LITERATURE REVIEW ON COMPLEX NETWORK METHODS APPLIED TO MEASURE ROBUSTNESS IN SUPPLY CHAIN DESIGN

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Summary

The aim of this work is to perform a literature review, using Citation Network Analysis and the related software package Citation Network Analyzer (CNA), on the concepts of robustness and resilience defined according to the complex networks theory and applied to Supply Chain Design. There are several contributions that consider the concepts of robustness and resilience in the Supply Chain Design (SCD) (http://www.husdal.com/2008/04/28/robustness-flexibility-and-resilience-in- the supply-chain-/), but few of them attempt to quantify these concepts using existing measures from the theory of Complex Networks (CN). The methodology employed in this work was as follows: first we have identified the relevant keywords, then, using CNA (http://www.lecy.info/resources/CNA%20Overview.pdf), we have investigated Google Scholar database through search strings (derived from grouping keywords) to find the documents

containing these keywords in the abstract or in the text and thus relevant for our purposes. Using CNA we have built a citation network and, finally, the generated network has been studied applying citation network analysis. Although the subject of this literature review can be of limited interest to a broad audience, we believe that the methodology employed is of general applicability. Any researcher, who wishes to study or apply concepts from other disciplines, needs skills in different fields. The proposed methodology is convenient, fast and objective, in supporting research and literatre review in different disciplines, albeit it presents some limitations primarily related to the consideration of the citations only.

1. Introduction

The representation of a field of research as a network and its analysis using citation-based approaches is not new. For example Thelwall et al. (2006) applied citation network analysis to water resource management performing a bibliographic research on Google. Kajikawa et al. (2007). Nakamura et al. (2010) and Colicchia and Strozzi (2012) investigated the development of sustainability science, supply chain research and supply chain risk management respectively analysing citation data collected from the databases compiled by the Institute for Scientific Information (ISI) through the Web of Science, which is the Web-based user interface for ISI's citation databases. Histcite and Pajek were used by Colicchia and Strozzi (2012) as bibliometric analysis tools. After a citation network is built a statistical analysis is necessary. Thewall et al.(2006) measured the frequency of occurrence of nouns or sentences, Kajikawa et al. (2007) and Nakamura et al., (2010) analyzed the clusters whereas Colicchia and Strozzi (2012) studied the Main Path (Hummon and Doreian, 1989) using the citation weight associated to the link.

In this work, we have used Google Scholar as a database and the software CNA together with Pajek (Batagelj and Mrvar 2003), for bibliometric analysis. All the software tools applied in this work are free or open source. The citation network analysis has been performed identifying clusters of papers in two ways: plotting the network using the energy based method of Fruchterman-Reingold (Fruchterman and Reingold, 1991) and applying the clustering method, based on a random walk, developed by Pons and Latapy (2005).

The purpose of this methodology is not to substitute human experience and careful reading of the existing articles, but, based on simple citations, to quickly identify clusters of connected works in which similar concepts are applied. In addition, it provides the non-expert on the field with a good starting point for a deeper and more focused literature review as well as an overview of the main areas in which research is being developed.

2. Citation network analysis

In recent decades there has been an exponential growth of the number of publications in all fields. This is due, in part, to the development of the Web that allowed more frequent contacts between researchers. The increase in the number of works has created the need of classifying and quantifying the findings in various fields and establishing the productivity of various authors and journals.

A citation network is a network whose nodes are articles connected by links indicating citations among them. The links are represented by arrows from cited to citing articles, showing the flow of knowledge from the cited articles that have allowed the development of the citing works.

The citation network approach is typically computer-based and operates on the assumption that citing and cited papers have similar research topics. By analyzing the citation network, we can comprehend the structure of a research domain which is often constituted by a huge number of papers that preclude an exhaustive reading of all of them (Kajikawa, 2007).

In theory, articles can cite only articles that appeared earlier in time, and then the citation network should be acyclic. Arcs never point back to older articles. However, there are usually some exceptions: articles that cite one another (e.g. articles appearing at about the same time and written by same authors), new editions of old books, etc. It is possible to eliminate these exceptions by removing arrows that are going against in the time (Nooy et al., 2000).

Methods based on citations can be useful to evaluate the importance of scientific contributions, i.e that contributed most to the theory-building and thus were most cited, and to unveil the underlying structure of a research field.

Different citations databases exist (WoS, SCOPUS, SCIRUS, Google Scholar, etc.) and some of them are free (Google Scholar, SCIRUS).

Google Scholar is the scholarly search tool of the world's largest and more powerful search engine Google (Noruzi, 2005). Google Scholar allows researchers to find more current information than they would through commercial databases. It is not restricted to articles but also preprints, technical reports, theses, dissertations and conference proceedings are also indexed. A detailed comparison between Google Scholar and Web of Science together with advantages and disadvantages has been discussed by Noruzi (2005).

2.1. Keywords selection

As explained above, the goal of this work is to analyze the existing literature on the concepts of robustness and resilience defined according to the complex networks theory and applied to

Supply Chain Design. To this aim the selected keywords inserted in CNA have been the following:

("complexity theory" OR "Social Network Analysis") AND ("supply chain design" OR "supply chain management") AND ("robustness OR "resilience" OR "vulnerability").

The reasons for this selection are the following

- ("complexity theory" OR "Social Network Analysis")

Many measures typical of Social Network Analysis can be applied to other complex systems such as supply chains. The network theory measures important aspects of complex systems. Depending on the skills, some authors prefer to speak about Social Network Analysis or, more in general, about Complexity Theory but they all refer to tools of complex networks.

- ("supply chain design" OR "supply chain management")

Supply chain design can be considered a part of Supply Chain Management and some authors prefer to refer to Supply Chain Management even when they are considering Supply Chain Design

- ("robustness OR "resilience" OR "vulnerability").

In particular we are interested to see how the concepts of robustness (sometimes called resilience or vulnerability) as they are defined in complex network theory, have been applied in the literature of supply chain design/management. The definition of these concepts is not clear and uniform in the literature of supply chain management and some authors interchange them.

2.2. Data collection and basic statistics

Citation network analyzer (CNA) is a software tool for bibliometric analysis and information visualization. Developed as an R-package by Prof. J. Lecy (http://www.lecy.info/resources/CNA%20Overview.pdf), CNA allows to search for the citations in Google Scholar, conversely to Histcite (Lucio-Arias andLeydesdorff, 2008) which does the same using ISI Web of Science (WoS) which is accessible only by subscription and with limitations on some journals. Moreover Noruzi (2005) showed that the same work can be cited more frequently if we consider the citations appearing on Google Scholar instead of WoS.

With CNA we can enter keywords, start the search in all the documents that are available on the web and then create files containing the citations network in different formats which can then be analyzed by the same CNA, R, Pajek (De Nooy et al., 2005) or other software for analysis of citation networks.After entering the keywords in the CNA, we have selected seed articles (the default number is ten) which are considered documents at zero level from which the citations research starts. The citation network built by CNA is the network of the articles that cite seeds (first level) or that cite works citing seeds (second level) and so on. Three levels

of citations is the default but it is possible to specify more or less. We can decide the percentage of the total citations found by Google Scholar (the default value is 10%).

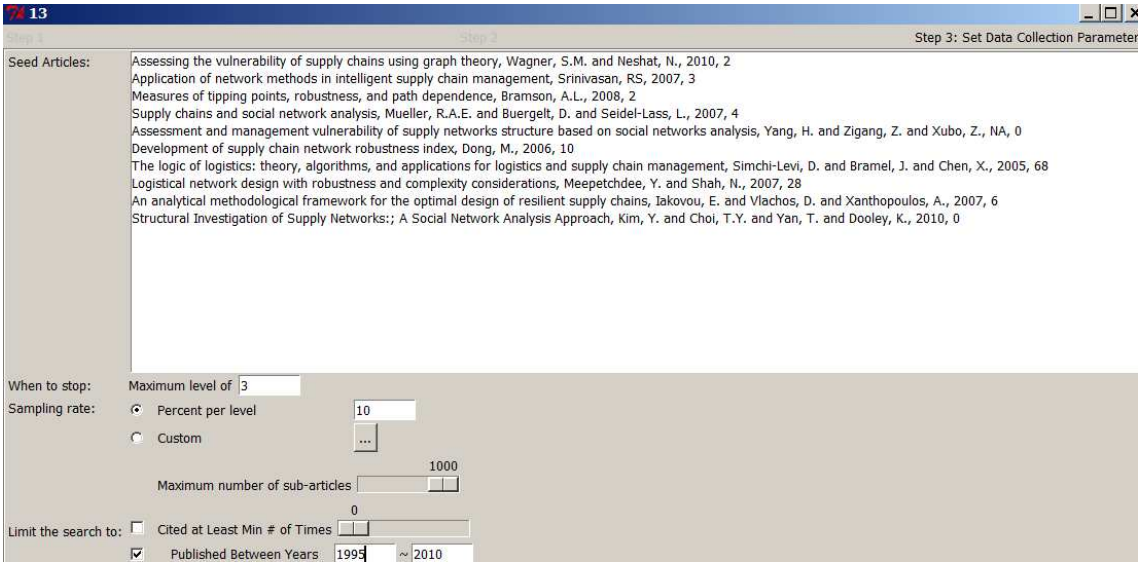

Figure 1. Selection of seeds article using CNA

ID	name	Title	Type	Author	Journal	Year	Cited	Publisher	Searc
1	wagner2010assessing	Assessing the vulnerability of supply chains using graph theory	article	Wagner, S.	Internatio	2010	2	Elsevier	0
2	srinivasan2007application	Application of network methods in intelligent supply chain management	article	Srinivasan,	Internatio	2007	3	Inderscien	0
3	bramson2008measures	Measures of tipping points, robustness, and path dependence	article	Bramson,	Arxiv prep	2008	2	NA	0
4	mueller2007supply	Supply chains and social network analysis	conference	Mueller, R	NA	2007	4	NA	0
5	yang2010assessment	Assessment and management vulnerability of supply networks structure based	conference	Yang, H.	NA	NA	0	NA	0
6	dong2006development	Development of supply chain network robustness index	article	Dong, M.	Internatio	2006	10	Inderscien	0
7	simchi2005logic	The logic of logistics: theory, algorithms, and applications for logistics and sup	book	Simchi-Lev	NA	2005	68	Springer V	0
8	meepetchdee2007logistical	Logistical network design with robustness and complexity considerations	article	Meepetch	Internatio	2007	28	Emerald G	0
9	iakovou2007analytical	An analytical methodological framework for the optimal design of resilient sup	article	Iakovou, E	Internatio	2007	6	Inderscien	0
10	kim2010structural	Structural Investigation of Supply Networks:; A Social Network Analysis Appro	article	Kim, Y.	Journal of	2010	0	Elsevier	0

Table 1. Seed papers and their references.

With the keywords selected and the 10 seeds, see Figure 1, CNA built the citation network with three levels and found 345 articles listed in Appendix 1. The circular plot of the citation network with separated components, obtained using Pajek, is shown in Figure 2.

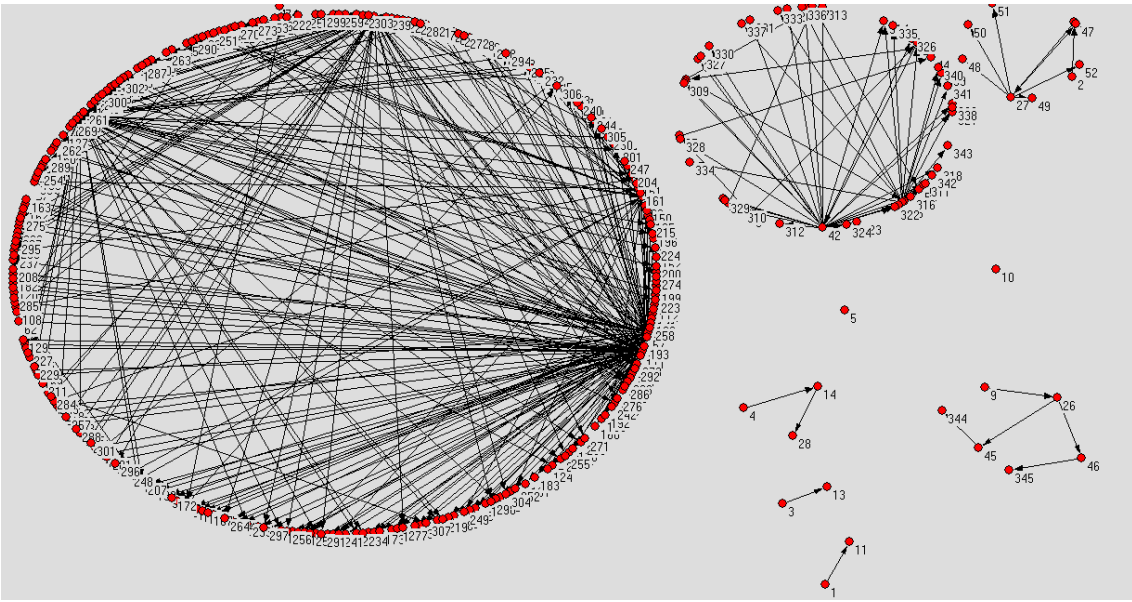

Figure 2. Circular plot of the citation network with separate component, using Pajek

With the commands *topCited* and *topJournals* of CNA it is possible to generate the dotchart of the most highly cited articles of the sample and of the most frequently appearing journals in the Network (see Figure 3).

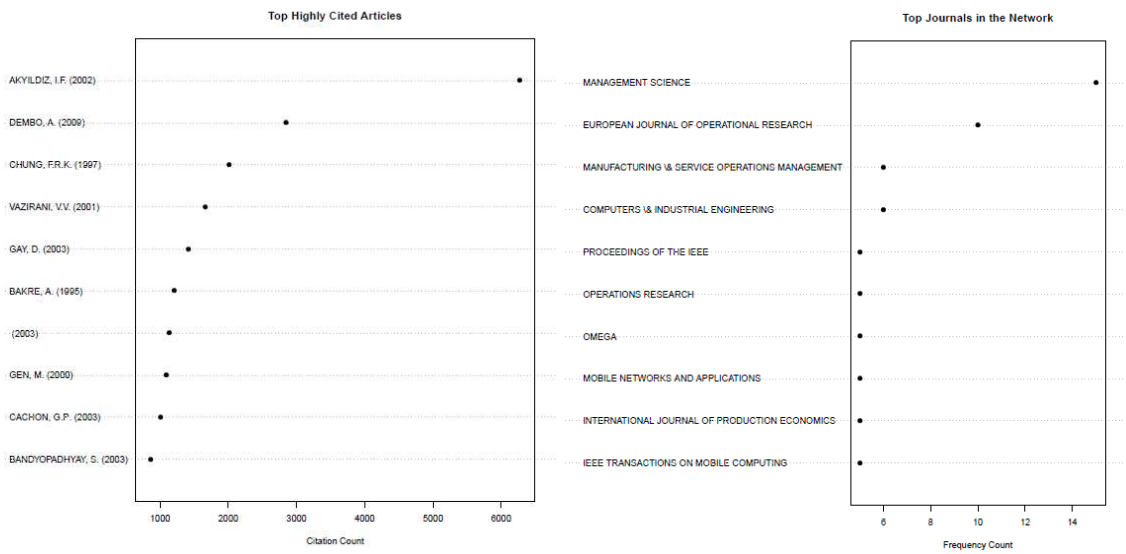

Figure 3. “TopCited” articles in Google Scholar and “topJournals” in the citation network

2.3 Cluster analysis

2.3.1. Fruchterman-Reingold Algorithm and Community Detection

The generic representation of the network as a circular network does not help to identify clusters in the largest connected component.

There are many different networks layout strategies that help to better visualize networks and, between them, the forced-based layout methods modify an initial vertex placement by continuously moving the vertices itself according to a system of forces based on physical metaphors related to systems of springs or molecular mechanics.

The Fruchterman-Reingold Algorithm (Fruchterman and Reingold, 1991) is one of the best known force-based algorithms to represent complex networks. The algorithm considers each vertex of the graph as an electrically charged element (repulsive force) and each edge as a spring that connects the two charges (attractive force). In this situation, the force exerted on a node is the vector sum of repulsion forces due to all other nodes and the sum of attractive due to the vertices connected to the vertex itself.

The application of the Fruchterman-Reingold Algorithm (Fruchterman and Reingold, 1991) to the citation network layout is shown graphically using Pajek in Figure 4. The ten seeds are shown in violet.

Our hypothesis was that the representation of the citation network using this algorithm would allow the detection of clusters. Close works in the plot are separated by shorter paths and thus it can be assumed they are more strictly related.

The clusters identified with Fruchterman and Reingold layout are highlighted in Figure 4. There are seven connected components (A, B, C, D, E, F, G) with more than one node. The two isolated nodes are not relevant for our analysis since they are not cited and they do not cite other works in the network. The B connected component is the largest and, thanks to this representation, it is possible to identify its sub-clusters (B1-B8).

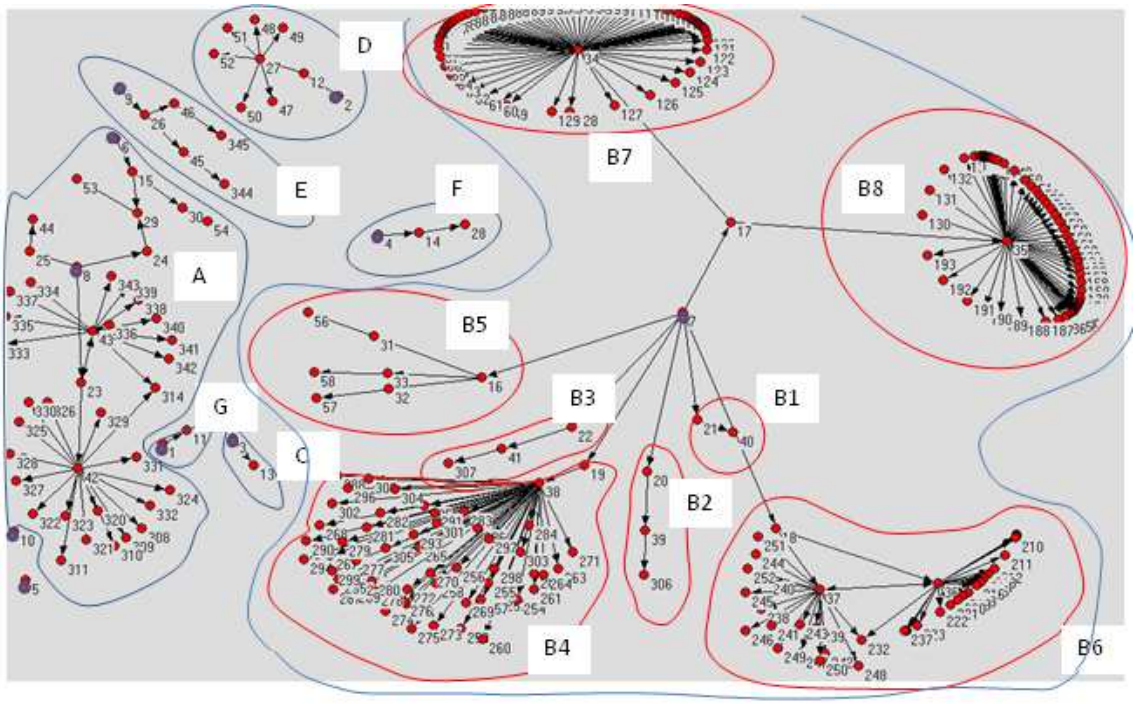

Figure 4. Citation network representation using Fruchterman-Reingold Algorithm. See Appendix 1 for the correspondence between numbers and references. The seeds are higthlighed in violet.

A detailed analysis of the clusters provides the following results:

Cluster A: Complexity of the Supply Chain Network (SCN) design

In all these works the Complexity of the SCN design is addressed. This complexity is due to the fact that the design of SCN involves a series of strategic decisions on the number, capacity, location and characteristics of production-distribution facilities. This implies a careful analysis of demands, services, flows, costs and revenues, not only for the present, but also for the future. The seeds of this cluster are the articles number 6 and 8.

In 6, "Development of supply chain network robustness index", (Dong et al., 2006) the authors present a system-wide approach to quantifying robustness index of supply chain networks. This approach considers network structural and functional robustness.

In 8, "Logistical Network design with robustness considerations" (Meepetchdee, 2007), the authors define the robustness in a supply chain as the ability to satisfy the demand even if some nodes fail. They developed a mathematical model in which the robustness is a constraint and they found the optimal design. Moreover they analyzed the relationship between robustness and complexity and redundancy of the supply chain.

The goal of 6 and 8 was the quantification of robustness to introduce it in a mathematical model. The leitmotiv of the other works of cluster A is the application of soft computing such as GA (e.g. 42, 314, 43,), memetic algorithms (e.g. 23), simulating Annealing (e.g. 24) and fuzzy

logic (e.g. 29) to solve a multi-objective supply chain design problem minimizing costs such as the distribution flow costs (43) or total flow time (42), or even maximizing the robustness and resilience simulating possible failures (8,25,15,30) or uncertainty (15).

Cluster B:

There is only one seed: article number 7, "The logic of logistic: theory, algorithms and applications for logistic management", (Simchi et al. 2005), that is a book recollecting a set of logistic problems and their mathematical formulations. The authors described existing models of inventory, design and coordination, facility location and Vehicle routing and for this reason in the cluster B it represents the "connection node" between different clusters related to complete different subjects. Another connection node is the node number 17, "Low energy tags for objects", (Gorlatova et al., 2009). For this reason we have divided cluster B in the following sub-clusters.

B1: The CNA program did not find references (see Appendix 1)

B2: Data Warehouse and Data mining for business decision making (20, 39,306).

B3: In 22, 41, 307 the authors studied the complex problem of Interplanetary logistic

B5: Cross-Dock scheduling (31, 56, 55) and the impact of RFID technology (16, 32, 57)

B4: centralization game (19) and newsvendor problem (38)

B7: Energy saving monitoring technologies. Communication with cubic-millimeter computer (34)

B8: Wireless network protocol (35).

B6: Combinatorial problem in logistics and their solution in polynomial time

In 36, 37 Jerrum et al. proposed an efficient algorithm to approximate the permanent of a matrix (useful mathematical object in the scheduling problems). In 18 another polynomial time algorithm is proposed for an inventory control problem.

Cluster C: Robustness definition and Complex Adaptive Systems (CAS)

Two works of Bramson (3 and 13) analyzed the definition of robustness and the related concepts of stability, resilience, reliability and sustainability, in the framework of Complex Adaptive Systems (CAS) and its application to different systems: engineered systems, ecologies, political regimes, computer algorithms, economies, homeostatic organisms, and decision procedures.

Cluster D: Supply chain networks models and their equilibrium

The seed that allows finding this cluster was the number 2 (Srinivasan et. al, 2007). The authors studied supply chain flow as a prerequisite for intelligent supply chain management. Measures from network theory are proposed for understanding and designing supply chain structures.

The cluster is composed mainly of papers whose authors belong to the group of Prof. Anna Nagurney, a mathematician and director of the Virtual Centre of Supernetworks. The Applications of Supernetworks group include: multimodal transportation networks, critical infrastructure, energy and the environment, the Internet and electronic commerce, global supply chain management, international financial networks, web-based advertising, complex networks and decision-making, integrated social and economic networks, network games, and network metrics.

In 27 (Nagurney et al., 2002) the authors developed a framework for the formulation, analysis, and computation of solutions to supply chain network problems in the presence of electronic commerce. They identify the network structure of the problem and derive the equilibrium conditions. In 50 (Nagurney, 2003) environmental criteria are introduced. In 48 (Nagurney et al., 2005) a supply chain network model is presented in which both physical and electronic transaction are allowed and considerations on risk are included. Again the authors studied network equilibrium. In 49 (Dong 2004) the authors studied the network equilibrium in a supply chain with random demand.

In 47 (Nagurney et al., 2005) the authors develop a network equilibrium model for the management of reverse supply chain of electronic waste which include recycling. Electronic waste include, but are not limited to: televisions, computers, microwave ovens, vacuum cleaners, telephones and cellular phones, stereos. The papers 12 (Zhang et al., 2009) and 2 (Srinivasan et al., 2007) are respectively a survey on CAS theory applied to supply networks design and the application of measures from network theory to design an intelligent supply chain.

This cluster is, without any doubt, dominated by Anna Nagurney group and the main themes seems to develop model of supply chain networks and the study of their equilibrium .

Cluster E: Innovation networks, policies for innovation networks and innovation cluster

In the seed 9, Iakovou et al. (2007), proposed an analytical methodological framework for the optimal design of a resilient supply chain. They presented a stochastic single period quantitative model that can assist in finding the optimal security protection-based configuration of a supply chain.

In 26 and 46 Cappellin (2009) analyzed the creation and innovation knowledge in medium-technology clusters of enterprises i.e. innovation networks. The authors explained the difference between innovation policy based only on research and knowledge and the ones based on innovation networks.

In 45, Benzler et al. (2010) described how it is possible to pass from agglomeration to technology- and knowledge-driven clusters. In 9 (Iakovou et al., 2007) the concept of innovation is related to risk. In 45 and 344 the aeronautic clusters are analyzed in the same way.

Cluster F: Supply chain and coordination problem in a Digital Fabrication Production System (DFPS)

A DFPS is a concept describing a set of process, tools and resources that will be able to custom produce an artifact according to a design, fast, cheap and easy, independently of location. A DPFS project is a complex assembly of custom parts that is delivered by a network of fabrication and assembly processes.

The seed of this cluster is the article number 4 (Muller et al., 2009): "Integrating supply chain and network science". This work introduces the concept of net-chains analysis. A net-chain is defined as a set of networks comprised of horizontal ties between firms within a particular industry, which are sequentially arranged based on vertical ties between firms in different layers. In the net-chains it is important to consider the coordination mechanism that depends on the types of interdependencies.

In 14 Papanikolaou and Mitchel (2008) and in 28 Papanikolaou (2008) some performance measurements of a net-chain, based on network theory, are proposed. These kinds of supply networks need strong coordination mechanisms together with cooperative strategies. The coordination mechanism is studied in 4 (Mueller, 2007).

Cluster G: Quantification of supply chain vulnerability and its reduction

The seed of this cluster is the number 1 (Wagner et al., 2010). In this work the authors developed an approach based on graph theory to quantify and hence mitigate supply chain vulnerability.

In 11, "Designing a reliable supply chain network model under disruption risks", the authors (Azad et al., 2010), introduced the probability of disruption centers depending on the amount of investment for opening them.

2.3.2. Community Detection using Pons and Latapy Algorithm

To identify clusters within the citation network using CNA it is possible to apply a specific function: *findGroups*. The *findGroups* function is the implementation of the Walktrap community finding algorithm developed by Pons and Latapy (Pons and Latapy, 2005).

The notion of cluster (or community) is difficult to define formally; however, most recent approaches have reached a consensus, and consider that a partition of the vertices of a graph represents a good community structure if the proportion of edges inside every subsets of the

partitions is high compared to the proportion of edges between them (see Fortunato et al. 2004, Newman, 2004; Newman and Girvan, 2004).

The approach of Pons and Latapy (2005) is based on the following intuition: random walks on a graph tend to get "trapped" into densely connected parts corresponding to communities. The direct comparison of this algorithm with previous one showed that this has a clear advantage in terms of quality of the computed partition and present the best tradeoff between quality and running time for large networks, however it needs quite large amounts of memory, which makes other approaches more suited for example in the case of millions of vertices, but this is not our case.

In Figure 6 the representation of network using Fruchterman and Reingold algorithm is superimposed to the information given by the cluster analysis with Pons and Latapy method. This method is able to distinguish connected components and to separate the biggest one in 5 clusters, but, for example, it is not able to distinguish the cluster B2, B3 and B5. This fact is due to the default value of one parameter: *r.walks*, i.e., the number of random steps to identify a community. Decreasing such number it is possible to increase the number of communities. The choice of the optimal value depends on case by case basis and it may be the subject of a future work.

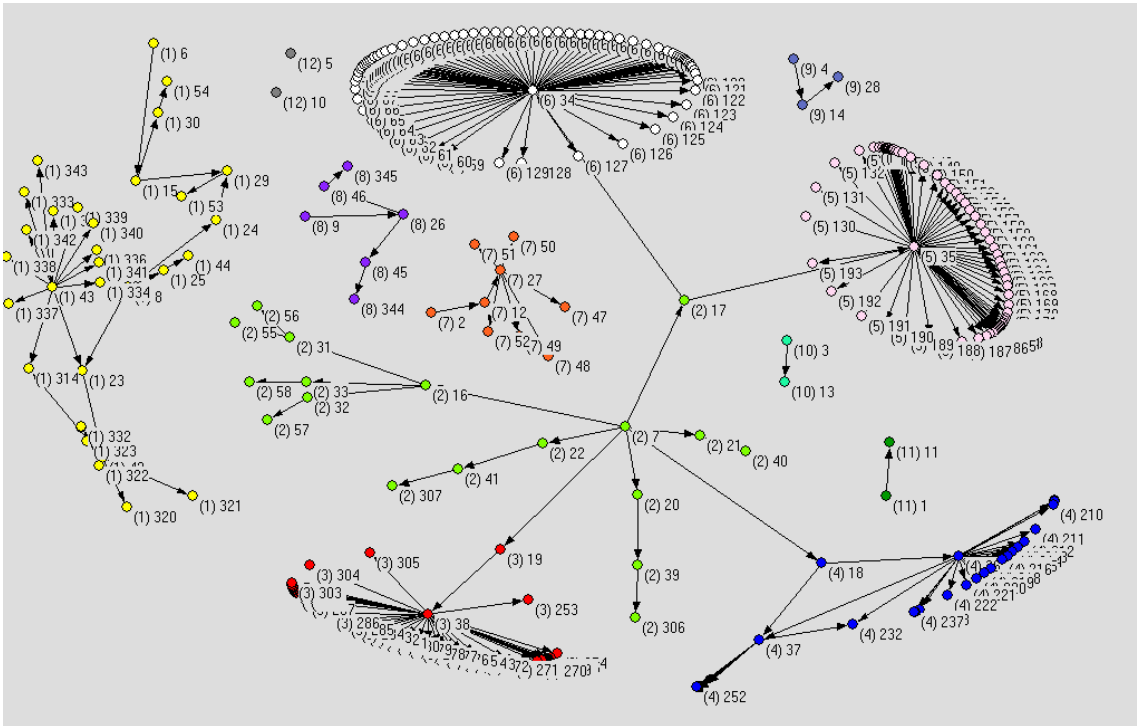

Figure 5.Community detection using Pons and Latapy method.

3. Complex networks methods applied to supply chain design to measure robustness

Our goal was to analyze the existing literature on the concept of robustness, vulnerability or resilience as they are defined in complex network theory and their application on Supply Network Design or, more in general, to Supply Chain Management. We can observe that using the keywords selected we found even papers that are not exactly exploring this subject. This can be due to different reasons:

a) only the seed articles contain the keywords, the paper of higher levels only cited the seeds and this does not imply necessarily that they embody the same keywords

b) sometimes the seeds themselves may not be important for our research because the concepts of robustness, vulnerability, resilience and complexity can be introduced in the text in the generic sense to indicate that they are only a possible consequence of the interconnections of a the system considered .

c) the string "supply chain design" is sometimes cited as a possible application, but not analyzed in detail in that paper

The consequences of the point a), b) and c) is that not all the clusters (A-G) in the citation network are relevant for our research in the sense that an exact definition of vulnerability, resilience or robustness is not considered always or applied to a Supply Chain Design (see Figure 5)

By analyzing in detail the papers of the various clusters we can identify the ones important for our research:

In cluster D only seed 2 implemented exact measures from complex networks theory to better understand the supply chain flows in order to design a more efficient and robust supply chain.

In paper 12 a supply chain is described as a Complex Adaptive System (CAS) and the authors tried to quantify the properties of an Adaptive Supply Network (ASN) using complex network theory

The other papers of this cluster are not so related with our keywords search.

In Cluster G papers 1 and 11 analyzed supply chain risk and the authors tried to quantify and mitigate the supply chain vulnerability representing the supply chain as a graph. They identified the vulnerability drivers (e.g. globalization of the sourcing network, customer or supplier dependence, supply chain complexity) then they measured the interrelationships and aggregate them in order to develop a supply chain vulnerability index.

These works can be useful from our point of view because they identify vulnerability drivers even if they did not apply vulnerability measures from complex networks.

In cluster C the authors of 3 and 13 introduced a probabilistic definition of robustness, resilience and vulnerability for a complex network taking into account the dynamic from one node to another applying a Markov Chain model but they did not consider explicitly the case of a supply chain networks.

In cluster E the seed 9 (Iakovu, 2007), introduce another stochastic analytical approach to resilience in supply chain risk management but the works citing it (26, 46) deal with innovation networks and then they are not related anymore with our keywords.

The papers in the cluster A introduced the definitions of robustness in the optimization process and then in the definition of the design of a supply chain. This cluster seems to cover exactly the problem defined with the keywords selected.

The other clusters are not so relevant from our point of view. The seed 4 of cluster F (Mueller, 2007) considers a supply chain as a complex networks but does not try to quantify its vulnerability.

Cluster B, the biggest one, is connected thanks to the node 7 that is a book of Simchi-Levi (2005) in which a huge number of supply chain models is analyzed, and this is the reason for which is able to connect very different branches of cluster B. Analyzing in detail the braches we saw that their subjects (such as energy saving monitoring technologies or wireless network protocol, etc.) are not so relevant for our research.

In our analysis we have excluded the isolated nodes since they are not relevant from the point of view of the citation networks but they are seeds and then they contain exactly the keywords. Nodes can be isolated for different reasons. They have out degree zero perhaps because they are recent and then they still are not cited by others, they have in degree zero perhaps because they do not use results from the works in the citation network we built because their authors belong to different research groups or their expertize come from different field in respect to the other authors. Another reason to be isolated nodes can be that the nodes are not papers but, for example, conferences or presentations.

In our citation network we have two isolated nodes the numbers 5 and 10. The number 5 is a conference. The number 10 Kim et al. (2010) applied different measures of Social Network Analysis to three automotive supply networks. Each supply networks is analyzed in terms of both materials flow and contractual relationships. Even if the application of Social Network Analysis is based on the willingness to compare a manmade network to a natural one in order to find the reasons of the vulnerability of the supply chain, in this paper there is not a special focus on the problem of robustness, vulnerability or resilience.

From this analysis we can observe how the keywords and the citation process can identify or not papers relevant for our research. The presence of keywords for which no exact definition

exist such as complexity, robustness and vulnerability leads to identify papers not relevant from our point of view. The citation process together with the definition of more than one citation level brings our research sometime far from our goal. The solution to this problem may consist in considering a huge number of seeds carefully selected trying with different string of keywords. The decrease of the search level number and a different choice of seed articles will be the subject of a future work.

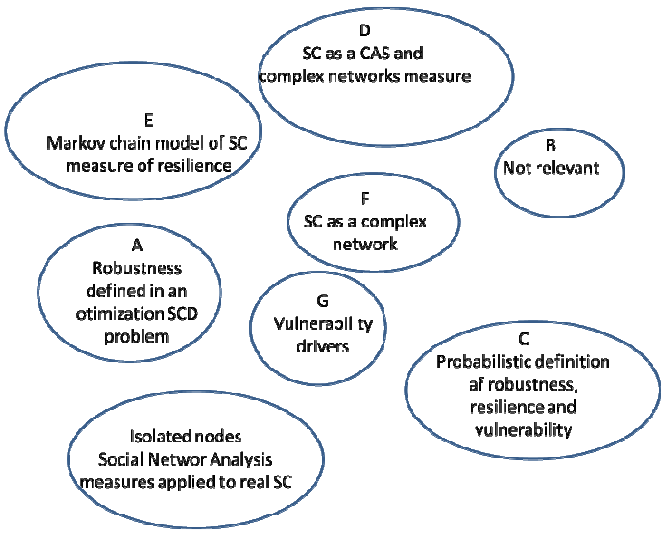

Figure 6.Main results in the different clusters.

4. Distilling the network

When the citation network is too big any layout can help in the cluster visualization. A common procedure applied so simplified the network maintaining the relevant nodes is the distillation procedure. It consists in deleting pendants, i.e. nodes that have in-degree one and out-degree zeros, isolates nodes and cycles. We have performed this distillation using Pajek and we have obtained a network of only 37 nodes (see Figures 7 and 8) which references are listed in Table 2.

To check if this network really contains the relevant information of the not distilled one we have applied again the clustering algorithms. The plot with FR algorithm again is able to separate articles of different clusters as in the complete network. On the other side, the Pons and Latapy algorithm with the default parameter changes completely the clusters and identify only the connected components.

Table 2.References of the articles in the distilled network

Table

#	Publications BibtexKey	Type	Title	Author	Journal	Volu	Num	Pages	Year	Publisher	SearchLevel
7	simchi20(	book	The logic of logistics: theory	Simchi-Levi, D.					2005	Springer Verlag	0
8	meepetcl	article	Logistical network design with	Meepetchdee, Y.	International Journal of Physi	37	3	201--222	2007	Emerald G Publishin	0
12	zhang20(	confere	Complex adaptive supply chain	Zhang, J.							1
15	klibi2010	article	The design of robust value-cre	Klibi, W.	European Journal of Operationa	203	2	283--293	2010	Elsevier	1
16	kim2008s	article	A strategy for third-party log	Kim, C.	Omega	36	4	522--534	2008	Elsevier	1
17	gorlatova	confere	Challenge: ultra-low-power ene	Gorlatova, M.				253--260	2009		1
18	halman2(	article	A fully polynomial-time approx	Halman, N.	Mathematics of Operations Rese	34	3	674--685	2009	INFORMS	1
19	chen2009	article	Inventory centralization games	Chen, X.	Operations research	57	6	1394--1406	2009	INFORMS	1
20	vercellis2	book	Business intelligence: data mi	Vercellis, C.					2009	Wiley Onlii Library	1
22	taylor20(	article	A Mathematical Model for Inter	Taylor, C.	Logistics Spectrum	41	1	23--33	2007		1
23	pishvaee,	article	A memetic algorithm for bi-obj	Pishvaee, M.S.	Computers \& Operations Resear	37	6	1100--1112	2010	Elsevier	1
24	pishvaee,	article	Reverse logistics network desi	Pishvaee, M.S.	The International Journal of A	47	1	269--281	2010	Springer	1
25	shang20(	article	Distribution network redesign	Shang, J.	Journal of Marketing	73	2	146--163	2009	Am Marke Assoc	1
26	cappellin,	book	International knowledge and in	Cappellin, R.					2009	Edward Elg Publishing	1
27	nagurney	article	Supply chain networks and elec	Nagurney, A.	Netnomics	4	2	187--220	2002	Springer	2
29	pishvaee,	article	A possibilistic programming ap	Pishvaee, MS	Fuzzy Sets and Systems	161		2668--2683	2010	Elsevier	2
30	klibi2009	book	The design of effective and ro	Klibi, W.					2009	CIRRELT	2
31	boysen2(	article	Cross dock scheduling: Classif	Boysen, N.	Omega	38	6	413--422	2010	Elsevier	2
32	cheung2(	confere	The impact of RFID technology	Cheung, YY				1673--1680			2
33	shen2009	article	Toward a framework of innovati	Shen, H.	Systems Research and Behaviora	26	2	297--309	2009	Wiley Onlii Library	2
34	warneke,	article	Smart dust: Communicating with	Warneke, B.	Computer	34	1	44--51	2001	IEEE	2
35	jones200	article	A survey of energy efficient n	Jones, C.E.	Wireless Networks	7	4	343--358	2001	Kluwer Acc ic Publish	2
36	jerrum19	article	Approximating the permanent	Jerrum, M.	SIAM journal on computing	18			1989		2
37	jerrum20	article	A polynomial-time approximatio	Jerrum, M.	Journal of the ACM (JACM)	51	4	671--697	2004	ACM	2
38	petruzzi1	article	Pricing and the newsvendor pro	Petruzzi, N.C.	Operations Research	47	2	183--194	1999	JSTOR	2
39	apanowic	article	Data Warehouse Discovery Frame	Apanowicz, C.	Database Theory and Applicatio			142--154	2010	Springer	2
41	gralla200	confere	A Modeling Framework for Inter	Gralla, E.					2006		2
42	murata1	article	Multi-objective genetic algori	Murata, T.	Computers \& Industrial Engine	30	4	957--968	1996	Elsevier	2
43	syarif200	article	Study on multi-stage logistic	Syarif, A.	Computers \& Industrial Engine	43		299--314	2002	Elsevier	2
45	benzler2(	article	From agglomerations to technol	Benzler, G.	International Journal of Techn	50	3	318--336	2010	Inderscience	2
46	cappellin,	article	La governance dell?innovazione	Cappellin, R.	Rivista di Politica Economica				2009		2
217	ambainis,	confere	One-dimensional quantum walks	Ambainis, A.				37--49	2001		3
226	feigenbau	article	Secure multiparty computation	Feigenbaum, J.	Automata, Languages and Progra			927--938	2001	Springer	3
231	nayak20(	article	Quantum walk on the line	Nayak, A.	Arxiv preprint quant-ph/001011				2000		3
232	moore20	article	Quantum walks on the hypercube	Moore, C.	Randomization and Approximatio			952--952	2002	Springer	3
314	altiparma	article	A genetic algorithm approach f	Altiparmak, F.	Computers \& Industrial Engine	51	1	196--215	2006	Elsevier	3
321	murata2(	confere	Specification of genetic searc	Murata, T.				82--95	2001		3

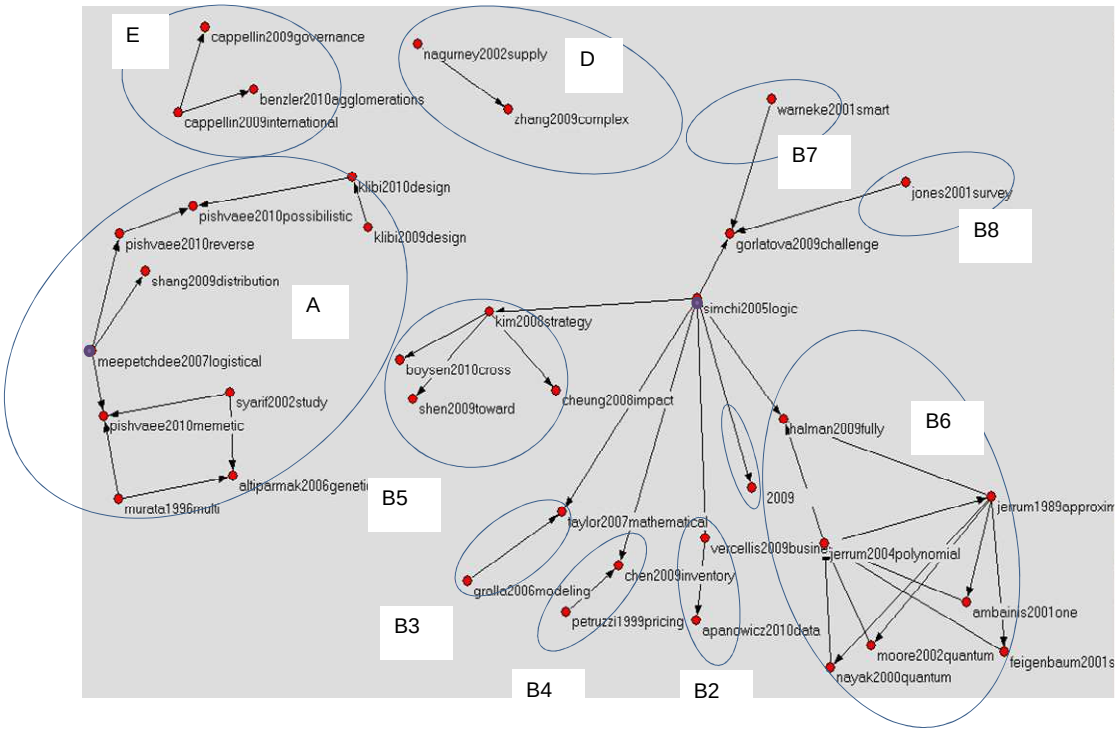

Figure 7.Distilled network with the seeds in violet. The clusters are identified using the layout of Fruchterman-Reingold

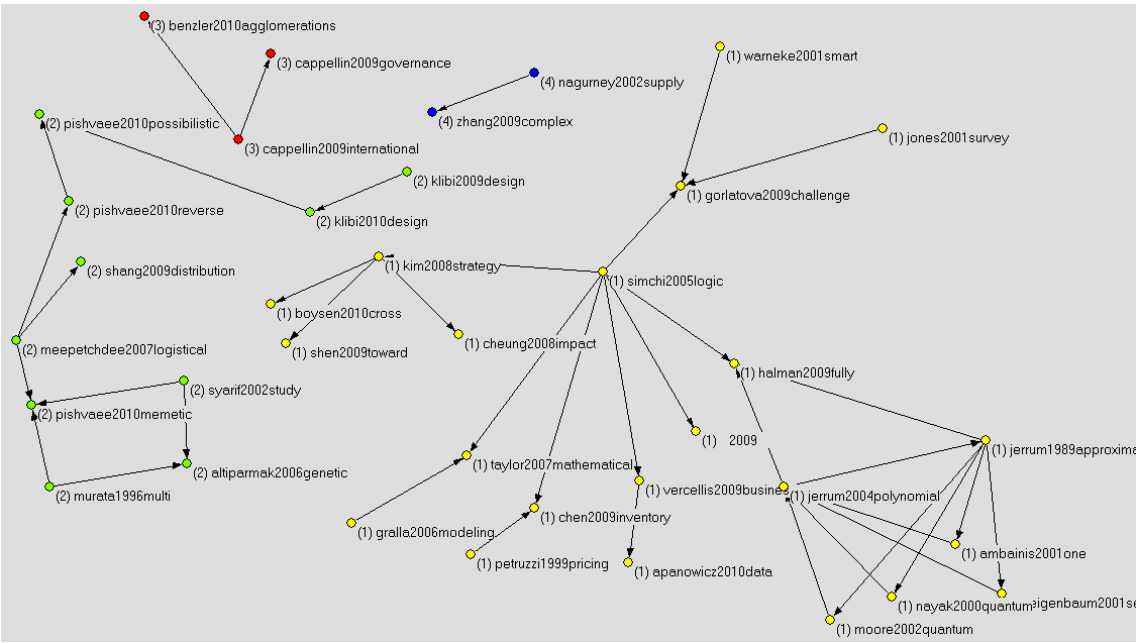

Figure 8.Clusters of distilled network using Pons and Latapy algorithm.

5. Results

The goal of this work was to obtain a citation network on the measure of robustness and vulnerability using the theory of complex networks applied to supply chain design. We have

made our search on Google Scholar using Citation Network Analyzer (CNA), a toolbox of R, and we have visualized the citation networks with Pajek (De Nooy et al., 2005). All the software used in this work is free or open source.

With the keywords selected we have chosen a list of 10 seeds, i.e. articles of zero level (see Table 1). Starting from them, with CNA we have built the citation network i.e. the articles which have cited seeds (first level) or cited someone who cited seed (second level) and so on until third level. In this way, starting from 10 seeds i.e. the articles containing the keywords, we have obtained a set of 345 works (see Appendix 1) and their links representing their citations.

The citation network is a direct network where, if article A cites articles B, there is an arrow from B to A which means that the work A was possible thanks to the work of B and the arrow represents a flow of knowledge from B to A.

The citation network was analyzed using cluster analysis. First we have applied Fruchterman-Reingold algorithm, an energy based method, to represent the network and identify empirically the clusters after we have compared the results with the clusters obtained using the random walk algorithm of Pons and Latapy (Pons and Latapy, 2005).

What information we can extract from the analysis made of the citation network? Why this representation may be useful?

Analyzing the topology of the citation network of Figure 4 with 345 nodes we can observe different structures:

- "Star clusters" i.e. clusters with center nodes and many rays (clusters B4, B7, B8). The centers are often literature reviews (node 38 is a review on newsvendor problem) or surveys (node 35 is a survey on energy efficient network protocols) and then of course they are able to connect different research line tend to receive higher number of citations.
- "Connection nodes" such as 17 or 7 which are nodes that connect different clusters and they can be, for example, books such as node 7: "The logic of logistics: theory, algorithms, and applications for logistics Management" which is a book on supply chain modeling and contains the description of all the standard modeling techniques.
- Clusters representing research groups such as the Virtual Center of Super-networks directed by Prof. Anna Nagurney (cluster D). They develop mathematical models of networks and study their stability (between other activities). They may have one or more centers and not so many rays as "star clusters".
- Clusters with more centers: they represent clusters of papers applying similar techniques to the solution of similar problems: for example the leitmotiv of cluster A is the development of mathematical models of supply chain solved using soft

computing techniques (Genetic algorithms, fuzzy logic, etc.), which also denotes the computer skills of the authors.

- "Chains" where the authors analyze narrowly defined fields such as the interplanetary logistic problem in the case of cluster B3. In this case the works are not so many and often follow one from another. This happen for example if they are of the same authors.

Of course the former classification is possible looking not only to the network by even reading the abstracts and possibly the full text of the papers. Anyway, placing the papers in a network helps in identifying and justifying their relationships.

The representation of literature review as a network and the application of clustering algorithms reflect the general need to put order on the increasing amount of works in all the fields during the last years. To go a step further in the direction of simplification we have distilled the citation network (Figures 7, 8), i.e., we have eliminated the pendants nodes (with in-degree one and out-degree zero) and the isolated nodes that are not relevant for our analysis since they are not cited and do not cite others.

- The representation of the distilled network using Fruchterman-Reingold algorithm (see Figure 7) allows identifying the backbone of the clusters of the original complete network (see Figure 4). It doesn't happen by using Pons and Latapy algorithm (see Figure 8).
- The stars are reduced to their centers
- The connection nodes still appear

The distilled network representation allows selecting a low number of articles that are more central in the network, but in this way we have lost some information. For example, it is more difficult to identify the literature reviews from the topology.

6. Conclusions

We applied free or open source software (R, Pajek, and CNA) and open access databases (Google Scholar) to build, visualize and analyze the citation network obtained when searching on the concepts of robustness and resilience of complex networks theory applied to Supply Chain Design. This procedure can be considered a starting point in the literature review that has to be followed by the careful reading of the abstracts and then the full texts of seminal papers. The representation of the literature as a citation network and a clear definition of the personal interests and goals lead to a fast approach to have a clear idea of the main subject, research areas, influential groups and journals.

This tool is important as an entry point in relative new fields for any researcher, but cannot replace a careful analysis and evaluation, nor the experience acquired with time of active researchers in the field of interest.

Which information we cannot extract from the citation networks? The drawback of citation network based on seed articles is the following. If we consider the network of 345 nodes it can be seen that contains only 10 seeds, i.e., only 10 articles should contain the keywords selected and they are not necessarily connected to each other. Therefore it is difficult to study, for example, the evolution of the concepts of robustness and resilience in the network. To do this one should build a network with hundreds of seeds and only one level beyond that of the seeds has to be considered. A fortiori this is true in the distilled network with 37 nodes which contains only 2 seeds.

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Appendix

Table A1.345 articles of the citation networks obtained using CNA and the selected keywords.

ID	Title	Type	First author	Journal	Year
1	Assessing the vulnerability of supply chains using graph theory	article	Wagner, S.M.	International Journal of Production Economics	2010
2	Application of network methods in intelligent supply chain management	article	Srinivasan, RS	International Journal of Services Operations and Informatics	2007
3	Measures of tipping points, robustness, and path dependence	article	Bramson, A.L.	Arxiv preprint arXiv:0811.0633	2008
4	Supply chains and Social Network Analysis	conference	Mueller, R.A.E.	NA	2007
5	Assessment and management vulnerability of supply networks structure based on social networks analysis	conference	Yang, H.	NA	NA
6	Development of supply chain network robustness index	article	Dong, M.	International Journal of Services Operations and Informatics	2006
7	The logic of logistics: theory, algorithms, and applications for logistics and supply chain management	book	Simchi-Levi, D.	NA	2005
8	Logistical network design with robustness and complexity considerations	article	Meepetchdee, Y.	International Journal of Physical Distribution & Logistics Management	2007
9	An analytical methodological framework for the optimal design of resilient supply chains	article	Iakovou, E.	International Journal of Logistics Economics and Globalisation	2007
10	Structural Investigation of Supply Networks:; A Social Network Analysis Approach	article	Kim, Y.	Journal of Operations Management	2010
11	Designing a Reliable Supply Chain Network Model under Disruption Risks	article	Azad, N.	Journal of American Science	2010
12	Complex adaptive supply chain network: the state of the art	conference	Zhang, J.	NA	2009
13	Formal Measures of Dynamical Properties: Robustness and Sustainability	conference	Bramson, A.L.	NA	2010
14	Attribute process methodology: feasibility assessment of Digital Fabrication Production Systems for planar part assemblies using network analysis and System Dynamics	article	Papanikolaou, D.	NA	2008
15	The design of robust value-creating supply chain networks: A critical review	article	Klibi, W.	European Journal of Operational Research	2010
16	A strategy for third-party logistics systems: A case analysis using the blue ocean strategy	article	Kim, C.	Omega	2008
17	Challenge: ultra-low-power energy-harvesting active networked tags (EnHANTs)	conference	Gorlatova, M.	NA	2009
18	A fully polynomial-time approximation scheme for single-item stochastic inventory control with discrete demand	article	Halman, N.	Mathematics of Operations Research	2009
19	Inventory centralization games with price-dependent demand and quantity discount	article	Chen, X.	Operations research	2009
20	Business intelligence: data mining and optimization for decision making	book	Vercellis, C.	NA	2009
21		article			2009

22	A Mathematical Model for Interplanetary Logistics	article	Taylor, C.	Logistics Spectrum	2007
23	A memetic algorithm for bi-objective integrated forward/reverse logistics network design	article	Pishvaee, M.S.	Computers & Operations Research	2010
24	Reverse logistics network design using simulated annealing	article	Pishvaee, M.S.	The International Journal of Advanced Manufacturing Technology	2010
25	Distribution network redesign for marketing competitiveness	Article	Shang, J.	Journal of Marketing	2009
26	International knowledge and innovation networks: knowledge creation and innovation in medium technology clusters	Book	Cappellin, R.	NA	2009
27	Supply chain networks and electronic commerce: a theoretical perspective	Article	Nagurney, A.	Netnomics	2002
28	Digital Fabrication Production System Theory: towards an integrated environment for design and production of assemblies	Article	Papanikolaou, D.	NA	NA
29	A possibilistic programming approach for closed-loop supply chain network design under uncertainty	Article	Pishvaee, MS	Fuzzy Sets and Systems	2010
30	The design of effective and robust supply chain networks	Book	Klibi, W.	NA	2009
31	Cross dock scheduling: Classification, literature review and research agenda	Article	Boysen, N.	Omega	2010
32	The impact of RFID technology on the formulation of logistics strategy	Conference	Cheung, YY	NA	NA
33	Toward a framework of innovation management in logistics firms: A systems perspective	Article	Shen, H.	Systems Research and Behavioral Science	2009
34	Smart dust: Communicating with a cubic-millimeter computer	Article	Warneke, B.	Computer	2001
35	A survey of energy efficient network protocols for wireless networks	Article	Jones, C.E.	Wireless Networks	2001
36	Approximating the permanent	Article	Jerrum, M.	SIAM journal on computing	1989
37	A polynomial-time approximation algorithm for the permanent of a matrix with nonnegative entries	Article	Jerrum, M.	Journal of the ACM (JACM)	2004
38	Pricing and the newsvendor problem: A review with extensions	Article	Petruzzi, N.C.	Operations Research	1999
39	Data Warehouse Discovery Framework: The Foundation	Article	Apanowicz, C.	Database Theory and Application, Bio-Science and Bio-Technology	2010
40	| | | [ ][ ]	Article		NA	NA
41	A Modeling Framework for Interplanetary Supply Chains	Conference	Gralla, E.	NA	2006
42	Multi-objective genetic algorithm and its applications to flowshop scheduling	Article	Murata, T.	Computers \& Industrial Engineering	1996
43	Study on multi-stage logistic chain network: a spanning tree-based genetic algorithm approach	Article	Syarif, A.	Computers \& Industrial Engineering	2002
44	Advances in Methods to Support Store Location and Design Decisions	Article	Hunneman, A.	NA	2011
45	From agglomerations to technology-and knowledge-driven clusters: aeronautics cluster policies in Europe	Article	Benzler, G.	International Journal of Technology Management	2010
46	La governance dell?innovazione: libero mercato e concertazione nell?economia della conoscenza	Article	Cappellin, R.	Rivista di Politica Economica	2009
47	Reverse supply chain management and electronic waste recycling: a multitiered network equilibrium framework for e-cycling	Article	Nagurney, A.	Transportation Research Part E: Logistics and Transportation Review	2005
48	Supply chain networks, electronic commerce, and supply side and demand side risk	article	Nagurney, A.	European Journal of Operational Research	2005

49	A supply chain network equilibrium model with random demands	article	Dong, J.	European Journal of Operational Research	2004
50	Supply chain supernetworks and environmental criteria	article	Nagurney, A.	Transportation Research Part D: Transport and Environment	2003
51	Dynamics of global supply chain supernetworks* 1	article	Nagurney, A.	Mathematical and Computer Modelling	2003
52	A retrospective on Beckmann, McGuire and Winsten's Studies in the Economics of Transportation*	article	Boyce, D.E.	Papers in regional science	2005
53	Ranking and defuzzification methods based on area compensation	article	Fortemps, P.	Fuzzy Sets and Systems	1996
54	A framework for the design of a military operational supply network	conference	Ghanmi, A.	NA	2009
55	Meta-heuristics implementation for scheduling of trucks in a cross-docking system with temporary storage	article	Boloori Arabani, AR	Expert Systems with Applications: An International Journal	2011
56	Scheduling the internal operations in distribution centers with buffer constraints	conference	Fanti, M.P.	NA	NA
57	Impact of rfid technology on supply chain: A simulation approach	conference	Li, F.	NA	2009
58	:	article			2010
59	Wireless sensor networks: a survey	article	Akyildiz, I.F.	Computer networks	2002
60	The nesC language: A holistic approach to networked embedded systems	conference	Gay, D.	NA	2003
61	An energy efficient hierarchical clustering algorithm for wireless sensor networks	conference	Bandyopadhyay , S.	NA	2003
62	Connecting the physical world with pervasive networks	article	Estrin, D.	Pervasive Computing	2002
63	Tinyos: An operating system for sensor networks	article	Levis, P.	Ambient Intelligence	2005
64	Research challenges in wireless networks of biomedical sensors	conference	Schwiebert, L.	NA	2001
65	Low energy adaptive clustering hierarchy with deterministic cluster-head selection	conference	Handy, MJ	NA	2002
66	Trajectory based forwarding and its applications	conference	Niculescu, D.	NA	2003
67	Body sensor networks	book	Yang, G.Z.	NA	2006
68	Energy harvesting vibration sources for microsystems applications	article	Beeby, SP	Measurement science and technology	2006
69	Three-dimensional battery architectures	article	Long, J.W.	Chemical reviews	2004
70	Distributed control applications within sensor networks	article	Sinopoli, B.	Proceedings of the IEEE	2003
71	Wireless sensor network designs	book	Hac, A.	NA	2003
72	Foundations of control and estimation over lossy networks	article	Schenato, L.	Proceedings of the IEEE	2007
73	A survey of research on context-aware homes	conference	Meyer, S.	NA	2003
74	Analysis on the redundancy of wireless sensor networks	conference	Gao, Y.	NA	2003
75	Online outlier detection in sensor data using non-parametric models	conference	Subramaniam, S.	NA	2006
76	Minimizing communication costs in hierarchically-clustered networks of wireless sensors	article	Bandyopadhyay	Computer Networks	2004

			, S.		
77	Prototyping wireless sensor network applications with BTnodes	article	Beutel, J.	Wireless Sensor Networks	2004
78	Secure broadcast communication in wired and wireless networks	book	Perrig, A.	NA	2003
79		article			2003
80	An autonomous 16 mm3 solar-powered node for distributed wireless sensor networks	conference	Warneke, B.A.	NA	2002
81	Communication paradigms for sensor networks	article	Niculescu, D.	Communications Magazine, IEEE	2005
82	The lighthouse location system for smart dust	conference	R{\\"o}mer, K.	NA	2003
83	First experiences with bluetooth in the smart-its distributed sensor network	conference	Kasten, O.	NA	2001
84	Lightweight deployment-aware scheduling for wireless sensor networks	article	Wu, K.	Mobile networks and applications	2005
85	Preprocessing in a tiered sensor network for habitat monitoring	article	Wang, H.	EURASIP Journal on Applied Signal Processing	2003
86	Everlast: long-life, supercapacitor-operated wireless sensor node	conference	Simjee, F.	NA	2006
87	Resilient data-centric storage in wireless ad-hoc sensor networks	conference	Ghose, A.	NA	2003
88	Scalable ad hoc routing: The case for dynamic addressing	conference	Eriksson, J.	NA	2004
89	Training a wireless sensor network	article	Wadaa, A.	Mobile Networks and Applications	2005
90	Random coverage with guaranteed connectivity: joint scheduling for wireless sensor networks	article	Liu, C.	IEEE Transactions on Parallel and Distributed Systems	2006
91	Distributed deviation detection in sensor networks	article	Palpanas, T.	ACM SIGMOD Record	2003
92	An ultra low-power processor for sensor networks	article	Ekanayake, V.	ACM SIGOPS Operating Systems Review	2004
93	Asymptotically optimal time synchronization in dense sensor networks	conference	Hu, A.	NA	2003
94	An ultra-low energy microcontroller for smart dust wireless sensor networks	conference	Warneke, B.A.	NA	2004
95	An ultra small individual recognition security chip	article	Takaragi, K.	Micro, IEEE	2001
96	A distributed light-weight authentication model for ad-hoc networks	article	Weimerskirch, A.	Information Security and Cryptology?ICISC 2001	2002
97	Self-organization in sensor and actor networks	book	Dressler, F.	NA	2007
98	Soapbox: A platform for ubiquitous computing research and applications	article	Tuulari, E.	Pervasive Computing	2002
99	Cluster-head election using fuzzy logic for wireless sensor networks	article	Gupta, I.	NA	2005
100	Fundamentals of energy-constrained sensor network systems	article	Sadler, B.M.	Aerospace and Electronic Systems Magazine, IEEE	2005
101	On the scalability of cooperative time synchronization in pulse-connected networks	article	Hu, A.S.	Information Theory, IEEE Transactions on	2006
102	A scalable simulator for TinyOS applications	conference	Perrone, L.F.	NA	2002
103	Adaptive sensing for environment monitoring using wireless sensor networks	conference	Arici, T.	NA	2004

104	Design and analysis of Hybrid Indirect Transmissions (HIT) for data gathering in wireless micro sensor networks	article	Culpepper, B.J.	ACM SIGMOBILE Mobile Computing and Communications Review	2004
105	MEMS for distributed wireless sensor networks	conference	Warneke, B.A.	NA	2002
106	Wireless sensor networks: leveraging the virtual infrastructure	article	Olariu, S.	Network, IEEE	2004
107	Energy optimal data propagation in wireless sensor networks	article	Powell, O.	Journal of Parallel and Distributed Computing	2007
108	DART: dynamic address routing for scalable ad hoc and mesh networks	article	Eriksson, J.	IEEE/ACM Transactions on Networking (TON)	2007
109	PINCO: A pipelined in-network compression scheme for data collection in wireless sensor networks	conference	Arici, T.	NA	2003
110	Field-based coordination for pervasive multiagent systems	book	Mamei, M.	NA	2006
111	FAME-DBMS: tailor-made data management solutions for embedded systems	conference	Rosenm{\\"u}ll er, M.	NA	2008
112	On-chip antennas in silicon ICs and their application	article	Kim, K.	Electron Devices, IEEE Transactions on	2005
113	Ambient intelligence visions and achievements: Linking abstract ideas to real-world concepts	conference	Lindwer, M.	NA	2003
114	Diffusion filters as a flexible architecture for event notification in wireless sensor networks	article	Heidemann, J.	ISI-TR-556, USC/ISI	2002
115	?Smart dust?: nanostructured devices in a grain of sand	article	Sailor, M.J.	ChemInform	2005
116	Electrolyte-based on-demand and disposable microbattery	article	Lee, K.B.	Microelectromechanical Systems, Journal of	2003
117	Towards a calculus for wireless systems	article	Mezzetti, N.	Electronic Notes in Theoretical Computer Science	2006
118	SoC issues for RF smart dust	article	Cook, B.W.	Proceedings of the IEEE	2006
119	Large-displacement vertical microlens scanner with low driving voltage	article	Kwon, S.	Photonics Technology Letters, IEEE	2002
120	Smart dust: Self-assembling, self-orienting photonic crystals of porous Si	article	Link, J.R.	Proceedings of the National Academy of Sciences of the United States of America	2003
121	Mulle: A minimal sensor networking device-implementation and manufacturing challenges	article	Johansson, J.	Proc. IMAPS Nordic	2004
122	It's alive: the coming convergence of information, biology, and business	book	Meyer, C.	NA	2003
123	Threshold key-establishment in distributed sensor networks using a multivariate scheme	conference	Delgosha, F.	NA	2006
124	On training a sensor network	article	Wadaa, A.	NA	2003
125	BeamStar: An edge-based approach to routing in wireless sensor networks	article	Mao, S.	IEEE Transactions on Mobile Computing	2007
126	Algorithmic aspects of the time synchronization problem in large-scale sensor networks	article	Hu, A.	Mobile Networks and Applications	2005
127	?Are You with Me??-Using Accelerometers to Determine If Two Devices Are Carried by the Same Person	article	Lester, J.	Pervasive Computing	2004
128	Tailor-made data management for embedded systems: A case study on Berkeley DB	article	Rosenmuller, M.	Data \& Knowledge Engineering	2009
129	Application of tracking and data-logging technology in research and conservation of seabirds	article	Burger, A.E.	The Auk	2008
130	I-TCP: Indirect TCP for mobile hosts	conference	Bakre, A.	NA	1995

131	Improving reliable transport and handoff performance in cellular wireless networks	article	Balakrishnan, H.	Wireless Networks	1995
132	Mobile ad hoc networking: imperatives and challenges	article	Chlamtac, I.	Ad Hoc Networks	2003
133	M-TCP: TCP for mobile cellular networks	article	Brown, K.	ACM SIGCOMM Computer Communication Review	1997
134	Design and analysis of an MST-based topology control algorithm	conference	Li, N.	NA	2003
135	Energy efficient indexing on air	conference	Imielinski, T.	NA	1994
136	Power aware page allocation	conference	Lebeck, A.R.	NA	2000
137	Energy-efficient target coverage in wireless sensor networks	conference	Cardei, M.	NA	2005
138	Topology control for wireless sensor networks	article	Wang, Y.	Wireless Sensor Networks and Applications	2008
139	Real-time communication and coordination in embedded sensor networks	article	Stankovic, J.A.	Proceedings of the IEEE	2003
140	Minimizing energy for wireless web access with bounded slowdown	conference	Krashinsky, R.	NA	2002
141	PowerScope: A tool for profiling the energy usage of mobile applications	conference	Flinn, J.	NA	1999
142	Greening of the Internet	conference	Gupta, M.	NA	2003
143	Mobile ad hoc networking and the IETF	article	Macker, J.P.	ACM SIGMOBILE Mobile Computing and Communications Review	1998
144	Energy-efficient deployment of intelligent mobile sensor networks	article	Heo, N.	Systems, Man and Cybernetics, Part A: Systems and Humans, IEEE Transactions on	2005
145	Error control and energy consumption in communications for nomadic computing	article	Zorzi, M.	Computers, IEEE Transactions on	1997
146	Topology control in heterogeneous wireless networks: Problems and solutions	conference	Li, N.	NA	2004
147	A MAC protocol to reduce sensor network energy consumption using a wakeup radio	article	Miller, M.J.	IEEE Transactions on Mobile Computing	2005
148	Energy efficient routing in ad hoc disaster recovery networks	article	Zussman, G.	Ad Hoc Networks	2003
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188	Approximate minimum-energy multicasting in wireless ad hoc networks	article	Liang, W.	IEEE Transactions on Mobile Computing	2006
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Lo scopo di questo lavoro è quello di eseguire una revisione della letteratura dei concetti di robustezza e resilienza nel Supply Chain Design (SCD) definiti secondo la teoria delle reti complesse. Per fare ciò è stata utilizzata la Citation Network Analysis ed il relativo pacchetto software Citation Network Analyzer (CNA). Esistono banche dati di contributi che considerano i concetti di robustezza e resilienza nel SCD (http://www.husdal.com/2008/04/28/robustness-flexibility-and-resilience-in- la fornitura-catena), ma pochi di loro tentano di quantificare questi concetti utilizzando l'analisi della rete di citazioni ovvero appicando misure in vigore dalla teoria delle Complex Network (CN). La metodologia utilizzata in questo lavoro è stata la seguente: in primo luogo abbiamo individuato le parole chiave pertinenti, poi, con CNA (20Overview.pdf http://www.lecy.info/resources/CNA%), abbiamo cercato in Google Scholar utilizzando stringhe, derivate dal raggruppamento delle parole chiave, per trovare i documenti contenenti queste parole chiave nel summary o nel testo, e quindi rilevanti per i nostri scopi. Utilizzando il software CNA abbiamo costruito una rete di citazioni ed, infine, alla rete generata è stata applicata l' analisi tipica delle reti di citazioni che permette di individuare i paper più rilevanti ed i cluster in cui si possono raggruppare i diversi articoli. Anche se il soggetto di questa revisione della letteratura può essere di scarso interesse per un vasto pubblico, riteniamo che la metodologia impiegata sia di applicabilità generale. Qualsiasi ricercatore, che vuole studiare o applicare i concetti di altre discipline, necessita di competenze in diversi campi. La metodologia proposta è conveniente, veloce ed obiettiva, anche se presenta ovviamente i limiti derivanti dalla considerazione del solo processo di citazione.