Correlation between Supply Chain Visibility, Supply Chain Sustainability and the Use of New Technologies

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Abstract

The purpose of this research is to determine the correlation between supply chain visibility, supply chain sustainability and the implementation of new technologies in the supply chain domain. Its significane is huge as it opens new roads of understanding the above correlation in order to assist supply chain managers to adapt to more sustainable supply chain operations This research is following the systematic literature review approach. Therefore, is following specific methods/frameworks that include a systematic screening process with inclusive/ exclusive criteria, the implementation of the SALSA method, the CASP checklist, the PRISMA 2009 statement checklist with 3 items, while the findings were divided into 4 major thematic categories. The findings highlighted a strong indirect correlation between supply chain visibility and supply chain sustainability. This correlation is facilitated via the implementation of new technologies, like RFIDs, blockchain, A.I. etc. Although a lot have been written in terms of supply chain visibility and sustainability and of course, about the new technologies, their combination in the light of the strong correlation between visibility and sustainability in a supply chain have not been discussed a lot till now. The implications of the research, from a managerial point of view, are huge as they can be the springboard for the development of new approaches/ operational frameworks towards more sustainable supply chains. Until now, supply chain visibility, although was a priority for supply chain professionals, was not implemented with an eye in supply chain sustainability, but instead was focused more on operational aspects. Now, with the use of new technologies, both are possible.

Keywords: Appraisal; Synthesis; Analysis framework; Critical Appraisal Skills Program; Blockchain; Preferred Reporting Items for Systematic reviews and Meta-Analyses; Internet of Things.

1. Introduction

In the contemporary globalized environment, supply chains face a lot of challenges. These challenges are connected to social and economic implications, to trade and regulations and to environmental risks and threats. In such uncertain environment, supply chain actors need to find ways to mitigate risks and to support the resilience and robustness of their supply chains, while they need to not loose grip on their supply chain sustainability, something which is crucial today due to the climate change and the global environmental issues that our planet is facing.

One way to achieve this goal is to increase supply chain visibility. Supply chain visibility can be defined as "the extent to which actors within a supply chain have access to, or share information which they consider as key or useful to their operations and which they consider will be of mutual benefit" (Barratt and Oke, 2007, p.2).

Supply chain visibility refers mainly to the visibility of customer demand and inventory levels information across a supply chain. If visibility will be improved, it can increase the accuracy of demand forecasting, it can accelerate the adjustment of production plans towards matching current demands, it can improve delivery performance and of course, it can reduce the inventory amount at all levels of the supply chain in question (Barratt and Barratt, 2011; Barlett et al., 2007; Bottani et al., 2010; Goel, 2010; Heah and Omar, 2005; Kim et al., 2011; Rai et al.,2012, as cited in Somapa et al., 2018, p.308). It is therefore obvious that increased supply chain visibility can have a positive impact in reducing wastes and improve supply chain sustainability. Since sustainability is one goal that supply chains need to reach the years to come in order to help societies to tackle the already worrying environmental problems that climate change has brought, we can easily understand why an increased visibility in our supply chain can benefit in so many ways not only business per se, but also the environment as well.

New technologies like the IoT (Internet of Things), metaverse technologies, A.I. (Artificial Intelligence), blockchain technologies etc., can play a vital role in enhancing supply chain visibility, thus cement supply chain resilience and robustness towards supply chain risk mitigation and sustainability. According to Wong (2022), new technologies can improve visibility, especially in complicated supply chains, something that can also improve collaboration and the efficiency of the working relationships between customers and suppliers, an efficiency that can benefit both the business and the environment via waste reduction.

In order this research to reach its goal, specific methods were followed. These methods are the SALSA method, the CASP checklist and the PRISMA 2009 statement checklist with three items. The above mentioned three methods are significant because they add value to the research by providing a rigor framework for data gathering and presentation, while they give a practical and easy way to validate the whole research in terms of whether is in the right direction and follows the appropriate methods and approaches.

1.1. Aim of the Literature Review

The aim of this research is to investigate through a rigor and systematic literature analysis the correlation between supply chain visibility, supply chain sustainability and the use of new technologies. The literature in the respective field of supply chain will be "annotated" and a rigorous selection of the existing bibliography will be systematically attained in order to provide reliable and transferable advice on information sources in the field to future researchers, scholars and professionals.

1.2. Research Question

The research question that this study aims to answer is the following:

Is there a correlation between new technologies, supply chain visibility and supply chain sustainability?
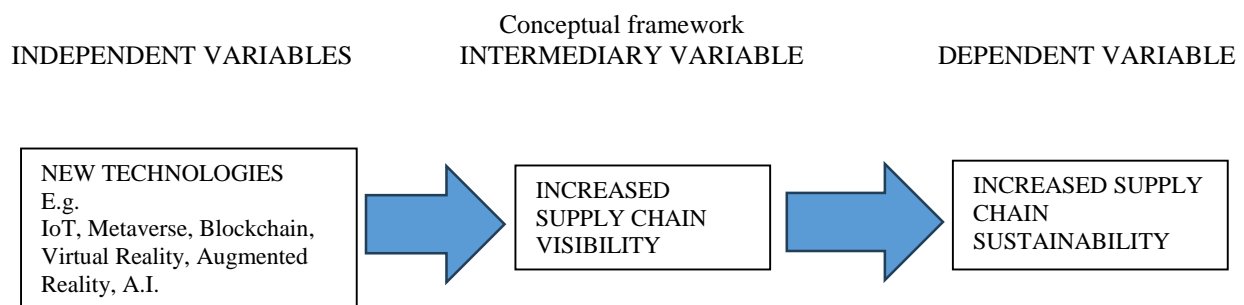
Conceptual framework

INDEPENDENT VARIABLES	INTERMEDIARY VARIABLE	DEPENDENT VARIABLE

NEW TECHNOLOGIES
E.g.
IoT, Metaverse, Blockchain, Virtual Reality, Augmented Reality, A.I. → INCREASED SUPPLY CHAIN VISIBILITY → INCREASED SUPPLY CHAIN SUSTAINABILITY

Figure 1. The conceptual framework

In the above figure we can see the conceptual framework upon which the whole literary analysis is based. In the conceptual framework we can see the dependent, the intermediary and the independent variable (from right to left). We can also see why the research question was framed in that way, as it is focused on finding the connection between an increased supply chain sustainability via an enhanced supply chain visibility, which of course, it is enhanced via the use of the new technologies as they are described in Figure 1.

1.3. Scope of the Research

In this part of the literature review we will try to define the main characteristics that can determine the scope of this systematic literature analysis. The scope of this research will be divided in the following categories:

- What exactly will be covered in this review?

In this research, three main areas will be covered, namely, sustainability in a supply chain, supply chain visibility and new technologies (specifically will be covered the following new technologies: Internet of Things, Block chain, Artificial Intelligence). Another factor that will be analyzed and explained will be the correlation between them. The reason behind that is that this analysis can lead us to understand whether the increased supply chain visibility via the use of the new technologies is correlated to an increased supply chain sustainability.

- How comprehensive will it be?

This literature review will be very comprehensive as extensive bibliography will be assessed in order to shade some light on a topic that it was not deeply discussed by scholars till now.

- How detailed? Will it be a review of all relevant material or will the scope be limited to more recent materials?

The scope of this review will be limited to more recent materials, since only papers that were published after 2018 will be considered. In that way the researcher will be able to cope with the last trends and evolvements in new technologies and to describe their connection with supply chain visibility and supply chain sustainability. Older papers will only be considered on the basis of historical data that may be used in order to give a clear understanding of the background of the research.

- Will the reviewed materials be confined to English language only or will be included in the research materials in other languages too?

The reviewed material will be confined only to English language ones. The reason is that there are certain time and resources limitations that this research is facing and therefore e.g. professional translations from other languages are not possible.

Table I. Scope of the systematic Literature Review

SCOPE OF THE LITERATURE REVIEW	
What exactly will be covered?	The variables and their correlation
How comprehensive will it be?	Very.
How detailed the research will be?	Only materials after 2018 will be used
Will the reviewed materials be confined in English language ones?	Only English language materials will be used

1.4. Research Objectives

The main objective of this study is to implement a systematic literature review on the topic of sustainable supply chains in order to shade some light on how it is connected to two other major variables that influence supply chains of today; namely, new technologies and supply chain visibility and their correlation.

2. Methods

In this chapter we are going to describe the protocol that this literature review uses. The protocol that this research is following describes the several steps taken in order to establish an easy to understand and to follow approach. It not only makes sure that the right -legitimate papers were chosen, but it also validates the whole process in an easy and thorough way that leaves no doubts to the reader and to the future researcher that all sources used were relevant, legitimate, replicable, that the results were valuable and precise and that they worthed the time and resources used.

The given in this chapter protocol is consisted of:

A. The predefined eligibility criteria, which make sure that all the "screened -to -be" articles can be found under the right "umbrella/ topic" and that are following some important but generic guidelines.

B. Also, it includes the search strategies which consist of the specific screening process and the inclusion/ exclusion criteria,

C. The methodology, which involves four steps, which are following the Search, Appraisal, Synthesis, Analysis (SALSA) method, the searching strings and the types of the used data bases.

D. Finally, the used protocol is giving us a way to validate the whole gathering process by answering a set of predefined questions (Critical Appraisal Skills Program- CASP), which testing the risk and the bias that might have been involved with the whole process and that might have affected the validity of the research.

2.1. Predefined Eligibility Criteria of Literature Used

The general -predefined eligibility criteria that were used in this systematic literature review are the following:

A. The chosen articles needed to have been under a rigorous blind peer review, while the journals in which they would have been published should have been legitimate ones (only journals that were published in Web of Science/ Scopus journals were considered).

B. Also, the chosen articles should have been relevant to terms like supply chain management, supply chain visibility, sustainable supply chains, new technologies, A.I., IoT, block chain technologies and combinations of them.

C. As we will see in the methodology part, all articles in order to be used, were undertaken an initial screening which consisted of two phases with a main goal to narrow down the pool of the potential to choose between articles. In that way it was assured that the finally chosen ones would have been on target in terms of the needed articles to be used in this systematic literature analysis. More details regarding the inclusion/ exclusion criteria that going one step further from the predefined eligibility criteria and the screening phases will be given in the next sub chapter.

2.2. Search Strategies

Literature reviews in general, are conducted in order to meet one of the following criteria, or all, or a combination of them:

(a) To locate information on a specific topic, or to identify gap(s) in the literature which might will be areas of future studies, (b) To synthesize conclusions in an area of ambiguity or controversy, (c)To help researchers to inform decision -making and practice guidelines (Atkinson and Cipriany, 2018).

In addition, systematic literature reviews are using explicit and replicable methods and approaches in order to retrieve information about all the available on a specific topic literature in order to answer a predefined (research) question. This is why systematic literature reviews require a -priory strategies with explicitly predefined criteria regarding which studies will be included and which will be excluded. Such strategies need to be reported in full detail in a review protocol (Higgins & Green, 2011 as cited at Atkinson and Cipriany, 2018).

The review protocol and the search strategies that were followed throughout this systematic literature review are described in this chapter.

2.3. Screening Process (Inclusion/ Exclusion Criteria)

Due to the high volume of papers that were screened in this systematic literature review, the author had to adapt an easy -to -use screening process which would have assisted him in order to quickly and efficiently choose the right articles. Before the implementation of the screening process, the author established the inclusion/ exclusion criteria in a way that the gathering of the existing data would have been more efficient. The inclusion/ exclusion criteria are describing the criteria used in order to determine which articles will be considered before implementing the screening process. The inclusion/ exclusion criteria are described in Table 2:

Table II. The inclusion/ exclusion criteria

INCLUSION/ EXCLUSION CRITERIA
Date (only papers that were published after 2018 were considered)
Language of publication (Only papers written in English were considered)
Topic (Only papers relevant to the topics discussed by the variables of the research were considered)

As we can see in the above **Table** II, the focal points of the inclusion/ exclusion criteria are the date of publication, the language of the published paper and of course, the topic of the paper in question. The use of such criteria helped the author to efficiently determine which are the papers that need to be used in this research.

Since the inclusion/ exclusion criteria were chosen, the author continued with the screening process which aimed to pinpoint the right papers to be used for this literary review. The process of screening was subdivided into two phases/ levels. The first phase involved the screening of the title and the abstract of the potentially involved and selected paper, while the second step was the full screening of the papers that were qualified as suitable from the first step (Covidence, n.d.)

Table III. The screening process

SCREENING PROCESS
PHASE 1: Screening of the title and abstract
PHASE 2: Screening of the full paper as long as it was qualified from phase 1

Table II briefly explains the screening process which is based in two phases as were explained in the previous paragraph. Via this process, papers that after the careful reading of the abstract were not found as a suitable addition to this research were rejected by the author, while the ones that were suitable were qualified for the phase 2. Finally, only a few were qualified, after the conclusion of phase 2 and were considered for this research.

2.4.   Methodology

In terms of the methodological approach of this systematic literature review, four main steps were included according to the SALSA approach (Mengist et al., 2020), which are the following:

A.   The first step was to define the searching string and the types of data bases.

B.   The second step was the appraisal one, which incorporated the pre -defined by the author literature inclusion and exclusion, plus the specific quality assessment criteria.

C.   The third step was the synthesis of the findings of the gathered literature. (Mengist et al., 2020).

Table IV. Methodological Approach (SALSA Method) (Mengist et al., 2020).

METHODOLOGICAL APPROACH (according to the SALSA method)
FIRST STEP: Define the searching string and the types of data bases
SECOND STEP: Literature inclusion/ exclusion & quality assessment criteria
THIRD STEP: Synthesis of the gathered literature
FOURTH STEP: Analysis of the findings + narrative of the result + final conclusion

In the above Table IV, we can distinguish the four steps that are included in the SALSA method that is followed in this research and which were described in the previous paragraph.
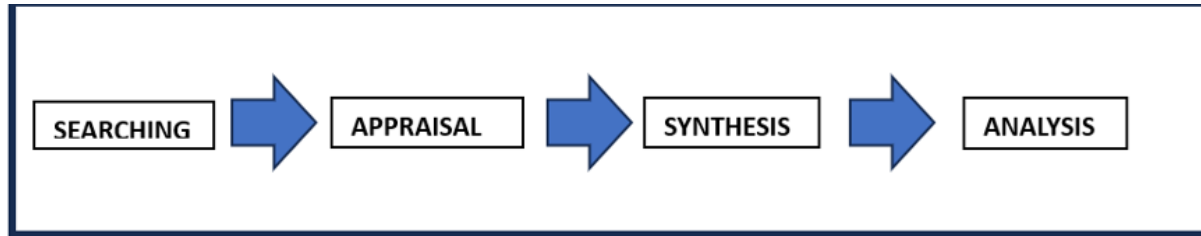
Figure 2. The SALSA Framework

In Figure 2, we can see the visual representation of the SALSA framework as provided in the Table IV. All four steps involved are included and the sequence is pinpointed via the arrows that were added between the different steps.

2.5.   Searching Strings & Types of Data Bases

This systematic research used several tertiary data bases like EBSCO, Springer link, Taylor and Francis and several data bases of online University libraries to which the author had access like the Kaunas University online library etc. Also, open access social sciences journals were used as legitimate data bases like Central and Eastern European Online Library (CEEOL) etc.

The searching strings that were used in order to fulfill the first step were the following:

The author used search terms like "supply chain", "sustainability", "supply chain visibility", "new technologies", "metaverse", "Augmented reality", "A.I.", "virtual reality" etc. Also, he used complete phrases like "sustainable supply chain", "supply chain visibility", "upstream supply chain visibility", "downstream supply chain visibility", "new technologies in supply chain management" etc.

From the combination of the above -mentioned terms and phrases, the author managed to create some search strings like the following:

STRING 1: ("Supply chain" OR "upstream supply chain" OR "downstream supply chain" OR "new technologies in supply chain management) etc.

STRING 2: ("Supply chain" AND "visibility" AND "new technologies" AND "sustainability") etc. or combinations that sprung from the above and/ or other similar strings.

The main operator that was used was the "and" one as the research was focused on the correlation between the examined variables. In these terms, the use of "and" was considered to be more useful and towards the right direction.

The above keywords, that were used for the formulation of the strings, were chosen based on an initial skimming of the relevant literature and on the researcher's professional experience in supply chain management and use of new technologies in relevant operations.

In specific search engines, like the EBSCO one, the combination of different keywords was easy enough, as the author only had to put in the first search bar the main keyword, e.g. "supply chain visibility" and then he could use not only between different operators like "and", "or", or "not", but also between different filters which included, like "author", "title", "date" etc. In the following Table we can see examples of the strings used.

TABLE V. Some of the strings that were used during the research

STRING 1	SUPPLY CHAIN VISIBILITY AND ARTIFICIAL INTELLIGENCE
STRING 2	SUPPLY CHAIN VISIBILITY AND NEW TECHNOLOGIES
STRING 3	SUPPLY CHAIN VISIBILITY AND SUPPLY CHAIN SUSTAINABILITY
STRING 4	SUPPLY CHAIN SUSTAINABILITY OR SUPPLY CHAIN VISIBILITY
STRING 5	SUPPLY CHAIN SUSTAINABILITY AND NEW TECHNOLOGIES
STRING 6	SUPPLY CHAIN VISIBILITY AND BLOCKCHAIN TECHNOLOGIES

In the above Table we see a detailed presentation of the strings used by the author, plus the specific terms and operators and how they were combined.

2.6. Validity of the Findings of the Included Studies (Assessment of Risk and/ or Bias)

In terms of the critical appraisal of the study the tool that was chosen to be used was the CASP checklist. It has been chosen between other tools like AMSTAR and AMSTAR 2 etc. as the most suitable for the occasion, as it can provide an easy to comprehend and use framework, based on a checklist that can help us "tick" all the necessary boxes in order to help us appraise the research itself. Also, the CASP checklist is very suitable for social sciences systematic reviews, while this was not the case with all the other available tools.

The CASP checklist offers a list of questions that need to be answered like the following (CASP, n.d.):
1. Did the review address a clearly focused question?
2. Did the author look for the right type of papers?
3. Do you think all the important relevant studies were included?
4. Did the review's author do enough to access the quality of the included studies?
5. If the results of the review were combined, was it reasonable to do so?
6. What are the overall results of the review?
7. How precise are the results?
8. Can the results will be applied to the local population?
9. Were all important items considered?
10. Are the benefits worth the harms and costs?

All answers to the above ten questions come in the form of "Yes", "Can't tell". "No" (CASP, n.d.). In the following F we can see the CASP checklist with its respective answers as they were answered for this specific literature review:

Table VI. CASP method for this review

CASP CHECKLIST for this systematic Literature Review			
QUESTIONS CHECKED	ANSWERS		
	YES	NO	CAN'T TELL
Did the review address a clearly focused question?	X		
Did the author look for the right type of papers?	X		
Do you think all the important relevant studies were included?			X
Did the review's author do enough to access the quality of the included studies?	X		
If the results of the review were combined, was it reasonable to do so?	X		
What are the overall results of the review?	Look at p.11		
How precise are the results?	Look at p.11		
Can the results will be applied to the local population?	X		
Were all important items considered?			X
Are the benefits worth the harms and costs?	X		

Using the checklists is very useful as it can help the author/ researcher to undertake a complex task, like the systematic literature review which involves many steps. It can also assist the researcher in being systematic by ensuring that all the important and relevant factors or considerations are taken into account during the research. Finally, they are an important tool in terms of decision making as they are transparent and they can be easily tracked (CASP, n.d.)
In our case the detailed answers to the CASP checklist are the following:

- Did the review address a clearly focused question? Yes, the research question posed was very clear and to the point. It considered all the associated variables (dependent, independent and intermediate ones).
- Did the author look for the right type of papers? Yes, the author followed the screening and inclusion rules posed from the beginning. Therefore, the research papers that were included in this literature review were the appropriate ones.
- Do you think all the important relevant studies were included? Can't tell. Although the research was very comprehensive and extensive data basis of the highest scientific quality was used, it is almost impossible to know whether every relevant and important study was included or not.
- Did the review's author do enough to access the quality of the included studies? Yes. The author followed from the beginning the relative and described protocol. The screening and inclusion processes were followed. Also, the author can be considered as an expert in the field, so he could quite accurately decide which exactly studies were of the needed quality. All the above help us come to the conclusion that the author did enough to access the quality of the included in this research studies.
- If the results of the review were combined, was it reasonable to do so? Yes, as from the beginning the main objective of this research was to find out the correlation between the variables in order to answer the research question. Under this prism, the combination of the findings was important, reasonable and mandatory for this research.
- What are the overall results of the review? The overall results of this review can be found in the synthesis and conclusions part of the review. In just a few words, we can say that this review highlights that new technologies can be a very important factor that can assist the visibility of a supply chain which can then enhance its sustainability.
- How precise are the results? The results of this research are as precise as the literature involved. Since the reviewed literature was of high quality, it is safe enough to say that the results were quite precise and of high quality.
- Can the results will be applied to the local population? Since supply chains can be found everywhere in the world and since we are entering industry 5.0, while we are already using some of the discussed in this review new technologies and in addition, we are aware of the importance of supply chain visibility and sustainability, especially nowadays as we are already experiencing the consequences of the climate change, we can safely argue that the results of this research can be applied to all local populations that can apply the new technologies in their supply chains.
- Were all important items considered? Can't tell. All the important items that the author was able to pinpoint, were considered. We need to have in mind that was impossible to include all important literature from all data basis that exist due to its magnitude and the limitations of this research that have already been discussed in 1.5.
- Are the benefits worth the harms and costs? This literature review can be seen as the springboard for future research on the topic. The included literature is of high quality and therefore can be used from the researcher of the future in multiple ways as the base for his/ her research on the topic. Sustainable supply chains today can be considered as a very important part of our societies, while the ramifications of the non -adaption of such strategies can be catastrophic to the global climate. These facts per se are indicative on why the benefits of this review far out weight, e.g. the costs and the time spend during this review.

2.7. The PRISMA 2009 Statement Checklist

This study follows the PRISMA 2009 statement regarding the items that need to be presented in order the study itself to be a comprehensive and legitimate one in terms of its validity and reproducibility.

According to the PRISMA 2009 statement checklist, three items related to literature search reporting need to be included (Rethlefsen et al. 2021):

ITEM 7: "Describe all information sources in the search and date last searched"

ITEM 8: "Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated."

ITEM 17: "Give numbers of studies screened, assessed for eligibility and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram (Rethlefsen et al., 2021).

The above -mentioned items are present in this research as we can see in the following graphics and tables in chapter 3.

3. Results

In this part of the review, the findings of the research will be presented in a systematic way. The literature that was examined will be presented after it was screened and categorized according to the methodology that was described in chapter 2. It will be divided into four major categories, which are the following:

A. The first category will be comprised by the literature which is relative to supply chain visibility.
B. The second category will include the literature which is related to sustainable supply chains.
C. The third category will present the selected literature which is relevant to the new technologies that are used in supply chains operations.
D. Finally, literature that highlights potential correlation between the variables will also be presented in this part.

In the following Table VII, we can see a summation of the above -described categories.

Table VII. The four categories of the chosen literature

CATEGORIES	
FIRST CATEGORY	Literature relative to supply chain visibility
SECOND CATEGORY	Literature relative to sustainable supply chains
THIRD CATEGORY	Literature related to the new technologies used in supply chains operations
FOURTH CATEGORY	Literature that highlights potential correlation between supply chain visibility, new technologies used in supply chains and sustainable supply chains

It is important here to notice that more than 500 papers were skimmed in the first phase of this research in order to find the suitable ones to be included in this study. In the following figure, we can see a depiction of the analogy between the tertiary data bases that were used during this research:
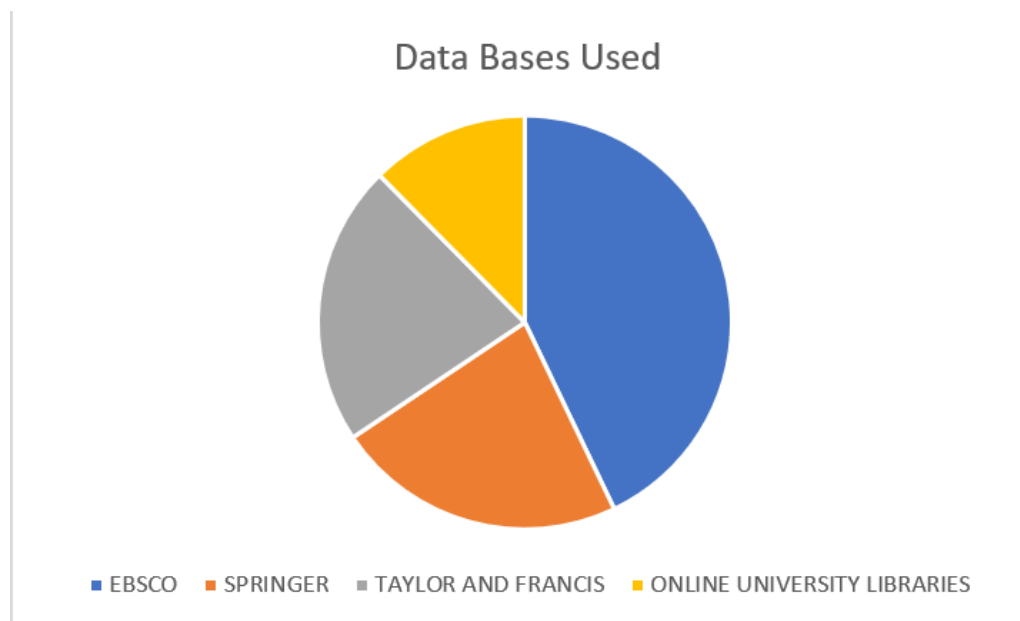

Figure 3. Depiction of the analogy between the tertiary data bases that were used during the research

As we can see in Figure 3, the big majority of the papers that were used in this research are coming from the EBSCO data base, while the three other major tertiary data bases that were used are almost equally present in this depiction (Springer, Taylor and Francis, Online university libraries).
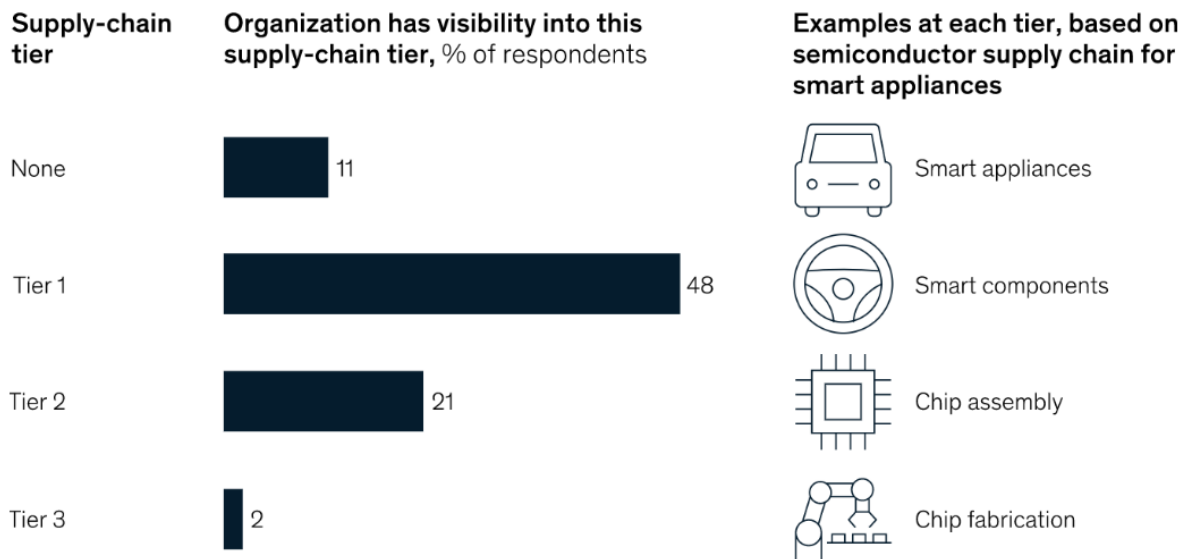
3.1.   Supply Chain Visibility

Supply chain visibility has to do with the capability of the supply chain actors to have access to and/ or to be able to provide the required and timely information needed from and to the involved supply chain partners in order to assist them with their decision making (Goh et al., 2011, cited in Messina et al., 2022).

Another definition of supply chain visibility comes from Dubey et al. (2020), according to which, supply chain visibility can be considered as an organizational capability that can enable supply chains to be more transparent in terms of demand and inventory levels.

What is very interesting about supply chain visibility is that only 2% of companies have visibility into their supply chains beyond their second tier (World Economic Forum, 2022). This can be vividly depicted in the following figure from McKinsey and company from the Davos agenda of World Economic Forum in 2022:

Only 2 percent of companies have visibility into their supply base beyond the second tier.

Supply-chain tier	Organization has visibility into this supply-chain tier, % of respondents		Examples at each tier, based on semiconductor supply chain for smart appliances
None	11		Smart appliances
Tier 1	48		Smart components
Tier 2	21		Chip assembly
Tier 3	2		Chip fabrication

Note: Companies surveyed manufacture smart appliances.
Source: McKinsey survey of global supply-chain leaders (May 4–June 16, 2021, n = 71)

McKinsey & Company

Figure 4. Supply chain visibility beyond tier 1 (World Economic Forum, 2022).

As we can see in Figure 4, the most astonishing finding is that only 2% of the organizations that were included in this study from the World Economic Forum were able to establish visibility on their third -tier level suppliers. For tier 2 suppliers, the percentage is also quite low, with only 21% of the involved in the study companies (one out of five), to be able to establish visibility within their supply chain on that tier level. The above -mentioned findings are indicative of why it becomes extremely important for companies to improve their supply chain visibility.

According to Somapa et al. (2018, cited in Kalaiarasan et al., 2022), the most important characteristics of supply chain visibility are the ones that have to do with information accessibility, accuracy, timeliness, completeness and usage to enhance operational and strategic activities that are executed during supply chain operations.

In addition, supply chain visibility is argued to be one of the most important determining factors that help supply chain professionals tackling risks related to supply chain operations (Christopher and Lee, 2004, cited in Dolqui and Ivanov, 2021).

Although the role of Supply chain visibility is crucial for supply chain operations, it is not easy to be achieved. Towards that direction, main supply chain actors need to collaborate effectively and timely (Lee et al., 2014, cited in Kalaiarasan et al., 2022). But even if this is the case, things are even more complicated especially nowadays with the advent of new technologies. Therefore, all actors involved in a supply chain need to not only understand the related processes, but also to understand how the usage of new technologies, e.g. in terms of data generation, handling, sharing and usage, can help them towards their common goal which should be the increased supply chain visibility (De Oliveira & Handfield, 2019, cited in Kalaiarasan et al., 2022).

The importance of supply chain visibility has been highlighted till now by many scholars. There are several reasons why it is that important for supply chain operations. One of them is because it can have significant effects on collaboration, agility and performance. In order to do so, a crucial paragon that acts as the catalyst in this case is information sharing (Baah et al., 2022). Information sharing has to do with data dissemination throughout the supply chain and via involving all possible actors that participate in supply chain operations.

One of the critical contributions of supply chain visibility in supply chain operations is that it allows organizations to be more agile (Christopher, 2000, cited in Dubey et al., 2020). In addition, supply chain visibility can be a valuable "asset" in creating strategic value for the organization in question (Wei and Wang, 2010, cited in Dubey et al., 2020). Finally, the importance of visibility in a supply chain in terms of enhancing its overall sustainability can be seen in the World Economic Forum's article titled "Visibility and Traceability. The Twin Engines of Sustainable Supply Chains" (World Economic Forum, n.d.). According to that article, sustainability and resilience in a supply chain are almost impossible to be achieved without the contribution of supply chain visibility. This happens because only with high supply chain visibility companies are able to see what is taking place across their supply chain and therefore increase items' traceability across the supply chain something that can help them in multiple ways. E.g. in that way they can increase their agility and their social contribution with more customer responsive supply chains and of course increase their financial bottom line and reduce CO2 emissions towards enhancing their sustainability. In addition, emerging new technologies are the ones that now enable companies to turn that need for visibility towards sustainability in supply chains, into reality (World Economic Forum, nd).

The huge importance that supply chain visibility has in terms of improving sustainability can be seen in the following figure which can be seen in the same article (World Economic Forum, n.d.):
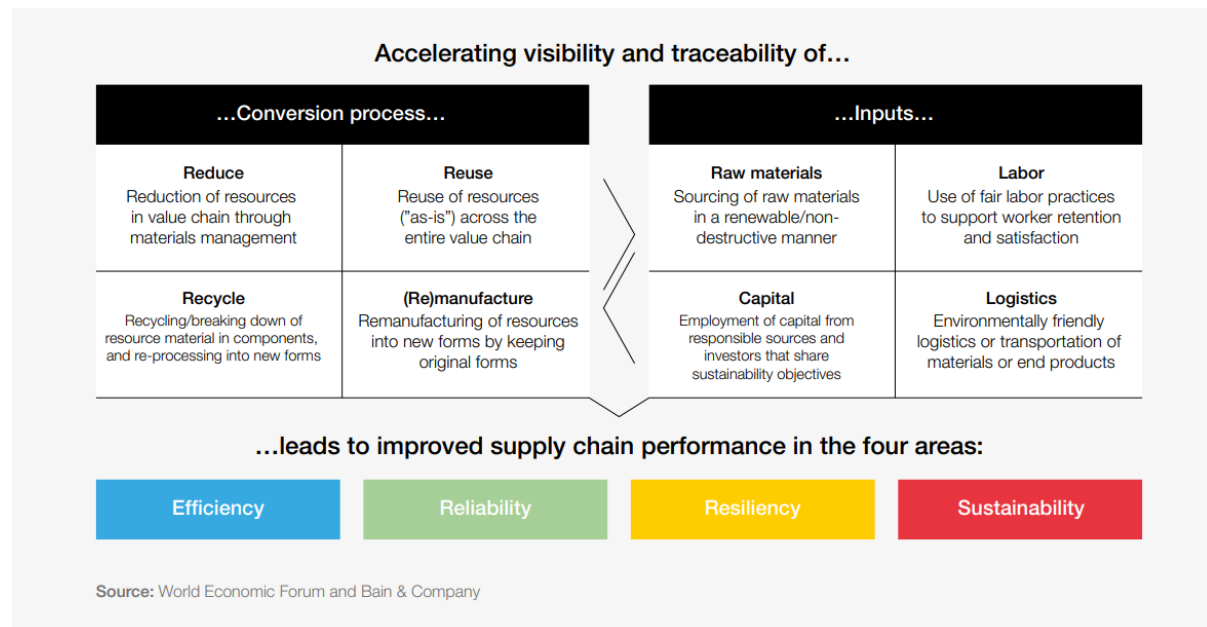

Figure 5. Connection between supply chain visibility and supply chain sustainability (World Economic Forum, n.d.)

As we can in Figure 5, accelerating visibility and traceability of goods across the supply chain leads to improved supply chain performance in four areas, one of which is sustainability.

3.2. Supply Chain Sustainability

Since sustainability is extremely important nowadays and has vast implications in so many parts of our lives, personal, professional and social, it is only logical to have vast implications in the operations of supply chains. In addition, companies nowadays starting to realize the importance of creating a sustainable supply chain and how this can have positive impact, not only in their business, but also for the whole society and the planet if it will be seen under the triple -bottom -line prism. According to Kumar et al. (2016, cited in Dubey et al., 2020), sustainable supply chains are the ones which integrate in the supply chain environmental, social and economic aspects (Triple bottom line- People, Planet, Profit).

Sustainable supply chains, as a notion, can be significantly reached via upstream, midstream and downstream mapping of a supply chain. Mapping is extremely important in this sense as it can be argued that well mapped supply chains can further improve supply chain sustainability (Sharfuddin et al., 2022). In addition, another important positive implication that springs from mapping in a supply chain is the increase in its visibility in terms of the actors that are involved in it. As we can see from the above paper, supply chain sustainability is highly correlated to supply chain visibility.

Xu et al. (2022), argues that from a supply chain sustainability perspective, it has been repeatedly observed that many global supply chains have severe issues in terms of lack in information transparency, something which might lead to product quality uncertainties. This is why the adoption of blockchain technologies in the supply chain operations as a broad -based strategy can significantly help towards the direction of attaining multi -tier goals like supply chain mapping, sustainability and supply chain integration (Sharfuddin et al., 2022). This linkage between supply chain visibility, sustainability and new technologies will be further investigated in the following sections of the research.

3.3. New technologies and their use in supply chain visibility

As we saw in the previous sub chapter, new technologies like blockchain etc, are tightly connected to supply chain visibility and sustainability. Digital supply chains that emerged the last years and new technologies like the blockchain one, the digital twins etc. can play a very important role in terms not only of supply chain connectivity, but also in terms of supply chain visibility (Queiroz et al., 2019; Cai et al., 2020; Fragapane et al., 2020, Ivanov and Dolgui, 2020a; Olsen & Tomlin, 2020; Frazzon et al., 2021, cited in Dolqui and Ivanov, 2021).

The digital transformation of supply chains is taking place in a very fast pace. Nowadays, the adoption from supply chains of complicated and advanced new systems and technologies like the IoT, the blockchain technology, cloud computing, data analytics, A.I. etc., if will be combined with the development and enhancement of the supply chain actors' digital skills and capabilities, can become fundamental paragons towards the digital transformation of supply chains (Akter et al., 2022, cited in Tsolakis et al., 2023).

One of the new technologies that are used successfully in a supply chain context is the blockchain technology. Blockchain, a new disruptive technology, is considered by many as an adequate digital application which can ensure a trustworthy implementation of A.I. application in real world situations, thus in a supply chain setting, as it encapsulates enhanced data security, reliability, usability, dependability, performance and governance (Nasar et al., 2020, cited in Tsolakis et al., 2023).

Blockchain technologies, although quite new, can be used in the supply chain environment in order to enable transactions between the different parties of the supply chain, transparency, authenticity, visibility, trust and security (Di Vaio & Varriale, 2019, cited in Laforet, 2021). One of the most important elements of this new technology, in order to be able to be implemented successfully in a supply chain, is that it requires the full participation of all involved companies/ actors in that supply chain. Only in that way the mutual trust between them will be enhanced. In addition, supply chain transparency and reliability will increase as well (Crosby et al., 2016, cited in Xu et al., 2022).

Khan et al. (2022), underlined in their research that blockchain technologies can have a vast impact in supply chain sustainability but in a not -direct way though. The way that they can achieve that is via the increased supply chain visibility. This supply chain visibility can be achieved via the application of extensive supply chain mapping which includes upstream, midstream and downstream supply chain activities. This is important because well mapped supply chains have increased visibility which accordingly can increase sustainability in a supply chain (Khan et al., 2022). In addition, Khan et al. (2022), argue that blockchain technologies need to be adopted by supply chain leaders simply because their adoption on strategic level can help them attain multi -tier goals, e.g. supply chain mapping, sustainability and integration (Khan et al., 2022).

On the other hand, one of the most important trade -offs of the use of blockchain technology in a supply chain is the high energy consumption. Therefore, it can been argued that although blockchain can help us improve supply chain visibility and increased visibility can vastly contribute to the triple -bottom -line of our supply chain, it can heavily increase our supply chain's energy foot print, something that can have a negative impact in the environment (Biswas et al., 2023).

One important element of the implementation of new technologies in a supply chain towards increased visibility that can lead to increased sustainability is that the combination of new technologies can be even facilitated further as e.g. blockchain technology can augment the A.I. implementation in both upstream and downstream supply chain operations (Grover et al., 2022, cited in Tsolakis et al., 2023). In addition, this combination of different digital systems (e.g., a combination of blockchain technologies and A.I.), can help supply chain related companies to pursue, in a more effective and realistic way, their Sustainable Development Goals (SDG), by leveraging the synergetic capabilities of those systems (Del Rio Castro et al., 2021, cited in Tsolakis et al., 2023).

There are several characteristics that new technologies, that are used in a supply chain, need to have in order to increase its visibility, like the following (Sanders & Swink, 2019, cited in Kalaiarasan et al., 2022):

- They need to be able to enable data connectivity
- They need to be able to achieve real -time data generation and data collection as well
- They need to be able to facilitate data management
- They need to be able to ensure that the use of the data in question can improve both operational and strategic activities related to supply chain (Sanders & Swink, 2019, cited in Kalaiarasan et al., 2022).

Dolqui and Ivanov (2021), stress that industry 4.0 technologies, IoT, edge computing, additive manufacturing, big data analytics and blockchain are already driving supply chain transformations towards networks that are more capable now of adapting, while they maintain their structural variety and their multifunctional processes (Zhong et al., 2017; Tang & Veelenturf, 2019; Dolgui et al., 2020b,; Kusiak, 2020; Roeck et al., 2020; Dubey et al., 2021; Ivanov et al.,2021; Park et al., 2020, cited in Dolgui and Ivanov, 2021)

According to Wagner and Postel (2022, p. 34), the key technologies that are used today in terms of supporting supply chain visibility, can be seen in the following Figure 6. In the following figure we can see the new technologies like WiFi, RFID, NFC, Bluetooth etc. depicted in a two -axis system which is consisted of the variables of data capacity (on the vertical axis) and range (on the horizontal axis). The control variables used in this figure are two; the total cost of ownership and the energy consumption.
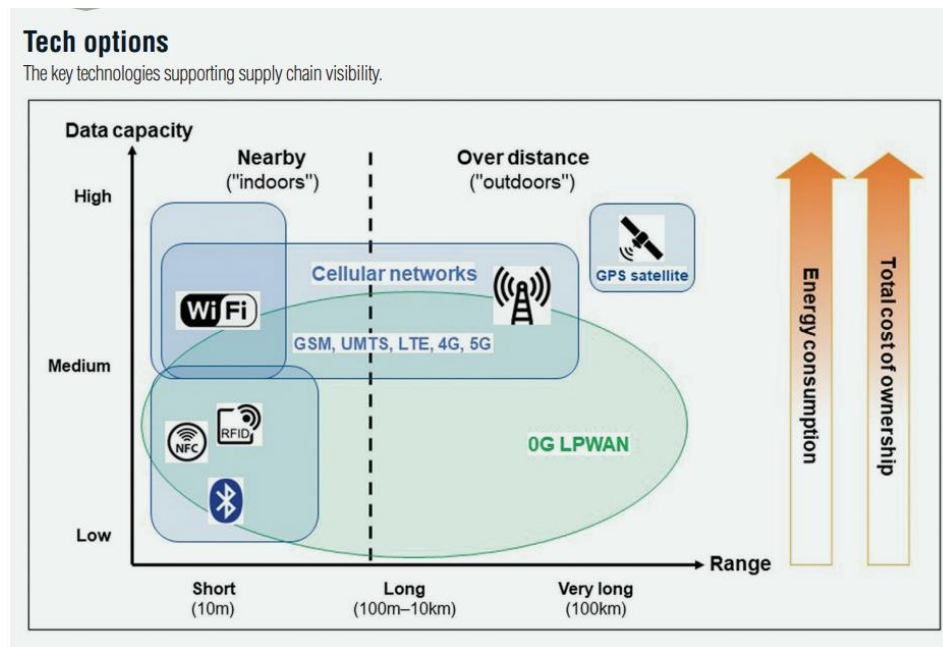

Figure 6. Key technologies supporting supply chain visibility (Wagner and Postel, 2022, p.34)

According to Ahmed et al. (2021), IoT technologies, including RFID (Radio -frequency Identification), WSN (Wireless Sensor Network), M2M (Machine -2 -Machine), HMI (Human -Machine -Interaction) etc. are also used in supply chains today and can increase supply chain visibility in many ways. E.g. they can help supply chain actors to improve their supply chain mapping, supply chain collaboration, traceability, transparency, flexibility, performance management and order management (Ahmed et al., 2021).

In terms of utilizing the right technology towards the enhancement of supply chain visibility, several parameters need to be taken under consideration, like the following:

   A. The distance that needs to be served,
   B. The energy consumption (since we also want to improve sustainability in our supply chain without compromising visibility) and of course
   C. The total cost of ownership

(Wagner and Postel, 2022, p.34).

According to a paper titled "A machine learning approach for predicting hidden links in supply chain with graph neural networks", the authors of the paper propose a method to increase supply chain visibility via the use of a machine learning methods, via which they try to shed some light on how to solve network issues. Such issues usually start with the network's topology and can create a ripple effect across the whole network (Kosasih and Brintrup, 2022). It is evident from the above -mentioned paper that new technologies like machine learning can assist in increasing supply chain network visibility.

Another new technology that can play a vital role in the enhancement of supply chain visibility towards an increased sustainability in the supply chain in question, is the use of digital twins. According to a study by Moshood et al. (2021), digital twins would help companies to develop predictive metrics, diagnostics, projections and physical asset descriptions which can help them to increase their supply chain visibility.

3.4. Correlation between Supply Chain Visibility, Sustainability and new Technologies

According to a study conducted by Al-Khatib & Wael (2023), the implementation of IoT technologies in the supply chain industry denotes a positive correlation between supply chain visibility and supply chain sustainability (triple bottom line). In addition, the above -mentioned author argues that supply chain visibility mediates the relationship between each of the industrial IoT and economic, environmental and social performance (Al-Khatib and Wael, 2023).

According to Kalaiarasan et al. (2022), one of the most important factors that can play a vital role in increasing supply chain visibility, is the implementation of a company culture which can lead to strong and efficient inter -organizational collaboration and trust. In addition, what is also very important is the use of the right business processes in terms of aligning business, information sharing, information quality and supply chain integration (Kalaiarasan et al., 2022). Information sharing and information quality are two factors that are heavily involved in the use of new technologies (e.g., use of blockchain technologies, data analytics, virtual reality, metaverse technologies etc.) (Kalaiarasan et al., 2022). In terms of information sharing, real -time data can be collected via e.g., the use of sensor -based technologies (Dolgui and Ivanov, 2022, cited in Kalaiarasan et al., 2022). This kind of technologies have as their main representative the so -called RFID technology (Radio Frequency Identification). This kind of technology has vastly been implemented in dolphin chois the last years.

Rogerson and Parry (2020, cited in Vaibhav et al., 2023), argue that blockchain technology is also widely used in supply chains today as a powerful solution in terms of enhancing decentralization, increasing trust between the different supply chain actors and increase supply chain visibility. Block chain technology is used in order to allow information sharing between the different supply chain partners in a way that data transparency can also be provided to the customers as a positive addition to the services and or goods that they purchase (Cole et al., 2019, cited in Vaibhav et al., 2023). So, it can be argued that blockchain technologies are extremely useful for the contemporary supply chains as they can facilitate the collaboration between all involved stakeholders, can increase accountability, transparency, anonymity if and when needed and persistence (Kumar et al., 2020, cited in Vaibhav et al., 2023).

In the same wave length, Sunmola (2021), argue that not only there is strong correlation between the use of blockchain technologies and sustainable supply chain visibility, but in addition, this correlation is also extended to the supply chain's capacity and capability.

The role of blockchain becomes more eminent, as one can argue that supply chain visibility can be considered as the descendent of information sharing (Barratt and Oke, 2007, cited in Dubey et al., 2020). In that sense, blockchain as

an enabler of safe and transparent information sharing technology can be said that it is a valuable facilitator and influencer of supply chain visibility. Research from Holcomb et al (2011, cited in Dubey et al., 2020) adds to that, as they argue that supply chain visibility relies heavily on shared data and information, while in addition, Brandon -Jones et al. (2014, cited in Dubey, 2020), argue that supply chain connectivity and information -sharing are immediate antecedents of supply chain visibility.

What it is also very important is that supply chain connectivity and information sharing which enhance supply chain visibility, can build capabilities for the supply chain in question which can further strengthen sustainability wise supply chain performance under the prism of the company's size, product complexity and time (Dubey et al., 2020).

Zulkaif and Qingyu (2021), argue that sustainable practices can significantly influence the company's sustainability performance and most importantly, this relationship between sustainable practices and the company's overall sustainable performance is moderated by supply chain visibility (especially for the manufacturing and procurement distributions). So, according to these researchers, there is a strong connection between supply chain visibility and sustainable supply chain performance, something which is very important part of this literary analysis. In addition to that, a research from Saqib and Zhang (2021), underlined that sustainable practices for manufacturing, procurement and distribution have vast influence in the company's sustainable performance, while this very relationship is moderated by an enhanced supply chain visibility.

Dubey et al. (2020), argues that in a supply chain which have to deal with increased product complexity, supply chain visibility can also play a significant role in supply chain sustainability as it can be seen under the prism of enhancing the supply chain's triple bottom line, since it seems to affect the supply chain's social and environmental performance as well.

IoT seems to be another technology area which seems like a very valuable component of supply chain visibility nowadays. The results of its implementation are tangible and very important (Wagner & Postel, 2022). They can be a reduce of the size of supply chain assets, e.g. reduce of the needed fleet without decreasing the service levels and availability, thus customer service quality (Wagner & Postel, 2022), or a decrease in turnaround times of around 20%, or a decrease in the tied -up capital of around 15% etc (Wagner & Postel, 2022).

What it is even more important is that increased supply chain visibility via the use of new technologies like IoT, can have a very positive impact on the supply chain's sustainability, especially since factors like the use of energy consumption and CO_2 emissions usually play a critical role in decision -making processes in the logistics industry. Therefore, logistic companies, in order to mitigate climate -change, they need to decarbonize their processes, something which can vastly be assisted by the use of new technologies like IoT, smart sensors, RFID technologies etc. (Wagner & Postel, 2022).

Another important new technological trend that can heavily assist in increasing supply chain visibility and sustainability is big data, a technology which accelerates innovation making easier not only mass production, but also the customization of products etc. (Sanders et al., 2019). In addition, additive manufacturing can assist towards that direction, as it can increase sustainability in a supply chain by assisting in manufacturing products which give less Co2 emissions, often via the use of recycled materials and by producing zero – waste products (Sanders et al., 2019).

Sanders et al., (2019), adds that new technologies that can assist in both supply chain visibility and sustainability can be e.g. smart sensing robots and autonomous vehicles. These new technologies can increase supply chain visibility via the utilization of the IoT (smart sensing robots) and can reduce CO_2 emissions (autonomous vehicles). Such contributions can be extremely important especially in terms of helping logistic actor to solve the urban last mile logistics problem.

Supply chain visibility the last years has also been enhanced via the use of telemetry and GPS which enabled supply chain operators to have increased visibility even from the more remote supply chain parts (Sanders et al., 2019).

Another important and very contemporary ways to increase supply chain sustainability via the use of new technologies is artificial intelligence. According to Yu et al. (2021), artificial intelligence can not only help supply chain actors to upgrade the performance of their operations, but it can also help them to follow a leaner approach by minimizing wastes and reduce their CO_2 footprint (Mor et al., 2021, cited in Maghsoudi et al., 2023).

The extremely interesting thing with artificial intelligence is that apart from helping towards the improvement of supply chain sustainability, it can also assist towards the improvement of supply chain visibility. A.I. can assist in tracking supply chains, something which can assist supply chain professionals in identifying potential issues across

their supply chains. In addition, it can be used as a valuable tool in suggesting solutions towards the improvement of supply chain's efficiency (Sanders et al., 2019, cited in Maghsoudi et al., 2023).

A.I can also assist in decision making in a supply chain, especially when such decisions are towards the direction of complying with the sustainable practices, regulations and legislations that the key stakeholders of the supply chain need to abide to (Maghsoudi et al., 2023). Unethical practices can be minimized in that way and also companies can assist themselves in taking the right strategic oriented decisions that can help them to achieve their sustainable goals in a quicker and efficient way (Naz et al., 2022, cited in Maghsoudi et al., 2023). In addition to that, according to a study by Ransbotham et al. (2017), in 2017, 86% of organizations were considering artificial intelligence as a strategic tool that can be used towards helping the company in question to achieve a competitive advantage (Deveci, 2023).

Supply chains, especially the last years and mainly after the covid -19 era are facing a lot of challenges and need to deal with a lot of uncertainties which of course include sustainability. Under these lenses, a study by Mastos et al. (2021), states that circular economy will play a vital role for the redesigning of supply chains via the use of the Industry 4.0 technologies. Some benefits that can spring from this combination of Industry 4.0 technologies, circular economy and supply chain redesign, can be the linking to the six circular economy dimensions of the RESOLVE model, namely regenerate, share, optimize, loop, virtualize, exchange (Mastos et al., 2021).

Another emerged new technology which can impact in a positive way the sustainable approach of supply chain management is the so -called metaverse. Chen and Huang (2023), state that the virtual environment which metaverse is using can be seen as a catalyst in supply chain management towards sustainability in the supply chain context. The sense of physical proximity that can create and the emotional attitude that can be seen during the interactions between the actors in a supply chain can facilitate sensory feedback and can, therefore, strengthen the emotional expressions between the participants (Chen and Huang, 2023). The result of the above is that supply chain actors can now adapt rational behavior and can implement mutual trust between them, something that can easily facilitate the achievement of a more environmentally friendly approach in the supply chain operations (Chen and Huang, 2023). It can also promote the sharing of green knowledge, thus it can be seen as a positive contribution to the development of a sustainable environment in a supply chain context (Chen and Huang, 2023).

As it has been discussed in the previous chapters, transparency, communication and visibility are extremely important parts of the eurythmic operations of a supply chain. In addition, another aspect that it is equally important and it is strongly connected to the improvement of supply chain visibility is the interconnection between the different supply chain actors. (Pessot et al., 2022). Such interconnection, can increase the supply chain visibility, while it can also enable the human -machine interaction, especially during the execution of operational and training related tasks (Pessot et al., 2022). Augmented reality and virtual reality technologies are able to support supply chain actors in performing their tasks, even from a remote position (Ersoz, 2019, cited in Pessot et al., 2022), thus can be a catalyst towards the interconnection between the supply chain actors that Pessot et al (2022) stresses. This interconnection can not only enhance visibility and the transmission of information between the different supply chain parts, but also can reduce emissions since e.g. workers don't need to commute to their physical positions, or to the specific point of interest across the supply chain in question.

4. Discussion

In this chapter a synthesis of the findings and the author's conclusions will be presented in order to highlight the correlation between the above -mentioned categories which are depicting the variables that were be examined via this literature review. Therefore, a discussion will follow which will also give us a comprehensive understanding of this correlation in order to let us answer the research question posed by this research.

According to the findings of this literary analysis, several new technologies are used nowadays in order to assist companies to increase their supply chain visibility. Such new technologies include blockchain technologies, A.I., machine learning, RFID technologies, metaverse technologies, augmented reality etc. All these new technologies can have a vast impact in terms of enhancing supply chain visibility. In addition, this increased supply chain visibility can

have a strong positive impact in the triple bottom line of the company in question via its impact on the social, financial and environmental aspects of its supply chain.

Especially, enhanced supply chain visibility is heavily relying on information sharing across the supply chain. Since information sharing is crucial and need to be built upon trust, while also need to follow quick paths from one point in the network to the other and between the various stakeholders, the use of blockchain technologies seems crucial, since such technologies enable the trust between the stakeholders which can be seen as blockchain nodes. In addition, apart from transparency, agility and swiftness can also be achieved.

Some concerns exist in terms of some trade -offs that can be associated with the use of new technologies like the blockchain one. In the case of blockchain the concerned trade -offs spring from the high energy consumption that the use of this technology needs, something which has a negative environmental impact. Since the use of blockchain technologies need high energy consumption, automatically the increase in supply chain visibility and thus to the increase of supply chain sustainability might be contradicted by that high energy consumption. Further research can potentially, shade some light on whether the use of blockchain technologies can have, as its bottom line, a positive impact on supply chain sustainability.

In addition to the above we also noticed that new technologies that can create a virtual supply chain environment, like augmented reality, virtual reality and metaverse, can not only enhance supply chain visibility but they can also decrease emissions, thus positively impact sustainability in a supply chain context. They can also improve decision making and human collaboration, something that can also increase visibility and trust, which can be seen as an increase on the social impact of the supply chain, thus its sustainable performance.

Finally, this research highlights some strong correlation between the increased supply chain visibility and the increase in the supply chain sustainability. This correlation is straight forward and direct and springs via the fact that enhanced supply chain visibility can have vast impact in the triple bottom line of the supply chain.

From the above, we can understand that the conceptual framework provided has been proved completely right and relevant and denotes a strong correlation between the three variables that were examined; namely, supply chain visibility, supply chain sustainability and new technologies that can be used in a supply chain.

4.1.   Answer to the Research Question

After the synthesis of the findings, we can answer the research question that this research posed. The research question was the following:

Is there a correlation between new technologies, supply chain visibility and supply chain sustainability?

The answer to the research question is that there is a strong correlation between these three variables (namely; new technologies, supply chain visibility, supply chain sustainability). This correlation comes in a direct way between supply chain visibility and supply chain sustainability and in an indirect way between the use of new technologies and supply chain sustainability. The reason behind this difference in the way that the three variables are correlated is that the use of new technologies is taking place in a way that it can enhance supply chain visibility and then supply chain visibility can enhance the supply chain's sustainability by impacting in a positive way its triple bottom line (people, planet, profit).

4.2.   Research Gap that is Filled

This is a literature review which was based on the exploration of the existing literature in many important and extended tertiary data bases.

Although, the last years, a lot have been written about supply chain sustainability, supply chain visibility and the use of new technologies in a supply chain, not much have been written with a focus on the correlation between supply chain visibility and supply chain sustainability via the use of new technologies. This research comes to fill this gap and to shed some light in the relationship between the three above mentioned variables.

The findings of this research are extremely important, not only for scholars and researchers, but also for supply chain professionals, environmental organizations, regulatory authorities, consumers etc. The vast array of the involved stakeholders and the urgency to address supply chain visibility and supply chain sustainability make this research not only contemporary but also very important. In addition, since this research is a literary review, it can be seen as the

springboard for the researcher of the future towards paving new paths of knowledge and research in order to improve the sustainability of our global supply chains.

This research contributed to the existing gap in the literature by highlighting the correlation between supply chain visibility and supply chain sustainability and how this can be successfully facilitated via the use of new technologies. Several new technologies were examined in terms of their correlation with the other two variables and also in terms on how they can facilitate the passage from supply chain visibility to supply chain sustainability. Finally, the importance of this correlation was highlighted and discussed thoroughly in an effort to underline all its dimensions and implications.

4.3.   Practical Implications and Managerial Insights. The Suez -Canal Case.

This research highlights the need for the use of new technologies in global supply chains, especially when are complex. The reason behind this is that such supply chains have low visibility, which in some industries, as we saw, might even reach levels as low as 2% of their third -tier suppliers (World Economic Forum, 2022).

The findings of this research are very important for companies that want to enhance both their visibility and sustainability in their supply chains, because they pinpoint the tools that they can use in order to achieve these goals. In terms of the applicability of these findings, it can be argued that it is not horizontal, as not all companies have access in new technologies, many of which are still expensive. A solution to this problem might be outsourcing to 4PL (Fouth Party Logistics) companies which have the ability to implement the new technologies towards an improved visibility and therefore towards improved sustainability.

According to Silvia de Face (2023), "4PL providers can tap into innovative technology such as specialised software, AI technology and automation to improve visibility across the supply chain, predict congestions and effectively manage logistics with worse visibility." This statement is showcasing that 4PL providers can act as catalysts in improving supply chain visibility via the use of new technologies, something which as we saw in this research can finally enhance supply chain sustainability. On the other hand, outsourcing to 4PLs, can be argued that, is not affordable for all companies. The answer to that argument is that reality shows that not all companies can afford such a 4PL collaboration, but we also need to bear in mind that the companies that mainly are in need of 4PLs are the bigger ones which usually have to deal with complex, international supply chains which by definition are difficult to be handled.

The importance of the implications of the findings of this research are emphasized via the World Economic Forum (2021) which underlines the importance for robust, resilient, but also sustainable supply chains which be based on transparency, visibility and diversification. From this statement we can understand that the findings of this research, if adapted especially in complex and international supply chains, can create chain reactions that will impact positively the triple bottom line of the companies in question. Transparency and visibility can be achieved e.g. by the use of blockchain technologies as discussed in this research. Block chain technologies can not only enhance visibility and transparency, but can also implement new payment methods, like the use of cryptocurrency, between the actors of the supply chain, something which can also enhance the "profit" aspect of the supply chain actors' triple bottom line.

Increased supply chain visibility in an era which is characterized by unforeseen events that made almost all forecasting models to crash, sounds like the holy grail of supply chain management. The use of the new technologies can assist managers in their job in so many ways and can help them make a difference in their respective industry. As discussed during this research, new technologies like the metaverse one, or the blockchain, can assist supply chain managers in acquiring the means to reach enhanced and more holistic decision -making processes that can be based on quick and transparent information sharing.

The use of new technologies via the increased visibility that they can provide, can also be seen as powerful tool in terms of risk mitigation. Examples towards that direction might be the use of new technologies in changing the routes of shipping in real time when e.g. an unforeseen natural disaster occurs. An excellent example is the blockage of the Suez Canal during 2022. Increased visibility via the use of new technologies could have helped logistics managers to take swift decisions towards the change of routes of their vessels the moment they have been informed about the blockage. Such a quick response might have helped them to avoid the blockage and deliver their merchandise OTIF (On Time In Full). In that way, they could have had a positive impact in their triple bottom line as they could have impacted positively the society with the OTIF delivery of e.g. sensitive food, or medicine etc., their profit as all contracts would have been fulfilled and the environment as they would have generated less emissions and wastes.

Another potential use of new technologies in terms of increasing visibility towards increased supply chain sustainability is the use of RFID technology in order to increase the return rates towards increased recycling, in an industry which usually has low recycling rates; the mobile phones industry (Ullah and Sarkar, 2020).

4.4. Research Perspectives

This systematic literature review tries to underline the implications that spring from the correlation between three extremely important elements of the contemporary supply chains, which are supply chain visibility, supply chain sustainability and the application of new technologies as the facilitator between the first two. The challenge for the researcher of the future is to dig deeper, via field research, in how exactly specific new technologies like e.g. metaverse technologies can change the game in terms of supply chain visibility and/ or supply chain sustainability.

Also, another research perspective might be the investigation of how SMEs (Small and Medium Enterprises) can leverage these new technologies in order to achieve their competitive advantage, in order to stay antagonistic in their respective markets. SMEs are the backbones of all societies, so understanding how they can become sustainable now with the advent of industry 5.0, should be one of our top priorities.

Finally, another point of potential future research might be the study of the implications of the use of the new technologies on the social paragon that is correlated with supply chain operations. Although, as we saw, new technologies can help in increasing supply chain visibility and sustainability, the transcendence of technologies like A.I., or metaverse etc. might end up in many lay -offs in the global supply chain industry. The vast implications of such phenomenon might hurt the triple bottom line of the companies in question, something which might have huge social implications. The study of this potential phenomenon is vital.

5. Conclusions

This literary review tried to shade some light to a topic which is extremely contemporary and has many implications; the correlation between supply chain visibility, supply chain sustainability and how the use of new technologies can facilitate this correlation. The findings showcase a strong correlation between visibility and sustainability in a supply chain, while the use of new technologies like A.I., IoT, blockchain etc. not only can facilitate this correlation but it can also be considered as a catalyst. The managerial implications of the findings have to do with the adaptation of new technologies which can increase supply chain visibility which accordingly can enhance the sustainability of the supply chain in questions. Supply chain managers need to focus not only on the visibility of their supply chain, but also on its sustainability. The results will be vital in terms of OTIF deliveries, supply chain robustness and resilience, while there will be a huge positive impact in terms of the triple bottom line.

5.1 Research Limitations

This literary analysis has specific limitations which mainly have to do with the not that extensive bibliography on the topic. Although a lot have been written, especially the last years, about sustainable supply chains and visibility in supply chains, the combination of the positive implications that spring from the influence of the new technologies, that are used in order to enhance supply chain visibility, to supply chain sustainability have not been much discussed till now by scholars.

Another limitation of the research is the strict deadlines that the author is facing, which prevented him from implementing a literature review which might have included a broader base of published peer reviewed papers and articles from peer reviewed journals and tertiary data bases from all over the world.

Also, another evident limitation, as discussed in this chapter, is that the papers that will be included in this analysis will be papers that were published after 2018.

Finally, another limitation is that the papers that were reviewed for this research were only papers written in the English language. In the future, papers that are written in different languages might will be considered in order to enhance the already large data base for this literary review.

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