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# GLOBAL SUPPLY CHAINS MANAGEMENT AGAINST FUTURE RISKS - A POST-PANDEMIC VISION DURING THE ONGOING WAR

## Katarzyna Grondys [1], Michał Kot [2]

[1,2] *Czestochowa University of Technology, The Faculty of Management; Armii Krajowej 19B, 42-201 Częstochowa, Poland*

*E-mails: [1]katarzyna.grondys@pcz.pl; [2]kotmichal012@gmail.com*

**Abstract.** For several years, the global supply chain has been particularly exposed to various dangers in particular natural disasters, the COVID-19 pandemic or the armed conflict in Ukraine, which threaten its stability, continuity of efficiency. Each of the current events brings full economic environmental social risks that directly affect the supply chain. Companies wishing to adapt to current market situations, wishing to be competitive, must learn to properly manage the supply chain, monitor it and anticipate the possibility of specific risks. The main purpose of the article is to determine the impact of potential risk factors on the supply chain and its stability. In addition, the current capacity of companies to implement a number of supply chain activities such as management, monitoring through the lens of recent events, among others, was verified. A survey questionnaire was used to conduct the survey in the first quarter of 2023, which yielded 250 questionnaires, of which 212 properly completed copies were selected for the study, representing companies from countries such as Poland, Romania, the UK and Turkey. Subsequently, the data was subjected to in-depth analysis thanks to which it was possible to create a series of recommendations for companies that will minimize the possibility of risk, minimize the effects after the occurrence of such risks and help companies to operate on currently dynamic supply chains being competitive in global markets. It has been shown that in companies according to which the impact of economic and environmental factors does not have much influence on their company is observed significantly more often are more likely to have deteriorating efficiency results. It has been shown that in companies according to which the impact of economic and environmental factors is not high influence on their company is observed significantly more often are more likely to have deteriorating efficiency results.

**Keywords:** global; supply chain; management; risks

## 1. Introduction

In the 21st century and more specifically in recent years, the supply chain is exposed to constant destabilization caused by various events having their impact on a global scale. An additional factor causing SC instability is increased globalization and changes in global markets (Gomez-Mejia et al., 2021). The very wide range of products we consume or use are sourced, manufactured, modified in various sometimes distant geographic locations. Adequate management of global supply chains is necessary to meet the newly emerging challenges. (Choi et al., 2022). However, it is important to keep in mind that every global event brings with it both new opportunities and threats that can potentially affect the management of global supply chains (Kot et al., 2020). For the most part, companies are well aware of the definitions of supply chain risk management (Muangmee et al., 2022), however, recent events have shown that this knowledge is purely theoretical and in many cases focused only on their company or the closest links in its supply chain.

The most recent event that reinforces this was the COVID-19 pandemic. Entrepreneurs, in making their risk assessments, focused only on their own suppliers without taking into account that they themselves may have difficulty obtaining goods from their sub-suppliers. The issue of several companies sourcing from a single supplier was also overlooked. The best example of this is China. The introduction of restrictions in China, which is one of the largest suppliers of all kinds of raw materials, products, intermediates, caused supply chains to break down early on a global scale. These events have had a negative impact on companies in a variety of industries from both Europe and the United States. Another element that contributed to the large shortages of what? Was it the widespread use of the "Just in time" strategy, which is designed, among other things, to reduce inventory as much as possible, assuming that suppliers will meet their obligation to deliver goods on time. Undoubtedly, the COVID-19 pandemic brought with it a global crisis (Ali et al., 2022; Ivanov & Dolgui, 2020; Yang et al., 2020; Kot, 2021). It taught companies to take a broader view of risk assessment and to kind of anticipate the occurrence of an economic or economic crisis.

Not long after the world dealt with the effects of Pandemic COVID-19, we are faced with war and, more specifically, with Russia's military actions in Ukraine. Probably no one foresaw the possibility of a military conflict in 2022. Undoubtedly, this event had a strong impact on logistics and supply chains. A large number of Ukrainian employees from logistics and transportation companies resigned in response to the call for military service. Staff shortages have caused significant delays in orders, shipments. Many supply chains between Russia and Europe passing through Ukraine have been broken or severely curtailed (Melnychenko et al., 2022). In addition, economic restrictions imposed on Russia have contributed to destabilizing supply chains by cutting off sources of raw materials and products. Broken and restricted supply chains have contributed to shortages of raw materials and products in the West resulting in increases in commodity prices. The conflict also resulted in restrictions on the transportation of fossil fuels such as coal, oil and gas. In many European countries they were essential fuels for energy or heat production. The war in Ukraine has also caused a large reduction in the transportation of food from Ukraine, and it should be noted that it is in the top of the world in terms of sales of sunflower oil corn wheat or barley.

Undoubtedly, global events regardless of the plane on which they arise - environmental, economic, political, etc. - are difficult to predict and carry a high probability of multiple threats to the supply chain. (Davis et al., 2021). The purpose of the article is to identify the impact of potential risk factors on the supply chain and its stability based on recent events, i.e. the COVID-19 Pandemic and the armed conflict in Ukraine. The article also aims to verify the current ability of companies to carry out a number of supply chain activities such as supply chain management, monitoring and anticipating risks, adaptability in case of supply chain constraints. The results also aim to indicate the relationship between the assessment of risk factors in the areas of pandemic, political instability, environmental and economic, and company performance. Based on the research, recommendations have been created, with entrepreneurs as the main audience. The recommendations are complete because they

apply to each type of enterprise by size as well as the area in which they conduct their supply chain operations. The companies studied are located in different regions of the world and are members of different organizations, which will allow the illustration of a broader spectrum of cases from a global aspect. Recommendations are primarily aimed at illustrating ways to mitigate the negative effects of a crisis situation, as well as highlighting the significant impact of an appropriate way of running a business oriented toward supply chain and risk management activities. The research also identifies areas that need to be given special attention due to their significant impact on supply chain performance results.

## 2.    Theoretical background

Recent global events, i.e., the Covid 19 pandemic and the war in Ukraine, have strongly changed the perception of supply chain vulnerabilities. On the one hand, it has been observed that supply chain disruptions can occur at any level due to factory closures, quarantine, accidents. On the other hand, producer disruptions have also occurred recently due to the conflict in Ukraine. (Passarelli et al., 2023). Supply chain disruptions (SCDs) are unexpected events that disrupt the flow of goods and products or create a discontinuity S.C. (Ali et al., 2021; Althaf and Babbitt, 2021). Supply chain disruption can also be defined as "the manifestation of a company's inability to match supply and demand." company's inability to match demand and supply" (Hendricks et al., 2005). Disruptions in supply chains can result from a variety of causes: climate change or natural disasters (e.g., floods, earthquakes, hurricanes, epidemics) (Ghosh & Sanyal, 2021; Moosavi et al., 2022) or human factors (e.g., wars, tariffs on specific products, economic crises, on specific products, economic crises) (Villalón-Huerta et al., 2022; Sarkar & Shankar, 2021) , the inevitable consequence of which is the disruption of the normal flow of materials and information within supply chains (Cardoso et al., 2022).  Events such as a pandemic or war bring unexpected challenges such as demand and supply shocks resulting in stockpiling, labor shortages, restriction of transportation primarily across borders (Nikolopoulos et al., 2021).

Usually companies have a strategy within the framework of an emergency, few have dealt with the situation caused by the Covid-19 pandemic and related restrictions. The same situation occurred with regard to the ongoing war in Ukraine and the sanctions imposed on Russia. Some companies were forced to act unsystematically which was further hampered by little information, poor situational forecasts and led to increasing uncertainty. The war in Ukraine and the COVID-19 pandemic caused major disruptions and even interruptions in supply chains (Golan et al., 2020; Ivanov and Dolgui, 2020; Mehrotra et al., 2020), which revealed their vulnerability to potential risks (Ivanov, 2020; Sodhi & Tang, 2021).

### The Long-Term Impact of Pandemic COVID-19 on the Supply Chain

Covid-19 was hailed as the most serious disruption that caused many disruptions and broken supply chains (Araz, 2020). The impact of the Covid-19 pandemic was felt even in the years following its occurrence in aspects such as politics education and social relations (Chandasiri, 2020; Lipscy, 2020; Cooper, 2021). Its impact can also be seen in the economy especially in aspects such as production, consumption, flow of goods and services, and foreign trade (del Rio-Chanona et al., 2020; Fleming, 2021). The COVID-19 pandemic disrupted the availability of many global supply chains thereby paralyzing many industries (Araz et al., 2020) a phenomenon previously unheard of and undescribed in the literature (Butt, 2021a). A pandemic differs from traditional disruptions due to its long-term effects, unpredictable spread and wide-ranging impact on multiple levels of the supply chain and multiple regions around the world (Ivanov, 2020a). The flagship impacts of Pandemic COVID-19 cited in the literature in the context of transportation and the supply chain include the following issues.

Changing consumption patterns: Pandemic COVID-19 caused a change in consumption patterns, increasing demand for certain products such as foodstuffs, personal protective equipment and medical products. Companies

that manufacture and distribute these products have had to quickly change their supply chains to meet increased production and demand (Kráľ et al., 2022).

Restrictions on movement of goods and people: the COVID-19 pandemic has caused border closures, restricting the movement of goods and people, making logistics processes difficult (Gomes & Lopes, 2022). Transportation by road, sea and air is now hampered, meaning that moving goods from one country to another is becoming increasingly difficult.

Supply problems and delays: As a result of restrictions on the movement of goods and people, many companies have experienced supply shortages and delivery delays. Companies that rely on importing or exporting goods face high transportation costs and difficulties in maintaining regular deliveries.

Rising transportation and warehousing costs: Rising transportation and warehousing costs are another effect of the COVID-19 pandemic on supply chains. Companies that rely on international supply chains have to deal with high transportation and warehousing costs, affecting their profit margins.

Need to adjust supply chains: The COVID-19 pandemic has forced companies to adapt their supply chains to new conditions and requirements. Companies must react quickly to changing situations and adapt their supply chains to meet new challenges.

**The Impact of the Ongoing Armed Conflict in Ukraine on the Supply Chain**
Factors destabilizing the supply chain, qualified in the market analysis as unlikely events but likely to cause business collapse, are, in addition to natural disasters, political tensions, armed conflict. The armed conflict in Ukraine is increasingly hitting the transportation industry and the logistics and manufacturing sector, which was just beginning to recover from the problems caused by the pandemic. The ongoing war and the economic sanctions being implemented are causing problems in the supply of raw materials. The flow of goods is declining, the supply chain is encountering more and more problems and is broken in many places. Instability is growing. In many ports, cargoes destined for Russia and Ukraine are backlogged blocking surface availability. This is causing many delays and stoppages at the ports. Warehousing capacity is limited and this is putting negative pressure on the supply chain in the form of rising costs, rising prices and rising inflation around the world. Sources report that the situation is increasing global demand for ship purchases and shipping costs around the world. Many companies are forced to relocate their supply chains due to reduced flow or disrupted supply chains due to the inability to obtain goods required from either Ukraine or Russia. The war in Ukraine is causing a huge impact on the supply chains of fossil fuels such as oil gas, but also on the supply chains of food and agricultural products such as grains and corn. In addition, the negative impact of the war has been noted in terms of higher energy prices. An important effect of the ongoing war is also increased political and economic tension. This affects both business decisions and company strategies. These companies must take into account the risks associated with investing in Ukraine and possible changes in government policies and regulations.

**Compilation of Covid-19 and the Conflict in Ukraine Based on the Impact on the Supply Chain**
The disrupted supply chains due to the COVID-19 pandemic and the war in Ukraine share many common features, but also have differences in some aspects. In both cases, border closures and restrictions on the movement of people and goods have caused major disruptions in supply chains. Companies are having to deal with delays, supply shortages and increased transportation costs. As a result of these disruptions, many companies are facing problems in maintaining their operations and sourcing necessary raw materials and supplies. However, in the case of the COVID-19 pandemic, supply chain disruptions are associated with restrictions on the movement of people and goods to prevent the spread of the virus. In the case of the war in Ukraine, disruptions to supply chains are caused by armed conflict and transportation restrictions due to security and political stability.

Additionally, the COVID-19 pandemic had a global impact on supply chains, while the war in Ukraine mainly affects countries neighboring Ukraine and countries that rely on importing or exporting goods to Ukraine. Despite the differences in aspects of the two situations, both the COVID-19 pandemic and the war in Ukraine have demonstrated the importance of having flexible and diverse supply chains that can respond quickly to changing conditions. Companies that are able to adapt to these challenging conditions are more resilient to future supply chain disruptions.

**The Impact of the COVID-19 Pandemic and the Conflict in Ukraine on the Scientific Community and the View of SCRM**

The reaction to these developments reflects the interest of many organizations in the topic of supply chain risk management (SCRM) which will help ensure continued supply to meet demand. Supply chain risk management (SCRM) is critical to the competitive growth of companies by successfully connecting them with manufacturers, retailers and customers, among others (Li & Chen, 2019). As organizations today increasingly prefer to rely on incorporated supply chain networks, they are becoming more vulnerable to supply chain disruption risk (SCDR) (Novoszel & Wakolbinger, 2022).

In order to correctly identify issues related to the occurrence of supply chain disruptions, one must categorize the risks that cause them into appropriate divisions.

Disasters-are caused by natural disasters or human behavior. We are primarily talking about earthquakes, floods, fires and hurricanes. Current literature points to the need to take natural risks into account in managing the global supply chain and countering the impact of risks (Gunessee et al., 2018). Natural or man-made (geopolitical) disruptions are low probability and high impact events with devastating consequences. High probability and medium impact disruptions include sudden changes in demand, supply shortages, congestion in supply or distribution networks, and supply constraints (Katsaliaki et la., 2021)

Systems-e.g., information disruption-occurred when the internet and new technologies were implemented less in supply chain management (Reshmi, 2021). We are referring to the use of various technologies in the implementation of Industry 4.0. The increasing deployment of new technologies has reduced information transaction times and inaccuracies (Ali et al., 2022). However, alongside the benefits of widespread Internetization and the introduction of new technologies, a new threat has emerged in the form of data security and information flow. We are speaking here primarily of cyber attacks (Durowoju et al., 2020; Reshmi, 2021). Current studies also show the doubtfulness of the information system and its security thus increasing the possibility of the risk of information disruption and disruption of the supply chain.

Delays-e.g., transportation disruption-is a risk that rapidly paralyzes the entire supply chain (Paul et al., 2020) Transportation disruption causes the interruption or stoppage of the temporary or total flow of goods (Lam & Yin 2022). Supply chain disruption can be caused by, among other things, incorrect human decisions by, for example, selecting inappropriate sub-suppliers.

The likelihood of supply chain disruption or interruption can be minimized or prevented altogether through continuous monitoring of the entire supply chain and factors potentially affecting supply chain performance (Scheibe & Blackhurst, 2018). To help companies become better prepared to deal with uncertainty, and thus become more resilient, the academic literature has contributed theoretical models for supply chain risk management.

## 3. Research Methodology

The research was aimed at investigating the difference between the performances of different areas of company efficiency due to macroeconomic factors affecting the supply chain. For this purpose, in the first quarter of 2023, a survey was carried out initially among 250 companies, and finally 212 entities were left in the collection after the data was dumbed down. The survey was conducted in four selected European countries viz: Poland, Romania, the United Kingdom and Turkey. These countries are at a similar level of economic development, with similar annual GDP levels (4.9%; 4.8%; 4.1% and 5.6%, respectively). At the same time, two of these countries are members of the European Union. The collected data were subjected to statistical analysis according to the assumptions of selected statistical methods. It was assumed that:

H1: The level of assessment of the impact of environmental, economic, organizational and resource factors on the supply chain causes a change in the efficiency of enterprises operating in the chain.

Table 1 presents key information on the companies in the survey sample.

**Table 1.** Characteristics of the study sample by country covered [%]

| Features of the research sample - independent variables | Share of surveyed companies in total | Country | | | |
|---|---|---|---|---|---|
| | | UK | Poland | Romania | Turkey |
| | | 21,7 | 19,3 | 32,5 | 26,4 |
| Employment volume | | | | | |
| 10 to 49 people | 40,1 | 16,5 | 23,5 | 37,6 | 22,4 |
| 50 to 249 people | 25,5 | 46,3 | 13,0 | 9,3 | 31,5 |
| 250 > | 34,3 | 9,6 | 19,2 | 43,8 | 27,4 |
| Length of operation in the market | | | | | |
| Less than 3 years | 18,9 | 25,0 | 5,0 | 40,0 | 30,0 |
| From 3 to 7 years | 16,0 | 23,5 | 5,9 | 35,6 | 35,0 |
| From 8 to 15 years | 20,8 | 22,7 | 11,4 | 34,1 | 31,8 |
| More than 15 years | 44,3 | 19,1 | 34,0 | 27,7 | 19,1 |
| Number of global partners | | | | | |
| No | 4,7 | 20,0 | 40,0 | 0,0 | 40,0 |
| From one to three | 36,8 | 12,8 | 20,5 | 35,9 | 30,8 |
| Four to nine | 29,2 | 29,0 | 14,5 | 33,9 | 22,6 |
| Ten and over | 29,2 | 25,8 | 19,4 | 32,3 | 22,6 |
| The company's place in the supply chain | | | | | |
| Raw material | 9,4 | 30,0 | 0,0 | 30,0 | 40,0 |
| Semi product | 10,4 | 27,3 | 0,0 | 45,5 | 27,3 |
| Manufacturer | 33,0 | 17,1 | 28,6 | 28,6 | 25,7 |
| Distributor | 18,9 | 20,0 | 35,0 | 35,0 | 10,0 |
| Logistics Provider | 28,3 | 23,3 | 11,7 | 31,7 | 33,3 |

*Source:* Authors' elaboration

Analyzing the overall structure of the survey sample, it is observed that the most frequent participants in the survey are small enterprises (40.1%); which have been operating in the market for more than 15 years (44.3%), have one to three global partners (36.8%) and are manufacturers (33%). No more than 5% are occupied in the

sample by entities that do not have any global partner. This means that the conclusions drawn from the survey can be generalized to global supply chain risks. The largest number of companies were surveyed in Romania, which has the largest number of small and large entities, which have been in business for less than 15 years, have a large number of global partners and most often act as suppliers of intermediate products, are manufacturers or distributors. In contrast, companies from Turkey most often act as suppliers of raw materials and logistics services. Enterprises from Poland dominate in the case of seniority in the market and most often among the other countries surveyed do not have a global partner in doing business.

In addition to the independent variables that characterize the research sample, the study identified dependent variables that relate to potential risks that threaten the sustainability of the global supply chain. The identification of risks was based on five major macro-economic challenges that companies have been facing in global supply chain management over the past few years:
Pandemics (Covid-19, H1N1, Ebola);
Political instability (wars, economic sanctions, bad governance);
Environmental aspects (sustainability, green logistics);
Economic aspects (sanctions, trade disputes, financial crisis, market crash).
These challenges were detailed and given a five-point assessment (Table 2).

**Table 2.** Description of selected dependent variables

| **Covid - 19 the pandemic** (where 1 = very negative and 5 = very positive) **(Challenge C1)** | **Political instability** (where 1 = doesn't matter and 5 = very influential) **(Challenge C2)** | **Environmental aspects** (where 1=doesn't matter and 5 = very important) **(Challenge C3)** | **Economic and financial aspects** (where 1 = doesn't matter and 5 = very influential) **(Challenge C4)** |
|---|---|---|---|
| Labor shortage caused by pandemic **(C1a)** | War between nations **(C2a)** | Procurement strategy beneficial to the environment **(C3a)** | Inflation **(C4a)** |
| Transition to (work from home)/ remotely **(C1b)** | Change in the energy sources on the market **(C2b)** | reducing waste generation from company related activities **(C3b)** | Implementation of new economic and trade policies by countries **(C4b)** |
| The reduced amount of cash inflow **(C1c)** | Shift in the economic power (western countries to Asia) **(C2c)** | Employee participation in environmental conservation initiatives **(C3c)** | Economic sanctions on some countries **(C4c)** |
| Shortages at the supplier level **(C1d)** | Electronic equipment supply shortage (microprocessors, transistors, capacitors) **(C2d)** | The move toward greener and more environmentally energy sources **(C3d)** | Purchasing power (amount of money with customers and businesses available to spend) **(C4d)** |
| Weakness of just-in-time strategy **(C1e)** | Increase in fuel price due to OPEC plus nations producing less oil **(C2e)** | Choosing supply chain partners based on environmental regulations **(C3e)** Recycling of damaged and useless goods **(C3f)** | Economic growth of a country **(C4e)** |

*Source:* Authors' elaboration

The potential effects (P) that occurred as a result of the identified crises were assessed on a five-point scale (1=definitely worse than previous years , 2=worse than previous year , 3=comparable to previous years, 4=better than previous years, 5=definitely better than previous years) for the following indicators of company effectivity: lead time (P1); efficiency of the entire supply chain (P2); logistics costs (P3); efficiency in inventory and warehouse management (P4); human resource management (P5); fulfillment of customer requests (P6); mitigation of risk in the supply chain (P7); revenue of the company and market share: the share of the company in the whole market on which it operates (P8). The surveyed companies made an overall assessment of the level of efficiency of their operations, a summary of which is presented in Figure 1.
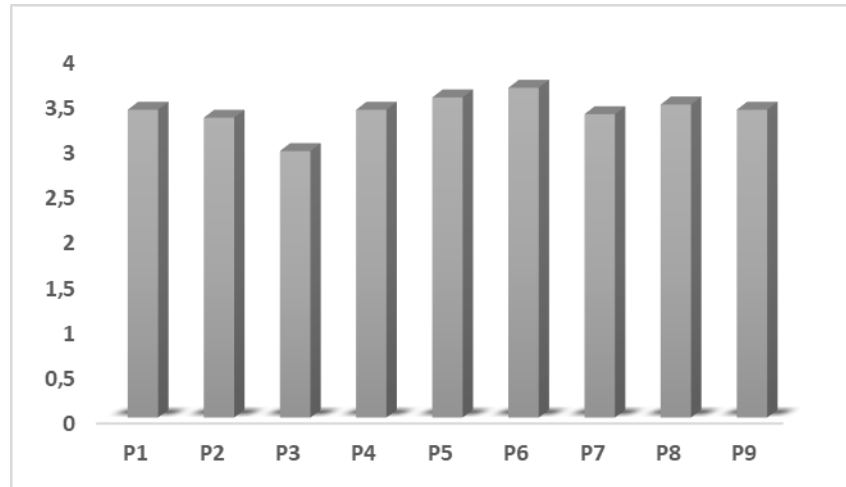
**Fig.1.** Mean of performing of the company in the present year 2022 compared to previous years
*Source:* Authors' elaboration

Of the several evaluated potential changes in the performance results of the surveyed enterprises, the highest scores were P6, or Fulfillment of customer requests, where the average score was 3.64, and P5, or Human resource management, where the average score was 3.54, which marked the achievement in 2022 of comparable results to previous years. Overall, the data obtained indicate the preservation of comparable results to the previous period in most of the surveyed companies. Half of the enterprises declared no impact for the variable P1, P2, P3, P4, P7 and P9 (Me =3.00). Half of the enterprises declared improved performance to the previous period for the variable P5, P6 and P8 (Me=4.00).

To compare the distributions of unidimensional statistical characteristics of the study populations, where data were expressed on an ordinal scale, the non-parametric Kolmogorov-Smirnov test was used. Due to the numerous dependent variables, factor analysis was used to reduce their set. It allowed to divide all variables into subsets according to the correlation index. Highly correlated variables were placed in one set. In the end, four sets were identified, defined as the main factors, which took into account the cumulative impact of each variable. In order to compare the four factors in terms of the independent variable, the non-parametric Kruskal-Wallis test was applied.

## 4. Study Results

**Characteristics of dependent variables and testing normality of distribution**
The next stage of the study was to identify the effect of the individual dependent variables (C1, C2, C3 and C4) on the independent variable P. In order to select a statistical test, the normality distribution was first tested for all the variables studied. The test of normality distribution in each group was carried out according to the assumptions of the Kolmogorov-Smirnov test. The resulting calculations for each variable viz: C1,C2, C3 and C4 and P, where Z (202) and $p < 0.001$ mean that the null hypothesis, which states that the distribution of the variable does not deviate from the normal distribution, should be rejected. The absence of a normal distribution and the ordinal nature of the variables under study, determined the choice of comparing the groups under study using a non-parametric Kruskal-Wallis test. At the same time, due to the large number of potential dependent variables that can affect the performance results of the company, the study of the impact of risk on performance results was preceded by factor analysis to reduce the number of factors. In order to check whether the variables have adequate statistical properties appropriate for factor analysis, the basic descriptive statistics of these variables were examined (Table 3).

**Table 3.** Basic statistics for dependent variables

| C1 | Mean | Median | Std. dev. | C2 | Mean | Median | Std. dev. |
|---|---|---|---|---|---|---|---|
| C1a | 3,0667 | 3,000 | 1,0739 | C2a | 3,3429 | 4,000 | 1,3257 |
| C1b | 3,0952 | 3,000 | 1,2101 | C2b | 3,4381 | 4,000 | 1,1813 |
| C1c | 3,0190 | 3,000 | 1,1065 | C2c | 2,6381 | 3,000 | 1,0904 |
| C1d | 3,1143 | 3,000 | 1,2005 | C2d | 2,9333 | 3,000 | 1,3783 |
| C1e | 3,1333 | 3,000 | 1,0810 | C2e | 3,3396 | 4,000 | 1,2837 |
| C3 | Mean | Median | Std. dev. | C4 | Mean | Median | Std. dev. |
| C3a | 3,1810 | 3,000 | 1,1473 | C4a | 3,7714 | 4,000 | 1,1921 |
| C3b | 3,1048 | 3,000 | 1,2054 | C4b | 3,5810 | 4,000 | 1,0873 |
| C3c | 3,2286 | 3,000 | 1,2316 | C4c | 3,6190 | 4,000 | 1,2011 |
| C3d | 3,6190 | 4,000 | 1,3152 | C4d | 3,7524 | 4,000 | 1,2434 |
| C3e | 3,3619 | 4,000 | 1,2383 | C4e | 3,8286 | 4,000 | 1,1106 |
| C3f | 3,6667 | 4,000 | 1,2578 | | | | |

*Source:* Authors' elaboration

The average level of impact for Challenge 1 is similar, with a rating of 3. According to the median value, at least half of the number of respondents rated the impact of the pandemic on supply chain management as neutral, with a standard deviation of 1, which is significant for such a scale. The values of the statistics are more varied for Challenge 2, where the average rating ranges from 2.6 to 3.4, and the median value for the variable C2a, C2b and C2e indicates a dominant rating of 4, or influential. The value of the standard deviation indicates a slightly greater dispersion of ratings in this area. The average rating values for Challenge 3 are above 3, and the results are the most dispersed. The highest average ratings are for Challenge 4, where half of the respondents declared a minimum rating of 4.

According to the assumption of factor analysis, the variances of the results within each variable were close to each other. Looking at the standard deviations for this purpose, it is observed that their values are close to each other, so a factor analysis can be carried out for the dependent variables. The second condition for conducting factor analysis is that the dependent variables are mutually correlated, which was checked using the basic K-M-O statistic. and Bartlett's The results obtained are presented in Table 4.

**Table 4.** Kaiser-Mayer-Olkin and Bartlett tests

| KMO measure of sampling adequacy. | | 0,852 |
|---|---|---|
| Bartlett's sphericity test | Approximate chi-square | 2404,203 |
| | df | 210 |
| | Relevance | 0,000 |

*Source:* Authors' elaboration

The K-M-O measure is more than 0.5, which means that factor analysis will give a satisfactory reduction of variables. Bartlett's test of sphericity for p < 0.001, in turn, allows us to assume that there are correlations between variables, that is, latent factors.

**Factor analysis**

One of the tasks of the analysis is dimension reduction, which allows to assess the optimal number of principal components. For this purpose, one of the most common methods of identifying the number of factors which is the Kaiser criterion was chosen. This criterion considers factors for which the eigenvalue is greater than the average of the eigenvalues to be significant. Table 5 indicates only those components that meet the eigenvalue criterion >1.

**Table 5.** Total explained variance

| Component | Initial eigenvalues | | | Sums of squares of charges after separation | | |
|---|---|---|---|---|---|---|
| | Total | % of variance | % cumulative | Total | % of variance | % cumulative |
| 1 | 7,765 | 36,976 | 36,976 | 7,765 | 36,976 | 36,976 |
| 2 | 2,587 | 12,318 | 49,294 | 2,587 | 12,318 | 49,294 |
| 3 | 1,545 | 7,358 | 56,652 | 1,545 | 7,358 | 56,652 |
| 4 | 1,199 | 5,710 | 62,362 | 1,199 | 5,710 | 62,362 |
| The method of extracting factors - the main components. | | | | | | |

*Source:* Authors' elaboration

The results showed that exactly four components meet the criterion for which the eigenvalue is greater than 1. The first two components are the strongest, explaining respectively 37% and 12% of the variability of all questions In total, all components explain 62% of the variability of all questions. This means that four factors should be extracted in further analysis. Values less than 0.3 have been removed from Table 6.

**Table 6** Matrix of rotated components

| Symbol | Risk area | Component | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| **C3e** | Choosing supply chain partners based on environmental regulations | ,866 | | | |
| **C3f** | Recycling of damaged and useless goods | ,787 | | | |
| **C3d** | The move toward greener and more environmentally energy sources | 0,765 | 0,390 | | |
| **C3c** | Employee participation in environmental conservation initiatives | 0,754 | | | |
| **C3b** | Reducing waste generation from company related activities | 0,660 | | -0,361 | |
| **C3a** | Procurement strategy beneficial to the environment | 0,622 | | -0,423 | |
| **C2a** | War between nations | 0,459 | 0,404 | -0,355 | |
| **C4d** | Purchasing power (amount of money with customers and businesses available to spend) | | 0,793 | | |
| **C4c** | Economic sanctions on some countries | | 0,770 | | |
| **C4b** | Implementation of new economic and trade policies by countries | | 0,749 | | |
| **C4e** | Economic growth of a country | | 0,698 | | |
| **C4a** | Inflation | | 0,663 | 0-,327 | |
| **C1d** | Shortages at the supplier level | | | 0,861 | |
| **C1e** | Weakness of just-in-time strategy | | | 0,734 | |
| **C1c** | The reduced amount of cash inflow | | | 0,710 | |
| **C2e** | Increase in fuel price due to opec plus nations producing less oil(opec = organizations of the petroleum exporting countries) | 0,351 | 0,334 | -0,552 | |
| **C1b** | Transition to (work from home ) / remotely | | | 0,510 | |
| **C2d** | Electronic equipment supply shortage (microprocessors, transistors, capacitors) | 0,307 | | | 0,710 |

| C1a | Labor shortage caused by pandemic | | | 0,396 | -0,653 |
| C2c | Shift in the economic power (western countries to Asia) | | | | 0,642 |
| C2b | Change in the energy sources on the market | | 0,364 | | 0,383 |

*Source:* Authors' elaboration

After performing an orthogonal rotation analysis of the factors using the Varimax method, it was found that the first factor strongly loads questions from the Environmental area and about the war in Ukraine. The second covers the entire economic area. The third factor partially covers aspects related to the pandemic and rising fuel prices. The fourth factor focused mainly on political factors and changes in the workforce as a result of the pandemic. The first factor (F1) can be called an environmental factor, the second an economic factor (F2), the third an organizational factor (F3) and the fourth a resource factor (F4). Each factor was checked for scale reliability, resulting in both question C2e and C1a requiring scale inversion. Ultimately, for each indicator $\alpha > 0.07$, the scale should therefore be considered reliable. The indices of the four variables were then estimated using a regression method that took into account the factor loadings of each question in each factor. The factors finally took on a binomial value, where 1 meant a value below the mean, while 2 meant a value above the mean (in terms of the variable in question).

**Testing the significance of differences**

Then, in order to test the significance of differences between the factor group and the efficiency results group, a K-W test was applied, the results of which are presented in Table 7.

Table 7. Results of the Kolmogorov-Smirnov test

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 |
|---|---|---|---|---|---|---|---|---|---|
| F1 | | | | | | | | | |
| H Kruskal-Wallis | 20,421 | 14,544 | 2,659 | 27,743 | 12,798 | 10,510 | 16,952 | 31,803 | 16,184 |
| Asymptotic significance | <0,001 | <0,001 | 0,265 | <0,001 | 0,002 | 0,005 | <0,001 | <0,001 | <0,001 |
| F2 | | | | | | | | | |
| H Kruskal-Wallis | 13,132 | 9,290 | 1,341 | 5,129 | 12,989 | 24,235 | 0,002 | 14,731 | 7,957 |
| Asymptotic significance | 0,001 | 0,010 | 0,512 | 0,002 | 0,002 | <0,001 | 0,999 | <0,001 | 0,019 |
| F3 | | | | | | | | | |
| H Kruskal-Wallis | 0,118 | 2,359 | 14,291 | 0,176 | 2,499 | 0,122 | 0,718 | 0,317 | 0,802 |
| Asymptotic significance | 0,943 | 0,307 | <,001 | 0,916 | 0,287 | 0,941 | 0,698 | 0,854 | 0,670 |
| F4 | | | | | | | | | |
| H Kruskal-Wallis | 0,545 | 4,254 | 3,655 | 0,136 | 0,781 | 1,430 | 0,426 | 0,174 | 4,416 |
| Asymptotic significance | 0,761 | 0,119 | 0,161 | 0,934 | 0,677 | 0,489 | 0,808 | 0,917 | 0,110 |

*Source:* Authors' elaboration

The assumption of the K- W test is that if $p < 0.05$ then the null hypothesis of no difference between groups should be rejected. Thus, for most of the variables studied, there are significant differences between their groups.

The most common differences are between the change in efficiency and the F1 factor for the environmental area and the F2 factor for economic aspects. Significant differences between the groups for the organizational area factor F3 occur only in the case of the change in performance from the Logistics cost area (P3). In contrast, for the resource factor F4, no significant differences were identified between groups for any of the performance indicators. Both the F3 and F4 factors similarly affect the level of change in performance indicators. The obtained results allow to partially confirm the main hypothesis. It is shown that the level of assessment of the impact of environmental and economic factors on the supply chain causes a change in the efficiency of companies operating in the chain. The further part of the study focuses exclusively on the analysis of significant differences between the group of factors and changes in efficiency scores.

**Table 8.** Shaping of the efficiency results of enterprises due to the evaluation of the influence of macro-transformation factors due to the relevance of links

| | F1 | | F2 | | F3 | |
| --- | --- | --- | --- | --- | --- | --- |
| | Low | High | Low | High | Low | High |
| P1 | 3,18 | 3,53 | 3,05 | 3,75 | | |
| P2 | 3,06 | 3,53 | 3,07 | 3,63 | | |
| P3 | - | - | - | - | 3,14 | 2,72 |
| P4 | 2,95 | 3,70 | 3,16 | 3,63 | | |
| P5 | 3,28 | 3,75 | 3,29 | 3,87 | | |
| P6 | 3,38 | 3,81 | 3,25 | 4,06 | | |
| P7 | 3,12 | 3,51 | - | - | | |
| P8 | 3,06 | 3,73 | 3,16 | 3,77 | | |
| P9 | 3,13 | 3,40 | 3,18 | 3,65 | | |

*Where a score of 1.0- 2.9 indicates a deterioration in performance relative to the previous period, an average of 3.0 - 3.5 indicates no effect of the factor on changes in the performance index, an average of 3.6 - 5.0 indicates an improvement in performance relative to the previous year.

*Source:* Authors' elaboration

In the case of statistically significant differences between the studied groups (Table 8), it can be observed that companies that rate the impact of the studied factors on supply chain operations at a below-average level have a higher risk of worsening efficiency results. This risk is greatest in the case of warehouse inventory performance management (P4) in the area of the environmental factor. In contrast, companies that rate the impact of the factors studied at above average levels are more likely to observe a lower risk of deterioration of these results. The lowest risk of unfavorable changes is observed in the fulfillment of customer requests (P6) in the area of the economic factor. At the same time, the greater the influence of the organizational factor (F3) on the functioning of the supply chain, the greater the risk of deterioration in the results regarding logistics costs (P3). What companies should be most concerned about are the environmental factor and the economic factor, which affect the largest number of performance indicators. This may mean that companies that rate the occurrence of macroeconomic factor risks higher have a greater awareness of the need to adapt to the surrounding environment. At the same time, it should be remembered that both the results of the impact of individual factors and performance indicators were most often at the average level, which somewhat narrows the judgment due to the high frequency of assessments with values close to the average.

## 5. Conclusion

Companies that rate the impact of economic and environmental factors below average are more likely to have deteriorating efficiency results. On the other hand, companies that rate the impact of each factor at above average have a greater chance of improving their efficiency performance compared to the previous period. At the same time, in the case of the entity management factor (F3), companies that rated the impact of this factor on the company's operations above average tended to observe a deterioration in efficiency in the area of logistics costs incurred. According to the McKinsey Global Institute report, the source of vulnerability and resilience building is supply chain operations. Depending on the effectiveness of risk monitoring, implementation of risk management strategies and proper planning of future operations, the impact of emergencies on efficiency results can be significantly reduced (Lund et al., 2020).

Emerging changes and crisis situations in the market, contrary to appearances, did not significantly worsen the performance results of the surveyed companies. This may be due to the increased activity of companies as a result of the changes taking place, in order to catch up with the competition and survive in a dynamic market. Awareness and the ability to anticipate risks and adaptability can significantly minimize the risk of reducing the efficiency of global supply chains. This is supported by the results of many studies. Henrich et al. (2022) highlight in their article the agility and flexibility of the supply chain, which is becoming one of the key prerequisites for companies to survive against rapidly changing and increasingly volatile customer needs. "Future supply chains will need to be much more dynamic-and be able to predict, prepare, and respond to rapidly evolving demand and a continually changing product and channel mix. In short, supply chains will need to become agile" (Henrich et al., 2022) In order to mitigate the negative effects of crisis situations, Raj et al. (2022) recommend choosing suppliers located closer to the company, redefining security levels or reaching for artificial intelligence tools. At the same time, it is almost impossible to exclude economically destructive events, so it is important in this aspect to mitigate their negative effects with appropriate risk management plans. Smirnov and Suresh (2020) proved in their research that risk management strategies benefit and help reduce the impact on supply chains. Accordingly, improving the flexibility and resilience of supply chains determines its well-being even during disruptions.

At the same time, our research has shown that an area that requires special observation concerns environmental and economic factors that significantly affect changes in supply chain efficiency scores, which include the companies studied. The demonstrated differences in changes in the level of efficiency differ significantly at the average level, where the evaluation of these indicators in relation to the previous year was above average, while the evaluation of the impact of individual factors on changes in the supply chain at the average level.

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**Katarzyna GRONDYS,** PhD, Czestochowa University of Technology, The Faculty of Management; Armii Krajowej 19B, 42-201 Częstochowa, Poland
**ORCID ID**: https://orcid.org/0000-0001-6461-5475

**Michał KOT**, Czestochowa University of Technology, The Faculty of Management; Armii Krajowej 19B, 42-201 Częstochowa, Poland
**ORCID ID:** https://orcid.org/0000-0002-5449-593X

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