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Social Network Analysis in Supply Chain Management: A literature review

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INTRODUCTION

As I come to the end of my studies, I have decided to look more closely at some of the areas and topics which, during my university career, have aroused my interest and particular thoughts: the importance of supply chains and how the relations within them and their single actors can be analyzed. Once I started my Master's Degree in International Management, I have always been fascinated by the complicated and mainly unknow mechanisms of interaction between businesses, in general, from both an economic, logistic and sociological point of view as sociology and economics have always been at the core of my curiosity. For this reason, I have decided to explore in a deeply way these aspects which are mostly new as they rose with the spread of globalization and Internet. In particular, the importance of supply chains has been recently underlined by the interruptions that occurred and are, in part, still in place since the end of 2019, when the Covid-19 pandemic has stated spreading all over the globe.

The objective of this thesis is to understand in which ways social network analysis is applied in supply chain management and find out how much has been written about that in the literature by conducting a systematic literature review. The paper is, thus, constructed upon three chapters: the first and the second one describe the two main topics, social network analysis and supply chain management, respectively, while the final one combines the previous two by presenting the systematic literature review conducted and its results.

Indeed, the first chapter describes and defines the methodology of social network analysis and it presents its main theoretical tools and areas of application, especially focusing on the business and management domain. Then, a section is dedicated to the instruments used to conduct the analysis, gather data and represent the results. Particular attention is devoted to the data: their typology and methods of collection. Finally, the graph theory and other mathematical aspects at the core of network analysis are discussed.

The second chapter, instead, focuses on supply chains: their definition and their management, especially by stressing the concept of supply chain management and its importance for business success. Indeed, the fact that the different supply chains activities of a single enterprise are located in diverse parts of the global and the need for coordination and integration in order to meet customer expectations, require handling solutions in order to mitigate risks and disruptions. This last aspect is dealt in the last section of the chapter, which presents the supply chain risk management approach that is implemented in companies in order to, on one hand, mitigate the vulnerability of supply chains and on the other hand, enhance awareness and protection regarding current and future potential challenges.

The final chapter, the third one, is about the systematic literature review conducted on the application of social network analysis in supply chain management, thus it has a central role as it consists in the combination of the topics discussed and analyzed in the previous chapters. In this section, the technique and process used to collect information and data is discussed and then the results of the analysis are presented. Furthermore, the outcomes of a sort of systematic literature review about the possible change in the risk perception after the spread of the Covid-19 pandemic, are described.

In conclusion, some final remarks and example are presented concerning the areas and ways of application of social network analysis in supply chain management. Furthermore, as an exemplary concept integrating the two topics at the core of this elaborate, it is introduced the Netchain analysis, which studies the simultaneous dependencies that occur in the inter-organizational context that have a strong influence in the business management procedures.

CHAPTER I: SOCIAL NETWORK ANALYSIS (SNA)

1.1 Definition and application

In recent years, the development and the widespread diffusion of information and communication technology has given birth to new economies which are based on the flow of data and knowledge. The linkages between people, services and products have become fundamental to make the difference and one of the most famous tools to examine these exchange processes is defined as social network analysis (SNA), which consists of a set of procedures for collecting, processing and controlling assumptions about relational data[1]. Moreover, according to the definition of the International Network for Social Network Analysis, or INSNA, which is an American non-profit organization founded in 1977 by Barry Wellman[2], who was the main architect of the process of institutionalizing and systematizing the of social network analysis technique,

"Social Network Analysis is focused on uncovering the patterning of people's interaction. Network analysis is based on the intuitive notion that the patterns of social structure are important features of the lives of the individuals who display them. Network analysts believe that how an individual life depends in large part on how that individual is tied into the larger web of social connections. Many believe, moreover, that the success or failure of societies and organizations often depends on the patterning of their internal structure. Social network analysis has found important applications in organizational behavior, inter-organizational relations, the spread of contagious diseases, mental health, social support, the diffusion of information and animal social organization. Today it has become an international effort with its own professional organizations, textbooks, journals, research centers, training centers and computer programs designed specifically to facilitate the analysis of structural data."[3]

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[1]Source: *L. C. Freeman, Lo Sviluppo Dell'analisi Delle Reti Sociali. Uno studio di sociologia della scienza. Milano: Franco Angeli, 2007 (or. 2004)*
[2]Source: *https://www.insna.org/*
[3]Source: *https://www.insna.org/*

This methodology is used not only in order to get additional information useful for the choices of decision-makers, but it also enables the identification of communication flows, the definition of subgroups (cliques) and their strategic positions and the recognition of types and intensity of relationships in order to provide formal concepts, measures and properties for theoretical frameworks based on a relational system among the actors or in testing theories on relational approaches. Furthermore, it consists of both a model to represent the relations within dynamic entities, and also to explain how the environment where social structures grow is influenced by their evolution occurring both in time and space.

Therefore, social network analysis can be applied for studying how the structure impacts on the way of functioning of the group or on the other hand, for understanding if the design of the network influences its members. The important aspect to underline is that by employing a network method explanation which includes the concept and information regarding the linkages between the units of the network object of the study, the focus is on stressing what arises from the relational and structural system created by the different actors within the network rather than on the properties and attributes of the single individuals as usually social and behavioral scientists do.

Even if social network analysis applies a sociological approach focusing on the relations and their effects between social entities it is a separate research field of social and behavioral sciences as firstly, it is the result coming from the advances that have been made in different domains and secondly, its measures and notions are the outcomes of the researches motivated by social theory concepts in order to describe empirical phenomena. Consequently, it consists in a tool that answers to standard research problems of social or behavioral nature by formally defining the political, economic and social environment[4] and as it captures the single units attributes by analyzing the linkages between the actors in order to study directly the network relational ties without any interference, it can be applied to every collection of actors.

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[4]Source: *S. Wasserman and K. Faust, Social Network Analysis – Methods and Applications, 1994*

social network analysis is a discipline that originated from social psychology of groups and then moved into sociology and social anthropology studies of factories and communities from which emerged the importance of informal and interpersonal relationships in all social systems. It is a science with ancient origins that has flourished in recent years due to the fact that data available is richer than ever and the conclusions that can be drawn from it are both useful and incredible. The first that begun the analysis of this methodology was Jacob Levy Moreno, who in 1934, introduced its sociogram as a tool for representing the formal properties of social configurations which did not contain any trace of mathematical or computational models: a picture in which people (or more generally, any social units) are represented as points in two-dimensional space, and relationships among pairs of people are described by lines linking the corresponding points[5]. This gave birth to sociometry, which is defined as the measurement of interpersonal relations in small groups[6] and considered the predecessor of social network analysis. In the following years studies went on, and scholars who wanted to study people, organizations or other entities not as stand-alone structures, but to analyze their relationships and to find out how they might influence behavior, were mainly divided into three lines of research: the one of the Gestalt/Form Theory by Wolfang Kohler, the one of the Harvard researches and the one of the Manchester anthropologists[7]. The first one led to Graph Theory through sociometrics and analyses of group dynamics; the second one demonstrated the existence of cohesive subgroups by studying informal relationships, and finally the third one used for the first time the network concept in a systematic way. The anthropological scholars from Manchester school, namely J. Clyde Mitchell, John Barnes, Elizabet Bott and Victor Turner, approached this methodology of social analysis as early as the late 1940s. They were the first to explicitly use the concept of the network to better describe the interdependent links that explain the solidity of community structures by using the idea of a social network simply in a metaphorical sense. Later, they transformed the image of a social network into a concept where to apply mathematical graph theory.

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[5]Source: *S. Wasserman and K. Faust, Social Network Analysis – Methods and Applications, 1994*
[6]Source: *S. Wasserman and K. Faust, Social Network Analysis – Methods and Applications, 1994*
[7]Source: *L. C. Freeman, The Development of Social Network Analysis, January 2004*

However, the foundations of the social network analysis as known nowadays, have been led by researchers from Harward University such as Harrison White, Scott M. Granovetter, R. Burt, B. Wellman and S.D. Berkowitz, who through their efforts led to the creation of instruments that could analyze and pay attention to the behavior of the actors within the network. Their research objective was about the identification of the techniques suitable for revealing the structure of sub-groups, i.e. cliques, blocks, clusters of which every social system is characterized and for which relational data were available. These researches consisted in a mathematical interpretation of sociological and relational phenomena between people and resulted in the concepts that emerged during those years of study, which show a sort of fusion between purely mathematical concepts, i.e. formulas, matrices, graphs, etc. and sociological ones, i.e. position of a person within a group, type of relationship with members of the group. In fact, social network analysis has been employed as a visual representation of the structure of groups and as a probabilistic model depicting the structural results where researchers pictured data networks through matrices, enhancing the application of mathematics. Usually, graphics with points and lines were used by respectively depict actors and communication paths as, in order to understand the impact of the network structure on the group behavior and the individual performance to solve problems, required a formal statement.

Even if Jacob Moreno was the first in introducing tools and methodologies in the sociometry's domain, the subject has become more popular at the beginning of the '70 as research has been pushed by the development and spread of computer technology. In fact, lately social network analysis has been used in the field of management, where it finds application in the study of international trade phenomena, in the functioning of institutions and in the dissemination of information. It remains that in recent decades it has also found important sources for theoretical, empirical and methodological contributions. Among the most significant ones, it is not possible to fail to mention the web and the internet, but also other types of environments such as the strategic, corporate, economic and financial ones. In the first periods of popularization and use of personal computers, this enormous amount of elements and concepts were brought to light after decades of study and research. In the same years, there was also the

introduction of the first software that was able to assist research in the field of social network analysis. However, the computerization of this science was not automatic and quick; in fact, a sort of agreement had to be found between the experts in the field to allow the sharing of theories and concepts created up to that point in order to develop further studies with the exploitation of the new ITC. The result of this consists in the opportunity that companies have in understanding the connections hidden within them, which are no more related to their structure, but to the web and to the informal ties. In fact, the spread of the Internet, social media and communication tools extended in an unprecedented way the abilities to create connections, exchange resources, obtain and provide information. If, on one hand, the pervasiveness of the Internet and social media is that 'networks are everywhere', it also encourages a tendency to reduce the multiplicity of structures of the Internet. The world of social networks and their constant growth are making a strong contribution to the evolution of markets. There are several businesses that now find space in the global market by offering social networking opportunities, thanks to which companies can offer their services and goods quickly and effectively. The online community space becomes a real communicative and relational environment, where it is possible to build and manage relationships with people near and far, known and unknown. Increasingly, companies today use tools such as intranets and portals to share information and access documents.

For what concerns the area of application of social network analysis in businesses in line with this elaborate, it is important to mention the sales and marketing department as this methodology can bring to new products, technologies or ideas, but also management in general. Indeed, it contributes with strategic suggestions in terms of communication and business strategies for the development of industrial ecosystems, partnerships and alliances, for the identification of critical links and players, thus discover the presence of clusters or communities, for finding out which are the most important countries, sectors or firms within the network, and which, on the contrary, are the most peripheral, for reorganizing the structure of the firm and for understanding its position in the network in order to act strategically in terms of decisions and business relations. According to these fields of application, social network analysis can be used by firms to internalize by establishing and cultivating relationships with partners in

foreign networks through the establishment of new relations with them in local networks in other countries, or to increase the value of investments in research and development as the existence of a network of relations influences the creation of value for companies because it enables them to combine the different knowledge assets of the various partners, or to gather information regarding the organization chart to understand the role played by individuals within it. Furthermore, it can be applied also in a more global way to examine the trade among nations referring to the different transactions such as the exchange of information, goods and services on an import and export base reflecting how the global economic system works. In fact, social network analysis can explain the economic features of the single nations and their position in the world economic system or the process of change of a group throughout the time in order to see how the world economic system itself modifies accordingly.

Therefore, an adequate knowledge of the network can help to make accurate predictions such as anticipating possible crises or allowing for a better management and also identify and explain complex phenomena such as productive relocations, chain failures between firms, spillover effects, etc. The main idea upon which this analysis is based is that it is possible to evaluate the informal networks by analyzing the relations that occur between teams, people, departments and organizations. This is especially important for managers, who think to know their organizations, but with an inaccurate perception as they are completely away from daily interactions that create the informal networks not only within the business, but also among businesses. For this reason, through social network analysis it is possible to have an X-ray about how the work goes across networks identifying who are the key individuals, crucial within the communication flows; who is perceived as a leader, innovator or change agent; what are the informal subgroups and how integrated are the different corporate functions and departments. Due to the idea of networks, the conventional theory regarding business has been reshaped shifting from a firm-centric view to a relational, contextual and systemic one. In this perspective, markets are defined as systems of networks where the context of business activities is represented by network relationships, which are analyzed by applying analytical tools in order to be understood as for social network analysis the world is a system of interaction and not just an aggregation of independent actors, who are related between them.

When social network analysis is conducted within business settings two main steps are followed: firstly, it is necessary to find out the elements or group of study and then come the interactions among the different actors and the characteristics of their nature as they vary accordingly to the typology of research. This latter aspect is important as the ties connecting people may reveal the possibility and the amount of information that can be shared across the diverse actors. There are two type of ties: strong and weak; and inside the business there should be a balance between them otherwise the exchanges become unfair. If ties are strong, it means that interactions are frequent, close and of multiple categories, while weak ties provide less interaction and do not push for innovation, but at the same time are higher in number and easier to maintain. Furthermore, ties may be reciprocal, so bi-directional or just one-way directed. This distinction could be very important because functionality is better when both parts share information. In fact, reciprocated ties are stronger than non-reciprocated ones.
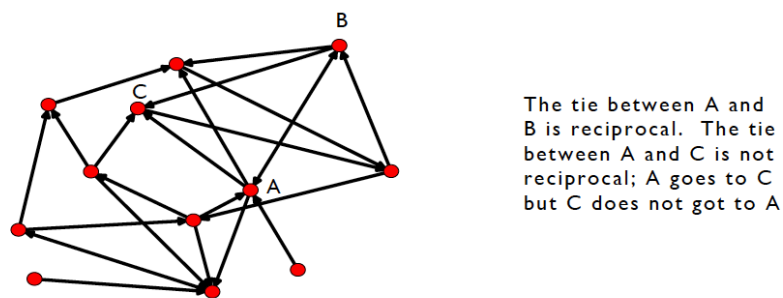

The tie between A and B is reciprocal. The tie between A and C is not reciprocal; A goes to C but C does not got to A

Figure 1. Representation of reciprocal and not – reciprocal ties [8]

After conducting the analysis, which helps in improving the movement of knowledge, ideas and information, action need to be taken in order to feed results back along the entire network, especially if the reference is to large corporations or multinational companies. However, despite the advantages in its application, organizations are still reluctant in empowering it in their organizational strategic management processes because of failure of managers in understanding its functions as little knowledge regarding its potential is available, due to an existing gap between the theoretic modelling and the real-world implementation.

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[8]Source: *Ehrlic K., Carboni I., Inside Social Network Analysis*

From this brief introductory analysis, it is possible to understand that social network analysis can be interpreted as a science that wants to be not only a descriptive means of a social network, but also an instrument that can be both predictive and explanatory at the same time. This methodology for approaching business problems differs from the conventional ones as it focuses on the assumptions that people are interdependent and not independent as usually thought. In fact, traditional social research focuses only on individuals' behaviors and not on the social and influencing aspects of the interrelations between them. The field is therefore the one of relations between humans, but examples of social networks are also found between non-human species, or between individuals and institutions, organizations and groups. For these reasons, social network analysis can be applied across different domains due to the fact that it focuses on the solution of problems that are quite similar. In conclusion, the developments in this discipline show that it provides a precise way to define important social concepts, a theoretical alternative to the assumption of independent social actors, and a framework for testing theories about structured social relationships and allows measurement of structures and systems which would be almost impossible to describe without relational concepts, and provides tests of hypotheses about these structural properties[9].

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[9]Source: *S. Wasserman and K. Faust, Social Network Analysis – Methods and Applications, 1994*

1.2 Representation and instruments of analysis

Social network analysis is a structural approach constructed upon four important aspects that stress its aim of analyzing the relations and their implications among the entities of a network:

- Both actors and actions are interdependent and not independent or autonomous
- Relations among actors are the tool for transferring resources both of material or non-material nature
- The structural environment surrounding the network can be a source of constraints for the single entities
- Models based on networks define the social, economic or political structure as lasting relationship between members

Social network analysis uses formal methods based on mathematical and graphical tools because they permit a compact and systematic representation and description of networks also through the implementation of computers software. The availability of a huge amount of relational data due to the proliferation of the technology and of the web and the higher importance of the relations between individuals instead of the single entities, are the main reasons of exploitation of this technique. As a matter of fact, it is applied both for explanatory and confirmatory matters as a branch of mathematical sociology. From the explanatory point of view, it helps in visualizing and exploring the characteristics of both nodes and networks, while from the confirmatory side, it transforms the subjectivity of the relations into abstract variables.

In order to better understand this methodology, it is necessary to portray the elements at the basis of the analysis: social networks, which consist in the connections that may rise between actors. A social network can be represented in an abstract way by nodes and lines, which, respectively define an individual, a group or a country and the relation between two of them consisting in an exchange of a specific resource such as trust, friendship, cooperation and competition. On the other hand, its subjective representation is based on the information and knowledge exchanged between the

nodes, which stand for the actor that receives or has the figurative object of the transaction. Consequently, social network analysis, is a tool used to describe and analyze the links between actors and, in general, within a network. It maps the relations in a visualized way that represent the structure of the network. Indeed, the focus on the different relations is what differentiates it from other methods of analysis.

Moreover, it is necessary to define some specific vocabularies upon which social network analysis is built on, as it deals with concepts and problems which are difficult to argue with traditional frameworks from the statistical and analytical domains. In addition, this is a way for noting the key features of this methodology that distinguishing it from the common schemes and approaches usually applied in social and behavioral sciences.

The entities are defined as actors such as individuals, corporations, people in a group, nation-states or departments. Then they are linked each other, usually in pairs, through social ties which can be of diverse nature such as business transactions, physical or biological connection and friendship. The example of the simplest type of relation is the one between two actors, which consequently, is a property of the pair and does not belong to a single individual. This type of representation is called dyad and consists of a pair of actors and the (possible) tie(s) between them and focuses on the properties of pairwise relationships, such as whether ties are reciprocated or not, or whether specific types of multiple relationships tend to occur together. However, there might be relations among larger sets of actors, such as triad: a subset of three actors and the (possible) tie(s) among them. From these explanations comes a broader definition, the one of a subgroup of actors which is any subset of actors, and all ties among them[10].

However, social network analysis does not consider only dyads, triads, or subgroups as in general the study of networks focuses on the ability of modelling the relationships within the system, which consists of ties among members of some (more or less bounded) group. For what concerns the application of social network analysis in management, the group is defined as the collection of all actors on which ties are to be measured even if other and different definitions have been given by social scientists. Another important element is the collection of ties of a specific kind measured on pairs

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[10]Source: *S. Wasserman and K. Faust, Social Network Analysis – Methods and Applications, 1994*

among members of a group from a specified actor set which defines a relation. Once actor, group, and relation have been classified, it is fundamental to define a social network, which consists of a finite set or sets of actors and the relation or relations defined on them[11]. The basic feature of network is the use of information of structural or relational nature in order to analyze or evaluate theories by providing definitions of formal type regarding the attributes of not just the structure between actors, subgroups of actors, or groups but also of the units themselves. For this reason, the resulted data are different from the ones gathered from social and behavioral science and consequently a new set of methods has been developed.

Social network analysis is based on structural variables measured on actors, which change according to the specific network object of study. It is fundamental to know the nature of the variables as they determine the analytic methodologies which are more appropriate to the different researches. The type of variable that can be found in a network are of two different natures: structural and compositional. The first ones are quantified on pairs of actors, they are the cornerstone of social network data sets and evaluate ties of a specific kind between pairs of actors[12]. These variables are mainly applied for measuring business transactions or trade between nations. On the other hand, the second ones are measurements of actor attributes and are defined at the level of individual actors[13] such as gender, race, ethnicity or geographical location.

Before gathering data for conducting network studies it is necessary to address some concerns: identify the population object of the study and sampling actors and their relations. Especially, the decision about which actors to include is the most relevant. For small and closed sets of actors it is easier to deal with this issue, but in other cases the process of determining the actors to include in the population is difficult if not impossible as they can leave the network, be of huge number or hard to define the set they belong to. However, sometimes there is an "external" classification of the actors' boundary. The definition of the set of actors, which depends on practical and theoretical

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[11]Source: *S. Wasserman and K. Faust, Social Network Analysis – Methods and Applications, 1994*
[12]Source: *S. Wasserman and K. Faust, Social Network Analysis – Methods and Applications, 1994*
[13]Source: *S. Wasserman and K. Faust, Social Network Analysis – Methods and Applications, 1994*

frameworks, is important as from them some relevant information can be gathered. Only when the boundary of the actors set cannot be defined, sampling methods are applied in order to find out the representation of a larger population by using sampled actors and data to study the network. It is obvious that social networks can be of different types according to the nature of the actors and the properties of the relations between them.

Now, it is important to consider how data of the networks are measured and collected, their accuracy and validity. Data in social networks consist of one (or more) relations measured among a set of actors. Here, what differentiates social and behavioral sciences from social network analysis is the fact that in networks there are relations that have implications regarding measurement concerns such as the unit of observation, which is the actor, from whom the information about ties is elicited, the modeling unit as network properties might belong to single actors, pairs or subgroups of actors and to the network as a whole, and the quantification of the links among actors that can be of four different types: directional or non-directional and dichotomous or valued. A directional relation is the tie between a pair of actors which has an origin and a destination, thus the tie is directed from one actor in the pair to the other actor in a pair. On the other hand, a non-directional relation is represented by the tie between a pair of actors does not have a direction. Moreover, dichotomous relations are coded as either present or absent, for each pair of actors; while valued relations can take on a range of values, indicating the strength, intensity, or frequency of the tie between each pair of actors[14]. Social network data are analyzed at different levels according to the actors: individual, pairs, triple, subset or network as a whole even if sometimes they are gathered at a different level from the one at which they are modeled.

In the social network analysis there are also tools aimed at understanding the evolution of network systems in the light of the different relational characteristics. In particular, it allows to investigate different perspectives at the same time; it combines, in fact, a Micro-Level, that of the single actor present in a network, with a Macro-Level, which

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[14]Source: *S. Wasserman and K. Faust, Social Network Analysis – Methods and Applications, 1994*

takes into account the effects related to the structure of the network as a whole or, even, of a significant part of it and a Meso-Level that stands between the two. The Micro-Level complexity is clearly the easiest to examine, as the analysis can be done from a single individual and then chart the network, indicating the relationships this has with other subjects in the network. At this level, three main metrics are applied to understand the network and the relations among actors: degree centrality, degree of intermediation (betweenness centrality) and proximity (closeness). In fact, analyses at this level are aimed at explaining the grade of relevance of actors within a given network structure or, using the terminology of social network analysis, their degree of centrality in the network. It is based on the level of activity of the actor in the network, which is measured by the number of relationships it establishes or, also, the degree of popularity among other actors. Indeed, the degree centrality of a node is simply its degree—the number of edges it has. The higher the degree, the more central the node. This is represented in the example of Figure 2: node P has the highest degree centrality of 9 as it is connected to 9 nodes (M, N, L, K, G, J, I, H and F), meanwhile, node F has a relatively low degree centrality of 5 as it is connected to 5 nodes (Q, A, B, O and P). Many other nodes have that same centrality value or higher (e.g., node D has a degree centrality of 5 as node F)[15].
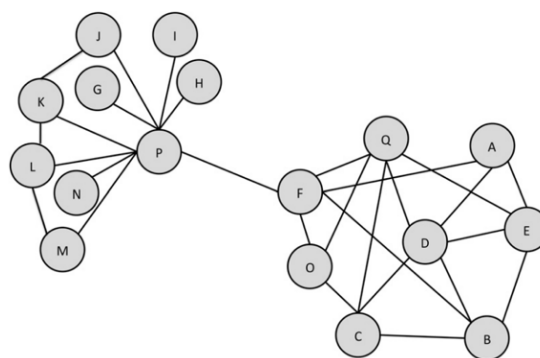

Figure 2. Degree of centrality[16] (example)

Then there is the indicator of closeness centrality, which is based on the concept that the most central actors in the network are those who can most easily transfer information to all the others; these actors also have the advantage of being able to learn, more quickly and easily, about the new cognitive resources developed in the network. It is calculated as the average of the shortest path length from the node to every other node in the network, thus lower values indicate more central nodes. The benefits of closeness centrality are that it indicates nodes as more central if they are closer to most of the nodes in the graph. This strongly corresponds to visual centrality—a node that would appear toward the center of a represented graph usually has a high closeness centrality. Figure 3 shows each node and the length of the shortest path from D. In this case the average of the shortest path length from D, so the closeness of centrality is 1.71 = (3+2+1+1+2+2+1):7[17].

Node	Shortest Path from D
A	3 (D–C–B–A)
B	2
C	1
E	1
F	2
G	2
H	1
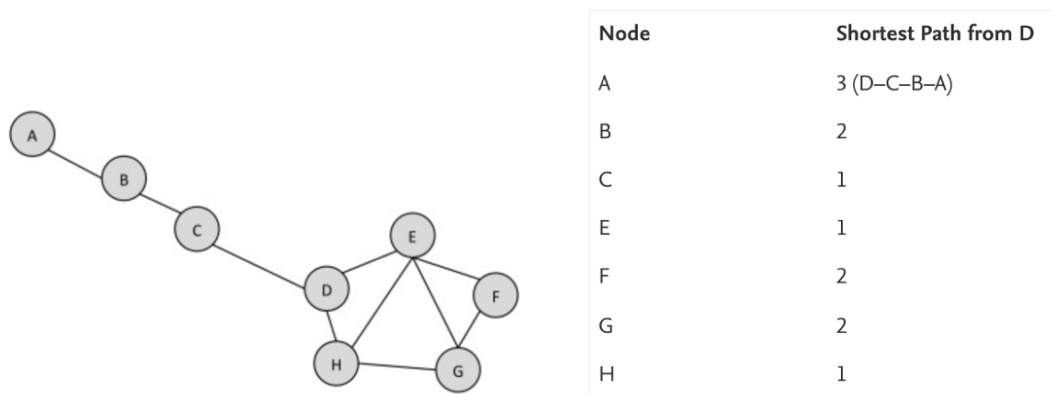
Figure 3. Closeness centrality[18] (example)

And, finally, the indicator of betweenness centrality, measures the capacity of the single actor to directly influence the passage of information within the network, thus influencing the behavior of the other actors in the network and its development. Technically, it measures the percentage of shortest paths that must go through the

[17]Source: *J. Golbeck, Analysing the Social Web, 2013*
[18]Source: *J. Golbeck, Analysing the Social Web, 2013*

specific node. The computation of this is quite complex, but every network analysis software tool will compute it for you. The important thing to know is that betweenness is a measure of how important the node is to the flow of information through a network. For example, consider Bob in Figure 4. He is the critical mode that allows information to pass from the cluster on the right to all the individual people he knows that were shown on the left. All information passing to and from those notes on the left must go through Bob if it is going to reach anyone else. Thus, Bob is very important to the flow of information through this network[19].
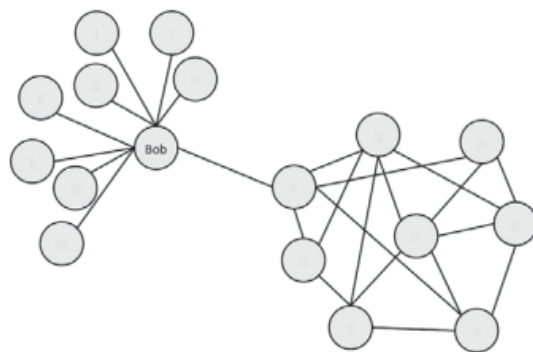

Figure 4. Betweenness centrality (example)[20]

At the Meso-Level the main feature consists in behaving as a link between the Micro-level and the Macro-level, thus conducting analysis that are particularly designed to reveal the connections between the two levels. A company is the best example to describe the Meso-Level analysis: colleagues work in collaboration and each one has to perform a number of tasks and duties in order to achieve a common goal. Finally, there is the Macro-Level, which is the most elaborated one, as the data to be analyzed is much larger and more complex than the previous levels described above. The analysis is made by studying large-scale networks, also considering the effects of operations and situations that occur simultaneously. In fact, by shifting the focus to this level, and thus going to analyze the effects of the whole network structure, one can use these methods

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[19]Source: *J. Golbeck, Introduction to Social Media Investigation, 2015*
[20] Source: *R. Rodriguez and R. D. Leon, Social network analysis and supply chain management, 2015*

of analysis to understand which actors share similar roles with respect to the set of relationships present in the network. Furthermore, the analysis at these three different levels can be conducted by applying three different approaches: relational approach, positional approach and statistical approach. The relational approach in a social network makes it possible to study how actors are connected to each other, also paying attention to the information flow between nodes, thus verifying their intensity of communication and patterning the network relations. Through this vision it is identified how the focal point of the study is represented by the way in which the actors come into contact with each other. Indeed, the focus of social network analysis is not simply the subject or node. Instead, it can be said with certainty that this modern science moves away from the analysis of the single element to focus on the entire structure. Consequently, the emphasis is on the linking relationships and on their creation. From R. Burt's studies[21], the focus should be on the attitudes that subjects have within an environment and how they establish their relationships. Network relations are not seen as answers in themselves but as patterns requiring interpretation. An example of the relational approach stands in the idea that organizations with similar characteristics tend to choose each other as partners. In fact, it is applied to understand the patterning of relations and systematically assess the extent to which different ideologies impact upon them[22]. By applying the positional approach, observation will focus on all those elements that make up the structure of the social network rather than relations, especially the spatial arrangement of the nodes. Positional (sometimes called 'structural') approaches to network analysis assume that it is the pattern of relations that results in given behaviors and beliefs, whereas relational approaches allow the view of the pattern of relations as a result of behaviors and beliefs rather than as a cause of them and tend to assume that the configuration of relations leads to behavioral conformity, and often result in misleadingly. For example, homophily, attributes and behavior can be conceived as determinants of relational structures rather than vice versa. In this case, for instance, attributes patterns in the money-exchange network

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[21]Source: *C. Haythornthwaite, Social Network Analysis: An Approach and Technique for the Study of Information Exchange, 1996*
[22]Source: *C. Saunders, Using Social Network Analysis to Explore Social Movements: A Relational Approach, 2007*

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between voluntary organizations are attributed to organizations' auspices. In his moral support network, value homophily leads to organizational proximity and organizations' scope of activities determines links in the information networks[23]. Finally, the statistical approach figures the statistical aspect that may represent the classic two sides of the same coin. On one hand, it can be said to have the nature of a mere statistical and descriptive calculation, but on the other hand, it reveals the ability to govern the variables of a social network in order to build small elementary networks. This analytical analysis can be interpreted as the researcher's ability to analyze situations at a micro level in order to then define a macro solution. Indeed, for example, this approach is used to study phenomena through numbers that then are used for cause and effect implications.

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[23]Source: *C. Saunders, Using Social Network Analysis to Explore Social Movements: A Relational Approach, 2007*

1.2.1 The methodologies for data collection

When conducting a social network analysis, lot of data are collected, especially the ones of relational nature, which reveals some kind of connection between individuals, groups, or things in the network[24]. In order to gather these data different methodologies are implemented such as questionnaires, which are the most used, observations, diaries, experiments, surveys, interviews and other techniques.

Questionnaires are carried out especially when the actors are people in order to get information about their relations. There are three different question formats that can be applied:

1) roster vs free recall – The roster format is constructed only when the researcher knows the members in the set prior to data gathering, while the free recall one is used when the researcher does not present a complete list of the actors in the network on the questionnaire and so respondents generate the list of members' names they have ties with.

   This category refers to the issue that arises while designing a questionnaire, whether the respondent should have a complete list or roster of the other members of the network or not.

2) free vs fixed choice – In a fixed choice design, each actor has a fixed maximum number of ties to other actors in the set, thus each person has a fixed number of "choices" to make; while in a free choice one, not such constraints on how many nominations to make are given.

3) ratings vs complete rankings – Ratings require each respondent to assign a value or rating to each tie, while complete rankings require each respondent to rank their ties to all other actors[25].

   This category concerns the request to respondents to rank or rate all the other members of the network according to the measure of their relations, which stands for the strength of the connections.

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[24]Source: *Digital Promise – Accelerating Innovation in Education, Planning a Social Network Analysis*
[25]Source: *S. Wasserman and K. Faust, Social Network Analysis – Methods and Applications, 1994*

Another common technique applied in order to study personal networks is the diary data collection, which asks participants to keep a record of other people with whom they interact for a specific period of time[26] (a short one due to the high number of communications that took place within an organization), especially their communication activities such as telephone calls, e-mail exchanges, personal (face-to-face) encounters, sending and receiving written materials. Usually this is a pre-structured method according to which respondents have to complete the form immediately after the communication activity has occurred, so that data are accurate even if something may be neglected. Similarly, network data can be collected by observing the interactions among small groups actors. The observation data may be gathered at various levels of detail as the information exchange moments may be taped or video-recorded, or researchers may take notes while observing, or wait for a suitable moment to leave the research scene and write down their observations in retrospect[27]. This method as well covers a limited period of time, thus data may not be representative of the "normal" members interactions and observers may interpret them coming to different conclusions as they cannot be present at all moments of the information exchange. Furthermore, interactions data can be collected by applying experimental designs, which can be of two different types. In the first case, a set of actors is chosen, and their interactions are observed in an experimentally controlled situation, thus every communication between all pairs of actors is monitored. In the second case, only some pairs of actors can interact during the experiment. Finally, the best method for gathering detailed data are surveys, as specific questions are asked, and customized answer options are provided. Indeed, each respondent can rate the personal interaction with the colleagues referring to the question on hand. However, this methodology is time-consuming and it is not appropriate for studying large networks.

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[26]Source: *S. T. Ricken, R. P. Schuler, S. A. Grandhi and Q. Jones, TellUsWho: Guided Social Network Data Collection, 2010*
[27]Source: *S. Wasserman and K. Faust, Social Network Analysis – Methods and Applications, 1994*

The collection of data is structured in two phases: name generation and name interpretation. Thus, firstly respondent recalls, or selects, the names of people in their social network and then secondly details such as demographics, communication characteristics, and relationship ties are provided on the individuals they named. According to this, data collection methods that concentrate on name generation focus the participant's attention on recalling a number of names and the type of relationships rather than on answering detailed questions about social ties. On the other hand, the name interpretation ones are used to obtain details from respondents such as relationship types, context, communication methods, frequency of contact, etc., in order to understand social ties, their strengths, and their social contexts[28].

However, it is also important to determine in advance the sample from which the data are drawn. According to this, social network analysis mainly uses two different approaches: the Full Network Method and the Snowball Method. The first one collects data from every member of the network following the idea that the more people are included, the more complete is the final understandings even if not everyone is involved. On the other hand, the second one focuses on a starting group of members of the network to whom, interviews and questionnaires are submitted in order to collect data on all their connections and then, at each step, new subjects in a progressive way are added. This procedure continues through successive iterations, until no new members emerge from the additional links. The main features of this method are that people who are not connected to the sample members are not taken into consideration, but at the same time there is the possibility to access to a wider sample of connected individuals that otherwise would not have been possible.

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[28]Source: S. T. Ricken, R. P. Schuler, S. A. Grandhi and Q. Jones, TellUsWho: Guided Social Network Data Collection, 2010

1.3 Graph theory and matrices

Social Network Analysis gathers data on networks also in a mathematical way according mainly to two different ways: graph theoretic notation and sociomatrices. The first one, is the most elementary method to represent actors and analyze their relations and since 1940 it is the basic framework to study networks, while sociomatrices are classified as complementary to the Graph Theory representation. Even if, the first one who introduced sociograms to depict relational interactions, was Moreno in 1934 as stated before, only recently, as innovation in this domain developed, the interest in representing social network data in a graphical manner has increased. As it is the oldest and easiest methodology to describe the links between actors, on one hand, it is very common, while on the other hand it is not always applicable especially when there are data on actors' attributes.

The foundation of social network analysis is on Graph Theory and matrix operations. Referring to the Graph Theory, which is a branch of mathematics, computer science and combinatorial geometry that allows the description of sets of objects together with their relationships and provides a unifying language to describe the structure of a network, it has been fundamental for Social Network Analysis for three main reasons. Firstly, because the vocabulary it uses is appropriate to label and denote social structural properties, which then are easier to refer to. Secondly, the mathematical operations it applies give the possibility to measure and quantify these properties. Finally, the union of the two reasons allow the representation of social structures through which theorems are proved and tested. When the Graph Theory is applied to social networks, points which are called nodes represent actors, while the lines connecting the points depict the relations among actors. In this visual way social ties are formally described and the structural properties are quantified. As an alternative to graph, social network analysis can be done through matrices, which contains the same information as graphs, even if data are more useful if applied for computation or computer analysis.

The Graph Theory originates from Euler and his 1736 paper in which he presented a mathematical solution to the riddle of the seven bridges of Konigsberg. Through his reasoning, Euler introduced the first graph, unknowingly he was initiated a new branch of mathematics, which then has interested numerous mathematicians over the centuries, until it became an independent discipline. Indeed, it was the first time that a graph was used to solve a mathematical problem.

The city of Konigsberg in Prussia (now Kaliningrad, Russia) was situated on both sides of the river Pregel and included two large islands which were connected to each other and to the two mainland portions of the city by seven bridges. The problem was to find out a walk across the whole city passing each of those bridges once. Euler formulated the problem in terms of graph theory, abstracting it from the specific situation in Konigsberg. He replaces each urban area by a point, i.e. a vertex or node, and each bridge by a line segment, i.e. an edge, arc or link. It has to be noted that three bridges start (and finish) at nodes A, B and D and five bridges at node C. Consequently, the degrees of the nodes are: 3, 3, 5, 3 respectively. After several observations and attempts Euler formulates the following theorem:

"Any graph is traversable if and only if it has all nodes of even degree, or two of them are of odd degree; to traverse a "possible" graph with two nodes of odd degree, you must start at one of them, and end at the other odd node."

Therefore, it is impossible to run Konigsberg as required by the thesis, since all nodes are of odd degree. The conclusion to which he came demonstrates that the properties of each graph or network are inherent in its architecture and that they can only be changed by modifying the structure of the network itself. Since then, the use and study of graphs has been refined and developed, finding applications in many fields. The demonstration had two important messages: some problems become simpler and more tractable if they are represented as a graph. In other words, networks have properties encoded in their structure that limit or enhance their behavior.

At the beginning Euler's theory about graphs was applied mainly to solve puzzle and analyze games. Then, in the middle of the 19th century, graphs started to be applied in different things on the interest of the society. Finally, it was in the 1900s that it developed, thus its implementation grew and spread among different domains.
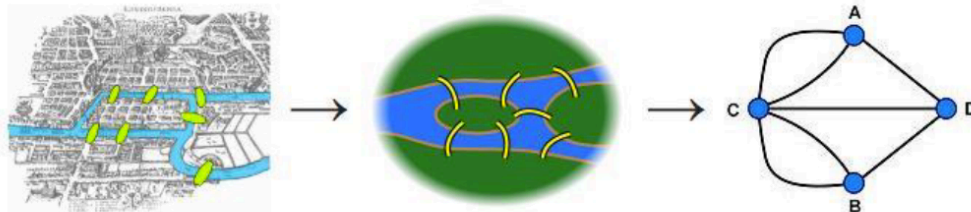

Figure 5. Topological solution to the riddle of the seven bridges of Konigsberg[29]

Thanks to the Graph theory it is possible to collect large-scale data using computers and computer networks that enables new approaches such as identifying statistical properties that characterize the structure of networks and providing ways of measuring them, creating models of networks and describing their formation and predicting the behavior of networks on the basis of models and structural properties. The denomination of graphs derives from the fact that they can be represented in a graphical way, that is what helps in understanding their properties. In fact, some definitions and concepts related to the Graph Theory belongs precisely from their graphical representation.

A graph G = (V;E) is defined as a pair of disjoint sets where V stands for a non-empty, discrete, finite set, whose elements are the vertices of the graph, while E, the set of edges of the graph, is a subset of the Cartesian product VxV, thus a set of vertex pairs of the graph. Sometimes the vertices of the graph are also called nodes or points, while the terms arc and side are synonymous with edge. Often, V(G) and E(G) are used to denote the set of vertices and edges of the graph G, respectively. Conventionally, the letters *n* and *m* indicate the cardinality of V and E, respectively, that is, the number of vertices

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[29]Source: *Giammetti R., Introduzione alla network analysis, Maggio 2018*

and edges of the graph: $n = |V(G)|$ and $m = |E(G)|$. It is made by "oriented" arcs when the edges are considered as ordered pairs of vertices, so in *(u;v) ≠ (v;u)*, and it is represented by an arrow, which denotes its direction, and it is composed of a "head" (usually represented by the tip of an arrow), which is said to reach a vertex at the entrance, and a "tail", which leaves it at the exit. Consequently, if *e = (u;v) ∈ E(G)* is an edge of the oriented graph G, we will say that the edge is leaving from *u* and entering in *v*. On the other hand, a "not-oriented graph" is designated by a set of unordered edges i.e *(u;v) = (v;u),* thus vertices and arcs where the connection *i - j* has the same meaning as the connection *j – i.*

Figure 6. Examples of "oriented" or "not-oriented" graphs, respectively [30]

In a weighted graph, each arc has an associated number that defines its weight, while in a marked graph, each arc has a positive or negative sign.

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[30]Source: *Giammetti R., Introduzione alla network analysis, Maggio 2018*

In addition, another feature distinguishing graphs regards the number of edges belonging to a pair of vertices. If for each pair of vertices *u, v* ∈ *V(G)* there exists at most one edge *(u, v)* ∈ *E(G)* we will say that it is a simple graph *G*. On the contrary, a multigraph is a graph in which there are two or more distinct edges which have the same pair of vertices at their extremities.
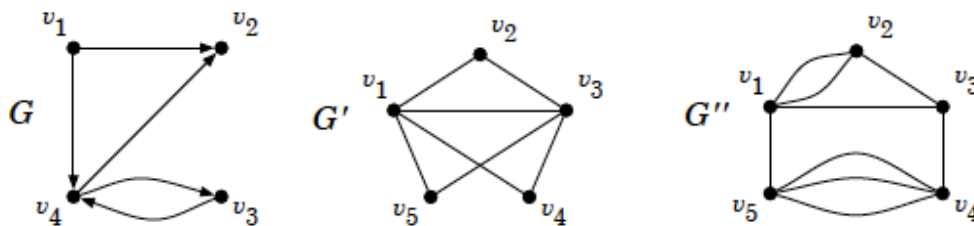

Figure 7. Examples of, respectively, an oriented graph, an undirected graph and a multigraph[31]

In order to better understand how graphs and networks in general work, it is necessary to refer to some basilar, but important definitions such as walk, trail and path. A walk is a sequence of nodes and lines, starting and ending with nodes, in which each node is incident with the lines following and preceding it in the sequence. The listing of a walk, denoted by W, is an alternating sequence of incident nodes and lines beginning and ending with nodes[32]. Obviously, the nodes at the beginning defined as origin and at the end denominated as terminus, might be different. Furthermore, nodes may be included once or more than once and ties, too. The length of a walk is the number of occurrences of lines in it and the inverse of a walk, denoted by W-', is the walk W listed in exactly the opposite order, using the same nodes and lines. In addition to walks, there are also paths and trails which have specific characteristics. A trail is a walk in which all of the lines are distinct, though some node(s) may be included more than once. The length of a trail is the number of lines in it. While, a path is a walk in which all nodes and all lines are distinct and its length is the number of lines in it. From the definitions, comes out that every path is a trail, and every trail is a walk, consequently, any pair of nodes connected by a path is also connected by a trail and by a walk. If the same node is both the start

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[31]Source: *Liverani M., Elementi di Teoria dei Grafi, Marzo 2014*
[32]Source: *S. Wasserman and K. Faust, Social Network Analysis – Methods and Applications, 1994*

and the end, the walk is denominated as closed. Another important aspect to consider for a graph is if it is connected or disconnected. A graph is connected if there is a path between every pair of nodes in the graph. That is, in a connected graph, all pairs of nodes are reachable. If a graph is not connected, then it is disconnected. A graph that is connected and is acyclic (contains no cycles) is called a tree, which in simple are graphs, since they contain the minimum number of lines necessary to be connected, and they do not contain cycles. Trees have several properties which are fundamental. Firstly, trees are minimally connected graphs since every line in the graph is a bridge (or line cut) and if a line is removed, the graph becomes disconnected. Secondly, the number of lines in a tree equals the number of nodes minus one (m = n - 1) and if lines are added the graph is no more a tree. Thirdly, there is only one path between any two nodes in a tree. If this is not true, the graph contains a cycle, which by definition a tree does not contain[33].

Path (and a walk) from 1 to 7:
1, 2, 3, 4, 5, 6, 7

Walk from 1 to 7 that is not a path:
1, 2, 3, 4, 5, 3, 7

Simple Cycle (and a walk)
from 1 to 1:   1, 2, 3, 1

Cycle (and a walk) from 1 to 1:
1, 2, 3, 4, 5, 3, 1
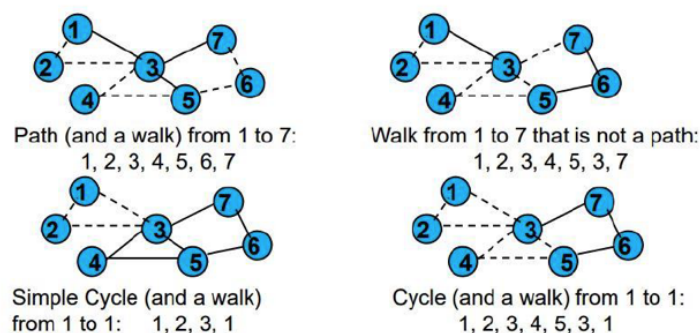
Figure 8. [34]Representation of networks' paths

To conclude, a graph is used to represent the relationship of functional type among variables having a predictive function and to depict a network, which consists of an aggregation of interconnected objects, in a formal way. In fact, many algebraic, probabilistic and logical problems can be translated into terms of graph properties to provide solutions to a variety of issues regarding arrangements, networking, optimizations, matchings and operations. Indeed, the Graph Theory aims to study

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[33]Source: *S. Wasserman and K. Faust, Social Network Analysis – Methods and Applications, 1994*
[34]Source: *Giammetti R., Introduzione alla network analysis, Maggio 2018*

graphs, which are discrete and simple objects that make it possible to schematize a wide variety of situations and processes and often allow them to be analyzed in quantitative and algorithmic terms. Furthermore, as stated above, it studies the metric and topological properties of binary relations that provides its application in various fields as structures that can be represented by graphs are present in several disciplines, in particular those related to networks. The Graph Theory is important as it is a logical structure through which more than one 'real structure' can be schematized using graphs, from a road network, to a calculation program or a data structure.

On the other hand, a graph G, which is composed by an ordered pair, G = (N, E), where N denotes the set of nodes, and E stands for the set of arcs, can represented through a matrix, called adjacency matrix A (n, n) whose elements a_{ij} are 0 if nodes i and j are not connected, and 1 otherwise.

$$A = \begin{pmatrix} 0 & 1 & 0 & 1 \\ 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{pmatrix} \qquad A = \begin{pmatrix} 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 \end{pmatrix}$$

Figure 9. Examples of adjacency matrix[35]

In fact, social network analysis, instead of graphs can use two types of matrices: adjacency matrix or the incidence matrix. The first one is denominated with A and as that because the entries in the matrix indicate whether two nodes are adjacent or not[36]. If it is applied for studying social network it is denominated as sociomatrix of size g x g (g rows and g columns) for one mode networks. According to the definition there is a row and column for each node, and the rows and columns are labeled 1, 2, . . . ,. The rows and columns index nodes in the graph, or actors in the network, in identical order. Despite the actor, the relations are codified through a binary code: 1 when there is the interaction between two nodes and 0 when it is absent. The adjacency matrix may be symmetrical or asymmetrical; in the case where the direction of the bond is not taken

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[35]Source: *Giammetti R., Introduzione alla network analysis, Maggio 2018*
[36]Source: *S. Wasserman and K. Faust, Social Network Analysis – Methods and Applications, 1994*

into account, the matrix is symmetrical, vice versa if the direction of the bond is taken into account, the matrix is asymmetrical. This consists in the simplest and most common matrix used to represent network relations: the number of rows and columns equals the actors, while the ties between them are designated by the elements.

CHAPTER II: SUPPLY CHAIN MANAGEMENT

2.1 Supply Chains (SC)

A company that sells products or services to a customer usually has to deal with a supply chain, which on one hand impacts the various business functions, but on the other hand permits the selling that otherwise would not be possible. For this reason, understanding the supply chain is fundamental for the strategy of corporate objectives and the organization of practices needed to achieve them. A successful business should have full visibility over its supply chain, as well as its processes and suppliers, in order to enable entrepreneurs to make decisions that will maximize profitability and ensure customer satisfaction.

A first important remark about supply chain consists in understanding its meaning: the process known as supply chain is very complex, articulated, dynamic and difficult to predict and control, thus it requires careful planning and allocation of resources. The aim is to make the company more effective, efficient and ready to respond to the needs of customers and suppliers. This process starts with the raw materials, continues with the realization of the finished product and its warehouse management, and ends up with the supply of the final product to the customer. As this description demonstrates, a supply chain is divided into several steps, within each of them several professionals are involved. Its complexity depends on internal and external factors such as the size of the company in question, the product, the context and the events surrounding the market.

Even if supply chains have always existed, their theories born around 1980s and 1990s. From a practical standpoint, the supply chain concept arose from a number of changes in the manufacturing environment, including the rising costs of manufacturing, the shrinking resources of manufacturing bases, shortened product life cycles, the leveling of the playing field within manufacturing, the globalization of market economies, outsourcing and the higher availability of information, that pushed businesses to integrate in order to gain more visibility. Indeed, for years, researchers and practitioners

have primarily investigated the various processes of the supply chain individually. Then, recently, however, there has been an increasing attention placed on the performance, design, and analysis of the supply chain as a whole due to the interconnections among its different actors.

The official definition of supply chain that has been provided by the Supply Chain Council[37], an independent not-for-profit organization established in 1996 whose members belong to companies and organizations interested in the application of state-of-the-art techniques and systems of supply chain management is:

"the supply chain comprises all the efforts involved in the production and distribution of a finished product, from the supplier's supplier to the customer's customer"[38].

It, therefore, is a system made up of a network of different economic entities, autonomous or semi-autonomous, consisting of suppliers, producers, distributors, retailers and final consumers who are connected by a common flow of materials (forward flow) and information (backward flow) that work together in an effort to: 1) acquire raw materials, (2) convert these raw materials into specified final products, and (3) deliver them to retailers[39] by meeting the customer requirements. Consequently, a supply chain defines the set of relationships among the different actors that facilitates the transformation of raw materials into final products. Due to this structure, in the modern competitive environment, the success of an individual organization depends on the ability of managing and integrating the company's network of business relationships towards a common goal.

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[37]Source: *ASCM – Association for Supply Chain Management, https://www.ascm.org/*
[38]Source: *M. Sartore, Tesi di Laurea Magistrale "La Supply Chain: una strada per il successo - Il caso AgustaWestland", 2013*
[39] Source: *Benita M. Beamon, "Supply chain design and analysis: Models and methods", 1998*
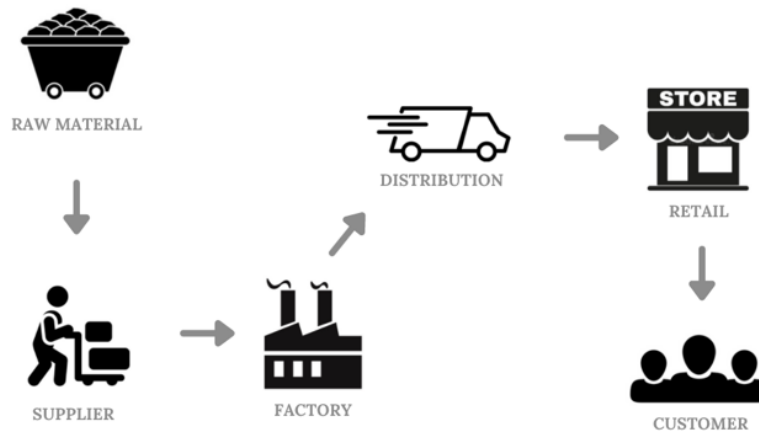
Figure 10. Example of a supply chain

The concept of supply chain is therefore broader than that of logistics, which refers to the process of planning, implementing and controlling the efficient and effective flow and storage of raw materials, semi-finished and finished products and related information within a single enterprise, from the point of origin to the point of consumption, with the aim of satisfying customer needs. Supply chain, on the other hand, stands for the set of activities that must be carried out in an integrated and coordinated manner not only within the company but also with all systemic entities involved in the management of supply chain flows[40]. This definition highlights some distinctive features of the supply chain concept such as that it is a cooperative system developed and managed within a unitary strategic design aimed at satisfying the end customer through the integration of its business processes and the development of appropriate interdependent relationships, which are governed by relevant coordination mechanisms. Accordingly, each component of the supply chain constitutes an entity characterized by its own managerial and strategic autonomy but which cooperates with all the other entities in the network in order to achieve certain levels of efficiency and effectiveness. Consequently, the coordination and integration of a group of isolated and fragmented processes is needed in order to have the chain running smoothly.

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[40]Source: *R. Pinna, L'evoluzione nella dimensione organizzativa della Supply Chain – Dalla gestione di un flusso alla gestione di una rete, 2006*

Supply chains have the aim of maximizing the creation of value linked both to the supply chain itself and its profitability. Therefore, the value in the supply chain is given by the difference between what the final product is worth to the customer and what the supply chain spends to meet the customer's requirements. In addition, the value in terms of profitability refers to the difference between generated by selling to the customer and the costs along the supply chain.

The environment in which companies operate has changed dramatically over the years. Transport times and the availability of distant supply markets have opened up a wide range of possibilities for companies. Until yesterday, the procurement markets for materials, processes and components had to be relatively close by, while today the industrial process can be widespread in several parts of the world. With the development of information transmission networks and the internet, and with the spread of computer systems and telecommunications, companies are being forced to change their organizational structure in order to take full advantage of all the opportunities offered by the technology sector and by the new supply markets in those countries where processes are less costly. The strong impact of globalization has pushed companies to operate in a market where speed and service are prerequisites and indispensable requirements that force businesses to change strategies and organization in order to reduce time-to-market and operate in real time, seamlessly. This stands for a continuous connection and collaboration with customers, suppliers and business partners in general. As this environment outlines, modern supply chains are more complex than in the past, due to the different challenges such as lack of transparency, waste and delays caused by inadequate production cycles which bring to have unsatisfied partners and customers, resilience to unpredictable external and internal changes and higher customer expectations. Companies must therefore rethink and redesign their internal processes and external relations using tools and methodologies aimed at gaining a competitive edge with a view to increase competitiveness, profitability and customer satisfaction, improve the capacity for innovation and ability to respond to changes in demand, consolidate the production process to optimal standards and create viable alternatives to the supplier base.

In general, supply chains are becoming increasingly complex and the actors and processes involved are more and more integrated. Their risks are growing, but with an effective Supply Chain Management, companies will be able to cope and adapt to enhancing complex situations. Digitizing the supply chain is the best tool companies have in their hands to face current and future challenges. All this without forgetting that a contemporary concept of this argument must take into account the idea of having to manage an international market. Even if today supply chains are intended for a long duration, due to the fast changing environment, they have to evolve accordingly for further improvements and to be continuously analyzed in an accurate way in order to serve their different purposes.

2.2 Supply Chain Management (SCM)

Today, it is rare for a company to complete the entire production cycle that makes up its business as typically, it is a link in a chain that includes other entities, i.e. subcontractors, distributors, suppliers, distributors, business partners.... and, finally, customers. Optimizing this whole chain does not only mean intervening in the internal activities of each of these individual links, but to act at a broader level, focusing above all on the interactions between the connections themselves. For this reason, the subject of supply chain management is more actual than ever: in order to efficiently manage the entire supply chain, it is necessary to define management methodologies and adopt software solutions capable of streamlining production and minimizing waste. Indeed, if understood and applied in the right way, it can bring interesting benefits to companies in terms of costs, timing, effectiveness and efficiency. Supply chain management is nothing more than a recent evolution of the purchasing and logistics functions into a strategic approach regarding the management of materials and distribution. It is a practice that started to be applied in industries since 1980s, considering that the different actors along the chain play different roles that vary according to the sector and to the company they belong to. For this reason, supply chain management is a discipline where different manufacturers, professionals and researchers focused on.

It is considered a recent concept as it developed once the business environment changed due to different aspects such as globalization, increasing competition and customer expectation, technological and geopolitical impacts. Therefore, even if in the past competition was among companies, today it is among supply chains, as the survival of a business depends only on its ability to have cooperation with its chain.

According to many scholars, the advantages of having a good supply chain management are diverse and varied. Especially, businesses that have greater control not only over direct suppliers, but also over suppliers of suppliers, are able to benefit from improved processes which lead to increasing performance. Furthermore, it represents a source of competitive advantage as it allows an increase in the level of service accompanied by a simultaneous reduction in costs and it contributes to the success of a business also in financial terms as it enhances differentiation and sales by penetrating new markets.

In recent years, the development of internet and new technologies, has facilitated the sharing of information between the various players and have therefore made visible the benefits and results that arise from well-coordinated and integrated relations. Everything has begun when manufacturers and services providers started collaborating and integrating as well as wholesalers and retailers integrated their functions within transportation and logistics according to the supply chain management perspective in order to improve competitive advantage. In order to apply supply chain management, companies have to be prompt to innovation and new different methods of working in order to make easier the installation of the respective systems.

Over the last years, approximately after 1990s, this topic had the attention of various scholars, but as it is mainly a current topic that has not comparisons and researches perceive the discipline differently, there is still not an unambiguous definition about the concept of supply chain management (SCM), even if it can broadly refer to the more managerial aspects of the supply chain. Consequently, it delineates the set of management methodologies and software solutions that enable the efficient handling of the entire supply chain. Moreover, the term usually is connected to the idea of globalization, referring to the need of manufacturers to source inputs and produce goods worldwide. Regarding this, it is important to underline that the market competition is based on the time delivering of products and on their quality as delivering a defect-free product to clients is not a competitive advantage, but a prerequisite to stay in the market; for this reason, suppliers and distributors need to highly correctly coordinate.

A simple and comprehensive definition of this discipline whose field of interest is very broad as it was born as a fusion of several specific aspects, delineates Supply chain management as a set of methods used to effectively coordinate suppliers, producers, depots, and stores, so that commodity is produced and distributed at the correct quantities, to the correct locations, and at the correct time, in order to reduce system costs while satisfying service level requirements."[41] Therefore, the first aim of supply

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[41]Source: *J.J Assey Mbang, "New Introduction to Supply Chains and Supply Chain Management: Definitions and Theories Perspective", January 2012*

Chain Management consists in the satisfaction not only of the end-consumer, but also of all actors along the chain, which is reached by having the right product, to the right place, at the right time and price.

However, in 1982, Oliver and Webber, with their paper "Supply Chain Management: Logistics catches up with strategy" were the first two scholars that begun to talk about supply chain management in the literature, defining it as a technique for reducing stocks in companies belonging to the same supply chain[42]. In this publication the term was used in reference to techniques for inventory reduction in companies that are part of the same supply chain and linked by customer-supplier relationships. In particular, SCM was initially defined as a management system that combines purely logistical activities, from a functional point of view, i.e. integrated transport, warehouse management and distribution activities), with managerial type activities, i.e. linked to the management of production flows, production planning, procurement, stocks and customer service. In general, the concept concerns the management of the entire distribution chain, with particular reference to logistics and the relationship with suppliers and above all it is based on forecasting, planning and coordinating the flow of goods and on the final expectations. In 2001, supply chain management was then defined as a systematic co-ordination of traditional business functions and tactics, within each organization and along the supply chain, with the aim of improving the long-term performance of the different actors operating in it[43]. Finally, in 2007 The Council of Supply Chain Management Professionals defined supply chain management as encompassing the planning and management of all activities involved in sourcing, supplying, converting and managing logistics activities[44]. It, thus, outlines that supply chain management is a logistical process linking a company with its customers and suppliers. In particular, the Council emphasized that the integration of physical and information flows throughout

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[42]Source: *Ing. R. M. Grisi, Dottorato di Ricerca in Tecnologie e Sistemi di Produzione Indirizzo Gestione del Rischio e della Sicurezza - Supply Chain Risk Management: Approcci, Tecniche e Modelli di Gestione, 2008*
[43]Source: *Supply Chain Management: cos'è e perchè è importante per le aziende, https://www.digital4.biz/supply-chain/supply-chain-trends/supply-chain-management-cose-e-perche-e-importante-per-le-aziende/*
[44]Source: *H. Ronald, Ballou, "The Evaluation and Future of Logistics and Supply Chain Management", European Business Review, Vol.19 No.4, pp. 332-348, 2007*

the supply chain was the basis of the supply chain management process. Information from customers and the market, in particular, had to be transferred into production and supply plans, through appropriate scheduling in production. However, integration concerned not only goods and information, but all present flows, processes and partners, who may be suppliers, intermediaries, service providers, and customers in the supply chain. Among the possible definitions of supply chain management, the most comprehensive is the following one:

"SCM is an integrated, process-oriented approach to the procurement, production and delivery of products and services to customers; it manages relationships with subcontractors, suppliers, internal operations, intermediaries, distributors and the final customer; it includes the management of raw materials, semi-finished and final products as well as information and economic flows."[45]

This definition emphasizes the importance, inherent in the supply chain management concept, of managing not only internal activities, but all the ones carried out by the production and distribution chain. In short, it integrates and coordinates the supply chain of an entity or a company and the management of the relationships between its various actors through the different stages, with the aim of improving the performance and efficiency of the entire flow of supply of resources and storage of finished products. In other words, supply chain management can be defined as the management of the different logistical activities of a business. The main idea upon which the discipline is based on, is that each part of the supply chain, through its action, adds value to the final product.

It is important to emphasize the fact that the strategic focus of supply chain management has changed over the years. In the 1950s and 1960s manufacturers strategy was based on mass production to reduce at minimum the unit production cost. Then in the 1990 evolved the capability of organizations to manage corporate resources

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[45]Source: *MIT, Massachusetts Institute of Technology* (Source: *Ing. R. M. Grisi, Dottorato di Ricerca in Tecnologie e Sistemi di Produzione Indirizzo Gestione del Rischio e della Sicurezza - Supply Chain Risk Management: Approcci, Tecniche e Modelli di Gestione, 2008)*

and so strategic suppliers and logistic functions were included in the chain. And, finally, the concept of supply chain management has been adopted to enhance efficiency with a customer-focus vision. As a matter of fact, at the beginning, the focus was more on the internal functioning of the company, which acted on the market as an entity in its own right, without substantial links with other companies. Moreover, in the past, management was focused on the individual node of the supply chain and the objective was to improve its efficiency, but later it was realized that the optimization of everything concerning the individual entity did not allow for an overall optimum in the supply chain and that, therefore, something more could be done. Instead, today, with the widespread use of the Internet in order to achieve a final product that goes directly to the customer, who is at the heart of the entire distribution system, it is necessary to act in interconnection with all the companies involved in the distribution and logistics process. Moreover, today's supply chain management systems are mainly digital and they include materials and software for all parties involved in creating products or services, fulfilling orders and tracking information, such as suppliers, manufacturers, wholesalers, transport and logistics service providers and retailers in order to use technology to make supply chains and businesses smarter.

Supply chain management is an essential linear and isolated function for businesses as its primary purpose consists in controlling performance and improve efficiency in order to optimize the level of service offered to the end customer, by rationalizing operating costs and committed capital. It therefore coordinates the activities that serve to optimize the individual links in the supply chain becoming one of the key drivers on which organizations can focus to increase their competitiveness and customer satisfaction. For this reason, today, supply chain management is an integral part of a company's success as it manages the entire chain and each step along it. In fact, an efficient supply chain management enables businesses to reduce time to market, lower product prices and ensure differentiation from competitors. Furthermore, the greater availability of information together with a quicker delivery performance represent tactic and strategic ways of reducing inventory, costs of transports and labor on one hand, and increasing sales on the other hand.

In particular, the Internet has enhanced flexibility, coordination, integration and communication among the chain, on one hand by improving customer service and the speed of communication and on the other hand by reducing process costs. This is also why supply chain management is not only about products, but also about information. Automation is poised to become the revolutionary of supply chain management, and it's already here. Industry 4.0 applied to supply chain management offers a significant advantage over traditional supply chain management, as it enables aligned planning and execution, while providing significant cost savings. Nowadays, supply chain management systems need to be flexible enough to mitigate all impacts generated by changes in the supply chain, including diverse and modified regulatory requirements. As a matter of fact, implementing an intelligent supply chain management system can help in being more efficient and reduce costs, while ensuring also compliance with changing legal requirements. With today's supply chain management parameters, the cloud is a natural ally, because cloud-based applications are inherently more flexible and adaptable to change. Indeed, cloud solutions are designed to make better use of the technologies that are becoming increasingly common in the Industry 4.0 model. Another significant benefit of integrating the cloud into a supply chain management system is the ability to adopt the right elements according to your specific business needs in order to customize the cloud integration accordingly to the current and future supply chain management needs. As for a business is important to know at all times what is happening at each point in the supply chain, intelligent supply chain management solutions offer this functionality as the modern and innovative ones are fully integrated cloud technologies and they offer 100% visibility across the supply chain and scale up or down in order to react to market realities. Advanced technology will be increasingly used to further enable supply chain management connectivity and usage: the whole planning function will become smarter to take into account consumer needs so that adaptability will be imperative.

In addition, there are other several factors that have made supply chain management an important topic such as the decentralization of production activity, with the creation of multi-site production in which several entities are involved in the production and delivery process; the shortening of distribution channels, with the producer getting closer and closer to the final consumer; the development of the world economy, with

increased demand for local products and the competitive pressure to provide customers with high quality services and products in ever shorter time frames.

Future supply chain management systems will also bring closer alignment between planning and execution, which is currently not available in most companies, thus the need for speed and accuracy will only increase. Ongoing trends such as outsourcing and information technology systems represent the opportunity for the progress in this discipline. Therefore, businesses will have to build up relations based on trust in order to exchange mutual information with their partners. In the past, supply chain planning was an activity performed periodically by companies. Instead, in the future, it will be on an ongoing basis.

Finally, it has to be stated that many people equate supply chain with logistics, but logistics is actually just one important function of a business and a component of the supply chain. Indeed, supply chain management was born and developed as an evolution of logistics management, i.e. management of the physical distribution process of products and the relationship between the warehouse and the transfer function. At a later stage, other functions such as production management, procurement, orders, etc. have been added and integrated with logistics management. Today, this discipline integrates an even greater number of functions, covering the entire chain of activities and relations linking the company to its suppliers and customers.

Figure 11. Supply chain management' activities

The gradual evolution of supply chain management and the trend towards extending the supported functionalities are driven by a number of factors:

- an increasing and more pervasive customer focus: the company needs to be able to ensure adequate service based on quality, product customization and speed of delivery;

- a more advanced use of technology: data and information flows affect all stages of the supply chain. In addition, the progressive development of the Internet means that the sales process is more direct and that the customer is provided with a better service;

- performance measurement: time and costs, as well as other parameters, are monitored at all times in the supply chain and evaluated against the final objectives with a view to progressive improvement;

- globalization: new opportunities are created for the company to purchase low-cost raw materials from emerging economies and, at the same time, new sales opportunities are created.

To conclude, supply chain management is a practice that helps the company to make decisions, and consequently to act, in line with its corporate strategy as it manages the flows within the different stages of the supply chain in order to maximize the total profitability of the supply chain.

2.3 Supply Chain Risk Management (SCRM)

In the past, the dominant businesses thinking was about the production of products with better quality at the least costs through standardization, thus increasing efficiency. Instead, in later years, enterprises have focused on the customer's satisfaction by increasing elasticity in production lines and developing new products in order to satisfy the diversified customer's expected patterns. Nowadays, companies deal with extended supply chain in order to meet these needs and consequently face a variety of risks. Especially, brought new sources of uncertainty and complexity are due to the changes there have been in the way firms interact, pushed by the introduction of new technologies and the design of new business models. Indeed, supply chains are becoming leaner and more dependent on the coordination of the different partners of the chain network. Furthermore, problems arise also due to the reduction of the product life cycles as a consequence of an increasing and rapid product obsolescence, due to more automated business processes that are not monitored and managed in the correct way and due to outsourcing, according to which firms depend on third parties in a more consistent way and consequently, risk events are more difficult to detect and respond to. Globalization is the most prominent supply chain risk driver, even if the causes of supply chain disruptions are numerous and of various sources including socio-political and economic developments, natural and man-made disasters and fast changes in market requirements[46]. All these issues have a significant impact on the company business and financial performance and consequently implementing a supply chain risk management process can help to make strategic decisions and operational plans to reduce the quantity of supply chain defects[47].

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[46] Source: *A Ghadge, S. Dani, R. Kalawsky, Supply chain risk management: present and future scope, 2012*

[47] Source: *H. ZandHessami, A. Savoji, Risk Management In Supply Chain Management, 2011*

In general risk is defined according to the following formula:

$$R = P \times D$$

R = Probability of occurrence X consequential Damage (D)[48]

Thus, risk (R) is the Probability (P) of a given event occurring (expressed on a scale of 1 to 4) and its consequential Damage (D), which depends on the different possible consequences that the event may bring (the scale of values varying from 1 to 4).

The most quantitative tool used to assess risk is the risk matrix, which has been adopted by businesses for its simplicity and effectiveness. Figure 12. shows an illustrative risk matrix where the probability of failure is shown on the vertical axis, and the severity of consequences is displayed on the horizontal axis. Qualitative outcomes are separated from each other by distinct colors which make it easier to visualize.

	Severity				
Almost Certain	Medium	High	High	High	High
Probable	Medium	Medium	High	High	High
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium
	Insignificant	Significant	Severe	Major	Catastrophic

Figure 12, Example of a risk matrix[49]

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[48] Source: *I. K. Faisal, P. R. Amyotte, M. T. Amin, Advanced methods of risk assessment and management: An overview (2020)*
[49] Source: *I. K. Faisal, P. R. Amyotte, M. T. Amin, Advanced methods of risk assessment and management: An overview (2020)*

The concept of risk expresses at least two fundamental factors: the uncertainty related to the occurrence of events and the related losses, measured in appropriate units, usually translated into monetary terms. The terms risk and uncertainty are often used interchangeably even if they are not the same. The distinction between risk and uncertainty, asserts that risk is something measurable while uncertainty is not quantifiable and the probabilities of the possible outcomes are not known. It relates to the situation in which there is a total absence of information or awareness of a potential event occurrence, irrespective of whether the outcome is positive or negative[50].

What most definitions of risk have in common are the three dimensions:

1. likelihood of occurrence of a particular event or outcome;

2. consequences of the particular event or outcome occurring;

3. causal pathway leading to the event[51];

The supply chain is exposed to many types of risks, that potentially delay systems and create additional expenses for the companies involved, as it performs a wide variety of processes and comes in different forms. Risk in this context can be defined as the potential for unwanted negative consequences that arise from an event or activity. Especially, it is an exposure to an event which causes disruption, thus affecting the efficient management of the supply chain network. Nowadays not only there are too many dangerous situations, but also the development of modern technology has brought about an exact knowledge of the risk probability in these cases. At the same time, technology makes available the instruments with which to estimate and control probable risks and avoids over all from them in all times. The risks in supply chains arise mainly due to:

• operational fluctuations such as variability in supply, demand uncertainties, and price variability

• natural events such as earthquakes, cyclones, epidemics

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[50]Source: *C. Colicchia, F. Strozzi, Supply chain risk management: a new methodology for a systematic literature review, 2012*
[51] Source: *R. Ritchie, C. Brindley, Supply chain risk management and performance: A guiding framework for future development, 2007*

- manmade crises such as terrorist attacks, unethical business practices and economic recessions

Further cultural, infrastructural and political differences and the trend towards strategies such as outsourcing, single-sourcing and lean practices that firms have adopted in order to be more efficient, have also made the supply chain more vulnerable to market uncertainties, dependencies and disruptions[52]. In this context, vulnerability is defined as an exposure to serious disturbance arising from risks both within and external the supply chain[53]. In addition, connected to this concept there are robustness and resilience, that taken together can be treated as a complement to vulnerability. Robustness represents the ability of the system to maintain its function unchanged, or nearly unchanged, when exposed to perturbations, especially, within supply chain management, robustness can be defined as the extent to which the supply chain is able to carry its functions for a variety of possible future scenarios. Instead, resilience implies that the system can adapt to regain a new stable position (recover, or return close to, its original state) after perturbations[54].

All these factors have triggered the interest of both academics and practitioners to consider risk issues and its management as prime concerns. Indeed, effective management of risks is becoming the focal concern of the firms to survive and thrive in a competitive business environment[55]. Especially, many recent events demonstrate that an event affecting one supply chain entity or process may interrupt the operations of other supply chain members. Hence, it is important to look at the entire supply chain, across all countries, when selecting and implementing risk management strategies[56]. Thus, in regard, the need to study different methods and strategies for

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[52] Source: *P. Singhal, G. Agarwal, M. L. Mittal, Supply chain risk management: Review, classification and future research directions, 2011*
[53] Source: *A Ghadge,S. Dani, R. Kalawsky, Supply chain risk management: present and future scope, 2012*
[54] Source: *C. Colicchia, F. Strozzi, Supply chain risk management: a new methodology for a systematic literature review, 2012*
[55] Source: *P. Singhal, G. Agarwal, M. L. Mittal, Supply chain risk management: Review, classification and future research directions, 2011*
[56] Source*: I. Manuj, J. T. Mentzer, Global Supply Chain Risk Management, 2011*

implementing an effective supply chain risk management in companies, has been put in agenda more than before due to its fundamental importance.

For managers, risk is a threat that something might happen to disrupt normal activities or stop things happening as planned such as increasing costs of raw materials, unsuccessful projects, delayed deliveries to customers, suppliers bankrupt, etc. The core problem when dealing with risks is that they may come in many different forms and at any point along the supply chain; consequently, they can have short or long term effects that can be localized in one part of the chain or entirely affect it. Especially, managers within the supply chain have to deal manly with two different categories, known vs unknown risks and internal vs external risks. Known risks, such as process breakdowns, supplier failure, poor material and component quality, and inadequate logistics, distribution capability, excessive demand instability, criminal action and natural disasters are very numerous, but are highly identifiable in advance and consequently could be prevented through mitigation efforts. Instead, unknown risks, are events that are difficult to predict, such as natural disasters, sudden political unrest or pandemics such as Covid-19. They require a special structure and preparation such as sensitizing and empowering the staff through employee training, performance standards and the creation of a control, analysis and reporting structure, in order to build up a risk-aware corporate culture. In addition, internal risks appear in normal operations, such as late deliveries, excess stock, poor forecasts, financial risks, minor accidents, human error, faults in information technology systems, etc; while external risks are events coming from outside the supply chain, such as earthquakes, hurricanes, industrial action, wars, terrorist attacks, outbreaks of disease, price rises, problems with trading partners, shortage of raw materials, crime, financial irregularities, etc[57]. The key feature of these risks is that they are outside managers' control. So, managers cannot change the risk, but they can design operations that work as efficiently as possible within a risky environment. Internal risks, instead, are generally less dramatic, but more widespread in their effects. These are the risks to operations that managers can control – such as delays and breakdowns – and there are traditional ways of dealing with them. For

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[57] Source: *D. Waters, SUPPLY CHAIN RISK MANAGEMENT - Vulnerability and Resilience in Logistics, 2007*

example, risks from suppliers can be avoided by having a multiplicity of them, so that when problems occur with one supplier it is possible to shift to another one. Similarly, risks concerning the flow of materials can be reduced by having a higher stock along the supply chain to be used as a buffer for unexpected variations.

As recently has spread the perception that businesses are becoming riskier, meaning that both the variety of risks and their consequences are increasing, risk management has expanded. This was confirmed by a survey from the Economist Intelligence Unit (2001), which found that many companies perceive a rise in the number and severity of the risks they face[58] and from the fact that even small events carry catastrophic consequences on the organization's performance and on its survival. Global competition, technological change and the continuous search for competitive advantage are the primary motives behind organizations turning towards risk management approaches. Risk management means recognition, analysis and economical control of risks or probability of risks which can threaten properties and economical incomes of companies. Especially, supply chain risk management is defined as an inter-organizational collaborative endeavour utilizing quantitative and qualitative risk management methodologies to identify, evaluate, mitigate and monitor unexpected macro and micro level events or conditions, which might adversely impact any part of a supply chain. Furthermore, as risk management is involved in decisions, it has become an intrinsic part of management. Indeed, it is not a separate activity from management, but it is management at all[59]. Moreover, supply chain risk management is a nascent area emerging from a growing appreciation for supply chain risk by practitioners and by researchers, that crosses over operations management, finance and marketing, among other disciplines. It has emerged as a natural extension of supply chain management with the prime objective of identifying the potential sources of risks and suggesting suitable action plans to mitigate them[60]. However, there is diverse perception of

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[58] Source: *D. Waters, SUPPLY CHAIN RISK MANAGEMENT - Vulnerability and Resilience in Logistics, 2007*
[59] Source: *D. Waters, SUPPLY CHAIN RISK MANAGEMENT - Vulnerability and Resilience in Logistics, 2007*
[60] Source: *P. Singhal, G. Agarwal, M. L. Mittal, Supply chain risk management: Review, classification and future research directions, 2011*

research in supply chain risk because researcher have approached this area from different domains.

The main issues arising from what stated above are about the fact that even if initially risks can cause delays and damages that affect operations, their consequences are even much larger. For instance, a late delivery of raw materials can rise costs due to an alternative way of transport or make the partners reconsider their trading conditions or raise the costs of work already in progress. For this reason, it becomes fundamental for managers to recognize risks and implement an approach in order to manage them, including, at least:

- the protection of stakeholders' interests;
- the safeguard of the continuing operations of the organization through the development of appropriate systems for risk management;
- the use of formal procedures to identify and analyze the threats from risk;
- the availability of processes in place for dealing with risky events that actually occur to mitigate their effects;

In order to apply a supply chain risk management process, three steps need to be followed: risk identification, risk characterization and risk management. Once the risks are identified, the nature, impact and importance of each of them are assessed. When assessing the magnitude of a risk, the two most important factors are the probability of occurrence and the severity of the expected loss. If historical data is available, it can be used to estimate both the size and frequency of risks. Sometimes complete probability distribution can be constructed for each risk factor, providing a rich sense of the likelihood of a risky event. When only a limited number of observations are available, specialized techniques are needed. When quantification is impossible, either because historical data is not available or is not perceived to be suitable, a qualitative approach must be used. In its simplest form, qualitative analysis involves eliciting information from experts about the probability of a risk event and its likely consequences. Even when mathematical models can be applied, risk characterization often requires considerable judgment on the part of the analyst, not only to define the model's structure and assumptions, but also to assess the relevance of historical data for estimating future

risks. When this second step is concluded, a plan for managing, mitigating and transferring risk is developed[61].

Thus, supply chain risk management approaches allow to understand the current and future challenges, offering the possibility to act before supply chain disruptions happen, and the significant stability and faster recovery that comes with a crisis. In addition, its application ensures that relations among the actors along the chain becomes stronger and closer and the transparency of the business strengthens them creating a culture of collaboration in order to reduce and resist risk, explore new supplier opportunities and enjoy economic stability. To summarize there are five main reasons why Supply Chain Risk Management is important:

- it pushes for supply best practices;
- it enhances the relations between chain partners as they both share risk and its information bringing to higher trust and commitment;
- it makes visible the ongoing risk to which the chain is continuously exposed;
- it urges for constant awareness on decisions, processes and practices due to the difficulty in measuring risk;
- and finally, it minimally optimizes the risk exposure while the business seeks to increase its reward as there should always been a trade-off between risk and reward.

Furthermore, it reduces risks in two ways: reactive and proactive. The first one is about monitoring changes, i.e. supply chain, technology, customer needs, strategies of partners and competitors. Instead, the second one identifies potential risks in order to previously asses their impact and probability. A last important and fundamental consideration about supply chain risk management is that the cost of its ongoing application, in most cases, is lower than the price of disruptions.

It is recognized as a fundamental procedure also for creating a strategic competitive advantage as it promotes an agile supply chain that:

- Outperforms competitors impacted by the same shared risks, thus boosting market share when a sudden common risk occurs;

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[61] Source: *S. Dailun, A review of enterprise supply chain risk management, 2004*

- Supports optimal supply chain design by reducing uncertainty and strengthening relationships and trust to reduce risk;

- Continually detects, optimizes and reduces risk exposure and cost when compared to competing supply chains;

Especially, the recent natural disasters as well as the increasing spread and application of information technology, have demonstrated the reward in terms of business management that are reachable through the application of this practice. Moreover, it aims not only to reduce costs and vulnerability but also to ensure profitability, business continuity, and potentially longer-term growth[62].

The effects, in terms of performance, of the implementation or not of the supply chain risk management procedure are showed in the simplified example of Figure 13. Following the occurrence of a risk event, the company's performance begins to decline more or less rapidly (Figure 13 - point 1) until actions are put in place to counteract this decline (Figure 13 - point 2). After a certain period of time, the company should be able to stop the decline in performance (Figure 13 - point 3) and begin to recover (Figure 13 - point 4), until a stable level is reached (Figure 13 - point 5). However, the level reached may be well below what it was before the risk event. If the company is prepared for the management of the risk event, the effects on performance of the occurrence of the risk event are much less evident (Figure 13 - dotted line) and the probability of recovering the original level of performance would be much higher and in a shorter time. It should be emphasized that risk management does not only bring benefits when directed towards the management of catastrophic events; indeed, very often, such risks are the least manageable. On the contrary, very often these risks are the least manageable. Indeed, smaller and more frequent risks are neglected, which could lead to serious consequences over time but which, on the other hand, are the most easily dealt with.

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[62] *Y. Fan, M. Stevenson, A review of supply chain risk management: definition, theory, and research agenda, 2017*
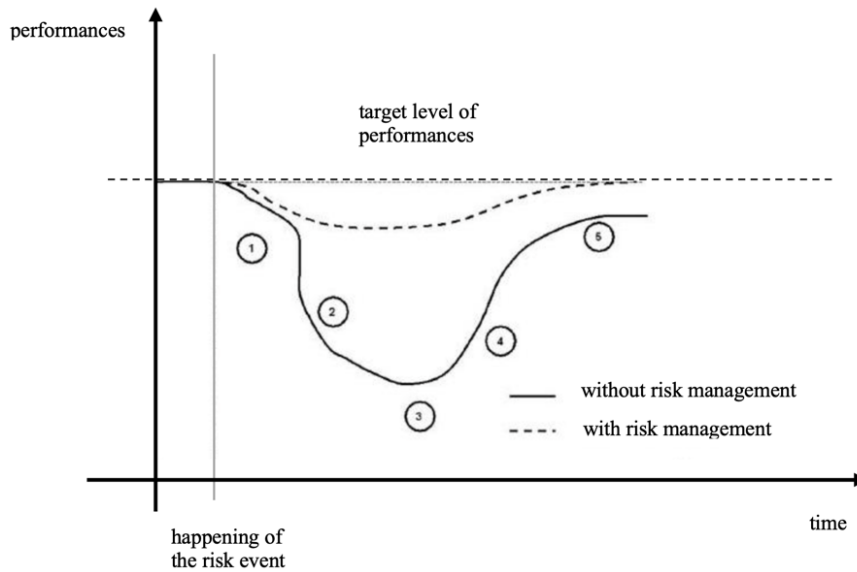
Figure 13. Impact on risk management performance[63]

The monitoring of risk is a needed procedure for a comprehensive supply chain risk management, but it is not an easy task due to the overwhelming volume of data to analyze and their relevance. Indeed, information from third-party sources are needed for the initial assessment. The percentage of firms worried about disruption of the supply chain is clearly rising, even though the number that have actually experienced disruption is falling as they have implemented supply chain risk management procedures[64]. Especially, managers should not wait the occurrence of damaging events and then start thinking about how to deal and solve them. On the contrary, they should be preventive and proactive by previously identifying potential risks and planning the respective responses. In this way, they are prepared and can immediately act when an unexpected event take place.

Supply chain risk management is an essential tool that organizations should use to minimize exposure and vulnerability to risks. By successfully implementing a defensive strategy, companies can ensure that their processes are able to continue through disruptions without sacrificing operational efficiency. In this regard, the application of

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[63]Source: *FabbricaFuturo, La Gestione del Rischio nella Supply Chain, October 2012*
https://www.fabbricafuturo.it/la-gestione-del-rischio-nella-supply-chain-parte-1/
[64] Source: *D. Waters, SUPPLY CHAIN RISK MANAGEMENT - Vulnerability and Resilience in Logistics, 2007*

the risk management process to supply chain activities is, on the one hand, to safeguard the company and, on the other hand, to guarantee the continuity of business processes (and therefore the creation of added value). However, the fundamental consideration is about the compatibility of the solutions for supply chain risk management with not only the mission and strategy of the business, but also with its products or services, its markets and its partners along the chain. To demonstrate the recent development of this discipline in 2001, the International Supply Chain Risk Management Network (ISCRiM) was founded. It constitutes a reference point for those involved in SCRM research. The mission of this network of academics is to improve and systematize research efforts, and to encourage and dialogue between academics and practitioners. disseminate the most interesting results. In conclusion, it is important to notice that despite its importance supply chain risk management has not received lot of attention as different strategies have been suggested, but there is no much knowledge about their past applications. From this literature review emerges two main challenges: the need for developing models of supply chains which take into consideration the uncertain and complex environment in which they operate and the need for a risk identification and assessment tool that takes into account the complex interactions that occur among partners within the chain, which are considered causes of disruption.

CHAPTER III: A SYSTEMATIC LITERATURE REVIEW

3.1 Definition

In order to conduct my analysis about how much has been written on the topic of the application of Social Network Analysis in supply chain management, a systematic literature review based on a reproducible and transparent literature research and selection process has been done. Literature review is an essential feature of academic research. It is a way to learn from previous existing papers as it allows to understand what is going on in the research field that it is addressed. Fundamentally, knowledge advancement must be built on prior existing work. By reviewing relevant literature, it is possible to understand the breadth and depth of the existing body of work, identify gaps to explore and then summarize, analyze and synthetize a group of related literature to formulate a specific hypothesis and/or develop new theories[65]. The important thing stands in finding out how to conduct an accurate literature review as we are overwhelmed of knowledge, thus it is not possible to read everything has been written regarding a topic in a broader space of time. For this reason, leading a literature review in the proper way is very difficult. Indeed, due to its importance there are many and different ways in which it can be used and done; such as according to Denyer and Tranfield "the most common technique in management research is the traditional literature review in which the researcher summarizes and interprets previous contributions in a subjective and narrative fashion"[66]. Its main area of application is the one of medical studies, or health fields in general, even if its use in social sciences and in the business and management domain has increased in recent years.

A literature review consists of a summary of sources, especially writings, of significant and relevant scholar nature, previously published, about a specific topic of research belonging to a particular area of interest within a certain period of time[67]. It is a tool to get an overview of the current and available knowledge in order to identify the relevant

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[65]Source: *Y. Xiao, M. Watson, Guidance on Conducting a Systematic Literature Review, 2019*
[66]Source: *Y. Xiao, M. Watson, Guidance on Conducting a Systematic Literature Review, 2019*
[67]Source: *J. Rowley, F. Slack, Conducting a Literature Review, 2004*

elements such as methods, theories and gap of the existing matter under question, to explain the differences between publications and how each of them contributes to the study.

A literature review is conducted by gathering information, that might be used to answer the topic of the research, from different sources such as books, web resourced, scholar articles and research journals which usually are the core of the reviews. The evaluation of this range of options, which availability of articles may vary tremendously depending on the research topic chosen might be a problem, especially for what concerns the web ones. However, most search engines, whether they check online databases, or the web, have two levels of searching options: it is possible to conduct Basic Searches using keywords, or to choose the Advanced Search alternative that offers a range of other devices to assist in the formulation of a more precise research. Recently, as the search algorithms used to retrieve documents have improved, it is possible to have a lot of sources also only with the Basic keyword search option. In order to have effective searches, it is important to use very precise terms or names according to which the search engine will generate a list of references ranked in order based on the frequency and location of occurrence of the words in the search term. On the other hand, the Advanced Search alternative, allows to be more specific about the search words as it applies Boolean operators such as NOT, AND and OR, according to which the truncation of words and the specification of the location for searching is possible. The first one excludes from the search those documents that have a certain keyword within them. The second one links two or more words, so that the database will return all indexed documents that contain all the words entered, and not just one of them individually. And the third one, is used when the search focuses on several terms, and does not need to include all of them, but only one of them. In this case, the database will then return documents containing both terms as well as only one of them. But, it is important to underline that what is extracted from an Advanced Search varies between search engines.

Despite the differences across the types of literature reviews, all of them are conducted following the same structure. The process consists of three main stages: planning, conducting and reporting the review. In the first one, the review topic is specified, while in the second one all the related data are selected, extracted, analyzed and then

synthesized in order to be written down in a final report, which stands for the third stage. Furthermore, this process is iterative in nature as unforeseeable issues, especially about the research matter, may arise while conducting the review.

The literature review, also named narrative review, is different from the systematic one, which is classified differently even if it is nothing more than a literature review which is conducted through previously well-defined methods. In other words, a systematic literature review consists of an attempt to synthetize the results and conclusions of two or more publications on a given issue, which is carried out through a rigorous scientific approach in order to reduce systematic and random errors. Therefore, it is defined as "a systematic way of collecting, critically evaluating, integrating, and presenting findings from across multiple research studies on a research question or topic of interest"[68]. In other words, a systematic literature review describes, summarizes and evaluates in a critical way the previous works related to the research problem object of the analysis. It may or may not include, a meta-analysis, which is a statistical analysis of the results of independent studies that generally aims to produce a single numerical estimate. In order to ensure that a good systematic literature review is conducted, it is necessary firstly to clearly define the topic of the research question, secondly to create a list of keywords related to it and finally to be sure that a proper methodology has been chosen to answer the matter.

Conducting a systematic literature review is important because it consists of a tool for identifying the current literature and understanding its limitations and potentials in order to answer the research question or to give guidance for further studies. The main difference between a narrative literature review and a systematic one, is that the first one does not focus on a specific research question, while the second one does. In fact, systematic literature review is mainly applied because reviewing the existing literature is more convenient than conducting a new study. Furthermore, it is more exhaustive, it applies a rigid and reproducible methodology and it compares the founded results.

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[68]Source: *R. J.Piper, How to write a systematic literature review: a guide for medical students, NSAMR, 2013*

The main reasons why the application of systematic literature reviews is increasing comparing to narrative ones (as Figure 14. shows) are that the number of publications and researches on a given topic is too large and considering only a part of the available information can lead to errors, because the methodological quality of studies is variable and thus the results of different researches on the same topic often differ. Furthermore, in recent years the interest for systematic literature reviews has grown as they have influenced other types of review methods and overtaken the traditional narrative literature review as they offer a broader and more accurate level of understanding.
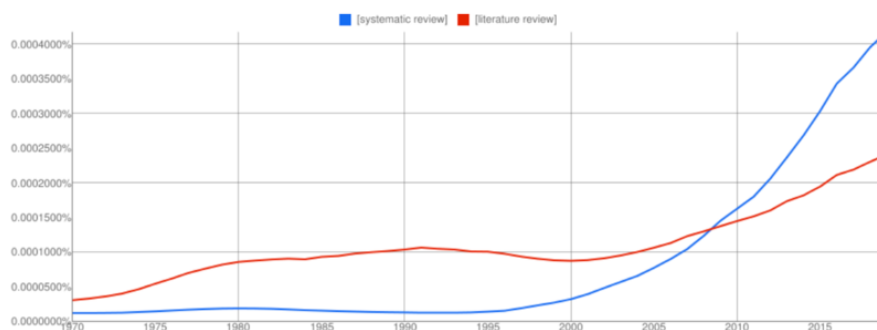

Figure 14. The evolution of the application of narrative literature review and systematic literature review[69]

Concerning the systematic literature review conducted for the research question of this work about the application of social network analysis in supply chain management, the sources have been screened through the Advanced Search option with keywords and the ISSN of ABS[70] 3, 4 and 4* academic journals rankings on the Scopus website. Each year the Chartered Association of Business Schools (ABS) produces a guide to academic journals which have been published within the Business and Management field in order

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[69]Source: *The difference between a systematic review and a literature review*
 https://www.covidence.org/blog/the-difference-between-a-systematic-review-and-a literaturereview/#:~:text=This%20brings%20us%20to%20literature,a%20new%20piece%20of %20research
[70]Source: *The Chartered Association of Business Schools (ABS) is the foremost guide covering 22 subject areas within the field of business and management research*
https://charteredabs.org/about-us/

to help authors in deciding which source to submit to their work. It is important as it gives indication about the quality and ranking of journals which are given a star rating from 1* (lowest) to 4* (highest). The latest and more recent is the 2021 version. Originally these rankings were applied only to the Business & Management community, but then they expanded into other subjects such as finance, psychology, mathematics, technology, engineering. Moreover, there are some countries that use the more well-known national lists of rankings, instead of producing their own ones.

3.2 Basic and advanced search

The process of the systematic literature review for this thesis started from the identification and definition of the research question: how much has been written about the application of the social network analysis in supply chain management. Before starting the research, information has been gathered about this methodology focusing on its mathematical feature rather than on the sociological one. However, at this point it is possible to anticipate that the results from the analysis of different journal articles, show that as social network analysis is a discipline that originated from psychological and sociological studies and that has only recently started to be used through mathematical or computational models, its main application in the business and management field consists in the use of surveys to get information about the relations and influence among the members of the network. Nevertheless, in order to study and analyze the network structure, numerical and graphical elements are used such as the degree of centrality, the closeness centrality and the betweenness centrality, which respectively, stand for measuring the level of activity, capacity of controlling interactions and ability to influence the transfer of information of a node within a network.

The search engine used for conducting this systematic literature review is SCOPUS, which is a comprehensive, expertly curated abstract and citation database with enriched data and linked scholarly literature across a wide variety of disciplines. It quickly finds relevant and authoritative research, identifies experts and provides access to reliable data, metrics and analytical tools. From researchers pursuing scientific breakthroughs to academic institutions and government agencies evaluating research, and ranking organizations conducting assessments, SCOPUS is the abstract and indexing database of choice. Worldwide, it is used by more than 5,000 academic, government and corporate institutions, that get access through a personal or academic subscription, as in this case[71]. Furthermore, it is one of the most important bibliometric resources, i.e. those that allow to know and assess the quality, quantity and relevance of scientific

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[71]Source: *Scopus website,*
https://www.elsevier.com/solutions/scopus?dgcid=RN_AGCM_Sourced_300005030

publications and their circulation index, H-Index, which is a bibliometric indicator that measures the impact of authors within the scientific community based on the number of publications and citations received. Its bibliographic citation database provides access to the world's largest collection of abstracts, bibliographies and indexes not only of scientific, technical and medical literature, but also of business, social sciences and humanities. Designed by Elsevier and updated daily, it offers access to abstracts and bibliographic citations from peer-reviewed literature, increasing regularly, from around 20,000 journals (many of them open access) and hundreds of books, published by more than 5,000 international publishers. Moreover, as this database has an interdisciplinary coverage, it includes all the journals and articles where the relevant discussion of the topic under investigation in the different disciplines takes place, even if it is a recent one. Scopus has been designed primarily to meet the information needs of high scientific level. However, nowadays, it is a useful tool for anyone who wants to find abstracts and citations for research works. In order to simplify and shorten the search path, its interface has recently been reshaped. In fact, as depicted in Figure 2., it allows an intuitive use of its offered tools offered such as:

- launching the search according to one of the four possibilities in the start-up interface (simple; by author; by institution; advanced);
- displaying the list of results in the order you prefer (date, number of citations, relevance...);
- accessing, via a simple link, the form with the data relating to the title of your interest.

each record in the list includes the title of the document, the authors and the main bibliographical details

from the boxes on the left it is possible to refine the search

by clicking on the report, the page with details and full abstract open

Figure 15. SCOPUS's interface[72]

Through SCOPUS it is also possible to do two different type of researches: a basic one by keywords and an advanced one by query strings. In the first case, the research is wider and more general as it consists only in writing the key terms in the search bar, while in the second case an "advanced document search" is conducted as an entry query string is added to the keyworks to narrow the search field only to the specific one of interest. However, in both cases it is possible to refine the results for example according to the access to source, the year of publication, the author's name, the subject area, the type of document, the publication stage and others as Figure 16. shows, in order to reduce the number of sources to the more appropriate ones.
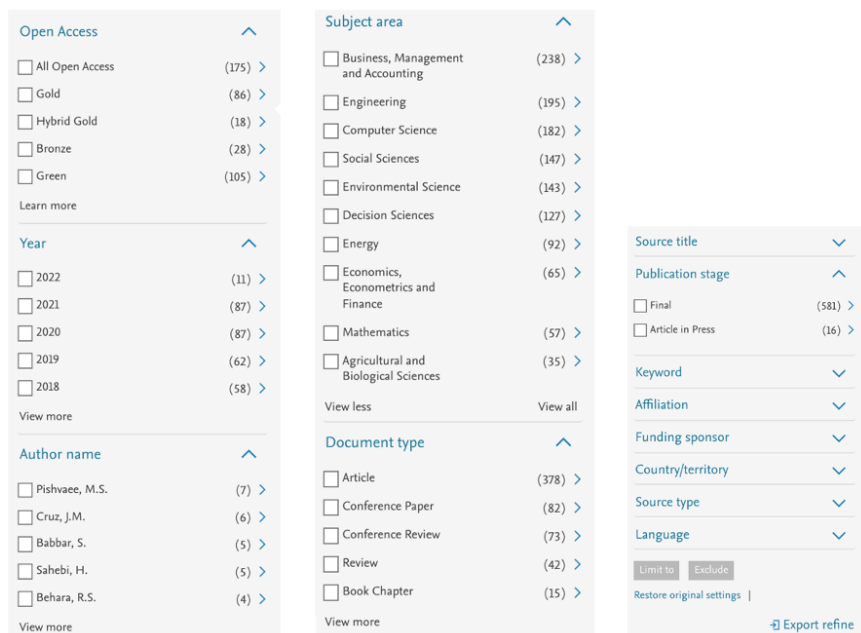
Figure 16. SCOPUS's refining results system[73]

Concerning this systematic literature review, both methodologies have been applied in sequence as the idea was to start from a general understanding about the already existing literature, in order then to shift the focus to a specific range of resources to be analyzed. Furthermore, SCOPUS, provides also the analysis of the results on:

- documents per year (and then by source)
- documents by author
- documents by country/territory
- documents by type
- documents by subject area
- documents by funding sponsor

The main information of interest concerning the research question is about how much has been written throughout the years, of which typology, from which country and the subject area of belonging.

[73]Source: *SCOPUS website*
https://www.scopus.com/results/results.uri?sort=plff&src=s&st1=social+network+analysis+in +supply+chain+management&sid=fc4db7eec7762ca7200b702c9f957fd9&sot=b&sdt=b&sl=6 5&s=TITLE- ABSKEY%28social+network+analysis+in+supply+chain+management%29&origin=searchba sic&editSaveSearch=&yearFrom=Before+1960&yearTo=Present

Initially, on the 2ⁿᵈ of December, 593 document results came out through the basic research by just searching according to the keywords *("social network analysis in supply chain management")* without making any refinement to filter the sources.

By looking at the graph that SCOPUS makes available about the analysis of the resulted documents, it is possible to see that the majority of them have been written in the last two years, even if already something has been published in the year that has just began, 2022. This, highlights what has been said in the previous chapter regarding the recent application of social network analysis in the domain of business. On the other hand, Figure 17., illustrates the increasing importance that the topic has gained throughout the years, as publications has always been stable until a pick in 2020. The search was not restricted by publication date, even if it is evident that relevant contributions do not go back earlier than 2007, and it includes the ones up to 2022.
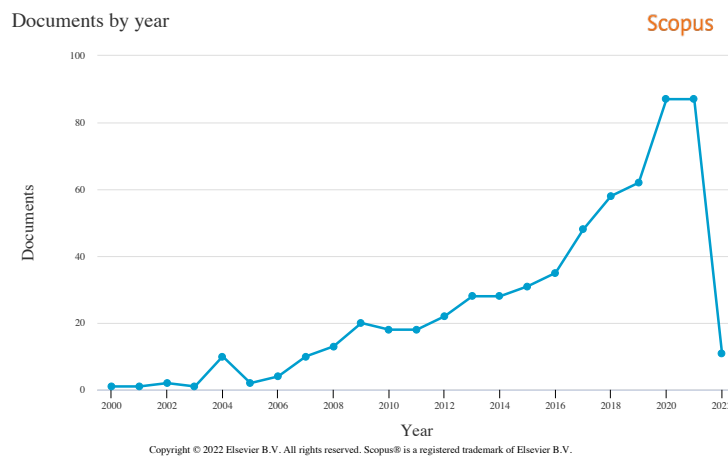
Figure 17. Number of published documents per year on the research question[74]

As this first research is the most wide and general for this literature review, the resulted documents are of different nature, especially the majority is made of articles, conference papers and conference reviews (as shown in Figure 18.). In addition, they

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[74]Source: *SCOPUS website*
https://www.scopus.com/results/results.uri?sort=plff&src=s&st1=social+network+analysis+in +supply+chain+management&sid=fc4db7eec7762ca7200b702c9f957fd9&sot=b&sdt=b&sl=6 5&s=TITLE- ABSKEY%28social+network+analysis+in+supply+chain+management%29&origin=searchba sic&editSaveSearch=&yearFrom=Before+1960&yearTo=Present

belong to different areas of interest (as depicted in Figure 19.), even if the most affected are Business, Management and Finance, Engineering and Computer Sciences.

Documents by type
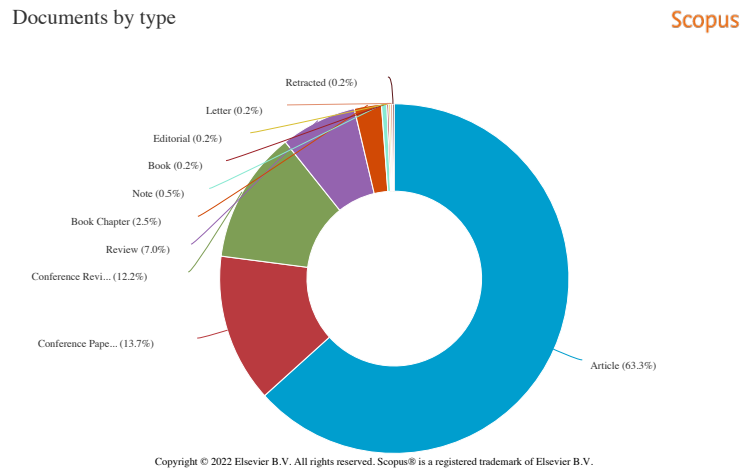
Figure 18. Type of published documents on the research question

Documents by subject area
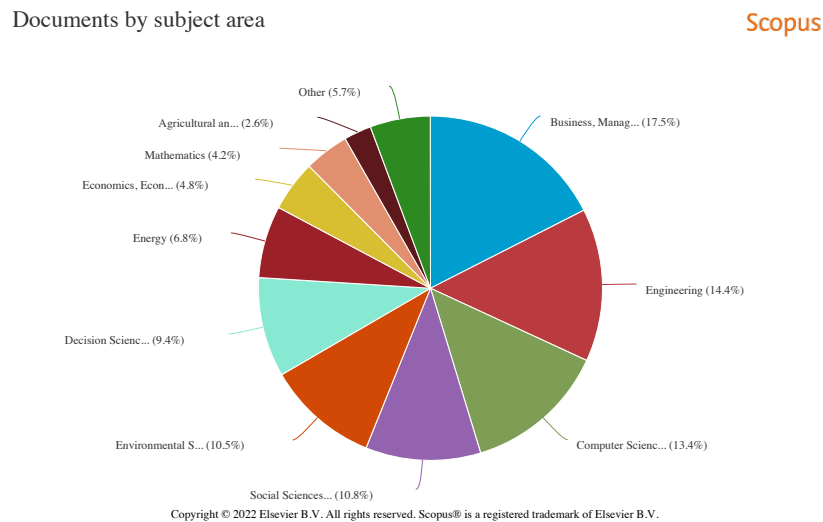
Figure 19. Subject area of belonging of published documents on the research question[75]

Furthermore, it is interesting to look also to Figure 20., which shows the country of origin of the documents that resulted from the basic research through keywords. In the first two positions there are the most developed countries, United States and China, while in the third one there is Iran. This is quite curious, as articles or journals of a certain level are generally expected to be written by the most industrialized and research-advanced countries, which in this case alternate with undeveloped ones.
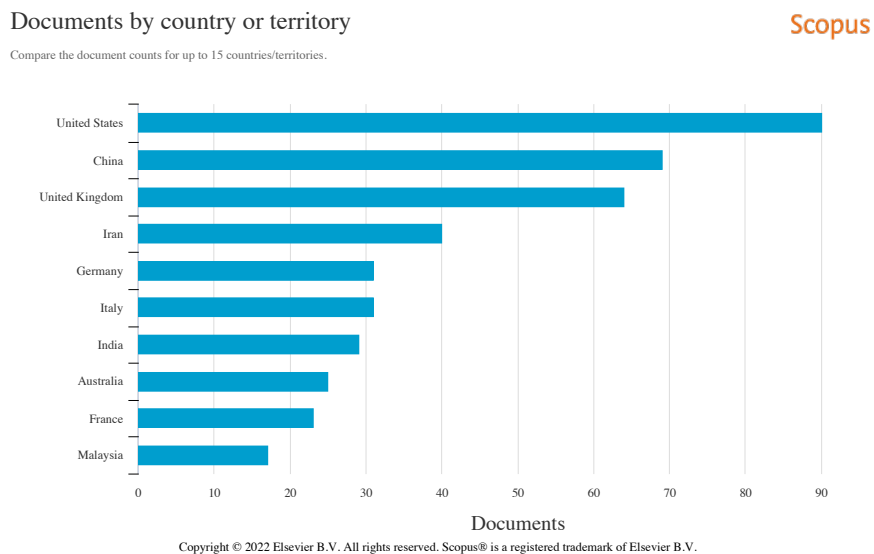

Figure 20. Countries/territories of origin of published documents on the research question[76]

Then, the "advanced document search" has been conducted by adding to the keywords a query string (the one shown in Figure 21.) to screen the sources according to the ISSN, which stands for "International Standard Serial Number", or International Standard Number of serial publications and it identifies periodicals, magazines, newspapers, yearbooks, monographic series and all other types of serial publications[77], of the 3, 4

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[76]Source Fig. 7: *SCOPUS website*
https://www.scopus.com/results/results.uri?sort=plff&src=s&st1=social+network+analysis+in +supply+chain+management&sid=fc4db7eec7762ca7200b702c9f957fd9&sot=b&sdt=b&sl=6 5&s=TITLE-ABSKEY%28social+network+analysis+in+supply+chain+management%29&origin=searchba sic&editSaveSearch=&yearFrom=Before+1960&yearTo=Present
[77]Source: International Standard Serial Number website, http://www.issn.it/

and 4* academic journals of the Chartered Association of Business Schools ranking, thus, to study only high level articles of the existing literature concerning the research question.

1741-315X OR 1873-1872 OR 2042-5805 OR 1097-0266 OR 0305-750X OR 1743-9655 OR 1460-3616 OR 1467-954X OR 1467-9531 OR 1475-147X OR 1534-7605 OR 1466-4526 OR 1554-0634 OR 1537-5331 OR 1477-0288 OR 1552-7514 OR 1469-9923 OR 1467-6435 OR 1469-7823 OR 1461-7269 OR 1095-8630 OR 1743-9140 OR 1464-3650 OR 1471-0374 OR 1468-2672 OR 1873-6416 OR 1520-5851 OR 1873-6890 OR 1469-5766 OR 1467-7660 OR 1099-0836 OR 1468-4446 OR 1467-8330 OR 1467-9566 OR 1469-8684 OR 1873-5347 OR 1539-6924 OR 1472-3433 OR 1545-2115 OR 1939-8271 OR 1537-5390 OR 1878-5794 OR 1879-2340 OR 1879-2375 OR 1552-7395 OR 1747-7646 OR 1873-4693 OR 1757-1049 OR 1873-5657 OR 1746-031X OR 1944-9089 OR 1879-2367 OR 1879-3193 OR 1552-6763 OR 1552-7379 OR 1873-7722 OR 1360-063X OR 1879-2308 OR 1435-5957 OR 1873-1392 OR 1467-9787 OR 1872-9495 OR 1461-7145 OR 1472-3409 OR 1752-1386 OR 1360-0591 OR 1468-2710 OR 1944-8287 OR 1748-5991 OR 1470-8442 OR 1468-0009 OR 1520-6688 OR 1466-4429 OR 1461-7226 OR 1559-3169 OR 1475-6773 OR 1472-3425 OR 1552-3357 OR 1471-9045 OR 1467-9299 OR 1477-9803 OR 1468-0491 OR 1540-6210 OR 1795-990X OR 1470-7926 OR 1873-3506 OR 1758-7778 OR 1573-353X OR 0886-1528 OR 1473-5660 OR 1532-7043 OR 1547-8181 OR 1464-0643 OR 1366-5847 OR 1464-0597 OR 1872-9126 OR 1879-2057 OR 1464-5335 OR 1095-9920 OR 1095-9084 OR 1099-1379 OR 1939-1307 OR 2044-8325 OR 1744-6570 OR 1939-1854 OR 1948-5514 OR 1747-0226 OR 1860-0980 OR 1471-6402 OR 1430-2772 OR 1873-3549 OR 1930-2975 OR 1939-1285 OR 1552-5422 OR 1552-8766 OR 1099-0771 OR 1099-0992 OR 1551-6709 OR 2044-8309 OR 2044-8295 OR 1939-1471 OR 1939-1455 OR 1552-7433 OR 1939-1315 OR 1096-0465 OR 1939-2222 OR 1939-2192 OR 1467-8721 OR 1873-7838 OR 1469-1825 OR 1545-2085 OR 1467-9280 OR 0733-558X OR 0191-3085 OR 1873-3530 OR 1552-7417 OR 1461-7323 OR 1552-3993 OR 1552-7425 OR 1741-3044 OR 1873-3409 OR 1741-282X OR 1526-5455 OR 1526-5447 OR 1095-7189 OR 1879-0836 OR 1436-6304 OR 1873-5274 OR 1520-6750 OR 1526-5471 OR 1476-9360 OR 1573-2878 OR 1572-9397 OR 1872-8200 OR 1526-5528 OR 1545-8830 OR 2168-2232 OR 2168-2275 OR 1573-2908 OR 1530-9304 OR 1540-5915 OR 1873-765X OR 1573-2894 OR 1572-9338 OR 1558-1195 OR 1436-4646 OR 1941-0026 OR 1872-6860 OR 1526-5463 OR 1526-5501 OR 1758-6852 OR 1366-5871 OR 1526-5498 OR 1873-6505 OR 2158-1592 OR 1366-588X OR 1873-7579 OR 1558-0040 OR 1872-6194 OR 1937-5956 OR 1745-493X OR 1758-6593 OR 1873-1317 OR 1573-711X OR 1520-6793 OR 1741-301X OR 1573-059X OR 1547-7207 OR 1547-7215 OR 1520-6653 OR 1740-1909 OR 1557-7805 OR 1758-6763 OR 1873-2062 OR 1758-7123 OR 1873-3271 OR 1873-8001 OR 1526-548X OR 1552-7824 OR 1547-7193 OR 1547-7185 OR 1537-5277 OR 1532-7663 OR 1470-174X OR 1461-7307 OR 1469-3518 OR 1944-9585 OR 1879-2383 OR 1873-5509 OR 1467-9310 OR 1573-7047 OR 1469-8390 OR 1540-5885 OR 1873-7625 OR 2330-1643 OR 1083-6101 OR 1066-2243 OR 1557-9301 OR 1758-5813 OR 1572-9419 OR 1087-6537 OR 1873-7919 OR 1872-7530 OR 1872-9517 OR 1873-5797 OR 1873-1198 OR 1557-928X OR 1466-4437 OR 1365-2575 OR 1476-9344 OR 2162-9730 OR 1558-3457 OR 1526-5536 OR 1861-8901 OR 1740-8784 OR 1873-0620 OR 1468-5965 OR 1873-6149 OR 1572-9958 OR 1468-2621 OR 1878-5573 OR 1478-6990 OR 1552-8464 OR 1468-005X OR 1466-4399 OR 1468-2338 OR 1464-3669 OR 2162-271X OR 1873-7889 OR 1461-7129 OR 1461-7099 OR 1469-8722 OR 1468-232X OR 1099-050X OR 1467-8543 OR 1748-8583 OR 1573-7179 OR 2046-9136 OR 2045-9939 OR 1469-7696 OR 1467-9965 OR 1539-6975 OR 1573-045X OR 2168-8656 OR 1873-0639 OR 1873-0612 OR 1096-9934 OR 1878-0962 OR 1573-0735 OR 1475-6803 OR 1878-576X OR 1479-8417 OR 1879-1727 OR 2405-8505 OR 1872-6372 OR 1873-8079 OR 1099-1158 OR 1815-7556 OR 1873-5959 OR 1540-6288 OR 1468-0416 OR 1755-053X OR 1938-3312 OR 1432-1122 OR 1466-4364 OR 1468-036X OR 1467-8683 OR 1941-1375 OR 1573-692X OR 1538-4616 OR 1096-0473 OR 1756-6916 OR 1872-6313 OR 1465-7368 OR 0304-405X OR 1540-6261 OR 1532-9194 OR 1552-6542 OR 1873-7978 OR 1573-0697 OR 1468-2370 OR 0017-8012 OR 1468-0432 OR 1552-3977 OR 1740-4762 OR 2162-8564 OR 1552-4205 OR 2168-1007 OR 1467-6486 OR 2153-3326 OR 1467-8551 OR 1558-9080 OR 1557-1211 OR 1930-3815 OR 1930-3807 OR 1948-0989 OR 1941-6067 OR 1573-0913 OR 1540-627X OR 1741-2870 OR 1758-6534 OR 1741-6248 OR 1464-5114 OR 1932-443X OR 1873-2003 OR 1540-6520 OR 1564-698X OR 1432-217X OR 1467-9469 OR 1467-9442 OR 1475-4991 OR 1096-6099 OR 1540-6229 OR 1573-7101 OR 1464-3812 OR 1468-0084 OR 1543-8325 OR 1879-1034 OR 1095-9068 OR 1467-9892 OR 1467-9876 OR 1467-985X OR 2333-5963 OR 1573-0476 OR 0047-2727 OR 1432-1475 OR 1095-7243 OR 1873-1538 OR 1537-5366 OR 1465-7341 OR 1537-5285 OR 1744-1382 OR 1467-6451 OR 1548-8004 OR 1932-8664 OR 1879-1646 OR 1096-0449 OR 1573-7020 OR 1879-1743 OR 1879-1751 OR 1872-6089 OR 1537-2715 OR 1095-7227 OR 1099-1255 OR 1477-9552 OR 1751-5823 OR 1873-7986 OR 2041-417X OR 1099-1050 OR 1090-2473 OR 1573-6938 OR 1464-3618 OR 1873-572X OR 1573-1502 OR 1873-6181 OR 1873-7374 OR 1468-0335 OR 1432-0479 OR 1468-0327 OR 1465-7295 OR 1539-2988 OR 1368-423X OR 1532-4168 OR 1873-6106 OR 1872-7352 OR 1540-5982 OR 1464-3545 OR 1533-4465 OR 1941-1391 OR 1467-8276 OR 2640-2068 OR 1945-7685 OR 1945-774X OR 1555-7561 OR 1530-9142 OR 1756-2171 OR 1759-7331 OR 1467-9868 OR 1542-4774 OR 1537-274X OR 1873-1295 OR 1537-5307 OR 1873-0353 OR 1095-7235 OR 1944-7965 OR 2328-8175 OR 1872-6895 OR 1537-2707 OR 1468-2354 OR 1468-0297 OR 1469-4360 OR 1464-3510 OR 1945-7715 OR 1945-7790 OR 1467-937X OR 1531-4650 OR 1537-534X OR 1468-0262 OR 2168-8966 OR 1944-7981 OR 1471-6372 OR 1090-2457 OR 1474-0044 OR 1467-2235 OR 1468-0289 OR 2044-768X OR 1743-7938 OR 1096-1224 OR 1558-8017 OR 1061-9518 OR 1468-5957 OR 0148-558X OR 0737-4607 OR 1873-2070 OR 1094-4060 OR 1554-0650 OR 1468-0408 OR 1468-4497 OR 1095-9955 OR 0007-1870 OR 1095-8347 OR 1558-8009 OR 1558-7991 OR 1758-4205 OR 1558-7975 OR 1467-6303 OR 2159-4260 OR 1467-6281 OR 1573-7136 OR 1911-3846 OR 1475-679X OR 1879-1980 OR 1873-6289 OR 1558-7967

Figure. 21 Query string of the ISSN of 3, 4 and 4* academic journals of the Chartered Association of Business Schools ranking

The following list includes all the ISSN and names of the 3, 4 and 4* academic journals selected by the query string in conducting the advanced document search in the SCOPUS database.

ISSN	Journal Title
1558-7967	Accounting Review
1873-6289	Accounting, Organizations and Society
1879-1980	Journal of Accounting and Economics
1475-679X	Journal of Accounting Research
1911-3846	Contemporary Accounting Research
1573-7136	Review of Accounting Studies
1743-7938	Business History
2044-768X	Business History Review
1468-0289	Economic History Review
1944-7981	American Economic Review
2168-8966	Annals of Statistics
1468-0262	Econometrica
1537-534X	Journal of Political Economy
1531-4650	Quarterly Journal of Economics
1467-937X	Review of Economic Studies
1945-7790	American Economic Journal: Applied Economics
1945-7715	American Economic Journal: Macroeconomics
1464-3510	Biometrika
1469-4360	Econometric Theory
1468-0297	Economic Journal
1468-2354	International Economic Review
1537-2707	Journal of Business and Economic Statistics
1872-6895	Journal of Econometrics
2328-8175	Journal of Economic Literature
1944-7965	Journal of Economic Perspectives
1095-7235	Journal of Economic Theory
1873-0353	Journal of International Economics
1537-5307	Journal of Labor Economics
1873-1295	Journal of Monetary Economics
1537-274X	Journal of the American Statistical Association
1542-4774	Journal of the European Economic Association
1467-9868	Journal of the Royal Statistical Society. Series B: Statistical Methodology
1759-7331	Quantitative Economics
1756-2171	RAND Journal of Economics
1530-9142	Review of Economics and Statistics
1555-7561	Theoretical Economics
1540-6520	Entrepreneurship Theory and Practice
1873-2003	Journal of Business Venturing
1932-443X	Strategic Entrepreneurship Journal

1941-6067	Academy of Management Annals
1948-0989	Academy of Management Journal
1930-3807	Academy of Management Review
1930-3815	Administrative Science Quarterly
1557-1211	Journal of Management
1558-9080	Academy of Management Perspectives
1467-8551	British Journal of Management
2153-3326	Business Ethics Quarterly
1467-6486	Journal of Management Studies
1540-6261	Journal of Finance
0304-405X	Journal of Financial Economics
1465-7368	Review of Financial Studies
1872-6313	Journal of Corporate Finance
1756-6916	Journal of Financial and Quantitative Analysis
1096-0473	Journal of Financial Intermediation
1538-4616	Journal of Money, Credit and Banking
1573-692X	Review of Finance
1748-8583	Human Resource Management Journal (UK)
1467-8543	British Journal of Industrial Relations
1099-050X	Human Resource Management (USA)
1468-232X	Industrial Relations
1469-8722	Work, Employment and Society
1478-6990	Journal of International Business Studies
1878-5573	Journal of World Business
1526-5536	Information Systems Research
1558-3457	Journal of the Association for Information Systems
2162-9730	MIS Quarterly: Management Information Systems
1476-9344	European Journal of Information Systems
1365-2575	Information Systems Journal
1466-4437	Journal of Information Technology
1557-928X	Journal of Management Information Systems
1873-1198	Journal of Strategic Information Systems
1873-7625	Research Policy
1540-5885	Journal of Product Innovation Management
1944-9585	Academy of Management Learning and Education
1532-7663	Journal of Consumer Psychology
1537-5277	Journal of Consumer Research
1547-7185	Journal of Marketing
1547-7193	Journal of Marketing Research
1552-7824	Journal of the Academy of Marketing Science
1526-548X	Marketing Science
1873-8001	International Journal of Research in Marketing
1873-3271	Journal of Retailing
1873-1317	Journal of Operations Management

1758-6593	International Journal of Operations and Production Management
1745-493X	Journal of Supply Chain Management
1937-5956	Production and Operations Management
1526-5501	Management Science
1526-5463	Operations Research
1872-6860	European Journal of Operational Research
1941-0026	IEEE Transactions on Evolutionary Computation
1436-4646	Mathematical Programming
1526-5455	Organization Science
1741-282X	Human Relations
1873-3409	Leadership Quarterly
1741-3044	Organization Studies
1552-7425	Organizational Research Methods
1467-9280	Psychological Science
1545-2085	Annual Review of Psychology
1469-1825	Behavioral and Brain Sciences
1873-7838	Cognition
1467-8721	Current Directions in Psychological Science
1939-2192	Journal of Experimental Psychology: Applied
1939-2222	Journal of Experimental Psychology: General
1096-0465	Journal of Experimental Social Psychology
1939-1315	Journal of Personality and Social Psychology
1552-7433	Personality and Social Psychology Bulletin
1939-1455	Psychological Bulletin
1939-1471	Psychological Review
1939-1854	Journal of Applied Psychology
1744-6570	Personnel Psychology
2044-8325	Journal of Occupational and Organizational Psychology
1939-1307	Journal of Occupational Health Psychology
1099-1379	Journal of Organizational Behavior
1095-9084	Journal of Vocational Behavior
1095-9920	Organizational Behavior and Human Decision Processes
1464-5335	Work and Stress
1540-6210	Public Administration Review
1468-0491	Governance
1477-9803	Journal of Public Administration Research and Theory
1467-9299	Public Administration
1471-9045	Public Management Review
1944-8287	Economic Geography
1468-2710	Journal of Economic Geography
1360-0591	Regional Studies
1873-7722	Annals of Tourism Research

1552-7379	Journal of Service Research
1552-6763	Journal of Travel Research
1879-3193	Tourism Management
1879-2367	Transportation Research, Series B: Methodological
1537-5390	American Journal of Sociology
1939-8271	American Sociological Review
1545-2115	Annual Review of Sociology
1472-3433	Environment and Planning D: Society and Space
1539-6924	Risk Analysis
1873-5347	Social Science and Medicine
1469-8684	Sociology
1467-9566	Sociology of Health and Illness
1097-0266	Strategic Management Journal
2042-5805	Global Strategy Journal

The resulting list of journal articles was then further screened, thus the results have reduced from 593 to 49, even if not all of them are appropriately related to the application of social network analysis in supply chain management. This can be understood not only by passing through all the list of documents, but also by looking and analyzing the graphs that SCOPUS makes available. Most of the 49 documents object of the analysis have been written in 2016 and 2019 even if there has been a dropped in 2017, when the number of publications shrunk (as shown in Figure 22.). This underlines the fact that social network analysis is a recent innovation in the business and management field. Furthermore, it is important to make clear that the publication of high rate academic journals and articles takes time, consequently not always up-to-date resource are available, as for example for what has been written during the past year, in 2021.

Documents by year   Scopus
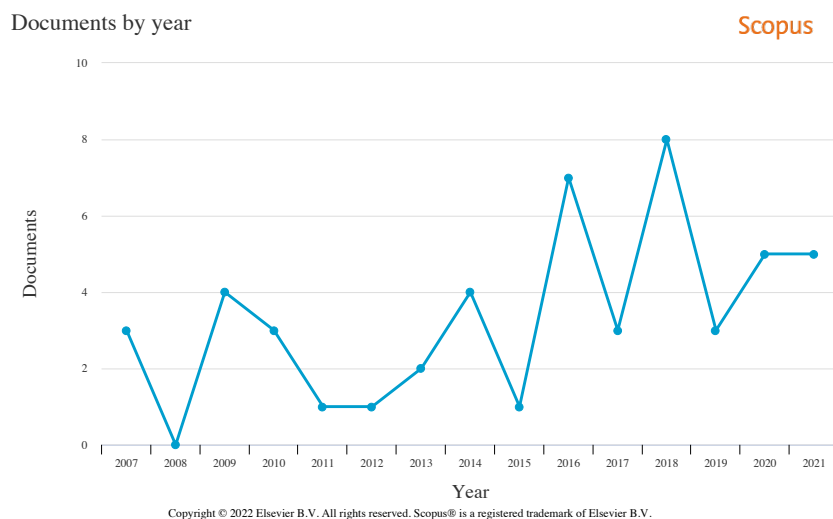
Figure 22. Number of published documents per year on the research question

The majority of these documents are articles belonging to the business, management and finance domain as Figure 23. and Figure 24. demonstrate. This comes from the application of the "advanced documents research" through the ISSN query string, which has refined all the initial and wider sources. However, as the two figures below show, the results are not completely filtered as there are articles for example of environmental and behavioral sciences which are not the focus of this systematic literature review.

Indeed, even if the query string is applied, the search engine continues to find results also according to the keywords that may pertain to different areas.

Documents by type

Conference Pape... (6.0%)

Review (16.0%)

Article (78.0%)
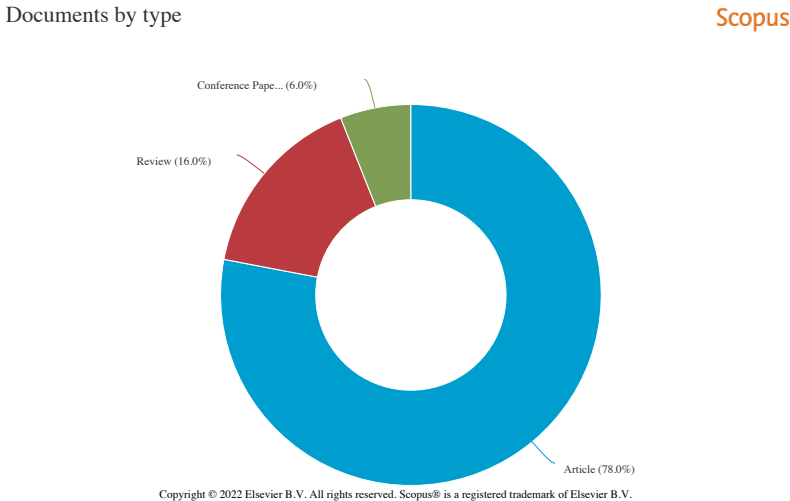
Figure 23. Type of published documents on the research question

Documents by subject area

Mathematics (0.8%)

Arts and Humani... (2.4%)

Computer Scienc... (4.0%)

Environmental S... (6.4%)

Social Sciences... (9.6%)

Business, Manag... (31.2%)

Economics, Econ... (9.6%)

Engineering (15.2%)

Decision Scienc... (20.8%)

Figure 24. Subject area of belonging of published documents on the research question[78]

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[78]Source Fig. 22-23-24: *SCOPUS website, https://www.scopus.com/term/analyzer.uri?sid=2121f0e76e793efd4d342b9edee05ee3&origin= resultslist&src=s&sort=plff&sdt=a&sot=a&sessionSearchId=2121f0e76e793efd4d342b9edee 05ee3&count=50&analyzeResults=Analyze+results&txGid=d3b35ecfcd38bbeee634dce27ae2a de1*

The last aspect of the resulted documents to analyze regards the countries or territories from which the majority of the published articles comes. As Figure 25. illustrates, the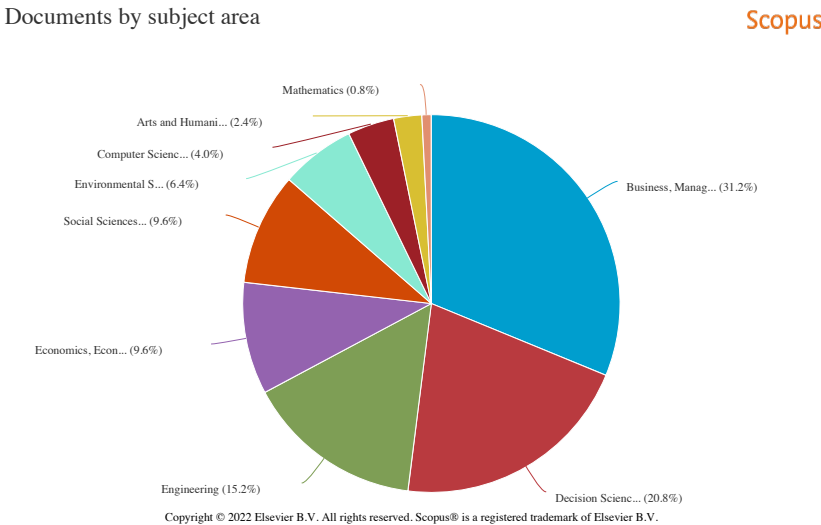y are mostly from the United States and Germany, while Italy and China follow in the last positions. This reflects exactly what the previous researches have demonstrated. However, in this case, it is important to note that the Indian results do not particularly and entirely belong to the field of interest of the research question of this systematic literature review.
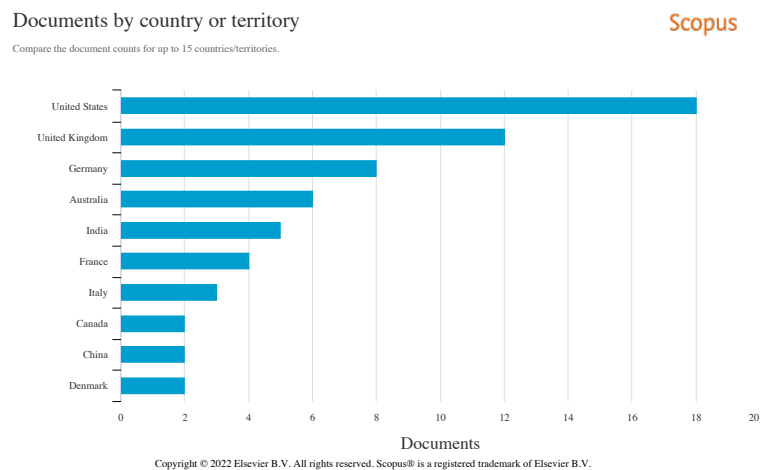
Figure 25. Countries/territories of origin of published documents on the research question[79]

Finally, all these 49 documents have been checked with respect to their fit to the topic of interest in order to get an answer for the research question from which this systematic literature review started. In fact, the aim is to understand what the literature up-to-now tells about how social network analysis is applied in supply chain management. The results were not the ones expected as the focus is more on the social and behavioral aspects rather than on the mathematical ones of the possible relationships within a network.

Indeed, in the business and management domain research is of empirical, theoretical and qualitative nature, as it is practical, applied to the real world, dominated by people

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[79]Source: *SCOPUS website,*
https://www.scopus.com/term/analyzer.uri?sid=2121f0e76e793efd4d342b9edee05ee3&origin=
resultslist&src=s&sort=plff&sdt=a&sot=a&sessionSearchId=2121f0e76e793efd4d342b9edee
05ee3&count=50&analyzeResults=Analyze+results&txGid=d3b35ecfcd38bbeee634dce27ae2a
de1

and it includes a wider array of subfields, such as human resources management, operations management, strategic management, organizational behavior and entrepreneurship[80]. In particular, the emphasis is on qualitative methods such as observation and interviewing because the business world can only be understood through people's interpretation due to the inevitable subjective element. In addition, through the qualitative research it is possible to discover worthy investigation phenomena, provide rich and in-depth information and stimulate further studies. Empirical research, on the other hand is based on observation and measurement of circumstances, directly experienced by the researcher. The data thus gathered may be compared against a theory or hypothesis, but the results are still based on real life experience[81]. However, these different typologies of research are usually applied also together as mixed methods as they are an excellent way towards obtaining exhaustive, useful, balanced and informative results having a long history and tradition both in social sciences and in management and business research[82].

Moreover, in order to get more appropriate sources, other advanced searches have been conducted by changing only the keywords such as "social network analysis in supply network management" or "social network analysis in supply chain". However, it is important to note that some of the relevant articles appeared in the different searches.

The field of research to consider has been reduced to the business and management domain regarding the various typologies of relations that may arise between the different actors, such as the one buyer-supplier or supplier-customer or the one between members of the same company working in the same or different levels and departments. Furthermore, the outcomes of the review indicate the interdisciplinary nature of the research field for which a common methodology and language have not emerged so far. Indeed, the available literature is mostly based on surveys rather than

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[80] Source: *L. F. Popescul and L. Jitaru, Research Methods Used In Studies On Management And International Affairs, November 2017*

[81] Source: *How to conduct empirical research, https://www.emeraldgrouppublishing.com/how-to/research-methods/conduct-empirical-research*

[82] Source: *L. F. Popescul and L. Jitaru, Research Methods Used In Studies On Management And International Affairs, November 2017*

on graph theory, even if recently few methods have been developed for merging the two domains of social network analysis and supply chain management. What is observed is that prior works addresses them separately and only few are focused on their intersection.

3.3 Analysis of the results

In total, 35 articles have been read and analyzed (Appendix - B), thus included in the review process, to get the answer of the research question: how much has been written about the application of social network analysis in supply chain management. Their selection process started from the 593 relevant documents (Appendix – A) that were identified by conducting a basic research through the SCOPUS database. Then, the advanced search followed, so that the resulted resources have been screened obtaining only 49. All these articles have been read and analyzed according to their title, abstract and correspondence with the research question in order to find out the most appropriate ones. Accordingly, 26 were selected from this list. Then, to have a bigger sample, other advanced searches have been conducted by changing the keywords, so that 9 additional relevant sources properly related to the research issue have been picked. From these steps, it comes that 23 out of the 49 resulted documents have not been included in the analysis, even if all of them have been read and analyzed, for different reasons, especially the fact of not being really suitable for the research question of the systematic literature review conducted for this thesis as they dealt with different arguments such as building the robustness of the supply chain, defining the organizational business model or enhancing the attention on sustainability.

The selection process, considering both included and excluded documents, is depicted in the following figure.
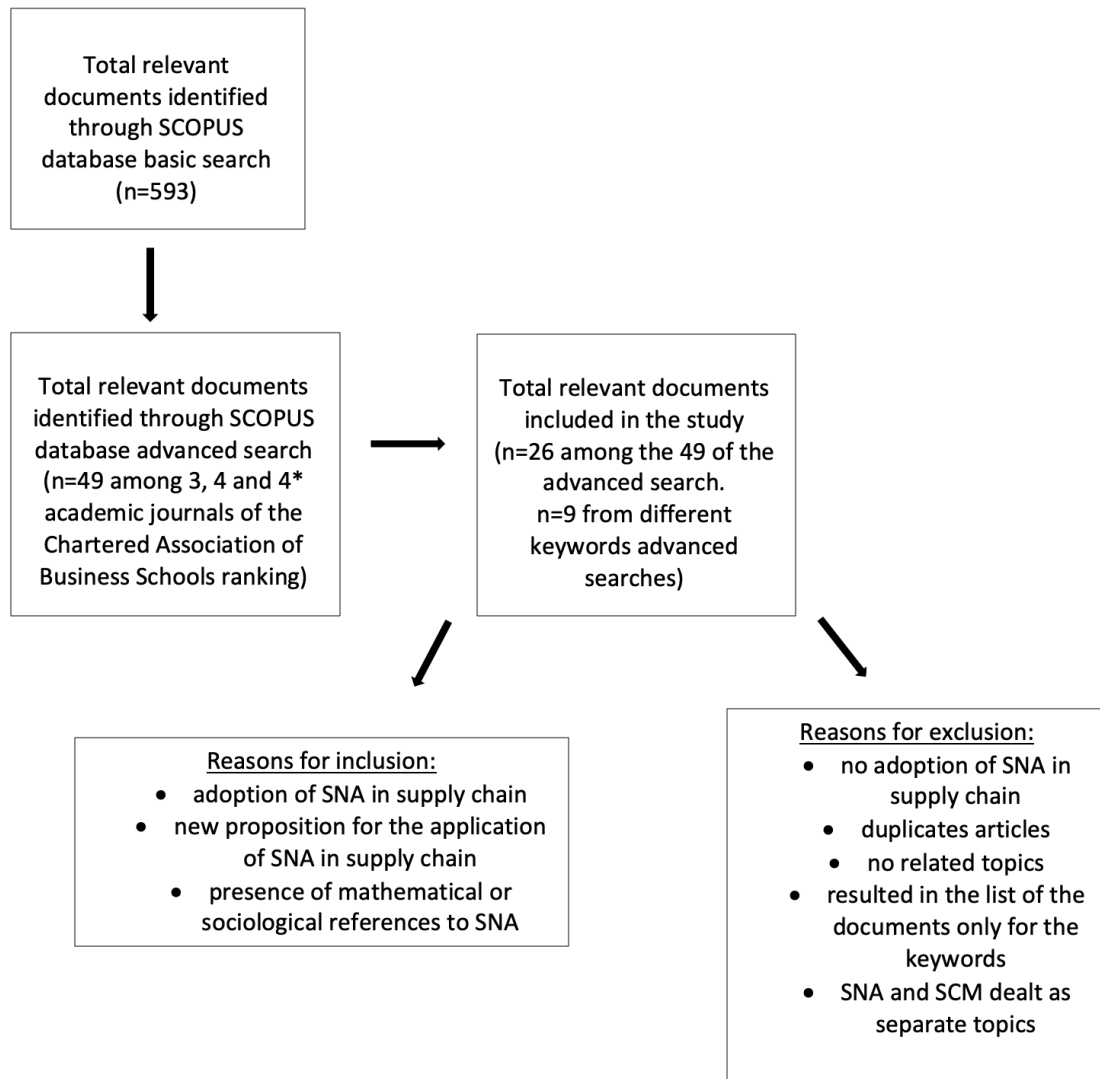
Figure 26. Article selection process

This procedure has started when each of the 49 sources resulted from the advanced research have been assessed according to the titles, keywords and abstracts. At this point some inclusion and exclusion criteria have been set in order to capture the 35 relevant articles for the research question. Specifically, for articles to be included, they had to address the adoption of social network analysis in supply chain management or to present elements for its further implications and studies or to deal with the mathematical or sociological methodologies applied by it. On the other hand, duplicated documents have been excluded as well as the ones without references to the adoption of social network analysis in supply chain management or the ones that were included in the resulted list by the database only because they correspond to the searching keywords but applied to different matters.

The selected papers have been analyzed in two ways: a quantitative and qualitative analysis. The first one has been conducted starting from the 593 articles of the basic research passing through the 49 ones resulted from the applied research and arriving to the 35 selected ones. The following tables demonstrate the most frequently used title words and author keywords in the resulted and chosen papers. Indeed, "supply chain", "network", "supply chain management" and "social network" are the most used and frequent, while "social network analysis" is less used. Furthermore, these tables prove that the majority of the documents selected and analyzed deal with the topic of social network analysis and supply chain management separately, as there is no correspondence between the title words or authors keywords for none of the three searches.

Table 1. The most frequently used title words and author keywords of the 593 resulted documents of the basic search

Title word	Count	Author keyword	Count
Supply chain	259	Supply chain management	131
Network	217	Supply chain	118
Social network	49	Social network	100
supply chain management	48	Social network analysis	74
Social network analysis	21	Network	62
Supply network	15	Supply network	15
Network theory	1	Network theory	4

Table 2. The most frequently used title words and author keywords of the 49 resulted documents of the advanced search

Title word	Count	Author keyword	Count
Network	23	Supply chain	43
Supply chain	23	Network	39
Social network	11	Supply chain management	19
Social network analysis	7	Social network	17
supply chain management	3	Social network analysis	14
Supply network	1	Network theory	3
Network theory	0	Supply network	2

Table 3. The most frequently used title words and author keywords of the 35 selected documents

Title word	Count	Author keyword	Count
Network	26	Network	126
Supply chain	17	Supply chain	99
Social network	13	Social network	48
Social network analysis	11	Supply chain management	29
Supply chain management	3	Social network analysis	27
Supply network	2	Supply network	9
Network theory	0	Network theory	6

Then, the quantitative analysis has been conducted in particular on the 35 selected articles resulted from the advanced researches in order to get the results on the research question: understand how much has been written on the application of social network analysis in supply chain management. Especially, to understand if the focus is more on the sociological or mathematical aspects.

Dimensions/Typologies	No. of papers used in total	Percentages
Network perspectives		
Dyad	17	49%
Triad	4	11%
Ego network	4	11%
Sub-network	6	17%
Small-world	1	3%
Eco-network	2	6%
Types of network ties		
Soft	6	17%
Hard	5	14%
Personal/Social attributes	31	89%
Unit of analysis		
Individual level	1	3%
Inter-firm level	19	54%
Intra-firm level	11	31%
Theories		
Network theory	15	43%
Graph theory	5	14%
Data collection		
Questionnaire/ interview /Survey	24	69%
Database/Software	7	20%
Data analysis		
Node level		
• degree centrality	10	29%
• closeness centrality	10	29%
• betweenness centrality	12	34%
Network level		
• network centralization	4	11%
• network density	2	6%
• network complexity	1	3%
Matrices	9	26%
Sociogram	4	11%

Figure 27. Summary of the results

On the other hand, the qualitative analysis has been conducted especially in reference to the second exclusion criteria, according to which some papers (Appendix – C) have not been included in the analysis as they deal with different aspects related to supply chain and supply chain management in absence of any connection with social network analysis such as:

- the formulation of strategy to combat risk in industry 4.0 environment
- the application of 5G technology in supply chain
- the sustainable supply chain management
- the compliance with the legislation in terms of sustainability
- the definition of a business model
- logistics
- Global Value Chains
- Stakeholders costs in supply chain management

The findings of this study reveal that there is a growing interest in applying SNA in supply chain management. The most investigated phenomena are both inter-organizational and intra-organizational relationships such as, respectively, buyer-supplier and among employees relations. According to the sources analyzed, it is important to study both the relations that arise within a company but also the ones of the supply network in which it operates. However, these informal links are as fundamental as they are difficult to understand, especially nowadays due to the de-layering of organizations, virtual work and globalization. In fact, informal networks have a strong influence in terms of knowledge sharing, organizational strategy, success and competitive advantage. For example, concerning inter-organizational ties, the supplier's network may influence the buyer's one or knowing the position of the competitor is useful from the bargaining point of view in case of opportunities or constraints; while in the case of intra-organizational ties, people are affected by some cultural meaning such as rules, obligations and norms according to which they seek out those who are similar to themselves, thus those they can trust more or in a hierarchical structure it is worthwhile to know the relations of people in determinant positions in case of needed implementations. In general, creating trust and sharing knowledge are at the basis for

the establishment of closer and long-term relations in order to construct efficient and responsive supply chains.

The review has demonstrated that all documents analyzed make reference to the sociological sphere, while few of them to the mathematical one, meaning that the available literature up to now stresses the personal and social attributes of the relationships between network's actors, rather than their visual representation applying the graph theory. In fact, the majority of the articles gather information about the relations among actors in a network through questionnaires, surveys or interviews and only then databases are used to get the results, which are represented both in a sociological and mathematical way through sociograms and matrices, respectively. Moreover, the focus on relations is on dyads, thus on links between two actors, that may be of hard or soft nature; especially, the soft ones are of strong importance due to the intangible flow of information through them. Finally, the last thing to consider is the recurrent reference to degree centrality, betweenness centrality and closeness centrality. Indeed, they are the three main metrics applied by social network analysis to understand the network and the relations among actors within it.

From this literature review it has emerged that social network analysis is applied in supply chain management both by managers and by organizations in general. On one hand it is used in the cross-functional working relationships and decision-making process to map the interactions of the members within organizations in order to identify the most central personnel, understand the informal relations on personal attributes and the employees' single influence and power in order to enhance internal collaboration. On the other hand, this methodology is employed to map the supply networks in order to understand the horizontal linkages of the partners, the diffusion of technology, how the portfolio of relations is managed (for example from the performance point of view), how extant findings regarding key interorganizational constructs such as trust, commitment, conflict, communication and opportunism work from a network perspective, how the portfolio of supplier relationships is managed to investigate the role of trust in the network and to support the human resource evaluation process. Furthermore, from a general point of view of the business and management domain,

the application of social network analysis in supply chain management occurs in order to understand and analyze how both "hard" and "soft" ties (e.g. the flow of resource flows and the less tangible personal relations, respectively) translate into a competitive advantage as the network of linkages among members is fundamental in creating trust which then facilitates coordination, communication and exchange as learning and knowledge are easily shared and members' cohesion increases. Then it is used to visualize social relationships through software (monitor, represent and identify knowledge), to analyze the performance of the supply chain, the relations within it, its issues and its complexity to study both inter and intra relationships and phenomena between different organizations or networks and to investigate the relationship between an actor's position within a network and its job performance. Finally, according to the analyzed literature, social network analysis in supply chain management is used an anti-counterfeiting tool in order to prevent this phenomenon, to understand the effects of social capital in economic transactions as behavior is predicated on social relations, in logistic initiatives where the position of actors, their relations and influence are fundamental to know, to enhance product development, supply chain innovation and sustainability and to assess the structure of a network after a change, such as an internal restructuring or acquisition. Indeed, it allows to deeply investigate the structural characteristics and the relationships of a network that otherwise would not be possible by applying the traditional approaches, which are not able to deal with intangible phenomenon, in order to intervene on their critical points.

This research outlines the importance of social network analysis in supply chain management as a tool for determining and analyzing the relations, especially the informal ones, which on one hand are influenced from the design of the organizational structure and on the other hand, impact on the business strategy. In fact, they enhance knowledge sharing, trust and collaboration which are needed for a company to gain a competitive advantage over competitors in order to be successful. Moreover, the mathematical aspect of this technique, meaning the use of graph and network designs, facilitate the understanding of the informal networks through their visual representation. In this way, managers' intervention and problems' solutions are more precise. For example, identifying people that are highly central in networks (and so disproportionately impact a group by controlling information or decision making) can

help a manager consider how to reallocate informational domains or decision-making rights so that the group as a whole is more effective. Alternatively, understanding who is peripheral in a network is important in order to craft ways to engage these people. As a consequence, organizational flexibility, innovation, and efficiency are fostered.

From the point of view of the systematic literature review, it reflects the novelty of this field as starting from sociological applications moving towards mathematical ones, researches have clearly demonstrated the extent to which informal networks pervade and effect life and work within organizations[83]. Furthermore, this research underlines the importance of conducting a systematic literature review to have a clear picture on a specific question matter according to highly referenced resources. Indeed, it, unlike other research methods, focuses on sources to identify, highlight and evaluate a high quality research.

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[83]Source: *R. Cross, S. P. Borgatti and A. Parker, Making Invisible Work Visible: Using Social Network Analysis in Support Strategic Collaboration, California Management Review, 2002*

The following table summarizes and highlights the main themes and arguments that emerged from the analysis.

TOPIC	MAIN FINDINGS	IMPLICATIONS
Social Network Analysis in Supply Chain Management	- Determination and analysis of relations (especially informal ones) within a business - Use of graph and networks to visualize relations (especially informal ones)	- Influence of the organizational structure design - Effects on the business strategy - More precise interventions and solutions from the managerial point of view → finding highly central people in a network = relocation of rights and domains for more efficiency → finding peripheral network actors = engagement - Facilitating understanding - Organizational flexibility, innovation, efficiency
Systematic literature review	- Novelty of the field → sociological and mathematical applications - Have a clear picture on a specific question matter - Focus on sources	- Demonstration of the pervading and effects of informal networks within organizations - Identify, highlight and evaluate a high quality research

In conclusion, it has been conducted also a basic search, not an advanced one in order to have a wider field of research, regarding the possible change that may have occurred in the perception of the risk after the Covid-19 by confronting it with the previous situation. As for the research question of this systematic literature review, only few relevant documents resulted from the basic search according to both the following groups of keyworks: "risk perception before and after Covid-19 in supply chain", "risk perception in supply chain management after Covid-19" and "risk perception in supply chain management before Covid-19". This is mainly due to the fact, that high level journals and academic articles need time to be published, thus the majority of them regarding this argument will be available in the next years.

The results of these searches are illustrated in the graph below (and all the documents analyzed are listed in Appendix - D): for each group of keywords there are the number of total documents found and the number of the relevant ones among them. For what concern the first and second group few articles resulted and none of them was pertinent. On the other hand, the results increased in the case of the third group, in which 6 articles were selected according to relevance of the title and of the abstract. The majority of them does not refer particularly to the search topic and treats the themes separately, but it is more focused on the perception of the risk in supply chains during disruptions.
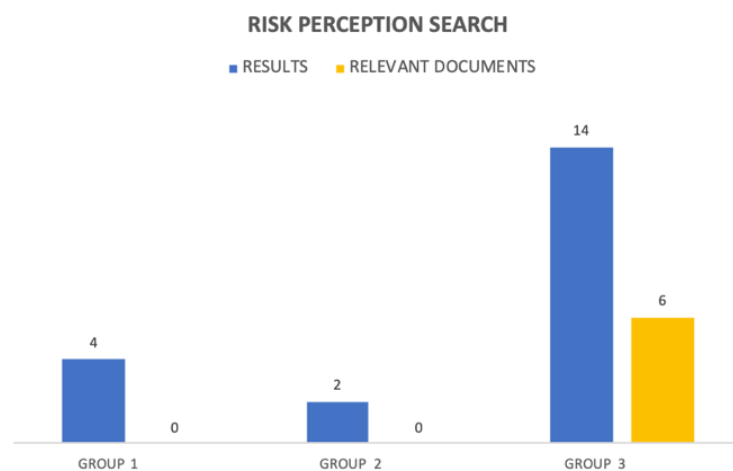

Figure 28. Results from the basic search on risk perception

Indeed, the non-relevant documents, focus on the supply chain topic, especially by dealing with risk perception, recovery strategies and supply chain management as separate matters from the Covid-19 and also to situations of disruption in general. The lack of a linking connection with the actual crisis circumstances caused by the pandemic may be mainly due to the recent nature of the events, which are under continuous studies in order to understand, on one hand the consequences, and on the other hand the ways for predicting both the happing and the impacts, and solving the difficulties. On the contrary, the selected articles represent specific case studies regarding the effects of the Covid-19 outbreak in the business domain, by focusing in particular on SME. What emerges from these documents is that supply chain disruptions may affect the overall business recovery after a critical event. Therefore, a slight move in one section of the supply chain could severely affect the situation as a whole, and problems in any link within the chain such as product transportation, materials supply, processing and sales could entirely affect it, which meant that then the collapse of a individual enterprises could lead to general enterprises collapses across the industrial supply chain[84]. Moreover, the unprecedent situation and the strong territorial nature of Covid-19 posed high uncertainty and different risk perceptions of it: enterprises operating both in domestic and exports markets had a lower perception as well as the ones with long cash flow coverage and high total assets value, which used them as a buffer against the effects of the pandemic spread. However, even if the perception and management of risk differ accordingly to the different organizational factors that need to be understood in relation to organizational size, the majority of businesses operates according to a just-in-time approach in absence of any written and pre-established guidelines for risk management. As a consequence, the Covid-19 has made them less resilient, on the contrary of the ones that, due to their higher risk perception, have internal guidelines for risk management.

As these findings demonstrates the perception of risk and its management are matters on which businesses put not so much attention, despite their importance. Furthermore, as a consequence of the issues that the pandemic emergency has outlined, managers

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[84]Source: *Y. Lu, J. Wu, J. Peng and L. Lu The perceived impact of the Covid-19 epidemic: evidence from a sample of 4807 SMEs in Sichuan Province, China, 2020*

have the pressure of implementing and promoting risk management practices, also by training operators and workers, in order to design effective policy interventions to mitigate not only the impacts of the current Covid-19 pandemic, but also to enhance the adoption of more integrated resilience-based approaches as preventive measures for possible further crisis and their recovery process. As a matter of fact, the positive side of this catastrophic situation that encompasses the entire globe, resides in the change of the risk perception vision that enterprises will put in place, reserving to it a core position in their management, as it is fundamental for being successful.

Covid – 19 impacts on SME as an example of situations of disruption and risk in general:
- High uncertainty
- Different risk perceptions

→ due to the territorial nature of the pandemic
- Different risk management

→ due to the organizational factors
- Supply chain disruptions may affect the overall business recovery

→ the collapse of a single enterprise could bring to general collapses within the industry
- Less resilience enterprise without internal guidelines for risk management vs more resilient organization with plans for managing risk due to their higher perception
- Use of cash flow coverage and high total assets value as a buffer

Managerial implications against disruptive events:
- Enforcement and promotion of risk management practices

→ training of workers and operators
- Adoption of resilience-based approaches

→ preventive measures
- Core position of the perception of risk and its management within the organizational management and strategy

→ to gain success

CONCLUSIONS

By reaching the end of this elaborate it is important to draw some conclusions. As the literature review has shown, in the field of management a sort of transformation is already underway as companies are increasingly structuring themselves as a network of relationships between individuals characterized by shared goals and values. This is the key for future business survival.

Social networks are often used as a basis for intercultural studies in sociology and anthropology. However, very different realities such as nature, society, economy, communication, Internet, etc. seem to function in the same way and can therefore be investigated and interpreted accordingly to their organizational structure, which is the element they have in common. As already stated in previous chapters, at the basis of it, according to the theories of numerous researchers, including Euler, who have been studying networks for years, there are simple mathematical laws that can be described and quantified, making it possible to identify the explanation of the relationships that are determined in the network. Indeed, recent years have been characterized by the concepts of network theory and knowledge of the mathematical laws that seem to govern the development of these environments. Especially, interesting is the application of the tools related to them, such as the social network analysis, in business contexts.

In the management field social network analysis is applied in order to study relationships, especially the ones transferring knowledge, which are not easy to interpret due to their intangible nature determined by fluid and volatile elements such as shared visions, goals and values, trust, mutual respect, friendship, group support, participation, empowerment, networking, cooperation and collaboration, teamwork, communication, functional conflict, negotiations and much more. However, these relations represent the so-called organizational social capital, which has become fundamental in determining the business success or failure.

Furthermore, social network analysis can also be useful for management projects because it can provide worthwhile information for understanding complex phenomena that, otherwise, are difficult to describe. In fact, in the business and management

context, it makes possible the approach to concrete problems such as: handling of distributed projects involving a large number of people, identifying the people with skills and experience that are vital for the future of the company in order to retain them with ad hoc programmes and incentives, and increasing innovative capacity, productivity and individual and group responsibility by reducing the knowledge gap between people. However, this methodology is only one option among the wide range of solutions and products that the market offers today. The basic idea behind them refers to the network theory, which has increasingly focused attention on the biological and social aspects of business, economic activities and social organizations in general. The focus is shifting towards people and their fluid, elastic and unpredictable way of relating and collaborating with each other as relationships are more and more based on trust. For this reason, social network analysis is nowadays effectively used to map and measure social networks, communities of people, organizations through the analysis of knowledge and information flows between the nodes that make up the network and their relationships. The use of this mechanism leads to concrete results in terms of personal and organizational productivity, innovation and adaptability to future challenges. In management, the benefits are manifold and specific to each individual application and project. For example, to name a few: costs can be reduced by better utilization and optimization of available resources, it is possible to identify the experts available in the organization e and their relationships and contacts and better understand how the existing informal relations operate and what are the key links that should not be broken in the phases of reorganization, downsizing or merger.

Furthermore, the application of the social network analysis in supply chain management, allows, on one hand, the reduction of contract dependency and transaction costs, while on the other hand it improves coordination and management both inside and between organizations. This is mainly due to the better knowledge about individuals' roles (individuals both as a single person or as a business) and their relationships based on a trust mechanism, which implications are reflected in organizational strategic decisions. For this reason, a deep understanding of such relations identifies the possibilities for different managerial actions such as: new interactions or intensification of existent relationships, implying new or denser

partnership relationships, joint-ventures, cooperation, intensifying qualification trainings and building new channels for the information flow.

In addition, as a representative example of the combination of the two main themes of this thesis, social network analysis and supply chain management, it is presented the netchain analysis concept. Indeed, the first two embody different and complex inter-organizational interdependencies on value sources and coordination mechanisms in order to reach collaboration, while the third one incorporates both vertical and horizontal linkages in a single analytical framework. Consequently, the netchain analysis allows the identification of the interdependence variable, between two firms or agents, since transactions arranged as chains (emphasizing vertical ties) or networks (emphasizing horizontal ties)[85], that explains the different facets of the simultaneous relationships that occur in the various inter-organizational settings. Furthermore, it focuses on the recognition of the relevant and simultaneous interdependencies within the inter-organizational collaboration system, in addition to the particular sources of value and the coordination mechanisms that are associated with them.

A netchain is a set of networks comprised of horizontal ties between firms within a particular industry or group, which are sequentially arranged based on vertical ties between firms in different layers. It differentiates between horizontal (transactions in the same layer) and vertical ties (transactions between layers), mapping how agents in each layer are related to each other and to agents in other layers[86]. This configuration is crucial for the analysis of the complex inter-organizational relations based on collaboration, as it stresses the mechanisms of value creation and coordination related to the horizontal and vertical production activities from the raw materials to the final product (also including information and financial flows), which are associated with cost reduction.

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[85]Source: *S. Lazzarini, M. L. Cook, Integrating supply chain and network analysis: The study of netchains, January 2001*
[86]Source: *S. Lazzarini, M. L. Cook, Integrating supply chain and network analysis: The study of netchains, January 2001*
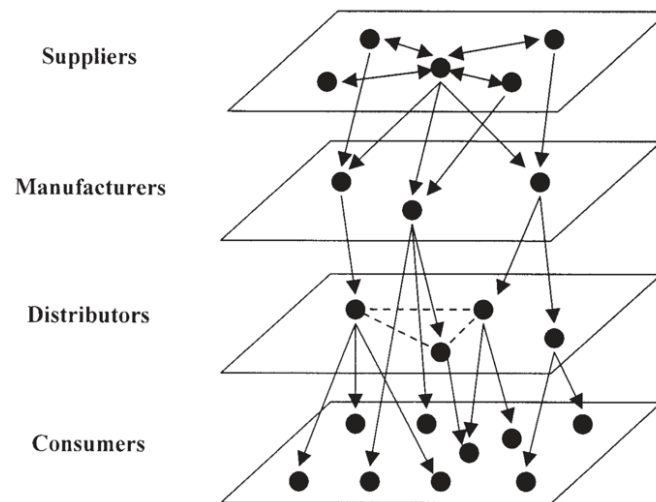
Figure 19. Example of a generic netchain[87]

Netchain analysis has the aim of determining all types of interdependencies in an inter-organizational setting. Indeed, as agents depend on choices and actions made by others, which implies tight relations in most cases, it is crucial to identify the nature of each interdependence[88]. Moreover, the netchain perspective is important also from the point of view of business policies and normative decisions, which need to take into consideration the inter-organizational interdependencies they address in the formulation of strategies.

A basic example of an inter-organizational relation in the business and management domain is the buyer-supplier one. While on one hand, traditional approaches managing this type of relationship have focused on the maintenance of its vertical nature, according to which a single buyer is individually linked with its suppliers, on the other hand the Japanese Toyota manufacturing represent the case of horizontal relations as suppliers are organized in associations in order to easily promote knowledge sharing and cooperation. In this way, Toyota organizes groups to enhance remedies and

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[87]Source: *S. Lazzarini, M. L. Cook, Integrating supply chain and network analysis: The study of netchains, January 2001*
[88]Source: *J. F. Kobbing, V. Beckmann, N. Thevs, H. Peng and S. Zerbe, Investigation of a traditional reed economy (Phragmites australis) under threat: pulp and paper market, values and Netchain at Wuliangsuhai Lake, Inner Mongolia, China (2016)*

improvements to production problems and processes, reduce costs and discover new solution.

Furthermore, the spread of internet has promoted the application of information technology also in the context of netchains as it supports inter-organizational collaboration through the usage of closed electronic data interchange (EDI) systems and Internet based procurements. EDI involves computer-to-computer exchange of information between buyers and suppliers, encouraging close trading relationships based on investments by both parties in private computer connections and training, implying a closed architecture of connection and agreements specifying information transfer codes [89]. The main advantages connected to this mechanism are: a reduction of inventory and transaction costs, especially referring to procurement and monitoring expenses, product optimization thanks to information sharing, and enhancing product quality. On the other hand, Internet-based procurement mechanisms known as business-to-business (B2B) exchanges enable the connection between autonomous agents creating interdependencies among them. The idea is to standardize the transaction procedures shared by different actors in order to create connection, contributing to the reduction of entry costs.

Despite its relevant contributions, the hybrid concept of netchain analysis is mainly applied to the relationship between firms as unit of analysis, and not to individuals. However, recently it has been developed the notion of "Social Netchain" which is different from the previous analytical frameworks as it focuses on individuals and their relationships, instead of firms and/or organizations. Indeed, a "Social Netchain" is defined as a set of interpersonal relationships networks comprised of horizontal ties between individuals of the firms or organizations within a particular agribusiness sector, which are sequentially arranged based on vertical ties between individuals of the firms or organizations in different layers. Accordingly, firms and organizations should be understood as a specific and intra set of interpersonal relationships of those individuals

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[89]Source: *S. Lazzarini, M. L. Cook, Integrating supply chain and network analysis: The study of netchains, January 2001*

that legally belong to it[90]. The main advantage in the application of this framework consist in the possibility to better understand the trust mechanism of governance at the basis of the relationships between individuals. From the managerial point of view, it improves the human resources management through the identification of the single characteristics in order to efficiently allocate the resources according to them and to the positions' requirements.

In conclusion, the systematic literature review has summarized the overview of the available and relevant empirical evidence on a given topic, providing its complete interpretation according to the obtained results. Consequently, this replicable process enables the in-depth study of a specific matter, also by comparing the outcomes and information coming from different previous researches and it improves further analysis. In this case, the systematic literature review conducted for this elaborate, has highlighted the reasons and ways of application of social network analysis in supply chain management. Indeed, it emerged the importance of a deep knowledge of the different interpersonal relationships within the business network that allows the identification of possibilities of new interactions or intensification of existent ones. This type of information is collected through subjective techniques such as questionnaires or surveys and then its patterns are explored and visualized by using mathematical tools and specialized software packages. As a matter of fact, social network analysis can complement the traditional perspective on supply chain by capturing the complexity needed to understand a company's strategy or behavior[91] and it can enhance the organizational competitive advantages through the facilitation of both internal and external communication and knowledge sharing, the increase of performance, the improvement of innovation capability and the handling of material flows, which are all elements affecting the supply chain management.

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[90]Source: *E. Talamini and G. M. Velloso Ferreira, Merging netchain and social network: Introducing the "social netchain" concept as an analytical framework in the agribusiness sector, 2010*
[91]Source: *J. B. Kim, Social Network Analysis of a Supply Network Structural Investigation of the South Korean Automotive Industry, 2011*

Appendix – A

This appendix contains the information about the 49 resulted documents from the advanced research that has been conducted starting from the 593 papers identified through the basic research.

Authors	Title	Year	Source title
Pandey S., Singh R.K., Gunasekaran A.	Supply chain risks in Industry 4.0 environment: review and analysis framework	2021	Production Planning and Control
Dolgui A., Ivanov D.	5G in digital supply chain and operations management: fostering flexibility, end-to-end connectivity and real-time visibility through internet-of-everything	2021	International Journal of Production Research
Shashi, Centobelli P., Cerchione R., Mittal A.	Managing sustainability in luxury industry to pursue circular economy strategies	2021	Business Strategy and the Environment
Reich J., Kinra A., Kotzab H., Brusset X.	Strategic global supply chain network design–how decision analysis combining MILP and AHP on a Pareto front can improve decision-making	2021	International Journal of Production Research
Fathollahi-Fard A.M., Ahmadi A., Al-e-Hashem S.M.J.M.	Sustainable closed-loop supply chain network for an integrated water supply and wastewater collection system under uncertainty	2020	Journal of Environmental Management
Han Y., Caldwell N.D., Ghadge A.	Social network analysis in operations and supply chain management: a review and revised research agenda	2020	International Journal of Operations and Production Management
Laosirihongthong T., Samaranayake P., Nagalingam S.V., Adebanjo D.	Prioritization of sustainable supply chain practices with triple bottom line and organizational theories: industry and academic perspectives	2020	Production Planning and Control
Rocchi B., Randelli F., Corsini L., Giampaolo S.	Farmer direct selling: the role of regional factors	2020	Regional Studies
Bier T., Lange A., Glock C.H.	Methods for mitigating disruptions in complex supply chain structures: a systematic literature review	2020	International Journal of Production Research
Walther O.J., Tenikue M., Trémolières M.	Economic performance, gender and social networks in West African food systems	2019	World Development
Swain A.K., Cao R.Q.	Using sentiment analysis to improve supply chain intelligence	2019	Information Systems Frontiers
Rasouli M.R.	Intelligent process-aware information systems to support agility in disaster relief operations: a survey of emerging approaches	2019	International Journal of Production Research
Chen Y., Wang S., Yao J., Li Y., Yang S.	Socially responsible supplier selection and sustainable supply chain development: A combined approach of total interpretive structural modeling and fuzzy analytic network process	2018	Business Strategy and the Environment
Kim S., Colicchia C., Menachof D.	Ethical Sourcing: An Analysis of the Literature and Implications for Future Research	2018	Journal of Business Ethics
Meinlschmidt J., Schleper M.C., Foerstl K.	Tackling the sustainability iceberg: A transaction cost economics approach to lower tier sustainability management	2018	International Journal of Operations and Production Management
Dalla Via N., Perego P.	Determinants of Conflict Minerals Disclosure Under the Dodd–Frank Act	2018	Business Strategy and the Environment
Stolze H.J., Mollenkopf D.A., Thornton L., Brusco M.J., Flint D.J.	Supply Chain and Marketing Integration: Tension in Frontline Social Networks	2018	Journal of Supply Chain Management
Chen S.	Multinational Corporate Power, Influence and Responsibility in Global Supply Chains	2018	Journal of Business Ethics
Viswanadham N.	Performance analysis and design of competitive business models	2018	International Journal of Production Research

Quentin D., Campling L.	Global inequality chains: integrating mechanisms of value distribution into analyses of global production	2018	Global Networks
Bloomfield M.J.	Global Production Networks and Activism: Can Activists Change Mining Practices by Targeting Brands?	2017	New Political Economy
Fazili M., Venkatadri U., Cyrus P., Tajbakhsh M.	Physical Internet, conventional and hybrid logistic systems: a routing optimisation-based comparison using the Eastern Canada road network case study	2017	International Journal of Production Research
Kumar R.S., Choudhary A., Babu S.A.K.I., Kumar S.K., Goswami A., Tiwari M.K.	Designing multi-period supply chain network considering risk and emission: a multi-objective approach	2017	Annals of Operations Research
Barrientos S., Knorringa P., Evers B., Visser M., Opondo M.	Shifting regional dynamics of global value chains: Implications for economic and social upgrading in African horticulture	2016	Environment and Planning A
Harrington T.S., Singhai J., Kumar M., Wohlrab J.	Identifying design criteria for urban system last-mile solutions -A multi-stakeholder perspective	2016	Production Planning and Control
Zimmer K., Fröhling M., Schultmann F.	Sustainable supplier management - A review of models supporting sustainable supplier selection, monitoring and development	2016	International Journal of Production Research
Govindan K., Jha P.C., Garg K.	Product recovery optimization in closed-loop supply chain to improve sustainability in manufacturing	2016	International Journal of Production Research
Han J., Shin K.	Evaluation mechanism for structural robustness of supply chain considering disruption propagation	2016	International Journal of Production Research
Jonsson P., Myrelid P.	Supply chain information utilisation: conceptualisation and antecedents	2016	International Journal of Operations and Production Management
Wichmann B.K., Carter C.R., Kaufmann L., Wilson J.R.	Making Environmental SCM Initiatives Work-Moving Beyond the Dyad to Gain Affective Commitment	2016	Journal of Supply Chain Management
Neumüller C., Kellner F., Gupta J.N.D., Lasch R.	Integrating three-dimensional sustainability in distribution centre selection: The process analysis method-based analytic network process	2015	International Journal of Production Research
Behara R.S., Babbar S., Smart P.A.	Leadership in om research: A social network analysis of european researchers	2014	International Journal of Operations and Production Management
Ting S.L., Tsang A.H.C.	Using social network analysis to combat counterfeiting	2014	International Journal of Production Research
Benedek G., Lublóy A., Vastag G.	The importance of social embeddedness: Churn models at mobile providers	2014	Decision Sciences
Tseng S.-C., Hung S.-W.	A strategic decision-making model considering the social costs of carbon dioxide emissions for sustainable supply chain management	2014	Journal of Environmental Management
Cruz J.M.	Mitigating global supply chain risks through corporate social responsibility	2013	International Journal of Production Research
Sloane A., Oreilly S.	The emergence of supply network ecosystems: A social network analysis perspective	2013	Production Planning and Control
Gilgor D.M., Autry C.W.	The role of personal relationships in facilitating supply chain communications: A qualitative study	2012	Journal of Supply Chain Management
Galaskiewicz J.	Studying supply chains from a social network perspective	2011	Journal of Supply Chain Management
Fearon C., Ballantine J., Philip G.	Understanding the role of electronic trading and inter-organisational cooperation and coordination: A conceptual matrix framework	2010	Internet Research
Oztekin A., Mahdavi F., Erande K., Kong Z., Swim L.K., Bukkapatnam S.T.S.	Criticality index analysis based optimal RFID reader placement models for asset tracking	2010	International Journal of Production Research
Bernardes E.S.	The effect of supply management on aspects of social capital and the impact on performance: A social network perspective	2010	Journal of Supply Chain Management

Burchielli R., Delaney A., Tate J., Coventry K.	The FairWear Campaign: An Ethical Network in the Australian Garment Industry	2009	Journal of Business Ethics
Borgatti S.P., Li X.	On social network analysis in a supply chain context	2009	Journal of Supply Chain Management
Jaehne D.M., Li M., Riedel R., Mueller E.	Configuring and operating global production networks	2009	International Journal of Production Research
Cruz J.M., Matsypura D.	Supply chain networks with corporate social responsibility through integrated environmental decision-making	2009	International Journal of Production Research
Carter C.R., Ellram L.M., Tate W.	THE USE OF SOCIAL NETWORK ANALYSIS IN LOGISTICS RESEARCH	2007	Journal of Business Logistics
Carter C.R., Leuschner R., Rogers D.S.	A social network analysis of the Journal of Supply Chain Management: Knowledge generation, knowledge diffusion and thought leadership	2007	Journal of Supply Chain Management
Wright C.M., Smith M.E., Wright B.G.	Hidden costs associated with stakeholders in supply management	2007	Academy of Management Perspectives

Appendix – B

This appendix contains the information about the 35 screened articles resulted from the advanced researches, that have been analyzed as the most appropriate ones to the research question of the literature review.

Authors	Title	Year	Source title
Han Y., Caldwell N.D., Ghadge A.	Social network analysis in operations and supply chain management: a review and revised research agenda	2020	International Journal of Operations and Production Management
Bier T., Lange A., Glock C.H.	Methods for mitigating disruptions in complex supply chain structures: a systematic literature review	2020	International Journal of Production Research
Walther O.J., Tenikue M., Trémolières M.	Economic performance, gender and social networks in West African food systems	2019	World Development
Swain A.K., Cao R.Q.	Using sentiment analysis to improve supply chain intelligence	2019	Information Systems Frontiers
Rasouli M.R.	Intelligent process-aware information systems to support agility in disaster relief operations: a survey of emerging approaches	2019	International Journal of Production Research
Chen Y., Wang S., Yao J., Li Y., Yang S.	Socially responsible supplier selection and sustainable supply chain development: A combined approach of total interpretive structural modeling and fuzzy analytic network process	2018	Business Strategy and the Environment
Kim S., Colicchia C., Menachof D.	Ethical Sourcing: An Analysis of the Literature and Implications for Future Research	2018	Journal of Business Ethics
Meinlschmidt J., Schleper M.C., Foerstl K.	Tackling the sustainability iceberg: A transaction cost economics approach to lower tier sustainability management	2018	International Journal of Operations and Production Management
Stolze H.J., Mollenkopf D.A., Thornton L., Brusco M.J., Flint D.J.	Supply Chain and Marketing Integration: Tension in Frontline Social Networks	2018	Journal of Supply Chain Management
Chen S.	Multinational Corporate Power, Influence and Responsibility in Global Supply Chains	2018	Journal of Business Ethics
Han J., Shin K.	Evaluation mechanism for structural robustness of supply chain considering disruption propagation	2016	International Journal of Production Research
Jonsson P., Myrelid P.	Supply chain information utilisation: conceptualisation and antecedents	2016	International Journal of Operations and Production Management
Wichmann B.K., Carter C.R., Kaufmann L., Wilson J.R.	Making Environmental SCM Initiatives Work-Moving Beyond the Dyad to Gain Affective Commitment	2016	Journal of Supply Chain Management
Behara R.S., Babbar S., Smart P.A.	Leadership in om research: A social network analysis of european researchers	2014	International Journal of Operations and Production Management
Ting S.L., Tsang A.H.C.	Using social network analysis to combat counterfeiting	2014	International Journal of Production Research
Benedek G., Lublóy A., Vastag G.	The importance of social embeddedness: Churn models at mobile providers	2014	Decision Sciences
Sloane A., Oreilly S.	The emergence of supply network ecosystems: A social network analysis perspective	2013	Production Planning and Control
Gilgor D.M., Autry C.W.	The role of personal relationships in facilitating supply chain communications: A qualitative study	2012	Journal of Supply Chain Management
Galaskiewicz J.	Studying supply chains from a social network perspective	2011	Journal of Supply Chain Management

Fearon C., Ballantine J., Philip G.	Understanding the role of electronic trading and inter-organisational cooperation and coordination: A conceptual matrix framework	2010	Internet Research
Bernardes E.S.	The effect of supply management on aspects of social capital and the impact on performance: A social network perspective	2010	Journal of Supply Chain Management
Borgatti S.P., Li X.	On social network analysis in a supply chain context	2009	Journal of Supply Chain Management
Jaehne D.M., Li M., Riedel R., Mueller E.	Configuring and operating global production networks	2009	International Journal of Production Research
Cruz J.M., Matsypura D.	Supply chain networks with corporate social responsibility through integrated environmental decision-making	2009	International Journal of Production Research
Carter C.R., Ellram L.M., Tate W.	THE USE OF SOCIAL NETWORK ANALYSIS IN LOGISTICS RESEARCH	2007	Journal of Business Logistics
Carter C.R., Leuschner R., Rogers D.S.	A social network analysis of the Journal of Supply Chain Management: Knowledge generation, knowledge diffusion and thought leadership	2007	Journal of Supply Chain Management
Cross R., Borgatti S.P., Parker A.	Making invisible work visible: Using social network analysis to support strategic collaboration	2002	California Management Review
Allesina S., Azzi A., Battini D., Regattieri A.	Performance measurement in supply chains: New network analysis and entropic indexes	2010	International Journal of Production Research
David N., Brennecke J., Rank O.	Extrinsic motivation as a determinant of knowledge exchange in sales teams: A social network approach	2020	Human Resource Management
Bezuidenhout C.N., Bodhanya S., Sanjika T., Sibomana M., Boote G.L.N.	Network-analysis approaches to deal with causal complexity in a supply network	2012	International Journal of Production Research
Battini D., Persona A., Allesina S.	Towards a use of network analysis: quantifying the complexity of Supply Chain Networks	2007	International Journal of Electronic Customer Relationship Management
Capó-Vicedo J., Mula J., Capó J.	A social network-based organizational model for improving knowledge management in supply chains	2011	Supply Chain Management
Nabiafjadi S., Sharifzadeh M., Ahmadvand M.	Social network analysis for identifying actors engaged in water governance: An endorheic basin case in the Middle East	2021	Journal of Environmental Management
Wichmann B.K., Kaufmann L.	Social network analysis in supply chain management research: Social network analysis	2016	International Journal of Physical Distribution and Logistics Management
Leon R.-D., Rodríguez-Rodríguez R.	Social network analysis and supply chain management	2015	International Journal of Production Management and Engineering

This appendix contains the information about the 23 articles of the 49 resulted ones from the advanced research that have not been included in the analysis as they deal with different aspects related to supply chain and supply chain management in absence of any connection with social network analysis.

Authors	Title	Abstract
Pandey S., Singh R.K., Gunasekaran A.	Supply chain risks in Industry 4.0 environment: review and analysis framework	In Industry 4.0 environment, supply chains have become prone to various risks due to rapid globalization and process digitalization. The uncertainties and unplanned and unnatural events that are internal to supply chain networks and external to the environment of a firm pertaining to global supply chains are regarded as supply chain risks. The objective of this study is to identify and analyze the various emerging supply chain risks for strategy formulation in Industry 4.0 environment. Based on a systematic literature review and experts' opinion, different supply chain risks in the present business environment have been analyzed. Major identified risks are operational and manufacturing process risk, behavioural risk, demand risk, governmental and organisational risk, system risk, financial risk, product recovery risk, social and environmental risk, supply risk, disruption risk, cyber security, and safety risk. For developing risk mitigation strategies, risk prioritization is very important. Sufficient research has not been done on ranking and categorization of these risks in the Industry 4.0 environment. Therefore, this study has tried to rank these emerging supply chain risks by the Technique for Order Preferences by Similarity to an Ideal Solution (TOPSIS) approach. These risks are further categorized as cause and effect using a Decision Making Trial and Evaluation Laboratory (DEMATEL). This classification of risks will facilitate top management of the organization in formulating strategies for risk mitigations in the Industry 4.0 environment. The findings of the study imply that supply chain managers should focus on disruption risk; cyber security and safety risk in the current Industry 4.0 environment. As supply chain risk management is an emerging research area in Industry 4.0 environment, the findings of this study will be very useful for industry professionals and researchers for further studies. © 2021 Informa UK Limited, trading as Taylor & Francis Group.
Dolgui A., Ivanov D.	5G in digital supply chain and operations management: fostering flexibility, end-to-end connectivity and real-time visibility through internet-of-everything	5G technology enables end-to-end connectivity in real time at a highly granular level along with the associated end-to-end visibility through the Internet-of-Everything. While some potential benefits of 5G for digital supply chain and operations management have been declared, literature is still silent about theoretical underpinning and structured conceptualisation of application areas, underlying implementation challenges, and the role of 5G in future transformations of value creation. This paper aims to offer some directions of how to close this research gap. We organise the discussion around five major capabilities of the digital supply chain and smart operations which can be enhanced by 5G, i.e. intelligence, visibility, transparency, dynamic networking, and connectivity. We delineate possible future research topics related to 5G in different areas of Industry 4.0-driven, digital supply chain and operations management which can be useful for researchers and practitioners alike when seeking to understand the impact of 5G on both short-term and long-term time scales. Our analysis encompasses both operational

		processes (e.g. transformations of manufacturing and warehouse operations by end-to-end connectivity of devices) and strategic perspectives (e.g. transformations of business models and supply network structures through end-to-end real-time visibility and connectivity of industry, public infrastructure, and consumers). Finally, cost-benefits trade-offs are discussed. © 2021 Informa UK Limited, trading as Taylor & Francis Group.
Shashi, Centobelli P., Cerchione R., Mittal A.	Managing sustainability in luxury industry to pursue circular economy strategies	Sustainable luxury research has received growing attention in the most recent years as it requires firms and supply chains to design circular business models and strategies to tackle environmental, financial, and social issues. However, previous research still falls short to deepen how luxury firms design and manage sustainable supply chain practices according to the circular principles. This paper adopts bibliometric and network analysis to evaluate a sample of 747 papers published over the last 35 years. The descriptive statistics and science mapping approaches utilizing cocitation analysis were performed with VOSviewer software to contribute to the ongoing development of sustainability in luxury research with the aim to develop a systemic framework for circular supply chain and offer a comprehensive overview on the topic. The main findings of this paper will help academicians and practitioners to improve the body of knowledge on the topic and provide an overview of promising future research avenues. © 2020 ERP Environment and John Wiley & Sons Ltd
Reich J., Kinra A., Kotzab H., Brusset X.	Strategic global supply chain network design–how decision analysis combining MILP and AHP on a Pareto front can improve decision-making	Integrating a broad range of information types and finding trade-offs between conflicting goals is a challenge in global supply chain network design (GSCND). Effective decision support systems (DSS) should be user-friendly, provide transparency, and support human judgement. There is a wide range of optimisation models that aim to improve the outcome of network design decisions. However, their practical performance often remains unknown, as their implementation into the managerial decision process is largely neglected. Such theory-driven models usually focus on single aspects of the decision, without being able to accommodate the practical problem comprehensively. We employ the CIMO approach to resolve the issue and contribute by showing how an integration involving these methods can be useful for managers once the proper knowledge transfer has been effectuated. An innovative decision support framework, which combines mixed-integer linear programming, the Analytical Hierarchy Process, and the Pareto front is created and analysed during a case study in the med-tech industry. Results show that the framework accommodates managerial experience, integrates qualitative as well as quantitative criteria, and provides transparency over the entire range of efficient solutions. The framework and application results contribute towards the development of more flexible and easy-to-use decision support systems for GSCND. © 2020 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group.
Fathollahi-Fard A.M., Ahmadi A., Al-e-Hashem S.M.J.M.	Sustainable closed-loop supply chain network for an integrated water supply and wastewater collection system under uncertainty	Today, an increase in the drought and water shortage all around the world is a challengeable threat for different governments and international committees. Water supply chain aims to manage the water consumption and to control the water shortage. Contrary to most of previous studies focused on the forward directions of the water supply chain, this paper also considers the reverse logistics known as a Closed-Loop Supply Chain (CLSC). Hence, an integrated Water Supply and Wastewater Collection System (WSWCS) under uncertainty is proposed. Furthermore, regarding the trend of sustainable development, the environmental dimensions and social benefits of the integrated WSWCS are contributed. To meet the

		standards of the sustainable development in developing countries, a case study in Iran is applied to a novel multi-objective stochastic optimization model based on triple bottom lines of sustainability. Having already been employed to similar optimization problems, the Social Engineering Optimizer (SEO) has been never applied in this research area. Another innovation of this study is to introduce an improved multi-objective SEO to solve this complicated model. Eventually, with regards to an extensive comparison contributing to the Pareto-based metrics and different sensitivities, some managerial implications are concluded as the main findings. © 2020 Elsevier Ltd
Laosirihongthong T., Samaranayake P., Nagalingam S.V., Adebanjo D.	Prioritization of sustainable supply chain practices with triple bottom line and organizational theories: industry and academic perspectives	The purpose of this study is to investigate the influence of sustainable supply chain management (SSCM) practices on triple bottom line (TBL) measures from the perspective of organizational theories. This study identified five SSCM practices using a comprehensive literature review and feedback from industry experts. These five practices were prioritized using a fuzzy analytical hierarchy process (FAHP). The results from FAHP analysis were further confirmed by conducting semi-structured interviews in five electronics parts/components manufacturing organizations. This study also prioritized theoretical drivers of SSCM adoption based on the consideration of three organizational theory perspectives – Institutional Theory; Resource-Based View, and; Social Network Theory. The results indicate that the economic dimension was the most important measure for implementing SSCM while sustainable design was the most important SSCM practice for achieving the TBL. The study also found that Institutional Theory is the most important theoretical driver for implementing SSCM. The research findings provide insight for management to allocate necessary resources and to develop effective strategic directions for the implementation of SSCM practices. © 2019 Informa UK Limited, trading as Taylor & Francis Group.
Rocchi B., Randelli F., Corsini L., Giampaolo S.	Farmer direct selling: the role of regional factors	This paper studies the factors affecting the decision of farmers to sell their products directly to consumers using micro-data on the entire farm population in Italy. The empirical setting of the analysis reflects a focus on the geographical determinants of farmers' choices as the model is estimated by adopting a multilevel approach and also including spatially lagged variables. The results support the idea that the diffusion of direct sale is a localized process of social innovation, based on knowledge sharing among actors. Policy design should consider the nature of this process in supporting more sustainable forms of supply chain. © 2019, © 2019 Regional Studies Association.
Dalla Via N., Perego P.	Determinants of Conflict Minerals Disclosure Under the Dodd–Frank Act	This paper examines conflict minerals disclosure (CMD) as mandated by the Dodd–Frank Act. We rely on a thorough content analysis conducted by the Responsible Sourcing Network on a sample of 122 firms that filed CMDs with the US Securities and Exchange Commission in 2015. We document that firms with long-term oriented incentives, a greater number of board meetings, strong corporate governance systems and inclusion in a sustainability index are associated with higher levels of CMD. Our results suggest that in the presence of enforcement leniency, both internal and external firm-specific factors affect strategic (non-)compliance with a mandatory social disclosure regime. We provide implications for supply chain managers, corporate reporters and policy-makers involved in the adoption of responsible sourcing strategies. © 2018 The Authors. Business Strategy and The Environment published by ERP Environment and John Wiley & Sons Ltd. © 2018 The Authors. Business Strategy and The Environment published by ERP Environment and John Wiley & Sons Ltd

Viswanadham N.	Performance analysis and design of competitive business models	In this paper, we define the business model of a company and its eight main components which are the customer value proposition, profit formula, partner network, the other four business model pillars include supply/service chain processes; key resources; delivery mechanisms and institutional and social constraints and finally the operational governance. The business model achieves the objective of making money by producing the products/services using the resources following the social and institutional constraints and delivering to various customer segments the products and services using all the sales opportunities including to the primary, secondary customers and cross-sales. We call this framework as the business model ecosystem. Then, we map the unified ecosystem for a unified company and illustrate using several examples. Our business model ecosystem is a generalised version of the business models published in the literature. We then present the GRIP (Governance, Risk, Innovation and Performance) framework. We present some of the example both established and new to illustrate our framework. We compare the traditional retail and e-retail in terms of their business models and discuss the issues involved in business model change. The takeaways from this paper are opportunities for both research and start-ups. © 2017 Informa UK Limited, trading as Taylor & Francis Group.
Quentin D., Campling L.	Global inequality chains: integrating mechanisms of value distribution into analyses of global production	The global value chain (GVC) analytic, as currently conceived in the literature on global production, tracks 'value added' along commodity chains but does not interrogate where value comes from and where it goes. This tends to deflect narratives that relate to systemic inequalities and the mechanisms by which those inequalities are reproduced. We seek to remedy that defect in two ways. First, we demonstrate that assumptions in GVC analysis about the distribution of value creation along the chain, which are generally adopted to support value chain 'upgrading' as a policy prescription, may be unreliable. Second, we combine the analytic with the emerging 'global wealth chain' analytic regarding tax outcomes, for this will enable us to map contestation over value capture between capital, labour and the state along the chain. We call this synthetic analytic the 'global inequality chain' (GIC). While we deploy Marxian value theory to provide a framework for this schematic mapping exercise, we emphasize that the GIC is amenable to other value-theoretical frameworks (provided such frameworks are objective rather than empirically reliant on realization in the form of prices). We illustrate the utility of the GIC by applying it to the topics of global gender inequality and corporate tax reform. Global Networks © 2017 Global Networks Partnership & John Wiley & Sons Ltd
Bloomfield M.J.	Global Production Networks and Activism: Can Activists Change Mining Practices by Targeting Brands?	In this article, I mobilise a global production networks (GPN) approach to study a campaign seeking to impact mining practices by targeting a key consumer market: gold jewellery. In doing so, I make two contributions. The first is empirical: documenting this exploratory campaign and mapping activist strategies and outcomes against the gold production network. The second is theoretical: evaluating whether the GPN toolkit can help explain how the nature of a commodity and its markets impact activist strategies and outcomes. Recasting industries as sites of social struggle, a GPN approach offers a more nuanced understanding of the power permeating markets than more conventional supply chain analyses. The results clarify the challenges activists face when politicising industries by targeting brands, particularly in the extractives sector. But the findings also illuminate opportunities, including the more subtle pathways of activist influence as they: (1) gather and disseminate information, (2) place social and environmental issues on the industry agenda, (3) spur industry to create institutions around these issues, (4) insert themselves and their agenda into the

		production network, and (5) form alliances with industry actors pushing for change. © 2017 Informa UK Limited, trading as Taylor & Francis Group.
Fazili M., Venkatadri U., Cyrus P., Tajbakhsh M.	Physical Internet, conventional and hybrid logistic systems: a routing optimisation-based comparison using the Eastern Canada road network case study	The Physical Internet (PI) logistics system is an innovative logistics concept that has been gathering a lot of attention lately. This system consists of open, modular and shared containers and transit hubs to move goods globally. The purpose of this paper is to compare the performance of PI with regard to the conventional (CO) logistics system in order to quantify the advantages and disadvantages of PI from a truck and driver routing perspective with an explicit constraint on maximum return time for drivers. The comparison presented in this work is carried out through Monte-Carlo simulation within a sequential three-phase optimisation framework. Based on our analysis, PI reduces driving distance (and time), GHG (greenhouse gas) emissions and the social cost of truck driving. On the other hand, it increases the number of container transfers within the PI logistics centres. This insight is a contribution of the paper and reinforces the current literature on PI. The other main contribution of the paper is a validation of the claim that the number of drivers who can go back home at the end of a work day remains consistently high in PI, regardless of the traffic level. © 2017 Informa UK Limited, trading as Taylor & Francis Group.
Kumar R.S., Choudhary A., Babu S.A.K.I., Kumar S.K., Goswami A., Tiwari M.K.	Designing multi-period supply chain network considering risk and emission: a multi-objective approach	This research formulates a multi-objective problem (MOP) for supply chain network (SCN) design by incorporating the issues of social relationship, carbon emissions, and supply chain risks such as disruption and opportunism. The proposed MOP includes three conflicting objectives: maximization of total profit, minimization of supply disruption and opportunism risks, and minimization of carbon emission considering a number of supply chain constraints. Furthermore, this research analyses the effect of social relationship levels between different tiers of SCN on the profitability, risk, and emission over the time. In this regard, we focus on responding to the following questions. (1) How does the evolving social relationship affect the objectives of the supply chain (SC)? (2) How do the upstream firms' relationships affect the relationships of downstream firms, and how these relationships influence the objectives of the SC? (3) How does the supply disruption risk interact with the opportunism risk through supply chain relationships, and how these risks affect the objectives of the SC? (4) How do these three conflicting objectives trade-off? A Pareto-based multi-objective evolutionary algorithm–non-dominated sorting genetic algorithm-II (NSGA-II) has been employed to solve the presented problem. In order to improve the quality of solutions, tuning parameters of the NSGA-II are modulated using Taguchi approach. An illustrative example is presented to manifest the capability of the model and the algorithm. The results obtained evince the robust performance of the proposed MOP. © 2016, The Author(s).
Barrientos S., Knorringa P., Evers B., Visser M., Opondo M.	Shifting regional dynamics of global value chains: Implications for economic and social upgrading in African horticulture	Global value chain and global production network analyses have largely focused on dominance of Northern retailers over suppliers in the global South. The expansion of retailers within the global South sourcing from and supplying consumer end-markets within their own geographic regions is reconfiguring value chain dynamics. This paper draws on GVC and GPN approaches and the concepts of multi-polar governance to analyse changing dynamics of global and regional retail supply networks. Drawing on a case study of supermarket expansion within South and East Africa, it analyses how 'waves of diffusion' by global and regional supermarkets provide new opportunities for 'strategic diversification' by some horticultural producers and workers. It examines the implications for economic and social upgrading and downgrading, finding mixed

		outcomes. Strategic diversification provides opportunities for economic and social upgrading by more capable suppliers and skilled workers, but economic downgrading pressures persist and some are excluded from both global and regional value chains. © 2015, © The Author(s) 2015.
Harrington T.S., Singhai J., Kumar M., Wohlrab J.	Identifying design criteria for urban system last-mile solutions -A multi-stakeholder perspective	This study presents a novel approach to design and evaluate last-mile solutions -encompassing the social and economic perspectives of key stakeholders. While urban system initiatives have been implemented in practice, theoretical gaps remain at the operational design level. A theoretical framework is developed, based on design criteria identified from a critical synthesis of supply chain and operations management literature, and operationalised using an in-depth case study demonstrating implementation of a Consumer Choice Portal-Package Consolidation Centre solution, within a densely populated urban geography. Findings suggest that there is a need to re-define the role of institutional actors beyond that of the traditional governance task, to one of being able to facilitate performance outcomes. Similarly, industrial efficiency dimensions need to be reorientated to include consumer participation, social considerations and multi-stakeholder service outcomes. Finally, implications for operations theory and practising managers in city logistics are highlighted, with suggested directions for future research. © 2016 Informa UK Limited, trading as Taylor & Francis Group.
Zimmer K., Fröhling M., Schultmann F.	Sustainable supplier management - A review of models supporting sustainable supplier selection, monitoring and development	In the last two decades, pressure from various stakeholders has forced many companies to establish environmental and social improvements both in their company and their supply chains. The growing number of journal publications and conference proceedings confirms this change also in academia. The aim of this paper is to analyse and review scientific literature on sustainable supplier management (SSM) with a focus on formal models supporting decision-making in sustainable supplier selection, monitoring and development. For this purpose, a framework on SSM is proposed and a comprehensive content analysis including a criteria analysis is carried out. Beyond this, in total 143 peer-reviewed publications between 1997 and 2014 have been analysed to identify both established and overlooked research fields. Major findings are the rapidly growing interest of this topic in academia in recent years, the predominance of Analytic Hierarchy Process, Analytic Network Process and fuzzy-based approaches, the focus on the final evaluation and selection process step and the rare investigation of social and quantitative metrics. This review may be useful for practitioners and scientists as it outlines major characteristics in this field, which can serve as a basis for further research. © 2015 Taylor & Francis.
Govindan K., Jha P.C., Garg K.	Product recovery optimization in closed-loop supply chain to improve sustainability in manufacturing	When business practices shift from a traditional open supply chain to a closed loop instead, the environmental and societal issues are efficiently integrated in business development. However, even an efficiently integrated shift introduces a number of trade-offs due to the contradictory goals that emerge from that businesss economical, environmental and social dimensions. In this paper, we propose a multi-objective mixed integer mathematical problem for a generic closed-loop supply chain (CLSC) network to rationalise how a systems product recovery helps to improve manufacturing sustainability. The CLSC network proposed in this study consists of a hybrid manufacturing facility, warehouse, distribution centres, collection centres and a hybrid recovery facility (HRF). The proposed model determines the best location for the HRF and optimal flow of products, recovered parts and material in the network while it simultaneously maximises profit, saves activity costs, helps to decrease the harmful effects of the

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		manufacturing process and makes a positive impact on societal development. To validate the model, a numerical illustration with the help of a case study from an electrical manufacturing industry is offered. The results authenticate the approach of the model towards the fulfilment of various environmental regulations. A sensitivity analysis, completed on demand, and the return rate also assists decision-makers to manage their decisions with a broader insight towards manufacturing sustainability. © 2015 Taylor & Francis.
Neumüller C., Kellner F., Gupta J.N.D., Lasch R.	Integrating three-dimensional sustainability in distribution centre selection: The process analysis method-based analytic network process	In this paper, we propose a combined methodology for the selection of distribution centres (DCs) by integrating and balancing economic, environmental and social sustainability aspects. The analytic network process (ANP) permits to systematically evaluate possible DCs on the basis of a situation-specific decision structure. A systematic development of the decision networks, which is one of the core challenges using the ANP, is supported by the process analysis method which we extend for that purpose. The validity and soundness of the proposed framework are demonstrated by means of a case study. The case study results reveal that omitting aspects of sustainability can lead to unfortunate results. © 2014 Taylor & Francis.
Tseng S.-C., Hung S.-W.	A strategic decision-making model considering the social costs of carbon dioxide emissions for sustainable supply chain management	Incorporating sustainability into supply chain management has become a critical issue driven by pressures from governments, customers, and various stakeholder groups over the past decade. This study proposes a strategic decision-making model considering both the operational costs and social costs caused by the carbon dioxide emissions from operating such a supply chain network for sustainable supply chain management. This model was used to evaluate carbon dioxide emissions and operational costs under different scenarios in an apparel manufacturing supply chain network. The results showed that the higher the social cost rate of carbon dioxide emissions, the lower the amount of the emission of carbon dioxide. The results also suggested that a legislation that forces the enterprises to bear the social costs of carbon dioxide emissions resulting from their economic activities is an effective approach to reducing carbon dioxide emissions. © 2013 Elsevier Ltd.
Cruz J.M.	Mitigating global supply chain risks through corporate social responsibility	This paper presents a decision model that captures supply-side disruption risks, social risks, and demand-side uncertainty within an integrated global supply chain and corporate social responsibility (CSR) modelling and analysis framework. The global supply chain decision-makers must decide on the level of investment in CSR activities and the choice of trading partners (manufacturer or retailer) given their CSR consciousness and perceived riskiness in order to maximise profit and minimise their overall risk. The model incorporates individual attitudes towards disruption risks among the manufacturers and the retailers, with the demands for the product associated with the retailers being random. The model allows one to investigate the effects of heterogeneous CSR activities in a global supply chain and to compute the resultant equilibrium pattern of product outputs, transactions, product prices, and levels of social responsibility activities. The results show that CSR activities can potentially be used to mitigate global supply chain risk. © 2013 Copyright Taylor and Francis Group, LLC.
Oztekin A., Mahdavi F., Erande K., Kong Z., Swim L.K., Bukkapatnam S.T.S.	Criticality index analysis based optimal RFID reader placement models for asset tracking	This study is aimed at optimising the RFID network design in the healthcare service sector for tracking medical assets. Two different optimisation models corresponding to two possible scenarios in RFID network design are developed based on the enhancement of location set covering problem (LSCP) and maximal covering location problem (MCLP). They are validated by considering a healthcare facility to

		optimise the real-time locating system for tracking assets. The methodology is original in that it analyses the trade-off between cost effectiveness and overall RFID system performance and hence provides possible decision guidance to optimise the RFID system. It is vital for healthcare providers to locate crucial assets in the shortest possible time, particularly in emergency situations where human lives are at risk. Hence, increasing the overall RFID system performance will definitely have a valuable effect on real-time information sharing, thereby decreasing related search time for crucial assets. © 2010 Taylor & Francis.
Burchielli R., Delaney A., Tate J., Coventry K.	The FairWear Campaign: An Ethical Network in the Australian Garment Industry	In many parts of the world, homework is a form of labour characterised by precariousness, lack of regulation, and invisibility and lack of protection of the workers who are often amongst the world's poorest and most exploited. Homework is spreading, due to firm practices such as outsourcing. The analysis and understanding of complex corporate networks may assist with the identification and protection of those most at risk within the supply chain network. It can also expose some of the key ethical issues and dilemmas of supply chain management and corporate social responsibility (CSR). Based on a case-study of the Australian FairWear Campaign (FWC), this article identifies an ethical network that aims to increase corporate accountability (CA) via greater transparency in corporate supply chains and improve work conditions for homeworkers and increase their recognition in the supply chain. © 2010 Springer Science+Business Media B.V.
Wright C.M., Smith M.E., Wright B.G.	Hidden costs associated with stakeholders in supply management	Many businesses fail to recognize the strategic importance of sourcing decisions. Companies often focus on the price and quality of goods provided to them, but it is easy to overlook the social and environmental standards of suppliers. Those who do may find themselves on the receiving end of aggressive attacks from a range of stakeholders, from customers and shareholders to the news media. Indeed, the business practices of Georgia Pacific, a hardwood plywood supplier, were at the heart of actions by the Rainforest Action Network aimed at disrupting operations at Home Depot; the practices of tomato growers that supplied Taco Bell restaurants were behind boycotts of the fast food giant; and fishing practices that endangered dolphins were the source of discontent with the tuna industry. Clearly the business practices of key suppliers can readily tarnish a corporate reputation, and the strategic impact - potentially including business disruption, business interruption, and even business failure - of neglecting these perceptions needs to be recognized by present and future business leaders. In order to examine the dynamics of change brought about as a result of negative stakeholder perceptions of supply management practices, we looked at the college and university athletic apparel industry, which between 1996 and 2001 came under scrutiny for dealing with suppliers and supply chains that produced goods in foreign factories with poor working conditions. When negative reactions escalated, the universities became the focus of activities aimed at changing the practices of their suppliers. This conflict was played out in the media, providing a solid approach - through discourse analysis - to investigating the events and reactions on both sides of the conflict. Our findings show that inattention to the practices of an organization's suppliers should serve to caution business leadership. Conversely, we show that a proactive stance toward managing supplier practices can serve to provide for successful resolution of stakeholder concerns regarding an organization's outsourcing. Copyright of the Academy of Management, all rights reserved.

Appendix - D

This appendix contains the information about the resulted articles from the basic research conducted in order to identify if there have been changes in the perception of risk after the spread of the Covid-19 pandemic.

Authors	Title	Year	Source title
Widiastuti W., Handayani A., Hermawan A.	Spatial Distribution on Recovery Strategy Due to the Impact of the Covid-19 Pandemic on the Conditions of Micro Small Medium Enterprises (MSME's) in Central Java Province, Indonesia	2021	IOP Conference Series: Earth and Environmental Science
Sakas D.P., Kamperos I.D.G., Reklitis P.	Estimating risk perception effects on courier companies' online customer behavior during a crisis, using crowdsourced data	2021	Sustainability (Switzerland)
Mertzanis C.	Epidemiological Susceptibility Risk, Adaptive Management and Firm Performance	2021	British Journal of Management
Hozalski R.M., Lapara T.M., Zhao X., Kim T., Waak M.B., Burch T., Mccarty M.	Flushing of Stagnant Premise Water Systems after the COVID-19 Shutdown Can Reduce Infection Risk by Legionella and Mycobacterium spp.	2020	Environmental Science and Technology
Ma J.-H., Ahn Y.-H.	Location efficiencies of host countries for strategic offshoring decisions amid wealth creation opportunities and supply chain risks	2021	Journal of Korea Trade
Hatab A.A., Liu Z., Nasser A., Esmat A.	Determinants of sars-cov-2 impacts on small-scale commercial broiler production systems in egypt: Implications for mitigation strategies	2021	Animals
Althaf S., Babbitt C.W.	Disruption risks to material supply chains in the electronics sector	2021	Resources, Conservation and Recycling
Khan S.A.R., Ponce P.	Investigating the effects of the outbreak of COVID-19 on perishable food supply chains: an empirical study using PLS-SEM	2021	International Journal of Logistics Management
[No author name available]	26th International Joint Conference on Industrial Engineering and Operations Management, IJCIEOM 2021	2021	Springer Proceedings in Mathematics and Statistics
Salama M.R., McGarvey R.G.	Resilient supply chain to a global pandemic	2021	International Journal of Production Research
Ghadge A., Er M., Ivanov D., Chaudhuri A.	Visualisation of ripple effect in supply chains under long-term, simultaneous disruptions: a system dynamics approach	2021	International Journal of Production Research
Friday D., Savage D.A., Melnyk S.A., Harrison N., Ryan S., Wechtler H.	A collaborative approach to maintaining optimal inventory and mitigating stockout risks during a pandemic: capabilities for enabling health-care supply chain resilience	2021	Journal of Humanitarian Logistics and Supply Chain Management
Abu Hatab A., Lagerkvist C.-J., Esmat A.	Risk perception and determinants in small- and medium-sized agri-food enterprises amidst the COVID-19 pandemic: Evidence from Egypt	2021	Agribusiness
Saylors K.E., Mouiche M.M., Lucas A., McIver D.J., Matsida A., Clary C., Maptue V.T., Euren J.D., LeBreton M., Tamoufe U.	Market characteristics and zoonotic disease risk perception in Cameroon bushmeat markets	2021	Social Science and Medicine
Lu Y., Wu J., Peng J., Lu L.	The perceived impact of the Covid-19 epidemic: evidence from a sample of 4807 SMEs in Sichuan Province, China	2020	Environmental Hazards
Donnan R.C., Edwards C.R., Iyer A.R., Karamete T., Myers P.F., Olson S.E., Prater R.S., Andrews D.J., Polmateer T.L., Manasco M.C., Hendrickson D.C., Lambert J.H.	Enterprise Resilience of Maritime Container Ports to Pandemic and Other Emergent Conditions	2020	2020 Systems and Information Engineering Design Symposium, SIEDS 2020

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