing an SC under conditions of uncertainty. Risk sources are modeled as a set of scenarios, the goal is to explore the trade-offs between investing in improving SC capabilities and reducing SC risks, and minimizing the cost of SC disruptions. The results in [4] show that SC empowerment can be seen as a mitigation strategy that allows a company to reduce the overall expected value of an SC prone to disruptions, including due to the COVID-19 pandemic. Liu et al. [5] discuss SC optimization in three settings: when considering a buyback contract, a subsidy policy, and a joint buyback and subsidy strategy under a carbon tax cap [5].

Chen et al. [6] conclude that the introduction of SC financing practice helps the electronic platform forge closer partnerships with SC partners and increase its competitive advantage. The study [7] analyzes the management of humanitarian SCs (a case study of India) in a normal market situation, not complicated by SC crises during the pandemic. It is proposed in [8] to identify and assess ICT-related driving forces for sustainable development initiatives. ICT is essential for the development of sustainability-oriented SC networks. An effective management information system helps, according to [8], not only to improve customer service and control costs but can also facilitate planning to achieve the sustainability of environmental, economic, and social development. The study [8] aims to identify and assess ICT-related driving forces for enhancing resilience in SCs.

SC resilience issues are studied in many research papers. For example, the authors of [9] view SC management as an organizational philosophy to achieve profit by reducing environmental risks and impacts while increasing factors of economic and social efficiency. SC resilience is viewed as a global issue in [10], especially against the backdrop of the global economic crisis caused by COVID-19. ICT plays an important role in the development of SCs focused on resilience in crisis conditions.

Industry 4.0 refers to the automation of industries by exchanging data between the SC and logistics [12]. The researchers note that the industrial Internet of Things is industrial machines connected to an enterprise’s cloud storage. Industry 4.0, together with the Internet of Things, could revolutionize global SC management, especially in the face of disruptions. Quality control techniques are used to improve the efficiency and quality of production and distribution across global SCs [12]. The Lean Six Sigma approach in the global SC using Industry 4.0 and the Internet of Things creates an ideal workflow that is highly optimized, perfect, and free from defects and waste. The models proposed in [12] can make the SC completely autonomous.

SCs based on the integration of industrial information (the concept of the integrated use of new information technologies such as 5G, the Internet of Things, Big Data, cloud services, wireless communication networks, and artificial intelligence in the field of modern industry)
have played a huge role in the delivery of materials for the prevention of the COVID-19 pandemic [30].

The use of ICT and digital transformation of business especially clearly show their effectiveness in times of crisis, when small and medium enterprises are forced to use ICT under the influence of external factors such as the COVID-19 pandemic: for example, the use of Internet resources and online applications in SCs can solve two problems at once: sales and logistics. Such an SC relies on online platforms that can connect businesses with both raw stock producers and customers [31].

The study [29] proposes to use the digital twin of the SC, a model that represents the state of the chain at any given point in time and provides full end-to-end visibility of the SC to enhance resilience and contingency plans [29].

Thus, the overwhelming majority of authors emphasize the necessity and benefits of using ICT in SC management systems, especially in the face of disruptions in global and local SCs. However, there is still little research that would investigate the impact of the used ICT tools on the efficiency of SCs, as well as the information environment as a factor in increasing the efficiency, competitiveness, and survival of business in the context of the pandemic, closed borders, and quarantine restrictions of various levels.

An analysis of information sources shows that it is in ICT that investments are currently being made, human and financial resources are accumulating, and the potential for overcoming the consequences of the pandemic is growing. Digital transformation significantly changes the process of forming value chains and, first of all, changes the competitive environment for doing business. By relying on the paradigm of using ICT for doing business, modern enterprises can gain significant competitive advantages necessary for business survival by actively shaping a new virtual environment and creating a new structure for interaction and business in a new information environment.

The purpose of this paper is to assess the impact of the widespread adoption of new digital technologies on the level of efficiency of SCs in the face of disruptions caused by the pandemic.

**MATERIALS AND METHODS**

To conduct a comparative analysis of statistical information, this study uses a logical-heuristic algorithm for the formation of a system of indicators for assessing the effectiveness of ICT and logistics. Statistical data for the period of 2010–2019 for the study were collected from official sources that are in the public domain [13–16]. To carry out calculations and visualize the results, MS Excel tools were used.

Often, in practice, many authors define developing countries as countries that are not members of the OECD [17]. In this study, to illustrate the influence of the level of economic development on the processes of SC management in the context of the influence of ICT, the countries that lead the ranking in terms of GDP per capita [13], as well as countries that have low indicators of economic development, were selected.
It should be noted that, due to the lack of more recent data, including taking into account the COVID-19 pandemic, this study used available data for 2011–2018. At the same time, a number of indicators, for example, the index of digital life, as an accumulated result of previous periods, will not be as affected by the changes associated with the pandemic as economic indicators.

RESULTS

At the first stage, let us consider the ratings of countries in terms of GDP per capita and select four countries for further analysis. The criterion for selecting countries for analysis is the value of GDP. The following were selected as representatives of different groups of countries in terms of their level of economic development: the United States, France, the Russian Federation, and South Africa. Fig. 1 shows graphs of changes in GDP values for selected countries.

As can be seen from the graphs (Fig. 1), despite the fact that the economies of these countries showed slight growth in the pre-crisis period, their differentiation by this indicator is clearly expressed. Thus, four economies were selected for analysis, two of which belong to developed countries, and two to developing ones. It should be noted that this division is very arbitrary. Therefore, the authors will further assume that the level of economic development, expressed by the value of GDP per capita, determines one of four groups. Then the selected countries are representatives of each of these groups.
Let us consider how the level of economic development and the level of logistics efficiency are related. For this, the authors will use the data provided by [18]. Fig. 2 shows a comparative assessment of the logistics performance index (LPI) for selected countries.

![Fig. 2 Comparison of estimates of the logistics performance index (LPI) (based on data from [18]) for 2016]

The analysis shows that LPI does not show the same uniformity in the assessment relative to the selected countries. From the diagram (Fig. 2), it can be seen that the values for France and the United States differ insignificantly. Let us consider this indicator in more detail. For an analysis, [18] provides the values of subindices, presented here in the form of diagrams in Fig. 3.

![Fig. 3 Comparison of the components of the LPI rating (based on data from [18]) (conventional units) for 2016]
Fig. 3 clearly shows that the values of the subindices for the United States and France practically do not differ, while the rest of the countries retain the sign of representation of different groups. An interesting fact is that Russia and South Africa have exchanged groups. Thus, based on the analysis of LPI, it can be concluded that countries with a high and above-average level of economic development have sufficiently high standards of logistics services and correspond to the group with a high rating level. For countries with a level of economic development below the average, LPI shows no direct correlation (0.2321) with indicators of the level of economic development.

Following the accepted research methodology in the next step, it is necessary to compare the selected countries in terms of ICT development. It is assumed that the efficiency of SCs, the level of which can be indirectly identified by the LPI rating, depends on the level of using information technology. For the analysis, the index of digital life (TIDL) was selected, which reflects all aspects of digital transformation in a country. Fig. 4 shows the TIDL index values formed on the basis of the data provided in [16].

Fig. 4 Comparison of the values of the index of digital life (TIDL) (based on data from [16]) for 2016

It should be noted that this indicator demonstrates a correlation with the level of economic development – the higher the level of economic development, the higher the index of digital life. However, the values between the representatives of the third and fourth groups are insignificant. According to the data provided in [16], TIDL is formed on the basis of an analysis and assessment of such areas of digital transformation as openness, entrepreneurship, and confidence, which makes it possible to fully reflect all the features of digitalization. Fig. 5 shows comparative characteristics in these areas for selected countries.

Fig. 5 shows that the components of TIDL performed differently for the selected countries. For example, in terms of digital confidence and openness, Russia is approaching the leading countries, but entrepreneurship in the context of the use of ICT lags far behind. Leaders remain in the lead across the board, keeping differences between the groups with a high level of economic development and the group of countries with an above-average economic level.
Thus, countries with a high level of economic development, expressed in persistently high values of GDP in the pre-crisis period, show high indicators both in terms of the efficiency of logistics systems and in terms of digital transformation of the economy. At the same time, countries with low and below-average levels of economic development do not show high results in the context of logistics systems, but they also do not demonstrate a correlation between the level of economic development and the level of logistics efficiency and the level of digital life. Thus, despite numerous confirmations in the academic literature of the facts of the importance of ICT implementation for improving the efficiency of corporate management, in particular for increasing the efficiency of SC management, in a global sense, ICT is not a factor that determines the efficiency of logistics in a country.

**DISCUSSION**

Academic research on the issues of the digital economy and the information society is today the most popular direction, not only because of the active introduction of ICT in all spheres of life but also because of the need for constant analysis and comprehension of the results of ongoing transformations, especially during the crisis period of global and local failures of SCs.

The authors’ findings do not support the conclusions that digital technology is the main driver of SC efficiency by supporting information sharing. At the same time, [19] examines the level of an individual company, while this study shows that the effect of the introduction of...
ICT is significant when the economic environment is favorable. However, one can agree with the opinion of the authors that in the conditions of the economic crisis, the use of ICT in SCs is becoming one of the ways for a business to survive [26]. Taking into account the integration in SCs, it can be assumed that the effect obtained from the introduction of ICT in a separate link can be completely offset by the lack of the necessary infrastructure or administrative base in the environment of another link in the same chain [28].

The results presented in [20] do not allow identifying the role of ICT in improving the efficiency of SC management. This study confirms the authors’ assumption that the external environment that creates inter-organizational ICT, as well as external factors such as the impact of the pandemic, have a direct positive relationship with SC efficiency [32].

Thus, many studies confirm the importance of ICT for SC development. Some authors focus on the individual enterprise level, others look at the global level. Obviously, everyone agrees that the prospects for the development of SCs and business survival in the context of the coronavirus pandemic are inextricably linked with the use of modern information technology [23; 26; 27]. In this context, the study focuses on the global processes that shape the profile of the country’s economy. The results show that, despite the importance of ICT, the impact of digital technologies is manifested in advanced economies.

**CONCLUSION**

The widespread introduction of digital technologies is reflected in the forms and methods of doing business, leading to an inevitable transformation of all processes and areas of activity. The importance of using ICT to preserve and restore SCs impacted by the COVID-19 pandemic and related quarantine restrictions at various levels cannot be underestimated. Numerous publications on the topic of SC management confirm the active ubiquitous use of digital technologies to improve the efficiency and survival of business in the face of disruptions in global and local SCs.

The field of SC management has evolved rapidly, driven by factors of globalization, innovation, sustainability, and technology. Qualitative research has been carried out in related academic studies. While many of the activities affecting the logistics performance, such as international infrastructure, trade corridors, rules, and services, have already been thoroughly analyzed by many researchers, assessing the role of ICT in improving efficiency and rebuilding SCs has gained new relevance as the coronavirus pandemic, closed borders, increased sanitary and hygienic requirements, and quarantine measures of various levels of severity destroyed many logistics chains, both transnational and local, that had been built over the years. As a result of this study, it can be concluded that the importance and prospects of the use of ICT are increasing in advanced economies, where digitalization allows achieving high efficiency indicators and restoring SCs.

The results of this study evidence that countries with a high level of economic development showed higher indicators of the efficiency of logistics systems and digital transformation.
Thus, the study has shown that the role of ICT in improving the efficiency of SCs becomes significant in favorable economic conditions in a country, and during crisis periods, the role of ICT increases significantly and contributes to the restoration of SCs and the survival of the business as a whole.

Relying on the paradigm of using ICT for doing business, modern enterprises can not only survive in the conditions of the coronavirus pandemic but also gain competitive advantages by actively shaping a new virtual environment and creating a new structure for cooperation and business in a new digital environment. Investment in digital infrastructure is now seen as a key condition for the survival and sustainable development of enterprises of all sizes.

The results of this study can be used by CEOs of enterprises of various levels in formulating the strategies and tactics of corporate development, including crisis management. Research methods and data can be applied by scholars to further research on the impact of ICT on the recovery and efficiency of global and local SCs, including updated data that take into account the impact of the coronavirus pandemic on the indicators used in this study.

The current research is limited to pre-crisis data. The study leaves room for further research on the impact of ICT on SC recovery and efficiency, including based on data showing the impact of the COVID-19 pandemic on the economic and other indicators of the countries used in the current study.

REFERENCES


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