IBIMA Publishing
Journal of Supply Chain and Customer Relationship Management
https://ibimapublishing.com/articles/JSCCRM/2022/450468/
Vol. 2022 (2022), Article ID 450468, 13 pages, ISSN: 2326-7046
DOI: 10.5171/2022.450468

Research Article

Supply Chains Strategies during COVID-19: Green Supply Chain vs. Supply Chain Sustainability

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Received date:13 September 2021; Accepted date :25 January 2022; Published date: 1 April 2022

Academic Editor: Sylwia Konecka

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Abstract

Purpose of the article During the COVID-19 pandemic in the years 2020 and 2021, supply chains have been heavily affected and disrupted. With the lack of material and the lack of available containers for oversea shipment, a further upcoming issue where the exploding oversea container transport prices. This situation has brought many companies and experts to think about future supply chain deglobalization and regionalization with regard to supply chain risk management and with regard to environmentally friendly and sustainable supply chains. In this article, we want to explore whether this assumed movement and changing of thoughts shows off in increased publication activity combined with the terms of deglobalization with green supply chains and with supply chain sustainability. **Methodology/methods:** This article makes use of publication data from Google Scholar, Scopus and the Web of Science. Using ANOVA and Levene-test the gathered data is statistically analyzed for the same means and for the same variances of the publications in the different databases. This analysis is conducted on a $p > 0.05$ significance level. **Scientific aim** While international supply chains underwent difficult times in the years of 2020 and 2021. In the past years streaming have become popular, such as supply chain regionalization and deglobalization, as well as supply chain sustainability and green supply chains assumed to facilitate regionalization. Regionalization and deglobalization might, in times of rising global container prices, further strengthen supply chain robustness and stability. For this, the article analyzes the publication metadata related to green supply chains and related to supply chain sustainability of the named streaming from the global economic crisis in 2009 until the container crisis in the cause of 2021. **Findings:** The analyzed data show significantly higher publication activities in the green supply chains area than there are for supply chain sustainability. However, the Levene-test further shows that the publication growth rates for both keywords are similar for the combination with the related keywords. A rising interest may be seen with digital supply chains. In combination with supply chain vulnerability and supply chain robustness the publications for green supply chains show an increasing growth in the last years. **Conclusions**: In this paper, we focused on the data retrieved from Google Scholar, Scopus and Web of Science. While the topic of green supply chains and the topic of supply chain sustainability has shown significant growth in publications, there is no evidence for a rise for keywords on deglobalization, regionalization and digitalization. Such significant evidence has been found for long-term risk management and supply chain robustness.

Keywords: Supply Chain Sustainability; Green Supply Chain; Digital Supply Chain; Robustness; Resilience; Vulnerability; Deglobalisation; Regionalisation

Cite this Article as: Miroslav MANDEL and Marcel Rolf PFEIFER (2022), "Supply Chains Strategies during COVID-19: Green Supply Chain vs. Supply Chain Sustainability" Journal of Supply Chain and Customer Relationship Management,Vol. 2022 (2022), Article ID 450468, DOI: 10.5171/2022.450468

Introduction

The COVID-19 epidemic was announced as ~~a~~ pandemic in March-2020 (WHO, 2020a) (WHO, 2020b). As a reaction to the spread of the pandemic, governments globally imposed new policies as countermeasures, such as social distancing and lockdowns (Balasa, 2020). As a consequence, supply chains got disrupted and following delays occured based on missing, late-coming, and incomplete deliveries (Chen, Wang and Zhong, 2021). In the second quarter of 2020, many European countries went into a complete lockdown and applied instruments to avoid unemployment (Su et al., 2021). Companies had to think of dismissing employees that were without work in the current situation. The state stepped in by paying part of the wage of the employee. Such policies have been researched e.g. in Italy, Germany, and Norway (Cook and Grimshaw, 2020).

Still in 2021 with the third COVID-19 wave in Europe, lockdowns were applied, also forcing companies to remain in home office frameworks or to send people on forced and government-subsidised holiday (Molloy et al., 2021). This further tightened the situation. With missing deliveries from Europe and from other countries caught in lockdown, deliveries were not able to suite the required delivery date and companies further downstream in the supply chains were affected directly (Ivanov and Das, 2020). This resulted in the lack of supply of several goods on the market, such as wood (Sprecher und Kleijn, 2021) and computer chips (Dosi, Federico and Virgillito, 2021).

A further development that took place in the course of the years 2020 and 2021 was the increase of the container prices. Relations from China to Europe, such as Shanghai-Rotterdam and Shanghai-Genoa, were increasing by 400 to almost 550% (Drewby, 2021). A further increase of the container prices cannot be excluded. Hence, this provides difficulties for companies relying on the cheap transport opportunities from Asia to Europe. Supply chains under fierce price competition may suffer from the container price increases, even more if the price remain on a high level or will continue to rise.

Supply chain risk management (SCRM) should secure supply chains against disruptions and uncertainties (Sreedevi and Saranga, 2017). In order to avoid spread of risks in supply chains, the whole supply chain tries to develop policies and mitigation strategies to prevent negative outcomes of the supply chain (Chang, Woojung and Ellinger and Blackhurst, 2015). Risk targeted may be understood in cultural differences, in physical distances, and also in the issues resulting during transportation (de Souza Feitosa, Carpinetti and de Almeida-Filho, 2021). Due to the changing risk framework over time, the focus in SCRM varies (Kumar et al., 2021a). With regard to the COVID-19 pandemic disruptions, there might be the need to change the view on SCRM and its mitigation strategies.

While the the research focus goes towards sustainable supply chains (SSC) and green supply chains (Kumar, Singh and Kumar, 2021) in order to conquer the environmental trends of the time, the rise of container, resource, and component prices on the world market raises the question of whether supply chains will not change their sourcing strategies. By putting a higher weight on the risk inhibited in the location of sourcing, regionalization strategies might again come into focus, not only for individual companies, but also for whole supply chains. Hence, it is a question of whether in the aftermath of the COVID-19 pandemic the sourcing strategies of those companies will go regional.

Literature Review

Mitigating risks arising from disruptions is part of the SCRM (Ivanov, 2018) that can be distinguished into operational and disruptional risk management. While the operational risk management focuses on daily-occurring risks of incomplete batch deliveries and time delays, the disruptional risk management targets risks that may be categorised to have a high impact (Singh and Hong, 2020). These risks have a low probability to occur (). In integrated supply chains this leads to a ripple effect (Dolgui and Ivanov, 2021), where primarily company-internal risks spread to put the whole supply chain at risk. As such, the supply chain integration may provide the ground for the risk spreading (see figure 1).

Disruptions are seen as the core of SCRM. Thus, these disruptions require a strategy to not be prepared for the inhibited risks to occur (DuHadway et al., 2019). SCRM is understood to provide strategies for the mitigation of risks.

Hence, it puts focus on reducing supply chain vulnerability (Rangel, de Oliveira and Leite, 2014). This should ensure the continuous flow of materials and information through the supply chain as planned, not falling prey of the risks. Each individual company has to develop its own strategy based on its actual reality to target the risks it is exposed to (Revilla and Saenz, 2017), while supply chains have to search for a concept that wants to reduce the risk for the whole supply chain (Aqlan and Lam, 2015).

Supply chains represent open systems (Kast and Rosenzweig, 1972) that are characterised by a given extend of uncertainty (Mackay, Munoz and Pepper, 2019). By enlarging the system through global supply chain integration, the degree of uncertainty is also rising (Chaudhuri, Boer and Taran, 2018), as all supply chain-internal factors have to be taken into consideration. This calls for an approach of risk management that is able to cover the uncertainties of the whole chain to make it against disruptions. Small and medium-sized companies (SMEs) have to be taken into close consideration, as these companies might have limited abilities to conquer risks (Kauppila, 2015). Due to their constraints in human, financial, and technical resources (Mittal et al., 2018), these companies lack skills in risk management.

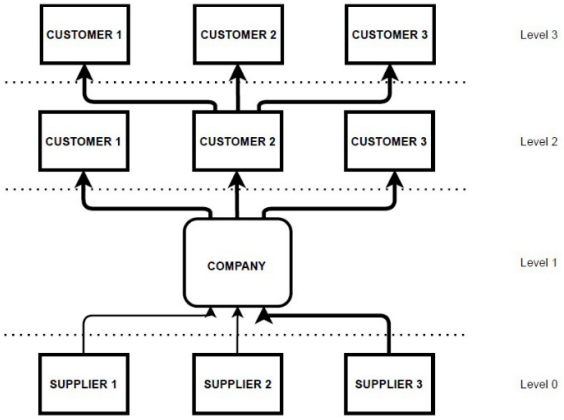

Figure 1: Corruption and attack distribution through the supply chain (Pfeifer, 2021)

Today's supply chains are usually able to cover operational risks due to their resilience (Lücker and Seifert, 2017). However, disruptional risks arising in crisis time are subject of the supply chain robustness, where the current COVID-19 pandemic development shows disruptions all over the globe (Flynn et al., 2020). Various industries, such as the food industry, the computer industry, as well as automotive were not able to cope with the sudden changes of the legislation changes during the pandemic and their aftermaths (Katsaliaki, Galetsi and Kumar, 2021). The potential to mitigate those disruptions is small, as upstream suppliers will affect the other supply chain members and the suddenness of those events does not allow for a robust strategy (Kirilmaz and Erol, 2017).

With rising concern on environmental issues, the supply chain sustainability and green supply chains. With a first publication in 2007, the terms of sustainability and of a green focus were intertwined in the approach towards reaching an environmentally-concerning approach of the supply chain from its process beginning to its end (Srivastava, 2007). This activities are not limited to manufacturing and logistics, but begin already in the designing and proposal processes where crucial decisions are taken (Martins and Pato, 2019). As such, green supply chain management represents a concept to reduce negative outcomes on the environment (Kannan, Sasikumar, and Devika, 2010). However, legislation-wise, there are different country-specific frameworks that do not yet set the same standards (Rühl, 2021).

Different motives exist in supply chains to go for a green way of working, such as a) building a green image (Zhu and Cote, 2004), b) pressure from citizens or c) country legislations (Lin, Chen and Nguyen, 2011) and d) the need to secure supply chain working for the long-term. Depending on the region of production and service, the availability of traditional resource is limited or inhibits a high extent of risk. An

example might be shortages in electricity supplies, as studies in India showed (Jayaram and Avittathur, 2015). Hence, the greening may therefore present a side effect than a primary supply chain strategy.

Already in 2009, the United Nations Department of Economic and Social Affairs (UNDESA) presented its strategy for a global green economy, called "Global Green New Deal". This strategy focused on the reduction of negative outcomes on the environment through economic regulation. It assumes, that green supply chains may be one component to leads to an overall green economy (Li et al., 2015). While the green economy goes far beyond, the green supply chain may play a crucial part in meating environmental and ecological targets.

Green supply chains may be understood to put a further burden on the member companies, as they have to follow additional requirements (Green et al., 2012). However, the studies has shown that the switch towards green supply chain principles may also lead to the creation of a competitve advantage (Barratt, and Oke, 2007) (Subir, 2009). Through cooperation, a green multiplier effect might be achieved, enabling members of the supply chain to profit from the advanced environmental level of the supply chain partners (Preuss, 2001). While studies have been done on the topic of green and sustainable supply chains, authors did not find evidence that a higher environmental and green performance would lead to a higher degree of environmental sustainability (Zhu, Sarkis and Lai, 2008) (Vachon and Klassen, 2006).

Researchers anticipate that the current COVID-19 pandemic might not only bring disruptions in supply chains, but also provide companies with the opportunity to implement changes (van Hoek, 2020). Sustainable supply chains might be considered to provide a limited approach to spare extensive non-sustainable resource exploitation (United Nations, 1987). However, there seems to be no general evidence that sustainability limits companies as such (Martins and Pato, 2019). Another viewpoint focuses on the understanding of sustainability as an integration of economic, environmental, and social aspects into supply chains (Ahi and Searcy, 2013).

Sustainable supply chain definitions went beyond the green supply chain definitions as far as their characteristics are concerned. While green supply chain characteristics focused on environment, flow, and coordination. Sustainable supply chain involved additional characteristics such as relationships (Haake and Seuring, 2009), stakeholders (Seuring and Müller, 2008), and performance (Carter and Rogers, 2008). Having been understood as a reactive framework to target negative outcomes, sustainability is understood today as a proactive strategy to guide and lead events and supply chains to the desired outcome (Giunipero, Hooker and Denslow, 2012).

While sustainability focuses on long-term aspects of the supply chain, the supply chain risks against disruptions are not targeted (Fahimnia and Jabbarzadeh, 2016). Concerning supply chain sustainability risks, Giannakis and Papadopolous claim that those should be targeted individually, separated from other supply chain risks (Giannakis and Papadopolous, 2015). Further, research found that little focus has been put on supply chain innovation with regard to sustainability and SCRM (Kusi-Sarpong, Gupta and Sarkis, 2018). These innovations may provide a measure for resilience and adaptability with regard to fending off disruptions.

While in recent years, the prevailing research content focused on the further integration of supply chains, the digitalization with the help of digital twins (Burgos and Ivanov, 2021), the vulnerability and resilience of supply chains, as well as green and sustainable supply chains (Farooq et al., 2021), a smaller trend focused on the research on the localisation of supply chains. These authors assume a development towards de-globalisation (Antrás, 2020), regionalisation (Enderwick and Buckley, 2020) and a "Slowbalisation" (Irwin, 2020) (Pegaro, Propris and Chidlow, 2020). Jetin assumes that a supply chain regionalisation in Asia has already begun prior to the COVID-19 pandemic and the accompanying crisis events (Jetin, 2020). While the debate on the relation between globalisation and regionalisation is ongoing, authors may also claim that regionalisation is an extended aspect of the globalisation of supply chains (Chen, Miao and Li, 2021).

This paper wants to have a look, whether the amount of literature published may suggest an increasing research focus on the regionalisation of supply chains in the future.

RQ1: Is there an increasing literature during COVID-19 as a hint for regionalisation,

localisation and deglobalisation together with supply chain sustainability and green supply chains?

RQ2: Do keywords, such as resilience, robustness and vulnerability, appear in publication the same frequently throughout the years?

Methodology

With regard to the trends published in the recent years, this article wants to have a look on the literature published with respect to sustainable supply chains, green supply chains, and regionalisation, globalisation, and deglobalisation. Therefore, this paper wants to have a look into the three different databases Web of Science (WoS), Scopus, and Google Scholar to assess the amount of papers published. With pre-determined key words that will be used for all three databases, the databases should provide comparable results for further analysis. In order to have papers with a primary interest in the topic, the research has a look on papers where the key words were found in the full text.

Further, in order to assess the publication activities on supply chain sustainability and green supply chain. In order to evaluate this publication activity, a supporting measure is defined as the ratio of the number of publications for each of the two keywords. This ratio is counted for a) the category title and abstract and b) for the full text.

In a second step, the retrieved data from the databases will be assessed with statistical analysis. For this, the database results will be categorised by the year of publishing in order to assess the trend of publishing from the years 2009 to 2021. This time period begins after with the economic crisis in the first decade of the century while it also includes the beginning of the COVID-19 pandemic.

The statistic analysis applies the analysis of variances (ANOVA) and the Levene-test in order to assess the similarity of mean values and variances in the acquired samples**.** The ANOVA is used to assess the signifikance of differences of the mean values of publication numbers associated with the key words >>“Supply Chain Sustainability“ and >>“Green Supply Chain“<<. With the help of the Levene-test, this paper assesses the significance of equal variances of the number of published papers in the different databases based on the year of publication. Further, with the help of ANOVA and Levene-test, this paper wants to have a look whether >>“Digital supply chains“<< are showing rising publications with >>“Supply Chain Sustainability“<< or >>“Green Supply Chain“<< and the risk-management terms >>“Robustness“<<, >>“Resilience“<< or >>“Vulnerability“<<.

The whole statistical analysis is conducted with a significance level of $p < 0.05$.

Sample

The sample consists of three tables derived from the databases Google Scholar, Scopus, and Web of Science with the keywords >>“Supply Chain Sustainability“<< and >>“Green Supply Chain“<<. Data was taken for the full text (table 1). from the beginning of July 2021. Due to the minor differences in search results found (+/- 10 papers), a further extension of the keyword query of >>“Supply Chain Sustainability“<< >>"Supply Chain Sustainability" and ("Regionalisation" OR "Slowbalisation" OR "deglobalisation")<< did not bring any further knowledge and was neglected for further analysis. The same was also derived for the relation of the queries >>“Green Supply Chain“<< and >>" Green Supply Chain" and ("Regionalisation" OR "Slowbalisation" OR "deglobalisation")<<.

Table 2: Number of publications in databases based on keyword finding in full text (own processing)

Keyword	“Supply Chain Sustainability”			“Green Supply Chain”		
Year \ Database	Google Scholar	Scopus	Web of Science	Google Scholar	Scopus	Web of Science
2021	1259	713	31	3265	2700	154
2020	1988	923	64	4988	4091	317
2019	1385	608	56	3984	3397	250

2018	880	429	50	2834	2592	247
2017	678	268	26	2394	1838	190
2016	405	192	40	1809	1553	145
2015	323	113	17	1439	1173	156
2014	258	73	9	1248	1037	94
2013	467	40	6	1631	821	93
2012	141	32	4	763	608	82
2011	76	34	2	589	474	65
2010	56	16	2	411	362	59
2009	37	9	1	296	219	48

Further data derived from the database is the ratio of the number of publications found for the two categories. Table 2 shows this ratio for searching a) only in abstract and title and b) for the full text. The ratios have been calculated as the ratio of number of publications for >>"Green Supply Chain"<< divided by the number of publications for >>"Supply Chain Sustainability"<< for each year from 2009 to 2021.

Table 2: Ratio of number of publications in databases (own processing)

Ratio	**Abstract + Title**			**Full text**		
Year \ Database	**Google Scholar**	**Scopus**	**Web of Science**	**Google Scholar**	**Scopus**	**Web of Science**
2021	5,4	4,9	4,9	2,3	3,8	5,0
2020	4,7	5,0	4,7	2,5	4,4	5,0
2019	4,9	5,4	4,4	2,9	5,6	4,5
2018	5,0	5,1	4,7	3,2	6,0	4,9
2017	7,3	7,8	7,0	3,5	6,9	7,3
2016	5,1	4,7	3,6	4,4	8,1	3,6
2015	4,8	5,6	8,6	4,4	10,4	9,2
2014	9,9	9,0	10,2	4,8	14,2	10,4
2013	9,2	12,4	15,3	3,5	20,5	15,5
2012	11,7	11,8	27,0	5,4	19,0	20,5
2011	15,3	15,6	32,0	7,7	13,9	32,5
2010	23,3	16,5	29,0	7,3	22,6	29,5
2009	17,0	14,0	46,0	8,0	24,3	48,0

Research

The ANOVA test was conducted with a degree of freedom of 51. Table 3 shows the results stating that the hypothesis H_0 of the same means of different years from 2009 to 2021 has to be rejected. Instead, the H_1 hypothesis of the significantly differing means in the years from 2009 to 2021 is accepted. Due to the steadily rising tendency of the publications for both key words, as well as for the ratio of publications of the two key words, the expected a steadily-rising and growing interest in the topic. However, during all the time, the term >>"Green Supply Chain"<< >>"Supply Chain Sustainability"<<

showed a higher frequency and had constantly higher numbers of publications.

Research showed that the analysis for a) abstract and title and b) for full text publications show the same outcome.

Table 3: ANOVA test for the mean of the number of publications throughout the databases by publication year (own processing)

Keyword	Df	F-value	critical F	p-value
"Supply Chain Sustainability"	51	1.40	2.01	0.2072
"Green Supply Chain"	51	1.25	2.01	0.2858
Ratio	51	1.10	2.01	0.3876

The Levene-test is also conducted with 51 degrees of freedom. However, for all keywords the H_0 hypothesis is accepted, while the H_1 hypothesis is rejected. This suggests that for both keywords, as well as for the ratio of the keywords the variances of publications throughout the years are same in all three analysed databases. Thus, the tendency of rising numbers of publications is expected in all three databases while the variances seem to be same on the $p < 0.05$ significance level.

Table 4: Levene-test for the variances of the number of publications throughout the databases by publication year (own processing)

Keyword	df	F-value	critical F	p-value
"Supply Chain Sustainability"	51	6.39	2.80	0.0010
"Green Supply Chain"	51	8.28	2.80	0.0002
Ratio	51	16.32	2.80	0.0000 *

The Levene-test shows a pattern for the variances. The variances for the different keywords show significant differences for the keywords as well as for the analysis of the keywords. Therefore, it may be understood that the number of publications including >>"Supply Chain Sustainability"<< is rising with faster speed than >>"Green Supply Chain"<<. The topic of Sustainability is coming more into focus in the recent years.

For the third research hypothesis, the ANOVA test was conducted in order to have a look on additional keywords, namely >>"Vulnerability"<<, >>"Resilience"<< and >>"Robustness"<< as SCRM-related terms in combination with further keywords, such as >>"Supply Chain Sustainability"<< or >>"Green Supply Chain". As digital supply chains accompany real supply chains with a digital twin and are of ever rising importance for supply chains with regard to industry 4.0 and the required real-time data exchange. The corresponding frequency tables may be found in appendix A, table 7 and table 8. The outcome of the ANOVA test are presented in table 5 and table 6. Table 5 and table 6 evaluate only numbers from Scopus and Google Scholar. Due to the small numbers of publications in Web of Science, these numbers cannot be used for statistical analysis.

Table 5: ANOVA-test for keyword combination for Google Scholar and Scopus publications (own processing)

Keywords	df	F-value	critical F	p-value
"Digital Supply Chain" and "Supply Chain Sustainability"/"Green Supply Chain"	12	2.09	3.38	0.0033
"Digital Supply Chain" and "Supply Chain Sustainability"/"Green Supply Chain" and "Vulnerability"	12	2.23	0.74	0.6984
"Digital Supply Chain" and "Supply Chain Sustainability"/"Green Supply Chain" and "Resilience"	12	2.28	1.16	0.3736
"Digital Supply Chain" and "Supply Chain Sustainability"/"Green Supply Chain" and "Robustness"	12	2.31	0.48	0.9001
"Digital Supply Chain" and "Supply Chain Sustainability"/"Green Supply Chain" and "Resilience"	12	2.60	1.06	0.4565
"Digital Supply Chain" and "Supply Chain Sustainability"/"Green Supply Chain" and "Resilience"/"Robustness"/"Vulnerability"	12	2.03	1.65	0.1205

The sample found significant differences in the mean values of the keywords including >>"Digital Supply Chain"<<. These differences may be found for all keywords, also in combination with resilience, robustness, and vulnerability separately and together. As found before, green supply chains show a higher average amount of publications than sustainable supply chains. Thus, the before-found trend does also not change when further related keywords belonging to the SCRM topic are taken into account.

While table 5 focuses on the ANOVA analysis of keywords based on different databases, table 6 has a look on the year-wise data.

Table 6: Levene-test for keyword combination (own processing)

Keywords	df	F-value	critical F	p-value
Resilience	12	2.35	2.01	0.0220
Vulnerability	12	1.09	2.01	0.3916
Robustness	12	0.87	2.01	0.5779
Resilience/Robustness/Vulnerability	12	2.52	1.90	0.0086

Table 6 shows that >>"Resilience"<< and >>"Resilience" OR "Robustness" OR "Vulnerability"<< paired with >>"Supply Chain Sustainability"<< and with >>"Green Supply Chain" show the same variances within a $p < 0.05$ significance value. >>"Vulnerability"<< and >>"Robustness"<< showed a significantly different variance. Thus, while >>"Resilience"<< seems to be the terms >>"Vulnerability"<< and >>"Robustness"<< show a higher variance and different means for "Supply Chain Sustainability"<<. Thus, it may be concluded that these two terms are discussed more with >>"Digital Supply Chain"<< than >>"Resilience"<<. It seems, that supply chain resilience in the last years was lost from focus, while supply chain robustness and vulnerability got increasing popularity.

Summing up the research, it may be said:

H1: rejected. It cannot be concluded that the number of publications in the databases are equal for the years 2009 to 2021.

H2: accepted. >>“Supply Chain Sustainability“ and >>“Green Supply Chain“<< show significantly equal variances throughout the databases and years.

H3: acepted. >>“Robustness“<< and >>“Vulnerability“<< show significant differences in means and variance for >>“Supply Chain Sustainability“<<.

Discussion

While green supply chains are understood to be only one aspect of sustainable supply chains, the literature on green supply chains in all analysed databases prevails. Depending on the search field criteria, there are roughly four to six times as much papers for “green supply chain“ than for “sustainable supply chain“ in the recent years. However, all computed ratios show a constant decline from 2009 to 2020 which may indicate a rising interest in the full aspect of sustainable supply chains.

The ANOVA test shows that the means of publication numbers in the three databases differ significantly from each other in the given years. And this applies for the keywords as well as for the given ratio of publications for the keywords. Even though, the H1 hypothesis has to be rejected indicating no equal means of the sample, the Levene-test hereafter suggests that the variances of the samples are equal. Thus, while the means differ, the varainces of the sample suggest a trend for the keywords, as well as for the ratio. This trend in all the three databases assumes a faster increase of >>“Supply Chain Sustainability“<< literature than of >>“Green Supply Chain“<< literature.

Further ANOVA and Levene-tests show an increasing focus of literature towards supply chain robustness and towards supply chain vulnerability in recent years. Recent development seemed to go away from short-term resilience, concentrating primarily on long-term robustness. However, deglobalisation and regionalisation are only rarely present in the supply chain literature. Data suggests that digital supply chains, paired with green aspects and the robustness and vulnerability may be the main research topics in supply chain management for the next years.

The increase of publications in these areas proposes a growing interest in the subject of sustainability and green aspects in supply chains. However, further aspects with regard to the stability of supply chains, such as resilience, robustness, and visibility, do not yet show a significant increase against the usual topics of the primary keywords. With this aspect, it will be interesting to see whether the supply chain disruptions due to the Asian container crisis will have a further impact on the publication activities in the analysed fields.

Conclusion

The recentness of events did not yet lead to a sudden increase in the number of publications in the field of supply chain sustainability or green supply chains paired with terms such as slowbalisation, deglobalisation, and regionalisation. Till date, there is no evidence that these terms would have received higher attention in the COVID-19 economic crisis. While some researchers suggested the deglobalisation and regionalisation as a slow-down of the globalisation already before this crisis, it must be said that no evidence in this could be found by the conducted analysis. While supply chain disruptions took place in 2020 and 2021 in the course of the pandemic, the meta-analysis of the publication activity does not yet suggest a significant difference to the pre-COVID-time. A potential explanation could be the fact that the descriptive scientific articles may come with a delay due to the current situation.

Concerning the amount of publications in databases, the three chosen databases show significantly different mean values of the number of publications in the databases for the years 2009 to 2021. These values differ throughout all three databases with respect to the years of analysis. On the other hand, the Levene-test suggests the variances of the different database samples to be equal. Thus, there seems to be a general trend in these three databases of simultaneously increasing numbers of publications for “Supply Chain Sustainability“ and “Green Supply Chain“. While publication numbers are highest in the Google Scholar database, also the higher-ranked databases Scopus and Web of Science show similar trends of increasing publication activity in this area. Even though the current pandemic could not be found as the initial shocking trigger yet, the interest towards sustainability and green aspects in supply chains got a broader focus in recent years. Rising interest was suggested by analyzing all three databases.

With the current situation and supply chain disruptions, it will be interesting to see the future development of these supply chains and how they will deal with the COVID-19 pandemic and its aftermath. While supply chains seem to be resilient to a certain extend against short-term disruptions, these chains have to prove whether they are also robust enough to overcome the aftermath of the current situation. Recent years have shown a rising interest in this research and publication area. Strategies to facilitate the robustness and to ensure supply in the case of pandemic events may provide a future need for supply chains to react and for research.

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Appendix A

Table 7: Frequency table according to the databases and the keywords including >> Supply Chain Sustainability<< (aggregated publication numbers from 2009 to 2021 for full text)(own processing)

Keywords	"Digital Supply Chain" and "Supply Chain Sustainability"			"Digital Supply Chain" and "Supply Chain Sustainability" and "Resilience"			"Digital Supply Chain" and "Supply Chain Sustainability" and "Robustness"			"Digital Supply Chain" and "Supply Chain Sustainability" and "Vulnerability"		
Database	Google Scholar	Scopus	Web of Science	Google Scholar	Scopus	Web of Science	Google Scholar	Scopus	Web of Science	Google Scholar	Scopus	Web of Science
2021	126	133	1	94	78		60	11		66	22	
2020	156	109	1	127	38		71	3		96	8	
2019	30	42		12	13		10	5		12	8	
2018	8	7		2			1			1		
2017	3	1		2						1	1	
2016	1	1										
2015												
2014												
2013												
2012												
2011												
2010	1						1			1		
2009												

Table 8: Frequency table according to the databases and the keywords including >>Green Supply Chain<<(aggregated publication numbers from 2009 to 2021 for full text) (own processing)

Keywords	"Digital Supply Chain" and "Supply Chain Sustainability"			"Digital Supply Chain" and "Supply Chain Sustainability" and "Resilience"			"Digital Supply Chain" and "Supply Chain Sustainability" and "Robustness"			"Digital Supply Chain" and "Supply Chain Sustainability" and "Vulnerability"		
Database	Google Scholar	Scopus	Web of Science	Google Scholar	Scopus	Web of Science	Google Scholar	Scopus	Web of Science	Google Scholar	Scopus	Web of Science
2021	103	68		62	42		43	5		37	10	
2020	229	50		187	20		139	4		143	4	
2019	150	20	1	125	4		125	2		127	4	1
2018	23	4		12	2		4	1		6		
2017	1			1			1			1		
2016	4	1		1			2			1		
2015	2			1						1		
2014												
2013	4	1		1			1					
2012	1									1		
2011												
2010	1						1			1		
2009	1											