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Identification and Classification of Global Theoretical Trends and Supply Chain Development Directions

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Abstract: The study presented in the paper is an innovative research approach. It is the result of linking the concept of supply chain management and global changes, which at present are clearly visible on a global scale, with research methodology based on the systematic literature review, knowledge visualization and an expert method that makes use of knowledge, experience and opinions of experts in a given field. This research is about a Delphi study that was conducted in the context of the development of trends of supply chain and global changes, based on the findings of a systematic literature review. The qualitative study was conducted with 30 Delphi experts in the field of the supply chain. This progressive approach to the research topic allowed us to discover key global trends and modern supply chain development directions in the context of global changes, as well as their assessment and projection of the developmental potential of these trends.

Keywords: supply chain; bibliometric analysis; knowledge visualization; Delphi; Industry 4.0; COVID-19 pandemic; consumption changes; environmental changes

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1. Introduction

Nowadays, changes are even faster and even more unpredictable. The contemporary world economy is characterized by increasing industrial and economic dynamism and the breakthrough nature of social changes. The digital and industrial revolution, pandemic circumstances and social changes continue to create new, previously unknown phenomena that shape the new economy and its new entities and services, previously completely unknown. The dynamic development of industry, including Industry 4.0, is the result of some processes, such as internationalization, and the development of information technology, as well as hyper-competition. The world is experiencing a progressive increase in the level of digitization, manifested by the interconnection of people, objects and systems through the exchange of data in real time. This also applies to supply chains that are in a permanent state of transformation.

Supply chains are groups of business organizations that together contribute to processing raw materials into final products [1,2]. These cooperating companies are perceived as an entity—separate but whole. Supply chains are developed by progressing the process of elimination of barriers between companies and transgressing traditionally defined boundaries of companies [3]. Global changes impose changes and modifications in supply chains, which should be designed in such a way that, if necessary, they could be easily and quickly adapted to rapidly changing levels and structures of supply and demand. Global competition and rapidly changing expectations and requirements of the final customer force major changes in the style and configuration of business organizations and supply chains [4]. The better the current and future needs of created structures are understood, the better the supply chain will function.

Since 1980, this concept has developed significantly in both the theory and practice of logistics management. As a consequence, we also have much more knowledge about organization, functioning and supply chain management [5,6].

The past few years have seen a growing trend in the number of research papers published on the topic of supply chains. It shows the importance of this issue concerning theoretical questions and economic practice. However, it also has negative consequences as knowledge is scattered and available in a fragmentary way. The threads raised are often quickly abandoned or evolve into new concepts. Hence, there is a need for knowledge about supply chains to be systematized and structuralized. The current state of knowledge requires an in-depth analysis to systematize and rationalize it. Therefore, it is justifiable to examine the process of knowledge development and its dynamics to reveal its evolution over time, and to identify global trends and supply chain development directions in the context of global changes.

Scientific considerations discussed in this paper take into account the epistemological aspect. Since management and quality sciences are polyphonic sciences, it means that each idea is independent and equal, and the coexistence of many ideas and paradigms is possible and indisputable. The conducted study and the presented paper feature two main research goals: (1) to indicate global theoretical trends and supply chain development directions in the context of global changes; (2) to assess the developmental potential of the identified trends, based on expert opinions. The research goals set in the paper seek answers to two questions:

1. What are the global theoretical trends and supply chain development directions that have appeared over the years?
2. What is the developmental potential of the identified trends in the research area?

The answer to the first question was obtained through a bibliographic analysis based on the systematic literature review and knowledge visualization. The answer to the second question was obtained based on expert opinions by using the Delphi method.

The rest of the article is organized as follows: part 2 discusses the context of global changes that businesses and supply chains must grapple with. In the part 3, the conceptual framework of the conducted research and the research methodology is presented. Part 4 presents the results of the study. The paper ends with a summary specifying further research directions.

2. The Context of Global Changes

The factor that inspires scientists to stimulate, research and leads to the generation of new knowledge is undoubtedly economic volatility. Enterprises and supply chains alike must react extremely quickly to the challenges and opportunities of the business world [7], adapting their structure and processes to customer requirements and introducing all kinds of innovations and changes. At present, an undeniable continuous material and technological progress can be observed. At the same time, symptoms of the disorder, inequality, asymmetry and dysfunction in the economic, social and environmental spheres are becoming more and more visible on a global scale.

The industry is an economic activity characterized by multilateral supply and production ties with other sectors of the economy and increasing relationships with the development of science. One can observe many-sided connections with economic and social development. Uncertainty and volatility on the market force changes and modifications to supply chains, which should be designed in such a way that, if necessary, they can be easily and quickly adapted to rapidly changing levels and the structure of supply and demand.

Global changes, or components of global changes, are related, among others, to:

- Dynamic development of technology and production organization, commonly referred to as the "fourth industrial revolution" or Industry 4.0. The approach of the so-called Industry 4.0—the "fourth industrial revolution"—may be also confirmed by reviewing leading domains in publications [8,9]. Industry 4.0 uses modern technological solutions, which include cyber-physical systems, the Internet of Things and cloud computing [10]. Industry 4.0 is a heterogeneous concept which combines many numbers of solutions of a different nature. Its enormous potential creates many new

opportunities, but at the same time it is a challenge resulting from the need to use advanced technologies [11–13]. The digitalization related to Industry 4.0 is unavoidably changing the way supply chains (SCs) are designed and managed [14]. It is believed that the integration of all stakeholders involved in value creation throughout the entire flow of goods is the best approach. Therefore, in the context of Industry 4.0, not only manufacturers, but entire supply chains in which manufacturers operate, should be analyzed and redesigned, modeled and managed;

- Highly dynamic global changes related to the COVID-19 pandemic and the resulting consequences for the sustainability and continuity of supply chains, which made everyone realize that creating and resting the supplier base in only one country/region or importing goods from the other side of the world may be too risky. The very nature of the epidemic threatens not only human life but also the foundations of the economy—the free movement of people and goods [15,16]. The social, political and economic shock caused by COVID-19 is self-evident, and the rapidly changing global crisis raises the question of whether our worldview has changed as well [17]. Supply chains had to adapt quickly to demand-related shocks that resulted from unpredictability and panic buying. On the other hand, they had to allow for any supply-related disruptions in their planning, i.e., potential shortages of human resources and transport disturbances [18]. The COVID-19 pandemic has affected supply chains by demonstrating their lack of resilience and effects felt by the negative impact of disruptions on a global scale. This is largely due to unreliable individual connections and nodes in the supply chain. The COVID-19 pandemic is a crisis of unprecedented proportions that has contributed to global changes—the near future is expected to see the beginning of a major redesign and remodeling of supply chains;
- Great changes in consumer behavior, which are the result of, among others, the global COVID-19 pandemic. They have affected the operational activity of supply chains. Additionally, the development of the global economy has caused a significant increase in the worldwide production of goods, including food and services, and an excessive increase in consumption. New organizational, consumer, political and supply chain behavioral patterns are now being identified [17]. Consumption and environmental changes are also related to the new European green deal. It indicates a comprehensive approach and the participation of all actions and policies of the European Union countries. More sustainable, intelligent social engineering systems are needed [19]. The new green deal promises interrelated initiatives (e.g., in climate, environmental, energy, transport, industrial, agricultural and sustainable finance policies). It also points to promoting and working towards a more dynamic, resilient and competitive European industry. This means basing the economy on the principles of competitiveness, single market integration, equivalence, cohesion, inclusiveness, solidarity, circularity and environmental protection while respecting social standards. A shortage of demand can be observed, which collides with overproduction and extensive negative consequences associated with it, such as destructive competition, aggressive advertising of goods, consumerism and degradation of the natural environment. Uncontrolled consumption leads to environmental degradation through the overexploitation of renewable and non-renewable natural resources. Increasing manifestations of the syndrome of the glut economy related to products and services can be noticed, which leads to wasting various resources. It contributes to the wastage of goods and human labor. It also causes significant economic disproportions between people [20]. Improper distribution of products contributes to wastage in highly developed countries and continuing shortages in poor countries [21]. These phenomena are closely related to growing social inequalities. The situation with COVID-19 shows that consumer behavior has changed. One can notice a distinctly newer pattern of consumption and shift to online shopping, delivery and e-commerce [22,23]. The main behavioral problem of the last year (2020/2021) has also been the fact that there is a negative perception of reuse and recycling.

Taking the above into account, it can be stated that the phenomenon of global changes makes supply chains more and more susceptible to disruptions. Their unpredictability and instability are becoming a daily occurrence. Disruptions, both natural and man-made, are an inherent element in the global context of all supply chains.

The supply chain concept goes beyond the area of an individual enterprise. It is a concept of inter-organizational problem solving, logistics and management at the level of meta-solutions. The holistic view of complex systems, which are supply chains, has caused that the central point of research in management sciences to shift from the aspect of a single enterprise operating in the environment towards the cooperation of enterprises in a larger community.

3. Methodology

The conducted study combines supply chain management and global changes. It also takes into account research methodology based on the systematic literature review, knowledge visualization and an expert method that makes use of experts' knowledge, experience and opinions. The overall research plan was divided into four stages (Figure 1):

1. The bibliometric analysis conducted employing the systematic literature review method [24] made it possible to evaluate the research results and comprehensively present the global scientific output. It provided essential information about the global structure of science and showed its dynamics. The analysis was carried out in three steps: (1) the scope of the analysis was identified; (2) keywords, document types and kinds and language were identified; (3) the selection, evaluation and synthesis of the existing set of reviewed and registered research papers in the analyzed databases were carried out. The result of this approach is a collection of scientific publications, identified in a systematic, open, comprehensive and repeatable manner, and yielding the same results [25]. The identified set of selected scientific publications was used to move to the second stage and conduct further research. Adopting this approach allows the identification and classification of trends of the supply chain that affect the development of knowledge in a given field in a more objective and scientific.
2. The identification and classification of global theoretical trends and supply chain development directions in the context of global changes, performed by cluster analysis using genetic algorithms, made it possible to identify conceptual clusters by singling out a group of similar objects which coexist intensively. The study was conducted using the VOSviewer free software. This stage allowed us to understand the interdisciplinary character of the studied area [26]. This stage of research was creating (generating) knowledge maps as semantic maps. It is an actively developing method of assessing the results of scientific research and a comprehensive approach to global scientific achievements. It provides important information about the structure of science and shows the dynamics of changes in scientific research directions. This stage of research enables the acquisition of both necessary and unique information. Semantic maps are a relatively new form of knowledge presentation [27]. As a result of cluster analysis, key global theoretical trends and supply chain development directions were identified, and the third stage was initiated.
3. Expert evaluation and projection of the developmental potential of the identified trends were carried out using the Delphi method. The Delphi method was used as an expert evaluation [28] to investigate possible trends in supply chains regarding their further development. The Delphi method relies on solid concepts to draw conclusions supported by arguments [29]. Experts from the academic community, both from Poland and abroad, who scientifically deal with the subject of supply chains were selected. They had extensive source knowledge. Thanks to this fact, it was possible to confront the experts' opinions with diverse and independent views representing diverse scientific circles. By analyzing the experts' opinions selected for the study, it was possible to indicate the potential of the specified trends in supply chains in the context of global changes and the possibility of translating the results of scientific

research on these trends into benefits resulting from the industrial implementation of these trends. The study allowed to develop recommendations and indicate further research directions.

4. Development of recommendations and indication of further research directions.

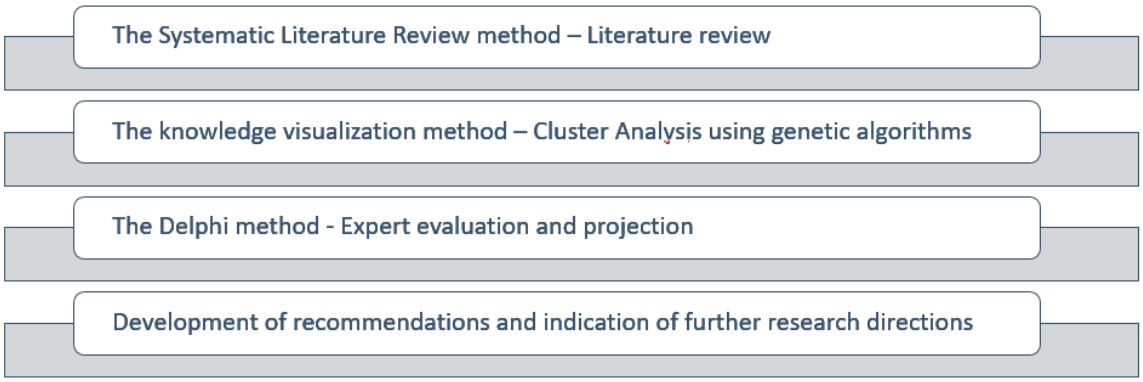

Figure 1. Research steps to carry out the study.

As mentioned above, the current state of knowledge was analyzed employing the systematic literature review. Firstly, the review provided a picture of the existing knowledge on supply chain trends and their diversity, and possible supply chain development directions. The study resulted in the creation of a set of key supply chain trends. Secondly, the study led to an initial framework for the structure of scientific output related to supply chains. It also provided a framework for the conceptual design and approach used in the Delphi method.

The literature review followed by an expert opinion analysis using the Delphi method was considered as an appropriate approach in finding answers to the research questions posed. It was also found that both of the applied methods were properly adapted and compatible in terms of their application. This, in effect, led to obtaining the right results. The Delphi study was conducted following a structured process. It included two Delphi rounds (to collect information from the experts) and the stage of verifying opinions and finally prioritizing the potential of supply chain trends (Figure 2).

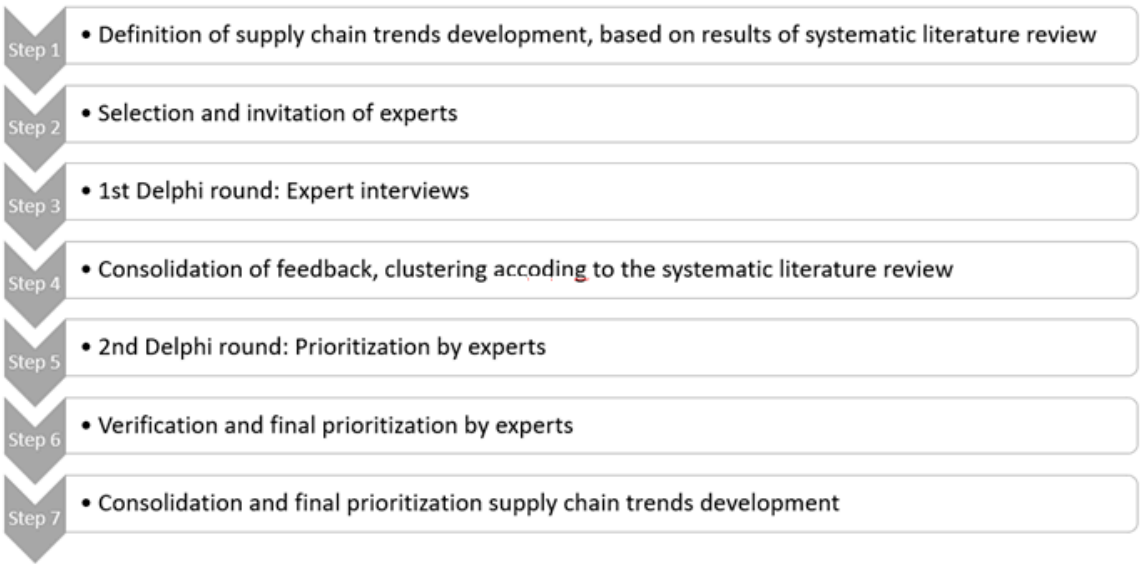

Figure 2. The structured process of the Delphi study for supply chain trends development.

The Delphi study was conducted by correspondence, which means that the entire research procedure was carried out without experts meeting each other. Experts invited to take part in the study did not even know the names of other study participants. Thanks to such a solution, it was possible to maintain the full anonymity of experts who, unhampered by time, had the opportunity to reflect longer before responding. Formulating answers at home, they also had the opportunity to use professional literature.

In the first step, the concept of individual rounds of the study was developed and a set of Delphi questionnaires for each round was prepared. The questionnaires were prepared based on the literature review results. The preparation of questions for experts was closely related to the result of the latter. In the next part of the study, each expert was sent an e-mail containing a reminder of the study objectives, instructions on how to complete the Delphi questionnaires and the Delphi questionnaire.

The second step in the study was to select a sample of thirty high-class experts from the academic circle—supply chain researchers of diverse scientific backgrounds. The experts invited to participate in the Delphi study were deliberately selected. It should also be emphasized that the selection of experts did not reflect a random sample of any given population. Selecting the right experts is a prerequisite for a successful Delphi exploratory study, the more so as the goal is to find an answer to a complex and new research problem. The quality and uniqueness of experts, not the number of participants, is therefore the most important factor for a qualitative study [30].

The group of experts consisted of representatives of the world of science from leading centers in Poland (15) and abroad (15). It was possible to maintain an equal gender division—50% women and 50% men. The structure considering the respondents' job experience was diverse (Figure 3). Experts with 10 to 20 years of job experience (63%) had the largest share in the sample, but there were also a lot of experts with 21–30 years of job experience (23%).

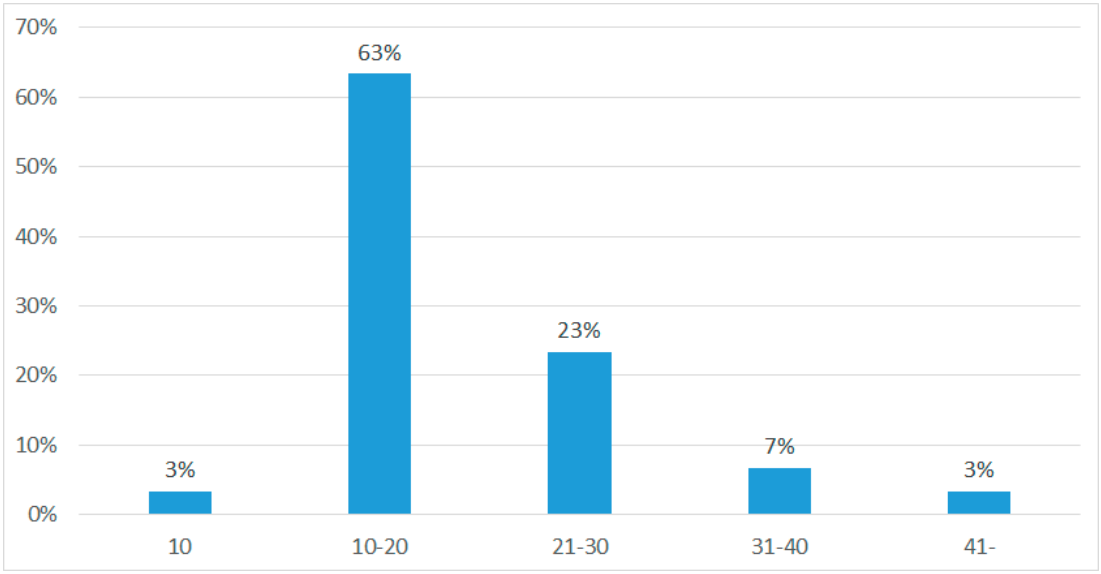

Figure 3. Structure of the Delphi expert study participants by job experience; own elaboration based on the conducted research.

Relying on experts' intellectual potential has important consequences in research methodology. The Delphi method is as accurate and reliable as the experts who take part in it. Therefore, the quality of opinions and predictions developed with this method depends on the quality of selected experts (Table 1). However, not everyone who considers themselves an expert is an expert, and not everyone who makes a critical or lower self-evaluation of their knowledge is not an expert. Therefore, the correct selection of experts and minimizing the risk of seeming expert knowledge are the main challenges related to conducting Delphi research.

Table 1. Demographics Delphi participants.

Delphi Expert	Job Experience Scientific Experience	Level of Expertise	Top-Expert
Expert 1	35	7	Yes
Expert 2	15	5	
Expert 3	18	5	
Expert 4	27	7	Yes
Expert 5	18	7	Yes
Expert 6	16	5	
Expert 7	19	6	
Expert 8	24	6	
Expert 9	22	5	
Expert 10	25	7	Yes
Expert 11	13	5	
Expert 12	15	7	Yes
Expert 13	15	7	Yes
Expert 14	27	7	Yes
Expert 15	40	7	Yes
Expert 16	25	7	Yes
Expert 17	20	7	Yes
Expert 18	14	7	Yes
Expert 19	20	5	
Expert 20	23	5	
Expert 21	15	5	
Expert 22	19	6	
Expert 23	15	5	
Expert 24	18	7	Yes
Expert 25	18	5	
Expert 26	45	7	Yes
Expert 27	14	6	
Expert 28	17	6	
Expert 29	15	5	
Expert 30	10	5	

Representatives of the world of science who hold the academic title of professor (22 experts, 73%) and doctor (8 doctors, 27%) were selected for the study. Experts with documented scientific achievements in the area of logistics and, above all, supply chains were selected. Based on the self-assessment of their knowledge (7-point Likert scale), the structure of participants in the expert study was established. A particularly high expert level (self-assessment 7), which manifests itself in a particularly high substantive experience, qualitatively and significantly exceeding the knowledge and experience of formally educated people, referred to 43% of experts, the so-called top-experts. On the other hand, 20% of experts indicated a high expert level (self-assessment 6; Figure 4).

To eliminate the effect of excessive optimism of top experts in the study and to minimize the lower tendency to change their opinions in subsequent rounds of the study than by other experts, it was justified to differentiate the level of expert knowledge (Figure 4).

The study, from the third to the sixth step, was conducted from February to May 2020. The study consisted of surveying the same group of experts twice and verifying their opinions. Only experts who took part in the first round of the Delphi survey were invited to participate in the second round and verify their opinion (third round). At the verification stage, the experts could, under the influence of the general opinion, change their position and opinion about the analyzed issue. They could also uphold them.

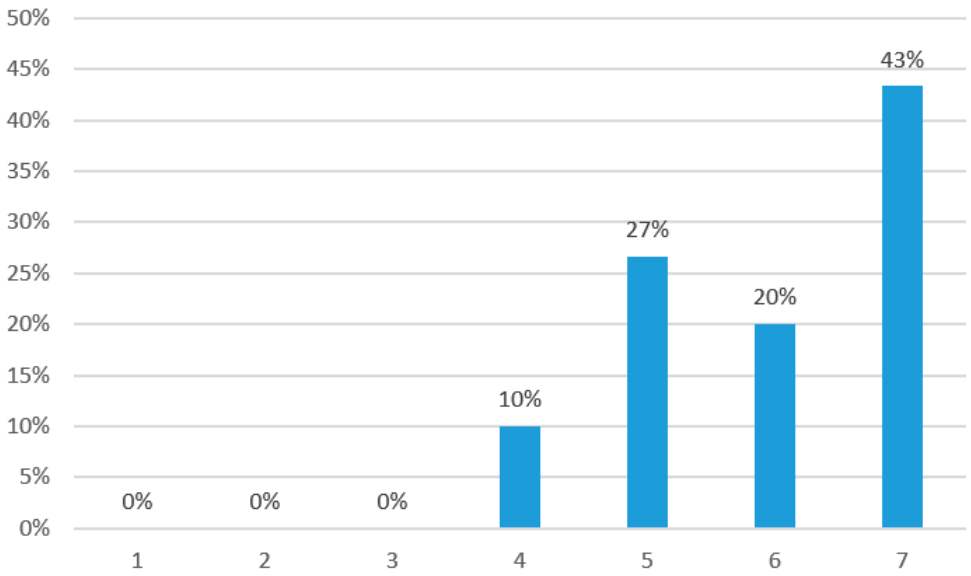

Figure 4. Self-assessment of expert knowledge on a 7-point Likert scale; own elaboration based on the conducted research.

The rules of the study were:

1. Observing the collective results after the first round;
2. Seeing the collective expert responses after the second round;
3. Obtaining a consensus based on the experts' responses from the previous round;
4. Avoiding dominant personalities during the responses;
5. Compliance of opinions, understood as equivalent to their truthfulness and accuracy;
6. Maintaining full anonymity of experts;
7. Lack of direct exchange of views;
8. Expert opinion feedback available as averaged results with a median.

These rules were assessed by the experts on a scale from 1 to 9, where 1 meant that "I disagree/do not value the rule" and 9 meant that "I fully agree/I highly value the rule" (Figure 5) and motivation of experts were assessed by the experts on a scale from 1 to 9, where 1 meant that "I disagree" and 9 meant that "I fully agree" (Figure 6).

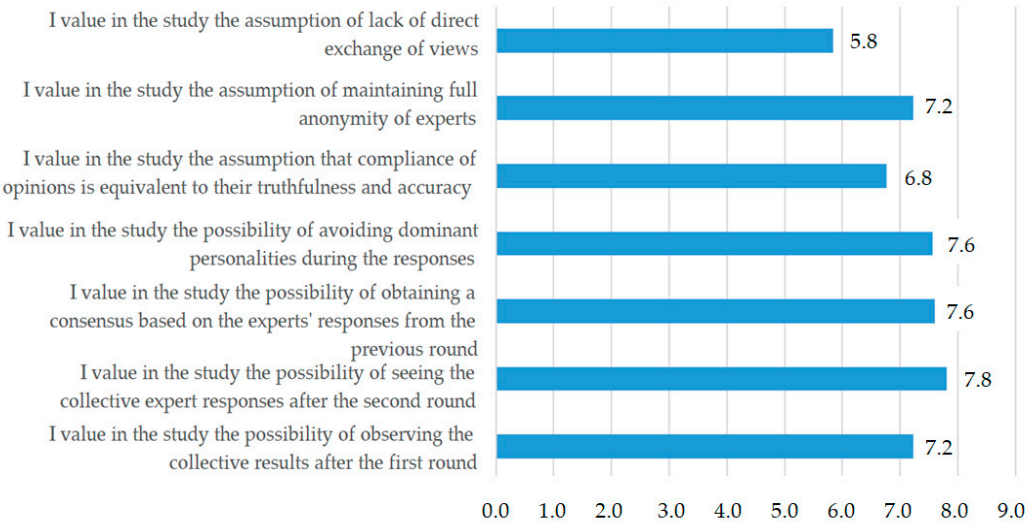

Figure 5. Experts' belief in the binding rules of the Delphi method study (mean values, sample n = 30); own elaboration based on the conducted research.

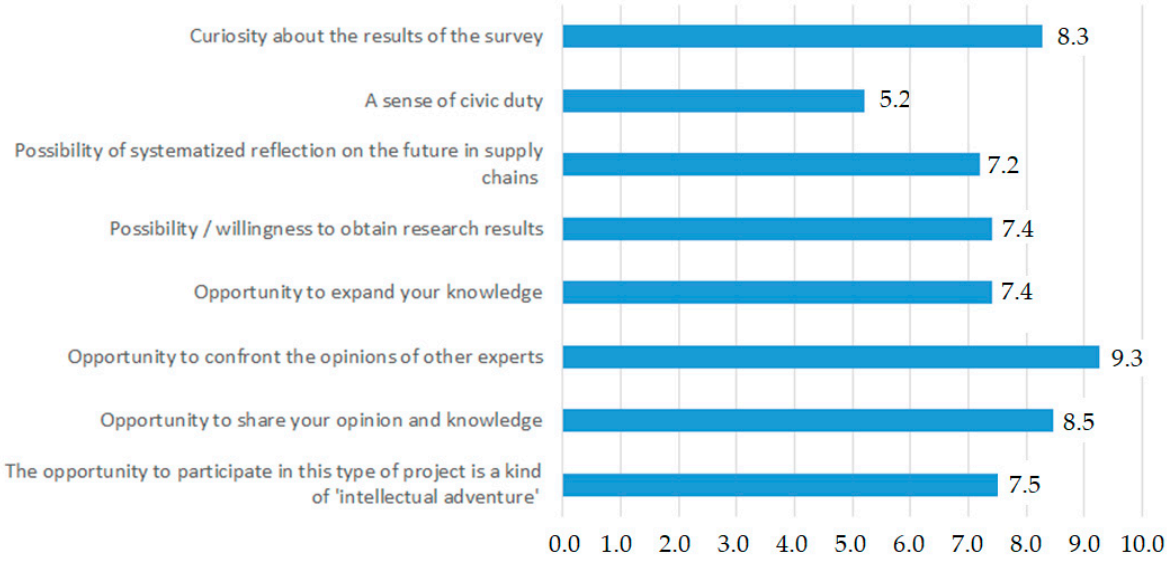

Figure 6. The motivation of experts to take part in the Delphi method study (mean values, sample n = 30); own elaboration based on the conducted research.

The Delphi method is a structured communication technique, which is developed as an interactive systematic prediction method, based on a panel of experts [28,31]. The Delphi technique facilitates collective intelligence [32]. The Delphi method therefore includes elements of an expert discussion (free from the influence of authorities and personalities), the effect of which is to build a consensus related to the shape of the future.

4. Research Results

Based on the bibliometric analysis using the method of the systematic literature review and cluster analysis performed with genetic algorithms, global theoretical trends in supply chains were identified (Table 2; Figures 7 and 8).

Table 2. Identified global theoretical supply chain trends, alphabetical order; own elaboration based on the conducted research.

No.	Supply Chain Trends
1	Closed-loop Supply Chain
2	Digital Supply Chain
3	Flexible Supply Chain
4	Food Supply Chain
5	Global Supply Chain
6	Green Supply Chain
7	Humanitarian Supply Chain
8	Multiagent Supply Chain
9	Multichannel Supply Chain
10	Resilient Supply Chain
11	Reverse Supply Chain
12	Service Supply Chain
13	Smart Supply Chain
14	Sustainable Supply Chain

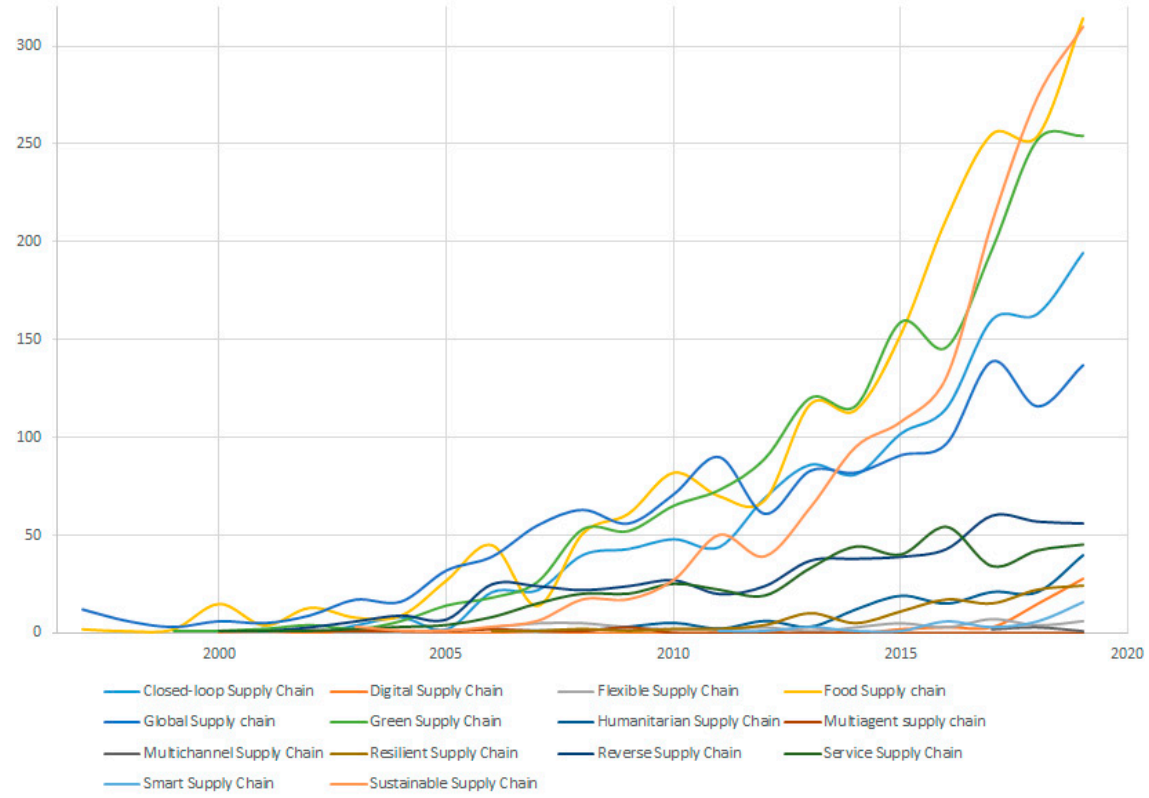

Figure 7. Supply chain trends (data including full trend names); own elaboration based on the conducted research.

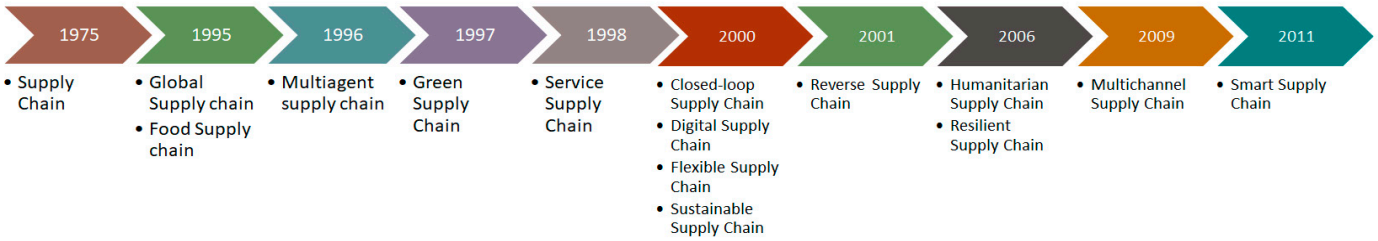

Figure 8. Supply chain trends recognized in own research; own elaboration based on the conducted research.

In the study conducted with the Delphi method, the experts were asked to indicate the potential of the specified trends in supply chains in the context of global changes and the possibility of translating the results of scientific research related to these trends into the benefits resulting from industrial implementation. This indication consisted in the experts performing the ranking (prioritization) of identified theoretical global trends in supply chains.

The purpose of assigning ranks and priorities was (1) to facilitate the resolution of issues related to the assessment of the actual rationality of the activities carried out, and (2) to standardize and facilitate taking future decisions related to the industrial implementation of the supply chain trend. The analysis was also intended to organize and channel future intellectual effort. In situations of the high variability of conditions (and such is the case nowadays), assigning ranks and priorities was also used to stimulate so-called selective thinking and acting to identify key supply chain trends and focus on them in the future.

In the first round of the study with the Delphi method, each identified supply chain trend was ranked on an adopted scale from 1 to 10, and then the final hierarchy was established based on the obtained results. Such ranking, unfortunately, did not reflect clear differences between the ranked trends in supply chains. It revealed its rather "flat" character. Therefore, a different ranking method was used in the second round of the study.

The experts were asked to rank the supply chain trends by allocating 100 points for the entire set of the studied supply chain trends. The distribution did not have to be even. This approach assumed that the sum of the final ranks of the assessed supply chain trends should be 100 points. This ranking method turned out to be both highly flexible, efficient, little time-consuming for the experts, and relatively simple. First of all, this method allowed for much greater possibilities of differentiating the final ranks compared to the technique used in the first round. The ranking method according to the distribution of 100 points was also used to verify the experts' opinions.

In the third round of the survey with the Delphi method (opinion verification), the personalized questionnaire indicated: (1) supply chain trends ordered according to the indications from the second round from the most numerous to the least frequently indicated, with the indicated (2) mean value and (3) median value from the respondents' statements from the second round and (4) the individual value indicated by the expert in the second round. Based on the opinions from the previous rounds, the experts were asked to maintain their opinion/rank or change it. The distribution of points by the experts took into account dynamic global changes.

As a reminder, three components of global changes were distinguished which affect the world economy and the condition of countries and societies. They are:

1. Dynamic development of production technology and organization (Industry 4.0);
2. Dynamic global changes related to the COVID-19 pandemic;
3. Great changes in consumer behavior.

4.1. Supply Chain from the Point of View of the Dynamic Development of Technology and the Perspective of Production Organization (Industry 4.0)

Bearing in mind the changes in the direction of dynamic development of technology and production organization (Industry 4.0), the experts ranked theoretical global trends in supply chains. The results of the expert assessment from the last round of the study are shown in Figure 9.

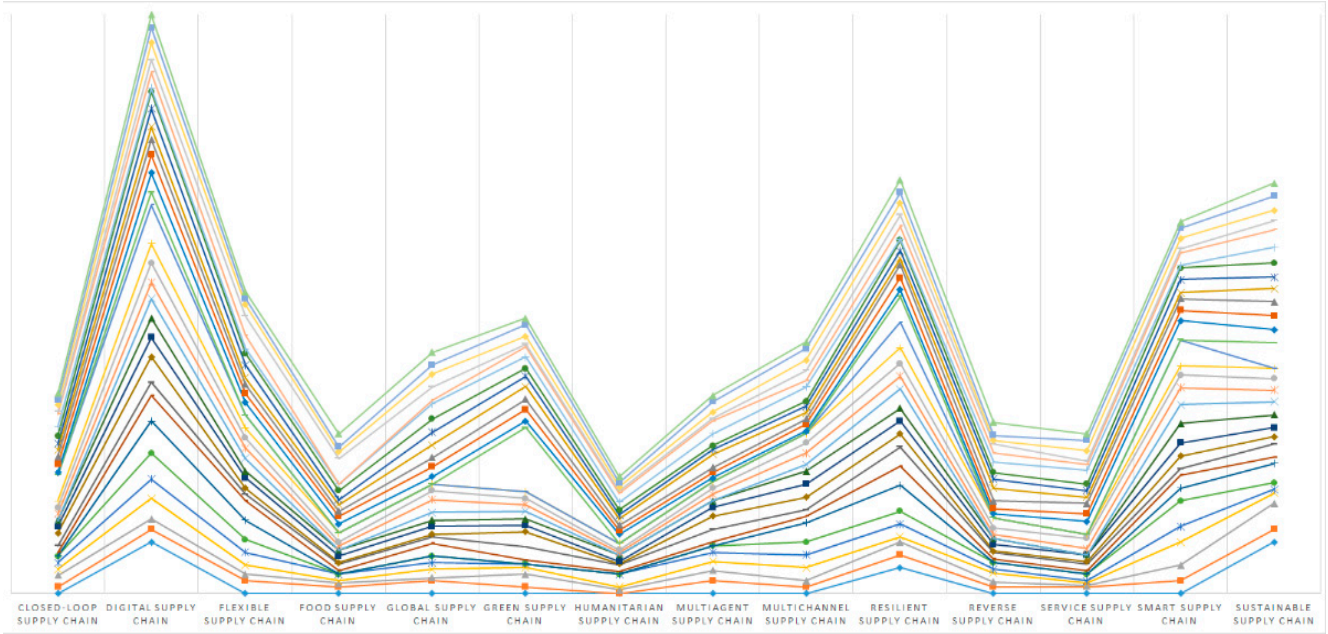

Figure 9. Ranking graph of global theoretical trends and supply chain development directions in the context of the dynamic development of technology and production organization (Industry 4.0) according to the experts' assessments 1–30; own elaboration based on the conducted research.

The graph (Figure 9) clearly shows the similarity of the experts' indications concerning the assessments of individual supply chain trends. According to the assumptions adopted in the Delphi method, the concurrence of opinions is understood as being equivalent with their validity and accuracy. Thus, according to the experts, concerning the dynamic development of technology and production organization (Industry 4.0), the digital supply chain (14.98) deserves special attention. The digitalization of supply chains will enable the implementation of perspective methods in the process of using data in the organization of these chains. The experts acknowledge that this trend can most effectively support the dynamic development of technology and production organization known as the fourth industrial revolution. To a slightly lesser extent, the experts also indicate the resilient supply chain trend (10.72). The above observations confirm the collective data presented in Table 3. In the study, the highest mode is the value of 15 points from the pool of 100 points, identified for the digital supply chain.

Table 3. Final results of opinions about global theoretical trends and supply chain development directions in the context of the dynamic development of technology and production organization (Industry 4.0) according to the experts' assessments 1–30; own elaboration based on the conducted research.

Supply Chain Trends	Mean	Median	Min	Max	Deviation	Mode
Digital Supply Chain	14.98	13.75	3	40	6.976	15
Resilient Supply Chain	10.72	10.00	1	20	4.759	10
Sustainable Supply Chain	10.63	10.00	0	40	6.911	10
Smart Supply Chain	9.63	10.00	0	20	5.129	10
Flexible Supply Chain	7.82	8.00	0	15	3.668	10
Green Supply Chain	7.20	5.00	0	50	8.723	5
Multichannel Supply Chain	6.68	6.25	0	15	3.607	5
Global Supply Chain	6.25	6.50	0	12	3.593	10
Closed-loop Supply Chain	5.35	5.00	0	20	3.684	5
Multiagent Supply Chain	5.13	5.00	0	10	3.060	5
Service Supply Chain	4.23	5.00	0	11	3.159	5
Reverse Supply Chain	4.20	4.50	0	10	2.941	5
Food Supply Chain	4.13	4.00	0	20	3.980	5
Humanitarian Supply Chain	3.03	3.00	0	10	2.526	0

The following supply chain trends are the least effective and supporting changes towards Industry 4.0: the food supply chain (4.13) and the humanitarian supply chain (3.03; Figure 10).

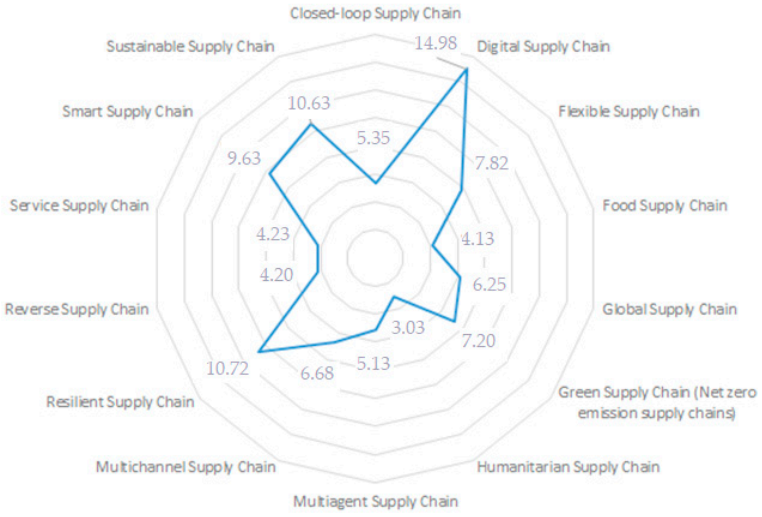

Figure 10. Mean ranking values of global theoretical trends and supply chain development directions in the context of the dynamic development of technology and production organization (Industry 4.0) according to the experts' assessments 1–30; own elaboration based on the conducted research.

4.2. Supply Chain from the Point of View of Dynamic Global Changes Caused by the COVID-19 Perspective

A similar situation can be observed regarding priorities for supply chain trends in the context of global changes related to the COVID-19 pandemic. The results of the expert assessment from the last round of the study are shown in Figure 11. Here, too, one can find some similarities and concurrence of the experts' opinions. A noticeably significant supply chain trend according to the experts is the resilient supply chain (12.05; Table 4).

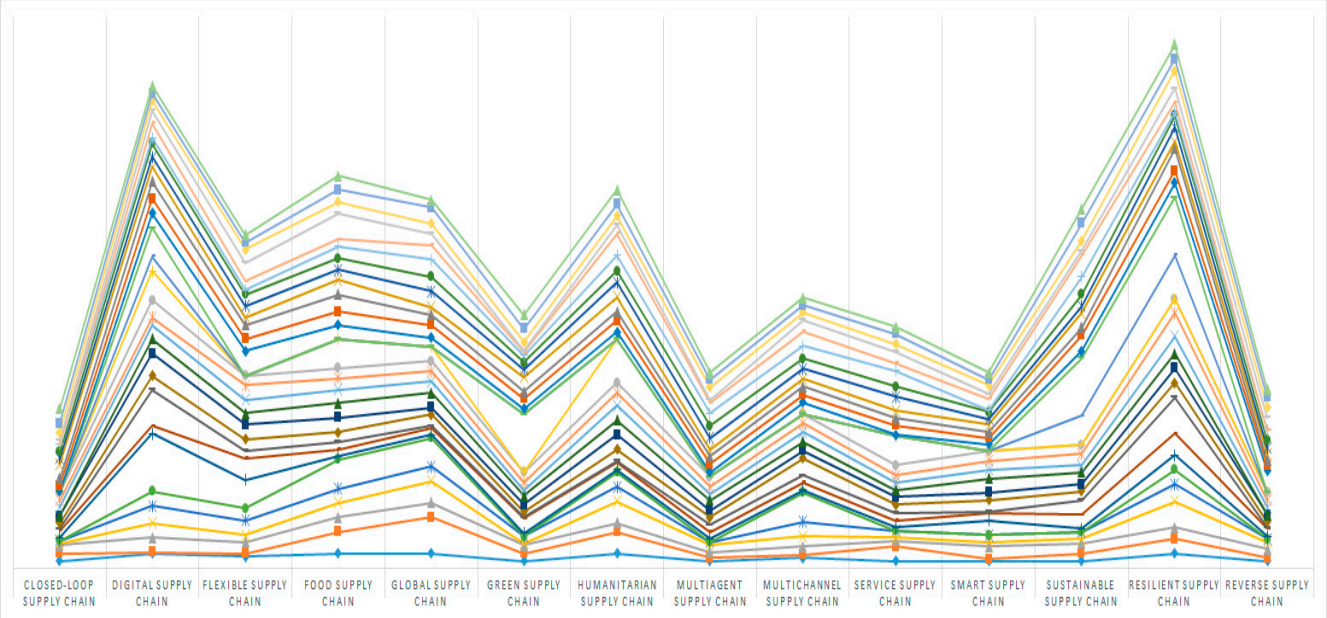

Figure 11. Ranking graph of global theoretical trends and supply chain development directions in the context of dynamic global changes related to the COVID-19 pandemic according to the experts' assessments 1–30; own elaboration based on the conducted research.

Table 4. Final results of opinions about global theoretical trends and supply chain development directions in the context of dynamic global changes related to the COVID-19 pandemic, according to the experts' assessments 1–30; own elaboration based on the conducted research.

Supply Chain Trends	Mean	Median	Min	Max	Deviation	Mode
Resilient Supply Chain	12.05	10.00	0	40	7.819	10
Digital Supply Chain	11.10	10.00	1	40	7.341	10
Food Supply Chain	9.03	9.00	0	20	4.745	10
Humanitarian Supply Chain	8.70	8.50	0	30	5.603	10
Global Supply Chain	8.47	8.00	0	25	5.237	10
Sustainable Supply Chain	8.25	6.50	0	40	7.347	5
Flexible Supply Chain	7.67	8.00	0	20	4.611	8
Multichannel Supply Chain	6.22	6.00	0	20	3.863	5
Green Supply Chain	6.13	5.00	0	40	7.050	5
Service Supply Chain	5.55	5.00	0	20	3.878	5
Multiagent Supply Chain	4.50	5.00	0	9	2.610	5
Smart Supply Chain	4.50	5.00	0	10	2.883	5
Reverse Supply Chain	4.10	5.00	0	15	3.241	5
Closed-loop Supply Chain	3.67	4.00	0	10	2.820	5

The experts point out the need for supply chains to be adapted to cope with uncertainty. This is especially important concerning unexpected phenomena and events with dramatically high risk and an extremely low, even unexpected, probability of occurrence. Such events often have a huge impact on the world and negatively affect the economy and

society. Therefore, supply chains should be able to return to their original state or transition to a new, more orderly and desirable state after perturbations.

The experts indicated two trends in supply chains as particularly important: the resilient supply chain and the digital supply chain, awarding them up to 40 points from a pool of 100 points (Table 4; Figure 12).

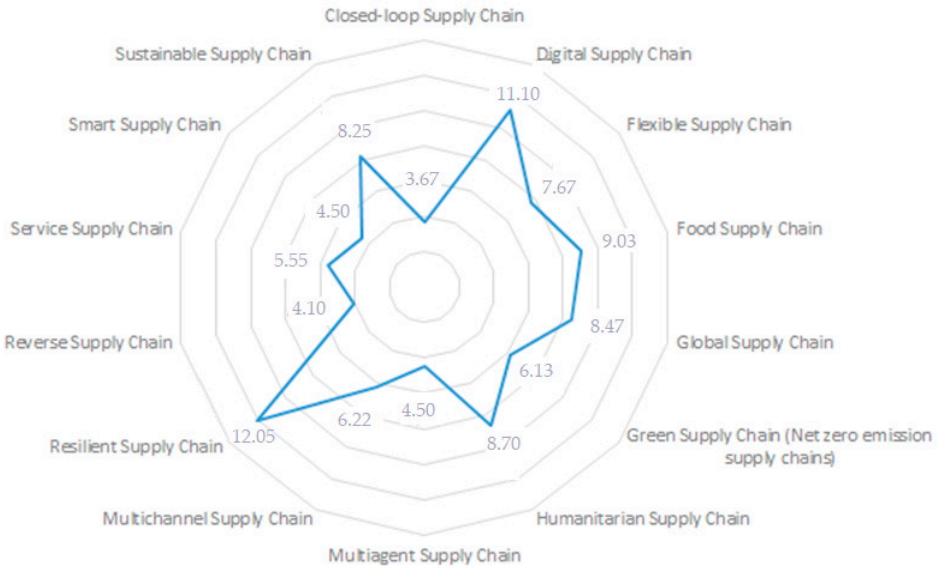

Figure 12. Mean ranking values of global theoretical trends and supply chain development directions in the context of dynamic global changes related to the COVID-19 pandemic according to the experts' assessments 1–30; own elaboration based on the conducted research.

The following supply chain trends are the least effective and supporting changes towards global changes related to the COVID-19 pandemic: the reverse supply chain (4.10) and the closed-loop supply chain (3.67).

4.3. Supply Chain from the Point of View of the Trend from Changes in Consumers' Behavior Perspective

When ranking trends, a particular concurrence of the experts' opinions can be observed concerning supply chain trends in the context of great changes in consumer behavior, which in turn affect the behavior of producers and entrepreneurs. According to the experts, the key trend is the sustainable supply chain (Figure 13). Sustainability in the supply chain is a key component of corporate sustainability—with a focus on three aspects of sustainable development—environmental protection, economic growth and social equity [33]. A sustainable supply chain is the management with social and environmental impacts explicitly considered [34]. The consideration of economic, environmental and social dimensions is known as the triple bottom line (TBL) of organizational sustainability [35]. The value most often indicated by the experts is 10 points from a pool of 100 points. One can also observe a relatively high value, i.e., 50 (Table 5), indicated for the green supply chain. It did not, however, significantly affect the average score of the assigned rank.

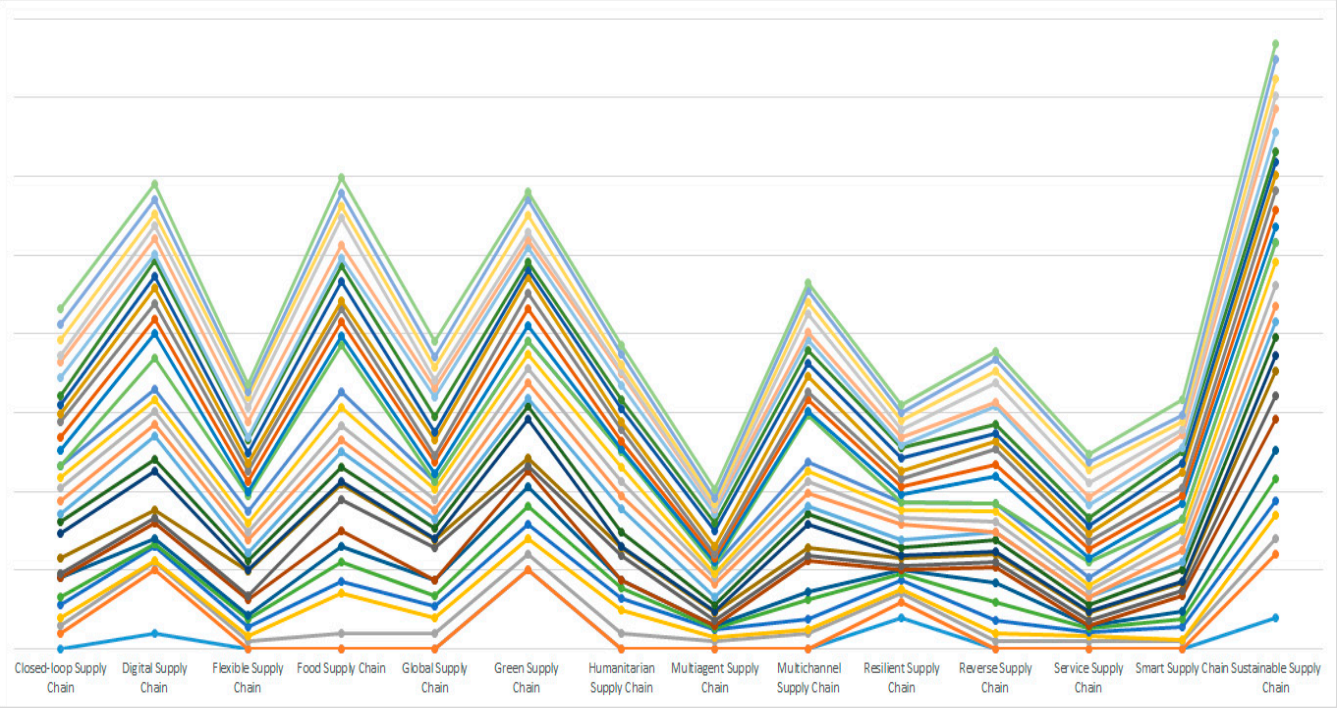

Figure 13. Ranking graph of global theoretical trends and supply chain development directions in the context of great changes in consumer behavior according to the experts' assessments 1–30; own elaboration based on the conducted research.

Table 5. Final results of opinions about global theoretical trends and supply chain development directions in the context of great changes in consumer behavior according to the experts' assessments 1–30; own elaboration based on the conducted research.

Supply Chain Trends	Mean	Median	Min	Max	Deviation	Mode
Sustainable Supply Chain	12.80	12.00	0	40	6.483	10
Food Supply Chain	9.97	9.50	0	30	6.371	10
Digital Supply Chain	9.85	8.50	1	40	7.560	10
Green Supply Chain	9.67	9.00	0	50	8.836	10
Multichannel Supply Chain	7.75	7.00	0	30	5.870	7
Closed-loop Supply Chain	7.20	8.00	0	15	3.595	10
Global Supply Chain	6.52	6.50	0	20	4.186	10
Humanitarian Supply Chain	6.42	7.00	0	15	4.287	7
Reverse Supply Chain	6.30	5.75	0	17	4.076	5
Flexible Supply Chain	5.62	5.50	0	15	3.269	5
Smart Supply Chain	5.27	5.00	0	10	2.993	5
Resilient Supply Chain	5.17	5.00	0	20	3.668	5
Service Supply Chain	4.12	5.00	0	10	2.572	5
Multiagent Supply Chain	3.37	3.00	0	10	2.399	5

The following supply chain trends are the least effective and supporting changes towards global changes related to the COVID-19 pandemic: the service supply chain (4.12) and the multiagent supply chain (3.37; Figure 14).

Figure 14. Mean ranking values of global theoretical trends and supply chain development directions in the context of great changes in consumer behavior according to the experts' assessments 1–30; own elaboration based on the conducted research.

The tables presented above indicate that, due to the high degree of similarity in the experts' opinions regarding the potential of: (1) the digital supply chain trend for supporting Industry 4.0, (2) the resilient supply chain trend for balancing unforeseen events such as a black swan, as is the case with the COVID-19 pandemic and (3) the sustainable supply chain trend, for supporting, among others, the positive behavior of producers and consumers, it is possible to:

1. Develop a limited number of key development scenarios for changing global supply chains;
2. Describe them precisely;
3. Perform further analysis.

The experts' highly concurrent opinions may also guarantee that building future scenarios of the development of supply chain trends with the greatest potential for the above-mentioned global changes and time forecasts for their implementation may be burdened with a lower degree of uncertainty. As a result, the span of the constructed time forecast intervals will be narrower.

The results of the first round of the Delphi method allowed us to confirm global theoretical trends in supply chains. In the second round of the Delphi method, the experts assigned priorities to supply chain trends. In the third round (verification), the experts confirmed the set of trends as a whole and confirmed or changed the assigned trend ranking, approaching unanimity in the prioritization of supply chain trends.

5. Conclusions

The contemporary global economy is characterized by increasing industrial and economic dynamism and the ground-breaking nature of social changes. The digital revolution, pandemic reality and social changes continue to create new, previously unknown, phenomena that shape new economies and their new entities and services.

The study confirmed that the applied methods are properly adapted and compatible regarding their application. The structured research procedure led to interesting and original conclusions. The methods in the described study are well adjusted and complement each other. The study led to obtaining answers to the questions posed in the research. Three key global theoretical trends in supply chains were identified for three components of global changes, indicating their developmental potential:

1. The digital supply chain to support Industry 4.0. The shift from a traditional supply chain to a digital supply chain appears as a necessity. The digital supply chain can be defined as the development of information systems and the adoption of innovative technologies, strengthening the integration and the agility of the supply chain. A new wave of factory automation (Industry 4.0) will be supported by the next generation of low-cost robotics.
2. The resilient supply chain to counterbalance unforeseen black swan events, as is the case with the COVID-19 pandemic. Resilience is defined as the ability of an organization to anticipate, prepare for, respond and adapt to incremental change and sudden disruptions in order to survive and prosper [1]. Supply chain resilience is defined as the ability of a supply chain to decrease the likelihood and/or impacts of possible disruptions, and to reduce the restoring and resuming times [36]. Chowdhury and Quaddus [37] and Hosseini, Ivanov and Dolgui [38] demonstrate that supply chain resilience (SCR) is a multi-dimensional measure.
3. The sustainable supply chain to support, among others, the positive behavior of producers and consumers. The approach encompasses three dimensions: economic, social and environmental [39,40], the combination and balance of which is supposed to result in equilibrium in the economy. The sustainable supply chain requires a broadened approach to the supply chain [34]. The sustainable supply chain is not only the trend recognized in research (indexed since 2000; the number of works published is dynamically increasing after 2010) but also the practical approach promoted by organizations and authorities.

The follow-up direction of research will concern the development of an integrated digital, resilient, sustainable (DRS) supply chain model in the form of a triple helix. With this model, it will be possible to analyze non-linear interactions between the three helixes for potential synergies. The digital, resilient, sustainable structural model of the supply chain aims to contribute to increasing the effectiveness of the DRS transformation of supply chains to global changes. On the other hand, the identification of DRS success factors of supply chains in the context of global changes, the development of adverse event registers for digital, resilient, sustainable supply chains and the identification of types of unprecedented events in DRS supply chains and their scenarios will contribute to the development of effective solutions and ways of responding to global changes. The designed undertaking has a complex and dynamic character, which will include cooperation and network synergy. Hence, the use of the triple helix model seems justified.

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