

Strategic and Operational Management of Organizational Resilience: Current State of Research and Future Directions

Abstract

This article uses both a systematic literature search and co-citation analysis to investigate the specific research domains of organizational resilience and its strategic and operational management to understand the current state of development and future research directions. The research stream on the organizational and operational management of resilience is distant from its infancy, but it can still be considered to be in a developing phase. We found evidence that the academic literature has reached a shared consensus on the definition of resilience, foundations, and characteristics and that in recent years, the main subfield of research has been supply chain resilience. Nevertheless, the literature is still far from reaching consensus on the implementation of resilience, i.e., how to reach operational resilience and how to create and maintain resilient processes. Finally, based on the results of in-depth co-citation and literature analysis, we found seven fruitful future research directions on strategic, organizational and operational resilience.

1. Introduction

The environment surrounding organizations increasingly challenges them by posing different threats in various forms from both inside and outside an enterprise's boundaries. Natural disasters, pandemic disease, terrorist attacks, economic recession, equipment failure and human errors are only some examples that help in understanding how many different events can undermine the stability and security of an organization and its environment [17]. Moreover, organizations live and compete in a world that is increasingly interconnected both socially and technologically. Challenges occasionally appear in the form of minimal and (apparently) insignificant uncertainties and offsets, but a little event can create the so-called "butterfly effect" in a wide interconnected network of companies. Consequently, it is currently always more difficult for an organization to be an independent entity and resist, or try to resist, shocks, impacts and disasters while maintaining a competitive position [90].

The ability to resist and respond to a shock (internal or external) and recover once it has occurred is called *Resilience* ([41], [153], [154]).

Why do some organizations successfully overcome these events, whereas others are not able to do so? What makes it possible for these organizations to withstand and adapt to challenges? What is the role of operations in managing shocks in a resilient view of companies?

Understanding these key issues has become even more important due to the growing number of challenging events that enterprises are facing – the 2001 World Trade Center attacks, the 2004 tsunami, Hurricane Katrina, the 2010 Icelandic volcano eruption, and the 2008-2009 economic crisis, to name a few. Crises of a radical nature, like financial crises or the introduction of a disruptive innovation, certainly undermine companies' survival; but also profound productive and technological innovations of incremental nature and also minor events – sometimes underestimated because their potential harmful is misunderstood – can seriously challenge the organizations' stability and security. This is the case for example of minor problems that could affect a supplier, causing the entire supply chain to slow down: the “conventional disruptions of supply variability, capacity constraints, parts quality problems and manufacturing yields” [161].

These and other events caused enterprises, and more generally the entire universe of management and business, to pay ever more attention to the concept of resilience as applied to financial markets, organizations and their elements, strategies, and to the networks made by organizations – the supply chains. Nevertheless, the common approach until today mainly consisted in planning and building organizational resilience in a defensive and reactive way. But the real managerial stake behind the topic of resilience is its profound comprehension at all organizational levels, together with the need to build it in a proactive manner, so as to turn resilience into a competitive advantage, and not only to use it as a defensive response to extreme events [156]. “Resilience thinking” can no longer be associated exclusively with defensive and reactive measures, but it has to involve the everyday activities of the organization, changing its nature and becoming a best practice to avoid also minor (if compared to disasters) problems [170]. Therefore, the managerial challenge is transforming organizational resilience from a set of redundant preventive actions, involving resources management, into a proactive strategy funded on a set of practices capable of fostering daily effectiveness of operations and processes.

Since the publication of Holling's paper in 1973 [203], the topic of resilience has attracted the attention of management scholars. Nevertheless, since the global financial crisis of 2008, the

topic has aroused a higher level of interest, in particular concerning strategic and operational management of resilience [90] and supply chain resilience [161]. Organizational resilience and supply chain/network resilience have shown a rising trend in academic publications, which was not observed even after the events of September 11, 2001. Subsequent years register the birth of two new research topics: economic resilience [3] and financial resilience [7].

The aim of this article is to investigate the specific research domains of organizational resilience and its operational management to understand the current state of development and future research directions. A primary motivation for this study is the absence of a literature review in reference to this particular topic and the increasing interest of scholars, as demonstrated by the increasing number of papers on resilience in recent years.

As evidenced in the following sections, the time trend of publications that focus on this topic showed a significant increase, representing ever more interest in resilience and its effects on operational and strategic dimensions of business management. These considerations highlight the need for a well-conducted and systematic review of academic literature on the topic and its main fields to clearly understand the most interesting directions of future research.

Moreover, most recent literature reviews on resilience date back to 2013, with the work of Downes et al. [65] focusing only on empirical studies on the topic. In 2012, Ponis and Koronis [144] wrote another review that mainly focused on resilience in the supply chain context, investigating its concept and formative elements.

Following these considerations, we identified the need for a more general work on the topic together with the aim of implementing an innovative methodology for our research. We employed co-citation analysis, a well-established bibliometric method that can bring a level of objectivity to reduce the bias inherent in alternative approaches, such as traditional literature reviews. After clarifying the meaning of “organizational resilience”, this paper explains the research methodology by beginning with a systematic literature search through the subsequent co-citation analysis based on factor analysis and multi-dimensional scaling methods. The results of the analysis are then shown. In the last section, we discuss the findings of our study and describe research implications, research limitations and future research directions.

2. What is organizational resilience?

The term resilience lends itself to a number of interpretations that have generated interest in a wide variety of research fields, ranging from ecology to metallurgy, individual and organizational psychology to safety engineering [17]. Nowadays the great majority of

management scholars agree with the definition of resilience, even if they belong to different subfields, but its conceptualization and its operationalization within managerial research originated and developed across different research fields through last forty years. The definitions proposed below show the evolution of the concept of resilience through time, starting from Holling's definition [203] given in 1973 and spanning a variety of research fields: firstly in natural sciences, mainly ecology and environment, and applied sciences, principally engineering, and then in social sciences, specifically economics (mostly in the sub-field of economic geography), strategic management and operations management.

The concept of resilience was born in the physical sciences and it refers to the capacity of a system to recover its former shape following a disturbance. In 1973, Holling [203] first introduced the concept of resilience linked with ecology and environment topics: in his paper, he defined resilience of an ecosystem as the measure of its ability to absorb change and still exist, comparing this concept to the one of stability, recognized by the author as the ability to return to equilibrium after temporary disturbance. In the ecological literature, after Holling's contribution, two types of resilience have been distinguished: first, "ecological resilience", understood as the ability of systems to absorb change and still persist after an external shock; second, "engineering resilience", dealing with resistance to disruption and speed of return to the pre-existing equilibrium. Coherently with the ecological perspective, Cumming [57] defines resilience as the "ability of the system to maintain its identity in the face of internal change and external shocks and disturbances" (p. 976).

From the engineering perspective, Dinh et al. [64] define resilience as "the ability to bounce back when hit with unexpected events". The concept of resilience engineering has been exhaustively treated by Hollnagel et al. [204] who define failure as "the result of the adaptations necessary to cope with the complexity of real world, rather than a breakdown or malfunction". Following this idea, success "is based on the ability of organizations, groups and individuals to anticipate the changing shape of risk before failures and harm occur".

Seminal studies on resilience in social sciences were born already after Holling's work. Two relevant contributions in administrative science were given by Meyer [206] and Weick [216]. Meyer found that there was no common path toward resilience, but the only commonality was that "the resilient choices were counterintuitive", given the normal operating conditions. The second one identified "four potential sources of resilience that make groups less vulnerable to disruptions, including improvisation, virtual role systems, the attitude of wisdom, and norms of respectful interaction." More recently, with the consideration of global threats such as

economic crisis, climate change and international terrorism, social sciences fully employed concepts of resilience coming from other research areas. In the last two decades, economics literature has significantly contributed to the development of researches on resilience. Moreover, the concept of resilience is starting to be more and more used also in evolutionary economic geography (economic resilience, territorial resilience, regional resilience) (e.g. [196], [197], and [213]). As regards the concept of economic resilience, Rose [153; 154] used the term “static resilience”, which is intended to indicate the ability of a system or organization to maintain its core functions when shocked, but he also introduced the concept of a “dynamic component” of resilience as the speed at which it is possible to return to ideal functioning conditions. Recently, Bristow and Healy [198] dealt with two different conceptions of resilience in regional studies. “The first is based on the engineering conception of resilience, which focuses on the resistance of a system to shocks and the speed to its return or ‘bounce-back’ to a pre-shock state or equilibrium. [...] The second definition is based on an adaptive notion of resilience [...] characterized by complex non-linear dynamics and an adaptive capacity that enables them to rearrange their internal structure spontaneously.”

Over the years, in management literature, the concept of resilience applied to organizations has taken on a deeper meaning; the simple concept of resistance to shocks and disasters expanded with the notions of recovery ability, recovery times, and costs of recovery. Therefore, according to the notions of ecological and engineering resilience, *organizational resilience* was firstly intended as the capacity to resist and recover from traumatic events, shocks or disasters that could affect an organization or a system either internally or externally (e.g. [54]; [90]). Christopher and Peck [49] and Sheffi and Rice Jr [161] highlight that the terms resilience and robustness are different, despite they are considered interchangeable in the management literature. They therefore differentiate the two terms by adopting robustness as a synonymous of physical strength, while resilience is defined as the ability of a system to return to a normal state, or a better one, after it has been disturbed. Regarding operations management, Iakovou et al. [95] interpret resilience only in terms of recovery time, i.e., the ability to restore operations quickly. Carvalho et al. [41] refine this definition focusing on supply chain resilience. The authors consider resilience as the system’s ability to return to its original state or to a new, more desirable one after experiencing a disturbance, and avoid failure modes; moreover, the goal of resilience analysis and management should be to prevent the shifting to undesirable states where failure can occur. More recently, management literature started to connect the concept of resilience with the strategic dimension of entrepreneurial activity, as already stated

by Sheffi and Rice Jr [161]: “[...] building a resilient enterprise should be a *strategic* initiative that changes the way a company operates and that increases its competitiveness. Reducing vulnerability means reducing the likelihood of a disruption and increasing resilience. [...] Resilience, in turn, can be achieved by either creating redundancy or increasing flexibility.” Furthermore, as evidenced by Teixeira and Werther [170], resilient organizations are anticipatory responders capable to follow up with disruptive industry-changing innovations. It clearly appears that building an organization’s resilience and robustness to disruptions is no longer a simple trade-off between the identified variables – redundancy and flexibility – but needs to be constituted as part of a decision process, finalized to strategy determination for a competitive advantage.

In our opinion, the definition of organizational resilience should include the concepts expressed by Carvalho et al. [41] (resilience as system’s capability to return to its original state or to a new, more desirable one), Rose [153; 154] (static and dynamic resilience), Sheffi and Rice Jr [161] (resilience as a strategic initiative) and Teixeira and Werther [170] (resilient organization as an anticipatory responder). Therefore, we propose the following definition: *“Organizational resilience is the organization’s capability to face disruptions and unexpected events in advance thanks to the strategic awareness and a linked operational management of internal and external shocks. The resilience is static, when founded on preparedness and preventive measures to minimize threats probability and to reduce any impact that may occur, and dynamic, when founded on the ability of managing disruptions and unexpected events to shorten unfavorable aftermaths and maximize the organization’s speed of recovery to the original or to a new more desirable state”*.

3. Research methodology

In this paper, we employ a bibliographic analysis. Bibliometrics provides a large number of analytical approaches and measures for understanding data derived from scientific publications. The fundamental methodology at the base of our research has been the co-citation analysis, a well-established bibliometric technique used to examine relationships among articles contributing to the development of a research field by giving a panoramic view of what has already been written on the topic [195] and identifying its intellectual structure [212]. The basic ‘building block’ of co-citation analysis is the relationship among publications. The fundamental idea is that the more two articles are cited together, the more they should be related and treat the same aspects of a topic – even if they are not in agreement – so that we

could assume that they belong to the same research cluster (or “front”). Co-citation analysis “has been applied increasingly across a variety of research fields for the purpose of uncovering and articulating their underlying structure. [...] As the applications suggest, the technique can be employed to discern patterns within a field of endeavor as they emerge, and before they are widely recognized and readily observable otherwise.” [199, p. 1189]

We began our research by systematically looking for papers that focus on strategic and operational management of resilience. After identifying a core set of articles, we adopted two multivariate techniques to assess the intellectual structure of the research field: Factor Analysis and Multidimensional Scaling. This approach is consistent with previous literature [205] and has been widely used in management literature (e.g., [201]; [207]; [208]; [214]). Factor analysis is a valuable data reduction method used also for discovering a research field’s underlying structure based on varying degrees of relatedness among the papers (e.g., [208]; [205]). Documents are classified in factors that represent groups of publications that may correspond to fields, subfields, or a core set of articles with commonalities among them. Multidimensional Scaling (MDS) graphically depicts the conceptual proximity, or similarity, between the publications and is adopted for a better understanding of the topic and the state of literature (e.g., [211]; [202]).

3.1 Searching and selecting the articles

We began the literature search by systematically looking for articles in four different databases: EBSCOhost, Scopus, Web of Science, and IEEE Explore. We decided to select only academic articles in English, including articles derived from conference talks, and reviews from 1990 to 2014. We also considered papers that were published in early 2015 but were accepted in 2014 to provide a more exhaustive view on the topic. As stated above, the purpose of this work is to investigate resilience literature with regard to the topic of organizational resilience, with a particular focus on the strategic and operational management of resilience. However, using too many specific search words would entail the risk of neglecting some important works that do not use those particular terms but nevertheless cover the same topic. For this reason, we carried out our systematic search as follows:

- EBSCOhost: we searched for “resilienc*” OR “resilient” in title and abstract, in Business Source Complete, Inspec and EconLit, finding 28243 works, of which 12459 were academic publications.

- Inspec: using the filters about arguments “resilience” and “risk management”, we selected 311 articles on the basis of title and abstract review.
- Business Source Complete: using the filters “management”, “business enterprise”, “risk management in business”, “business planning”, “leadership”, “industrial management”, “strategic planning”, “operations management”, “organizational resilience”, “personnel management”, we selected 564 articles on the basis of title and abstract review.
- EconLit: because all arguments were related to our search, we just selected entire articles and academic publications, obtaining 264 works based on title and abstract review.
- Scopus: in the areas Physical Sciences and Social Sciences & Humanities we searched for “resilienc*” OR “resilient” in article title, abstract, keywords, finding 43468 documents, of which 23059 were academic works in English. Then using the filter on subject areas “Business Management and Accounting”, “Economics Econometrics and Finance”, “Decision Sciences”, we obtained 1957 articles, from which we selected 151 articles based on title and abstract review.
- Web of Science: we searched for “resilienc*” OR “resilient” in Topic and Title, finding 112014 documents, then we filtered English publications in the research domains of “Science technology” and “Social sciences”, obtaining 65257 works; using the filters “Business economics” and “Operations Research Management science” in the research areas we found 1622 articles, of which we selected 170 works based on title and abstract review.
- IEEE: searching for “resilienc*” we found 4933 articles, and then we filtered them using other keywords in sequence:
 - “management”: 968 articles, we selected 26 articles based on title and abstract review;
 - “organizations”: 196 articles, finding 3 more articles;
 - “business”: 161 articles, finding 1 more article;
 - “enterprise”: 74 articles, finding 7 more articles.

The results of the database paper selection are synthesized in Table 1.

Table 1: Database paper selection.

Database	Number of database returns	Number of papers selected after title and abstract review
EBSCOhost	12459	-
Inspec	-	311
Business Source Complete	-	564
EconLit	-	264
Scopus	1957	151
Web of Science	1622	170
IEEE	4933	39

After this process, we also used citation analysis and hand searching to find every interesting work we may have missed in the first step. We retrieved a set of 428 papers with closer selection and deletion of copies (a single work may be present in more than one database). Finally, we performed a full-text analysis to identify only articles and papers about the specific research domains of strategic and operational management of resilience; we obtained a restricted set of 194 articles (see references 1 to 194).

Figure 1 shows that the topic is attracting greater levels of research interest as confirmed by the growing trend of the number of articles in the last seven years.

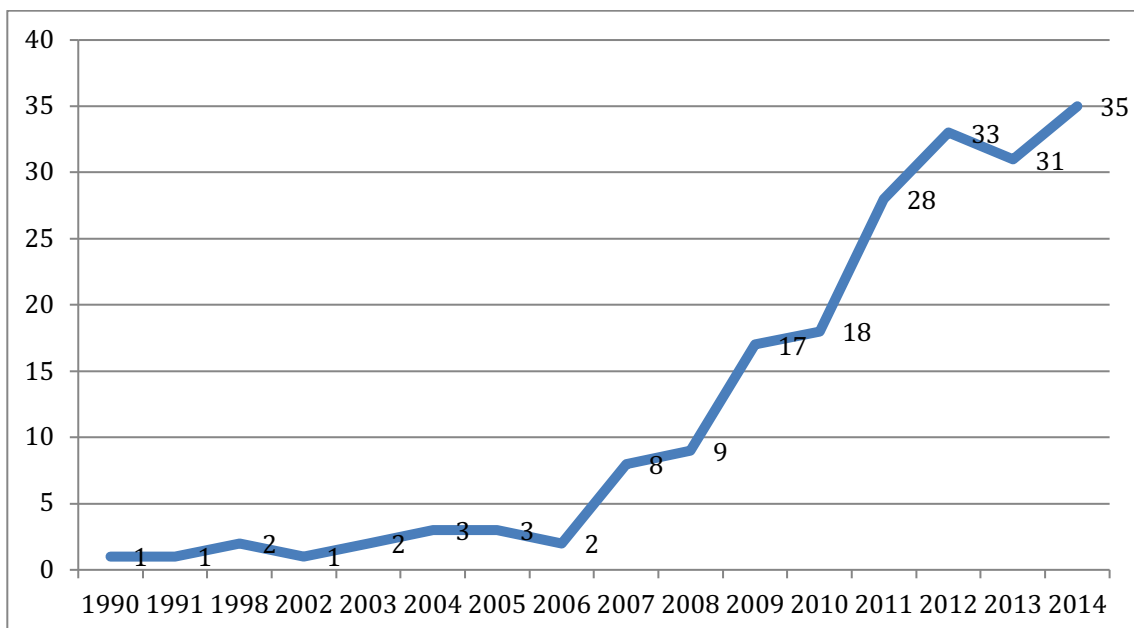


Figure 1: Selected publications per year from 1990 to 2014.

3.2 Analyzing the structure

Co-citation analysis requires counting the frequency with which a selected pair of works is cited together in published articles [215].

First, we constructed a citation matrix from the set of 194 papers, reporting on the rows the cited articles and on the columns the citing articles, so that we have a “x” in cell a_{ij} if j cites i . Using this matrix, we found some papers in the set that neither were cited by any other work nor cited any other work, so we decided to exclude them, which reduced our set to 132 articles. This forced us to eliminate some important and more recent works about resilience, although they were not relevant to our aim of defining the core set of publications addressing the topic. We then used the abovementioned citation matrix to retrieve co-citation frequencies and insert them into a co-citation matrix. This is a square matrix with rows and columns representing the articles in the set and cells representing the number of times each pair of works has been cited together.

By analyzing this matrix, we found that some articles only cited other works, without receiving any citations, so they presented a “0” value in every cell of corresponding rows and columns. Although they revealed themselves to be significant in identifying the “core” (fundamental and foundational works on resilience), these works would not belong to this restricted set of articles, the discovery of which was one of the aims of this work. Moreover, we found other articles receiving only “isolated” citations; they were cited by other works, but not together with other papers belonging to our set, so they also presented a “0” value in every cell of their rows and columns. Following our purpose of “identifying the core” we had to exclude these publications from our selection in this second “selection step”. With this matrix, we found a group of articles that were not cited together with any other (or they were only “citing articles”); excluding them and leaving only those works cited together with at least one other article, brought us to a definitive set of 72 publications (Table 2).

In the following step, we converted the co-citation matrix into a matrix of Pearson’s correlation coefficients (with citation frequencies turned into correlation coefficients), which represents a better measure of similarity between two works because they make it possible to standardize data and provide a better basis for statistical analysis. Using the correlation coefficients, it was thus possible to bring out multivariate techniques to analyze data, in particular factor analysis and multi-dimensional scaling.

Table 2: The core set of articles.

Authors	Year	# of citations	Typology	Methodology
Christopher, M., Peck, H.	2004	38	Conceptual study	-
Sheffi, Y., Rice Jr., J.B.	2005	32	Empirical research	Case study
Hamel, G., Välikangas, L.	2003	31	Conceptual study	-
Ponomarov, S.Y., Holcomb, M.C.	2009	27	Literature review	-
Pettit, T.J., Croxton, K.L., Fiksel, J.	2010	19	Conceptual study	-
Coutu, D.L.	2002	15	Conceptual study	-
Iakovou, E., Vlachos, D., Xanthopoulos, A.	2007	11	Conceptual study	-
Mallak, L.A.	1998	11	Conceptual study	-
Vogus, T.J., Sutcliffe, K.M.	2007	10	Conceptual study	-
Jüttner, U., Maklan, S.	2011	8	Empirical research	Case study
Blackhurst, J., Dunn, K.S., Craighead, C.W.	2011	7	Conceptual study	-
Crichton, M.T., Ramsay, C.G., Kelly, T.	2009	7	Conceptual study	-
Lengnick-Hall, C.A., Beck, T.E., Lengnick-Hall, M.L.	2011	7	Conceptual study	-
Rioli, L., Savicki, V.	2003	7	Conceptual study	-
Bhamra, R., Dani, S., Burnard, K.	2011	6	Literature review	-
Haimes Y.Y.	2006	6	Conceptual study	-
Burnard, K., Bhamra, R.	2011	5	Conceptual study	-
Cumming, G.S. et al.	2005	5	Empirical research	Case study
McManus, S. et al.	2008	5	Empirical research	Case study
Reinmoeller, P., Van Baardwijk, N.	2005	5	Empirical research	Survey
Somers, S.	2009	5	Conceptual study	-
Briano, E., Caballini, C., Revetria, R.	2009	4	Literature review	-
Carvalho, H. et al.	2012	4	Conceptual study	-
Gunasekaran, A., Rai, B.K., Griffin, M.	2011	4	Empirical research	Survey
Mallak, L.A.	1998	4	Conceptual study	-
Ratick, S., Meacham, B., Aoyama, Y.	2008	4	Empirical research	Survey
Rose, A.	2007	4	Conceptual study	-
Rose, A.	2004	4	Conceptual study	-
Acquaah, M., Amoako-Gyampah, K., Jayaram, J.	2011	3	Empirical research	Survey
Carmeli A., Markman G.D.	2011	3	Conceptual study	-
Colicchia, C., Dallari, F., Melacini, M.	2010	3	Conceptual study	-
Ismail, H.S., Poolton, J., Sharifi, H.	2011	3	Empirical research	Case study
Linnenluecke, M.K., Griffiths, A., Winn, M.	2012	3	Conceptual study	-
Zsidisin, G.A., Wagner, S.M.	2010	3	Empirical research	Survey
Beermann, M.	2011	2	Empirical research	Case study
Carvalho, H., Cruz-Machado, V., Tavares, J.G.	2012	2	Conceptual study	-
Datta, P.P., Christopher, M., Allen, P.	2007	2	Conceptual study	-
Demmer, W.A., Vickery, S.K., Calantone, R.	2011	2	Empirical research	Case study
Dinh, L.T.T. et al.	2012	2	Conceptual study	-
Haimes, Y.Y.	2009	2	Conceptual study	-
Ignatiadis I., Nandhakumar J.JN	2007	2	Conceptual study	-
Pettit, T.J., Croxton, K.L., Fiksel, J.	2013	2	Empirical research	Survey

Schmitt, A.J., Singh, M.	2012	2	Empirical research	Case study
Shukla, A., Lalit, V.A., Venkatasubramanian, V.	2011	2	Conceptual study	-
Yao Hu, Jingshan Li, Holloway, L.E.	2008	2	Literature review	-
Amann, B., Jaussaud, J.	2012	1	Empirical research	Survey
Azevedo, S.G. et al.	2013	1	Empirical research	Case study
Barroso, A.P., Machado, V.H., Cruz MacHado, V.	2011	1	Empirical research	Case study
Bhattacharya, A., Geraghty, J., Young, P.	2009	1	Conceptual study	-
Brandon-Jones E. et al.	2014	1	Empirical research	Survey
Briguglio L. et al.	2009	1	Conceptual study	-
Cabral I., Grilo, A., Cruz-Machado, V.	2011	1	Conceptual study	-
Caralli, R.A. et al.	2010	1	Conceptual study	-
Chopra, S., Sodhi, M.S.	2014	1	Conceptual study	-
Chrisman, J.J., Chua, J.H., Steier, L.P.	2011	1	Conceptual study	-
Erol, O. et al.	2010	1	Conceptual study	-
Glickman, T.S., White, S.C.	2006	1	Conceptual study	-
Golgeci, I., Ponomarov, S.Y.	2013	1	Empirical research	Survey
Hassink, R.	2010	1	Conceptual study	-
Klibi, W., Martel, A.	2012	1	Conceptual study	-
Madni, A.M., Jackson, S.	2009	1	Conceptual study	-
Murino, T., Romano, E., Santillo, L.C.	2011	1	Conceptual study	-
Ponis, S.T., Koronis, E.	2012	1	Literature review	-
Sawik, T.	2013	1	Conceptual study	-
Seville, E. et al.	2008	1	Empirical research	Survey
Soni, U., Jain, V.	2011	1	Conceptual study	-
Spiegler, V.L., Naim, M.M., Wilkner, J.	2012	1	Conceptual study	-
Vargo, J., Seville, E.	2011	1	Empirical research	Case study
Wang, J.W., Gao, F., Ip, W.H.	2010	1	Conceptual study	-
Watanabe, C., Kishioka, M., Nagamatsu, A.	2004	1	Empirical research	Action research
Wieland, A., Wallenburg, C.M.	2013	1	Empirical research	Survey

4. Findings

4.1 Findings from systematic literature search

In Appendix 1, we report the list of all sources of papers selected after a systematic literature search; these papers constitute the core set of literature about organizational resilience.

Our set of 194 articles has been subjected to two different “reductions”. In the first one, we identified and excluded all of the articles that neither cited nor were cited by any other article in the set. In the second one, using the co-citation matrix, we left out papers that, even if they were cited or they cited, have never been cited together with another one in the panel, thereby giving no contribution to our co-citation analysis. In so doing, we distinguished articles by assigning them to a class. Class A groups the articles from the final set of 72 papers; with class

B, we identified papers that were excluded in the second step of selection but passed the first one; all of the articles that did not pass the first selection were grouped in class C.

We divided the table in appendix 1 into three sections representing these classes, listing from top to bottom journals and conferences in which the papers belonging to that particular class have been published. Furthermore, each one of the adjacent columns represents a specific typology of the three we used to classify papers: conceptual study, indicating those works with a predominantly theoretical content and that provide a conceptual framework, such as [41], [49], [54]; literature review, such as [17] and [145]; and empirical studies. We subdivided empirical studies by distinguishing the methodology used: survey research, case study, or action research.

The first results come from qualitative analysis of the table in the appendix. The literature selected through systematic research aimed to consolidate knowledge about organizational resilience but also to develop new knowledge using empirical research. In fact, the table shows a slight majority of conceptual study: 109 versus 77 empirical studies and 8 literature reviews. 41 of these conceptual studies belong to class A and the number decreases in class B (39) and class C (29). Six of the 8 literature reviews are located in class A, and the remaining two are in class C. Empirical studies show a reverse trend compared with that of the conceptual studies; indeed, their number increases from class A (25) to class C (31); their composition is predominantly case studies (64%), followed by surveys (28%) and action researches (8%), and their proportion remains almost the same for all classes.

We can confirm that the core set of our bibliographic analysis contains the majority of theoretical studies, and we can therefore consider it to be the core of the intellectual structure about strategic and operational resilience. In fact, conceptual studies and literature reviews constitute 65% of class A, while empirical studies are 35%. In class B, 65% of papers are conceptual studies, while class C is made up of half conceptual studies and half by empirical studies. Nevertheless, the core contains empirical research aimed at theory building and at theory testing; 52% of the empirical studies in class A adopt the case study methodology and 44% surveys, whereas in class B, case studies constitute 62%, and action researches represent 14%.

4.2 Findings from factor analysis

We used Principal Components Analysis (PCA) as an extraction method to identify the factors and varimax rotation to obtain the rotated factors to give a meaning to the analysis and

interpret the results and Kaiser’s criterion along with a scree test to determine the number of extracted factors.

As shown in Table 3 we obtained a set of eight factors comprising all 72 articles in the core set and explaining more than 95% of variance, but we decided to consider only the first four factors, which explain almost 90% of variance. Moreover, the subsequent four factors comprised only one or two articles each, which is not of great significance for the aims of our analysis; the gain in terms of variance explained was not significant.

Table 3: Results of the Principal Components Analysis.

Factor	Value	Percent	Cum %
1	34.90686	54.5	54.5
2	14.37603	22.5	77.0
3	3.90693	6.1	83.1
4	3.63385	5.8	88.9
5	2.04363	3.2	92.1
6	1.04187	1.6	93.7
7	0.90263	1.4	95.1
8	0.81136	1.3	96.4

In Table 4 we report the factor loadings corresponding to each of the 64 articles belonging to the first four factors; these values represent the correlation between the paper and the factor. They can also be considered the degree to which the article belongs to that group. Consistent with prior studies ([199]; [200]; [210]), we decided to consider only factor loadings higher than 0.4 (absolute value), with a value of 0.8 or higher representing a strong correlation.

Table 4: Factors loading*.

	1	2	3	4
<i>Datta et al. (2007)</i>	0,9703			
<i>Zsidisin, Wagner (2010)</i>	0,9603			
<i>Jüttner, Maklan (2011)</i>	0,9579			
<i>Blackhurst et al. (2011)</i>	0,9579			
<i>Pettit et al. (2010)</i>	0,9502			
<i>Sheffi, Rice Jr. (2005)</i>	0,9452			
<i>Pettit et al. (2013)</i>	0,9350			
<i>Glickman, White (2006)</i>	0,9313			
<i>Ponomarov, Holcomb (2009)</i>	0,9281			
<i>Wieland, Wallenburg (2013)</i>	0,9276			
<i>Ponis, Koronis (2012)</i>	0,9264			
<i>Christopher, Peck (2004)</i>	0,9110			
<i>Haimes (2006)</i>	0,9024			
<i>Iakovou et al. (2007)</i>	0,8938			
<i>Briano et al. (2009)</i>	0,8914			
<i>Shukla et al. (2011)</i>	0,8667			

<i>Carvalho, Cruz-Machado, Tavares (2012)</i>	0,8344			
<i>Ratick et al. (2008)</i>	0,8271			
<i>Bhattacharya et al. (2009)</i>	0,8217			
<i>Madni, Jackson (2009)</i>	0,8217			
<i>Schmitt, Singh (2012)</i>	0,8063			
<i>Golgeci, Ponomarov (2013)</i>	0,7800			
<i>Barroso et al. (2011)</i>	0,7713			
<i>Colicchia et al. (2010)</i>	0,7710	-0,4699		
<i>Hassink (2010)</i>	0,7325			-0,4840
<i>Cumming et al. (2005)</i>	0,6471	0,4942		
<i>Carvalho, Barroso, Machado et al. (2012)</i>	0,6311	-0,5557	0,4833	
<i>Azevedo et al. (2013)</i>	0,6278		-0,4879	
<i>Brandon-Jones et al. (2014)</i>	0,6278		-0,4879	
<i>Chopra, Sodhi (2014)</i>	0,6278		-0,4879	
<i>Hamel, Välikangas (2003)</i>	0,5700	0,7253		
<i>Yao Hu et al. (2008)</i>	0,4760			
<i>Ioannis II Ignatiadis , Nandhakumar (2007)</i>	0,4348	0,4360		
<i>Sawik (2013)</i>	0,4290			-0,8668
<i>Gunasekaran et al. (2011)</i>	-0,4050	0,8920		
<i>Spiegler et al. (2012)</i>	-0,4624	0,8471		
<i>Watanabe et al. (2004)</i>	-0,4624	0,8471		
<i>Cabral et al. (2012)</i>	-0,4624	0,8471		
<i>Acquaah et al. (2011)</i>	-0,4668	0,8464		
<i>Beermann (2011)</i>		0,7331		
<i>Bhamra et al. (2011)</i>		0,9758		
<i>Briguglio et al. (2009)</i>				-0,8702
<i>Burnard, Bhamra (2011)</i>		0,9482		
<i>Caralli et al. (2010)</i>		0,6182		
<i>Carmeli, Markman (2011)</i>		0,9324		
<i>Coutu (2002)</i>		0,9245		
<i>Crichton et al. (2009)</i>		0,9706		
<i>Demmer et al. (2011)</i>		0,8870		
<i>Dinh et al. (2012)</i>			0,7737	
<i>Erol, Henry et al. (2010)</i>				
<i>Ismail et al. (2011)</i>		0,9125		
<i>Klibi, Martel (2012)</i>		-0,6149	0,7321	
<i>Lengnick-Hall, C. et al. (2011)</i>		0,9782		
<i>Linnenluecke et al. (2012)</i>		0,9524		
<i>Mallak (1998)</i>		0,9522		
<i>Mallak (1998a)</i>		0,7696		
<i>McManus et al. (2008)</i>		0,7702		
<i>Murino et al. (2011)</i>		-0,6149	0,7321	
<i>Reinmoeller, Van Baardwijk (2005)</i>		0,9238		
<i>Rioli, Savicki (2003)</i>		0,9413		
<i>Rose (2004)</i>		0,5484		
<i>Somers (2009)</i>		0,9147		
<i>Soni, Jain (2011)</i>		-0,6149	0,7321	
<i>Vargo, Seville (2011)</i>		0,6449		-0,4140
<i>Vogus, Sutcliffe (2007)</i>		0,9387		

*Extraction method: principal component analysis with varimax rotation. Variance explained: 88.9%. Only factor loadings higher than 0.4 are reported.

Analyzing the papers belonging to each factor, we characterized the four factors for common themes and similarities in subject and/or approach, starting from the factor loading(s) of each article:

1. Theoretical foundations and applications.
2. Implementation, improvement and measurement of resilience.
3. Models for resilience.
4. Other theoretical perspectives.

4.2.1 Theoretical foundations and applications

Factor 1 includes 32 articles (of 64) and constitutes what appears to be the core of literature about organizational resilience that we named “theoretical foundations and applications”. It contains 6 of the 10 most frequently cited papers in the set, covering 35% of total citations in the panel. Moreover, 4 of the 6 literature reviews belong to this factor.

In this set we have papers that can be considered fundamentals for the following literature, such as Sheffi and Rice Jr [161], Christopher and Peck [49], Iakovou et al. [95], Ponomarov and Holcomb [145], and Pettit et al. [142]. These papers are foundational for the field of research on *supply chain resilience*. The authors began addressing this issue a few years before it generated wide interest, anticipating what now appears to be the most developed theme. In fact, 4 of the 6 literature reviews belong to this factor, but they are focused on the topic of supply chain resilience. Other papers in this group follow this research direction jointly with other themes that are of emerging interest, such as Juttner and Maklan [103] who considered supply chain resilience in the global financial crisis; others focused on the practical implementation of resilience through the design of the supply chain (e.g., Carvalho et al. [40], Iakovou et al. [95]). Finally, we also found works about new research directions that appear to be interesting, such as the paper of Hassink [93] on regional resilience and economic adaptability.

Papers with a high loading on this factor principally propose conceptual frameworks concerned with the resilience definition, description and understanding of the processes by which it is generated and evolves.

4.2.2 Implementation, improvement and measurement of resilience

Factor 2, which we named “Implementation, improvement and measurement”, presents 27 articles of 64 total in the panel, and 4 of the 10 most frequently cited papers covering 40% of total citations: Hamel and Valikangas [90], Coutu [54], Vogus and Sutcliffe [180], and Mallak [124]. These are the oldest articles in the panel, but they have a lower number of citations than the papers belonging to the first group (e.g., Christopher and Peck [49] and Sheffi and Rice Jr [161]). This fact reinforces what we found after analyzing the first factor: supply chain

resilience will become the most important subfield in this research area, whereas studies that analyze resilience only from a general organizational perspective (e.g., Hamel and Valikangas [90] and Coutu [54]) have not yet created a clear research subfield.

Articles of this group seem to be less “homogeneous” in terms of arguments than articles from the first group, but they contain some key issues and future directions for research on resilience. Beermann [16], Linnenluecke et al. [117] consider resilience connected to climate strategies and extreme weather events; Mallak [123], Rose [153] and Somers [163] explore the possibility for resilience measuring; and Ignatiadis and Nandhakumar [96] and Riolli and Savicki [151] consider the impact of enterprise information systems on resilience.

4.2.3 Models for resilience

Articles in this group all address a particular argument about models for resilience.

Indeed Dinh et al. [64] develop a framework for planning resilience in industrial processes, discussing its characteristics and principles, together with basic factors to be considered when building resilient processes.

Klibi and Martel [109] focus on the design of supply networks; their paper proposes models based on stochastic programming, with particular attention to resilience formulation. Murino et al. [135] employ an SD model to study the behavior of a supply chain; they describe “the process of building the model and utilize the model to demonstrate the massive improvement that resilience can bring in a manufacturing enterprise.” In addition, Soni and Jain [164] propose a new framework for supply chain resilience.

The articles appear to be closer to the publications loading on factor 1, but they present a significant loading also on factor 2, positioning in the middle between these factors. The reason behind this result can be found by analyzing the citations structure. Soni and Jain [164], Murino et al. [135], Klibi and Martel [109], are all cited only once by Azadeh et al. [9]. This work is very recent and about transportation strategies in supply chains – an issue that has not been addressed by any other work in the panel.

4.2.4 Other theoretical perspectives

Factor 4 groups only two articles without common themes, so we named it “Other theoretical perspectives”. Sawik [156] focuses on supply chain resilience, but with particular attention to “optimal selection and protection of part suppliers [...] and the allocation of emergency inventory of parts to be pre-positioned at the protected suppliers.”

Briguglio et al. [31] instead address the concepts of economic vulnerability and economic resilience, developing a model for defining and measuring the second one.

We decided to consider this factor in our analysis due to its importance in explaining variance, and because although they are not related its articles represent some potential research directions on the topic of resilience that should not be ignored.

Compared to other multivariate techniques, factor analysis presents the remarkable advantage of considering multiple loadings of papers on factors and allows a more thorough review of the panel and its themes to be performed. As highlighted by Di Stefano et al. [199], papers with a significant but minor loading on other factors can be considered to constitute a subfield within the main research domain. Seven articles belonging to factor 2 have a significant loading also on factor 1, and we found the same result for three papers of factor 1 also loading on factor 2. Three paper from factor 3 shows a significant loading on factor 2, which appears to be strongly correlated with the main research directions, supporting our definition. These characteristics will become even clearer by analyzing the MDS graphic.

4.3 Findings from Multidimensional Scaling

Multidimensional Scaling (MDS) produces a graphic that represents conceptual proximity, or similarity, between publications. Using Pearson's correlation coefficients, MDS creates a bi-dimensional map (Figure 2), in which the position of each paper depends on its relationships with the other papers. Articles positioned near the center of the Cartesian axis have been co-cited most frequently with the others of the panel than those positioned near the border.

As suggested by other co-citation analysis performed using MDS (e.g., [205], [211], [200]), the name of the axes (and consequently the meaning) are an interpretation done by the studies based on position of the factors on the map and examination of the topics concerning the studies at the poles of the axes and their differences. We used the position of the four factors on the map to help with this, but we also read the studies in depth to give a meaningful interpretation.

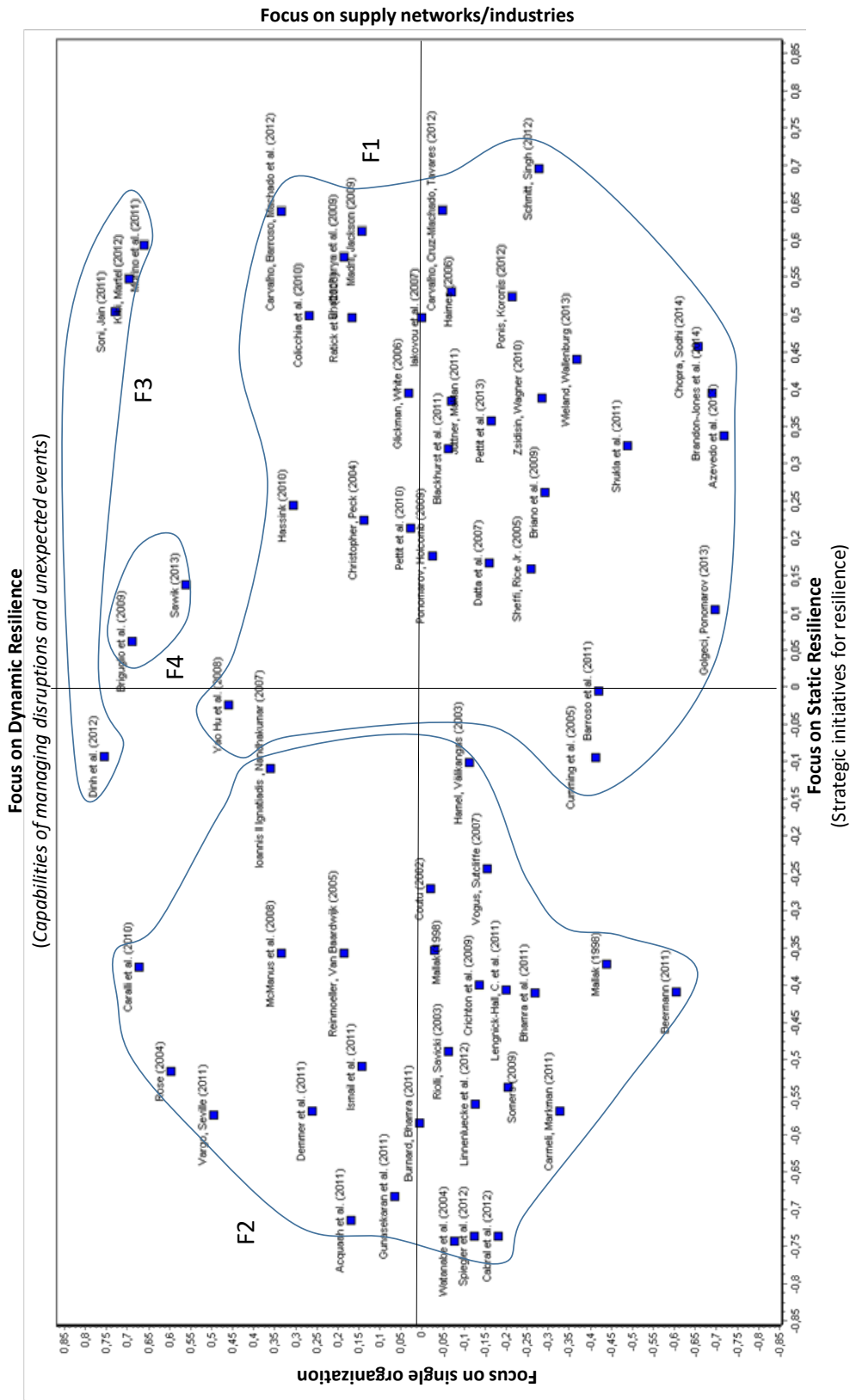


Figure 2: Multidimensional Scaling (circles on the map show where the four factors identified in Table 4 are positioned on the map)

Along the x-axis, starting from the left side, we have researches focused on the resilient design of organizations and on the management of internal resources for resilience, while when moving to the right side, we can observe a shift to the analysis of external resources, managerial actions and processes, like relationships and links in supply chains, supply networks or industries. For example, on the left side, there is a study by Cabral et al. [34] on a resilience management model to support decision making based on internal capabilities, as well as the papers of Gunasekaran et al. [86] and Acquaaah et al. [2] on resilience in SMEs (the first one uses the case study methodology while the second one the survey research). On the right side the MDS positions the study of Schmitt and Singh [157] proposing a quantitative model for analyzing disruptions in supply chains and the studies of Soni and Jain [164], Murino et al. [135], and Klibi and Martel [109] described above.

The y-axis presents on its lower extreme a focus on *strategic initiatives for resilience* linked to operational management of internal and external resources to minimize threats probability and to reduce any impact that may occur (*Static Resilience*). Golgeci and Ponomarov [83], for example, employ a linear regression model to test a hypothesis about links between firm innovativeness, innovation magnitude, disruption severity, and supply chain resilience.

We found interesting insights about strategic initiatives for resilience in researches situated in this part of the MDS. Brandon-Jones et al. [27] state that is crucial to “understand the relationship between specific resources (information sharing and connectivity), capabilities (visibility), and performance in terms of supply chain resilience and robustness”. Chopra and Sodhi [47] assert that “to protect their supply chains from major disruptions, companies can build resilience by segmenting or regionalizing supply chains, and limit losses in performance by avoiding too much centralization of resources”; Shukla et al. [162], proposing a design framework for supply chain resilience, demonstrate that “supply chain is much more reliable in the long term since a significant amount of robustness can be built into the system without compromising a lot on efficiency”. Cumming et al. [57] “equate resilience to the ability of a system to maintain its identity, defined as a property of key components and relationships (networks) and their continuity through space and time.” Beermann [16] argues that “introducing resilience thinking helps to identify strategic risks and opportunities coping with climate change, [...] mitigation is a profound element of long term adaptation strategies”.

On the upper extreme of the y-axis, we can find works dealing with *dynamic capabilities of managing disruptions and unexpected events* to shorten unfavorable aftermaths and maximize

the organization's speed of recovery (*Dynamic Resilience*), such as those belonging to the third and fourth factor discussed above. Moreover Caralli et al. [35] suggest a resilience management model defining processes for managing operational resilience in complex, risk-evolving environments and providing a path for making operational resilience a repeatable, predictable, manageable, and improvable process. In the work of Sawik [156] the optimal selection and protection of part suppliers and order quantity allocation in a supply chain is an interesting dynamic strategy for resilience, transforming resources management from a redundant preventive measure to a proactive one.

The lines on the map help in identifying the groups corresponding to the four factors. Factor 1 is consistent with our interpretation of its foundational role because all of its articles are grouped together and relatively close to the center of the map. Articles from the first two groups cover a wide area (they are sparse), the reason for which can be found in the variety of topics covered by them; indeed, regardless of whether the articles address implementation, improvement and measurement of resilience, these themes are treated from several points of view, all referring to different aspects of organizational resilience (left side of the map).

4.4 Findings from literature outside the core set of papers

Class B contains papers that, even if cited or citing, have never been cited together with another one in the panel and therefore provide no contribution to the co-citation analysis. Nevertheless, their contribution to the current and future development of the research stream on organizational resilience could be fundamental.

In Appendix 2, we report a table containing the papers in class B together with their research topic and related factor. The linkage comes from the papers contained in the core set, which cites or are cited by the articles in class B.

Because all of the papers related to factor 1 were published after 2010, we can hypothesize that some are not still included in the core of intellectual core due to their "young age". Overall, 46% of the papers (33) are related to factor 2, so we can affirm that the current and future research directions are linking studies about the implementation, improvement and measurement of resilience.

Indeed, we found some interesting papers about this topic belonging to class B, clearly related to Factor 2, which therefore have not received any co-citation and cannot be considered as belonging to the core set on organizational resilience, but only because they were published in recent years. Gong et al. [85] propose a restoration model and a problem-solving process to

enable a quick restoration of a supply chain, positioning itself as an element of continuity between the two main factors identified, addressing supply chain resilience and its improvement. Teixeira and Werther [170] argue that a key element in building resilience relies on anticipatory innovation, intended as an anticipation of buyers and markets' needs by establishing an innovation culture inside the firm itself. Jaaron and Backhouse [99], on the other hand, study whether it is possible, and how it is possible, to enhance resilience in service organizations through the application of the vanguard method of systems thinking. Finally Johnson, Elliott and Drake [101] aim to explore how social capital may act as facilitators or enablers of the four formative capabilities (i.e., flexibility, velocity, visibility, and collaboration)".

5. Conclusions

The purpose of our research was to overcome a specific challenge: understanding and explaining the directions this new research topic was taking, following the growing interest of scholars in the theoretical foundations and practical implications of organizational resilience, and the growing interest of scholars and practitioners about organizational robustness and strength, especially after the financial crisis. Therefore, we employed a literature search and analysis and a combination of multivariate techniques, such as factor analysis and multi-dimensional scaling.

The first result, the identification of four wide research fields in literature, emerge by analyzing the papers belonging to the factors identified using the factor analysis. Furthermore, using the MDS, we found that core researches focused on four different directions: (1) resilient design of organizations and on the management of internal resources for resilience, (2) resilient design and management of external resources, actions and processes for resilience (e.g. relationships and links in supply chains, supply networks or industries), (3) static resilience (i.e. strategic initiatives for resilience linked to operational management of internal and external resources) and (4) dynamic resilience (i.e. dynamic capabilities of managing disruptions and unexpected events).

The second result that arises from our analysis is that this research topic is far from its infancy, but it can be still considered in a developing phase. The number of authors and articles that treat organizational resilience are increasing and some research subfields are receiving increasing attention from scientific journals, but they are not yet clearly defined or consolidated. As we highlighted above, the more papers inside a group are represented closer

in MDS map, the greater the intellectual consistency of articles in that group appears to be. The great proximity of articles belonging to the group “theoretical foundations and applications” (Factor 1) shows that academic literature reached a *shared consensus* about resilience definition, foundations and characteristics.

Moreover Factor 1 allowed us to identify the main field of research about organizational resilience that has emerged since 2004, i.e., supply chain resilience. Nevertheless, the limited number of studies aimed at theory testing using survey methodology suggest that future studies should focus on consolidation of knowledge developed through case studies in the last years.

The dispersion of papers along the y-axis belonging to the group “Implementation, improvement and measurement of resilience” (Factor 2) in the MDS graph demonstrates that the literature is still far from reaching consensus about organizational and operational implementation of static and dynamic resilience (How can an organization become resilient? How to design, create and maintain resilient processes? Which are dynamic capabilities for resilience?). This will probably be one of the main directions of research.

In the last several years (2013 and 2014) the emerging topic following this research direction inside the main research area of supply chain resilience is the resilience of operations, i.e., how resilient operations management can have a key role in creating a competitive advantage for organizations during turbulent and unpredictable economic contexts.

Finally, as described above, a deeper examination of class B papers related to factor 2 revealed the presence of some works that address very interesting topics, such as those proposed by Gong et al. [85], Teixeira and Werther [170], Jaaron and Backhouse [99], Spiegler, Naim and Wilkner [165], Johnson, Elliott and Drake [101], Scholten, Scott and Fynes [158]. Moreover, we also found two articles related to the third factor, both published in 2014, which we believe may represent another future direction for research: Lampel, Bhalla and Jha [111], Pal, Torstensson and Mattila [139].

5.1 Organizational resilience: a future research agenda

Moving from our findings, we identified seven fruitful research directions. The first one derives from the relevant dispersion of articles belonging to Factor 2 in MDS; the second, the third and the fifth directions emerge from the analysis of some class A articles belonging to different factors, while the fourth one is strictly connected to Factor 3 about models for resilience. The sixth direction derives from the analysis of Class B papers, and the last one is about the need of

deepening the strategic initiatives and dynamic capabilities for resilience. In summary, our findings suggest that fruitful future research directions on organizational resilience are:

1. Theory testing on design, implementation, and improvement processes to enhance organizational resilience
2. Measurement of organizational and operational resilience
3. Resilience in Small Medium Enterprises
4. Restorations models for the supply chain and operational processes
5. Impact of introducing of information systems on organizational resilience
6. Anticipatory innovation to enhance processes' resilience
7. Strategic approach and dynamic capabilities for becoming a resilient organization

While the first four topics clearly emerge from previous considerations on factor analysis discussed above, the other three directions need further explanations and details.

As regards the impact of introducing of information systems on organizational resilience, Riolli and Savicki [151] first introduced the topic of information systems related to resilience, and Wang et al. [181] dealt again with this topic in 2010 recognizing that nowadays enterprises highly rely on timely information delivery identifying several issues related to information systems, to their security and safety. The issue is important for different reasons. First of all, these systems present a high interdependence, which exposes them to the risk of cascading failures, that is more problematic if we consider the sensitivity of the system to external disturbances. Moreover enterprise information systems are connected with Internet, making the boundaries of organizations more dynamic and uncertain. The final issue is that “the enterprise information system is overwhelmingly dependent on the human specialist who may make errors, or may not be available in time” causing in this way delays (adapted from Wang et al. [181]). However, despite the high impact of this topic on resilience, after the two previously cited works, there has been a lack of papers dealing with information systems and resilience. This lead us to identify it as a really interesting future research direction.

As regards anticipatory innovation to enhance processes' resilience, different authors introduced the innovation topic, like Carayannis et al. [36] and Dewald and Bowen [62], but Teixeira and Werther [170] first used the term “anticipatory innovation” to identify a completely new sub-field in innovation studies strictly related to resilience. They went beyond the traditional classification of companies in proactive companies, fast responders and slow responders, which respectively introduce the innovation and have more or less speed of response to the introduction of the innovations. They identified the category of anticipatory

firms that “go beyond mere innovations and create internal processes and conditions that lead to resiliency, which is in turn evidenced by successive innovations. [...] Resilient organizations are anticipatory responders that are able to follow up with successive industry-changing innovations.” This new “organizational behaviour” identified by Teixeira and Werther [170] is an interesting future direction, crossing and merging different research fields like organizations’ innovation strategies and resilience. After 2013, year of publication of the cited work, there has been a lack of papers dealing with this promising argument.

The last research direction, named “Strategic approach and dynamic capabilities for becoming resilient organizations”, originated from the work of Sheffi and Rice Jr [161], who identified resilience building a *strategic* initiative and not a “stand-alone process”. Despite this clear definition and the high number of works recognizing the strategic need of a systematic planning for resilience, there is still a lack of researches clearly dealing with this aspect of resilience.

5.2 Research limitations

This study has also shown the limits of the review methodology based on bibliometric techniques. The most important limit emerged clearly from the multidimensional scaling analysis. Two or more articles appear very close in the generated map if they have been co-cited, but the studies can refer to different sub-fields or subjects even if retrieved on the basis of a systematic literature search.

Generally, the closer papers appear on the map, the more likely they are to have similar intellectual content [199], but this is not always true and can lead to research bias. In our study, Acquah et al. [2] and Vargo and Seville [177] have been co-cited only once each Bhamra et al. [17] and Crichton et al. [56], have been cited together twice, such as Soni and Jain [164], Murino et al. [135], and Klibi and Martel [109], but they are located quite far on the MDS graph. We identified an evident intellectual distance between those articles cited above; it often happens that some works are represented closer only because they have been cited a similar number of times by the same articles.

We have overcome this limit of the co-citation analysis by reading all of the articles, but when the number of the papers is very high and there is a great chance of error, the research should be integrated with a proximity index. This index considers the relative positions of co-citations inside the text of a paper and can be used for further investigations.

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Appendix 1 – Sources of selected paper after systematic literature search

Source	Tipology					Total
	Conceptual study	Empirical research			Literature review	
		Action research	Case study	Survey		
Class A	41	1	13	11	6	72
Asia Pacific Business Review				1		1
Business Strategy & the Environment	1					1
Cambridge Journal of regions economy and society	1					1
Computers & Industrial Engineering			1			1
Disaster Prevention and Management	1					1
Ecosystems			1			1
Enterprise Information Systems	1					1
Entrepreneurship: Theory & Practice	1					1
Environmental Hazards	1					1
Growth and Change				1		1
Harvard Business Review	2					2
Health manpower management	1					1
Human Resource Management Review	1					1
IEEE International Conference on Automation Science and Engineering					1	1
IEEE International Conference on Industrial Engineering and Engineering Management	1		1			2
IEEE International Conference on Management and Service Science	1					1
IEEE International Conference on Systems, Man and Cybernetics	1					1
IEEE International Conference on Social Computing	1					1
IEEE Systems Conference	1					1
IEEE Systems Journal	1					1
Industrial Management	1					1
International Journal of Logistics Economics and Globalisation	1					1
International Journal of Logistics Management	1				1	2
International Journal of Logistics Systems and Management	2					2
International Journal of Logistics: Research & Applications	1					1
International Journal of Physical Distribution & Logistics Management	1			1		2
International Journal of Production Economics	1		1			2
International Journal of Production Research	1		4	2	2	9
Journal of Applied Business Research					1	1
Journal of Business Continuity & Emergency Planning				1		1
Journal of Business Logistics	2			2		4
Journal of Cleaner Production			2			2
Journal of Contingencies and Crisis Management	2					2
Journal of Information Technology	1					1
Journal of Loss Prevention in the Process Industries	1					1
Journal of Supply Chain Management				1		1
MIT Sloan Management Review	1		1	1		3
Natural Hazards Review			1			1
Omega	2					2
Oxford Development Studies	1					1
Production Planning and Control	1					1
Risk Analysis: An International Journal	2					2
Simulation Conference	1					1
Strategic Management Journal	1					1
Supply Chain Management			1	1		2
Technovation		1				1
Third Asia International Conference on Modelling & Simulation	1					1
WSEAS International Conference on System Science and Simulation in Engineering					1	1
Class B	39	3	13	5	0	60
Business Horizons	1					1

Cambridge Journal of Regions, Economy and Society				1		1
Decision Support Systems	1					1
Economic Systems Research	1					1
Enterprise Information Systems	1					1
European Management Journal	2		1			3
European Planning Studies	1					1
First International Conference on Infrastructure Systems and Services	1					1
IEEE International Conference on Industrial Engineering and Engineering Management	1					1
IEEE International Conference on Research and Innovation in Information Systems	1					1
IEEE International Conference on Systems, Man and Cybernetics	1					1
IEEE International Systems Conference Proceedings	1					1
International Business Review			1			1
International Journal of Agile Systems and Management	1			1		2
International Journal of Disaster Risk Reduction	1					1
International Journal of Logistics Systems and Management	1					1
International Journal of Logistics: Research & Applications	1		2			3
International Journal of Mathematics in Operational Research	1					1
International Journal of Production Economics				1		1
International Journal of Production Research	1		2	1		4
International Journal of Risk Assessment & Management	1					1
International Journal on Artificial Intelligence Tools	1					1
Journal of Business Continuity & Emergency Planning	1					1
Journal of Business Logistics		1				1
Journal of Human Resources in Hospitality and Tourism			1			1
Journal of Loss Prevention in the Process Industries	1					1
Journal of Management and Organization		1				1
Journal of Manufacturing Technology Management	1					1
Journal of Risk Research	2					2
Journal of Supply Chain Management				1		1
Journal of the Knowledge Economy	1					1
Logistics Research	1					1
Measuring Business Excellence	1					1
MIT Sloan Management Review	1					1
Natural Hazards Review	1					1
Omega	1					1
Planning Practice & Research	1					1
Production Planning & Control	1					1
Public Management Review			1			1
Safety Science	1					1
Supply Chain Management		1	3			4
Sustainability	1					1
Technology Analysis & Strategic Management	1					1
Total Quality Management & Business Excellence	1					1
TQM Journal	1					1
Transportation Journal			1			1
WSEAS Transactions on Systems	1		1			2
Class C	29	2	23	6	2	62
Asia Pacific Business Review			1			1
Bank of England Quarterly Bulletin			1			1
British Journal of Management			1			1
Business History			1			1
Economic Development quarterly			1			1
Emerging Markets Finance and Trade			1	1		2
Entrepreneurship & Regional Development	1					1
Entrepreneurship: Theory & Practice				1		1
Environmental Research Letters					1	1
Environmental Science & Technology	1					1
European Journal of Marketing					1	1
European Journal of Operational Research	1					1
European Planning Studies			2			2

Global Economy Journal	1					1
IEEE International Conference on Automation Science and Engineering	1					1
IEEE Systems Journal March	1					1
IEEE Transactions on Systems, Man & Cybernetics: Part C - Applications & Reviews	1					1
IIE Transactions	1		1			2
Intereconomics/Review of European Economic Policy	1					1
International Conference on E-Product E-Service and E-Entertainment	1					1
International Journal of Agile Manufacturing	1					1
International Journal of Agile Systems and Management			1			1
International Journal of Global Management Studies	1					1
International Journal of Industrial Engineering and Management			1			1
International Journal of Management and Enterprise Development			1			1
International Journal of Operations & Production Management			1			1
International Journal of Production Economics	1		1	1		3
International Journal of Production Research	2					2
International Journal of Services and Operations Management	1					1
International Journal of Theoretical and Applied Finance		1				1
Journal of Applied Business Research	1					1
Journal of Business Continuity & Emergency Planning	2		1			3
Journal of Business Venturing				1		1
Journal of Convergence Information Technology	1					1
Journal of Economic Dynamics and Control	1					1
Journal of Economics and Finance	1					1
Journal of Global Business Issues	1					1
Journal of International Development			1			1
Journal of international money and finance	1		1	1		3
Journal of Scheduling	1					1
Leadership & Management in Engineering	1					1
Management communication quarterly			1			1
Natural Hazards	1					1
OECD Journal: Economic Studies				1		1
Production and Operations Management	1					1
Quality and Reliability Engineering International			1			1
Service Industries Journal			1			1
Strategic Change			1			1
Supply Chain Management			1			1
Systems Conference	1					1
Thunderbird International Business Review			1			1
Work		1				1
Total	109	6	49	22	8	194

Appendix 2 – Papers in class B (topic and related factors)

Authors	Year	Topic	Related Factor
<i>Barroso et al.</i>	2010	Strategies for supply chain resilience	1
<i>Coles et al.</i>	2011	Definition of resilience measures	1
<i>Zobel, C.W.</i>	2011	Resilience definition	1
<i>Kantur, D., Arzu, I.-S.</i>	2012	Organizational resilience framework	1
<i>Mandal, S.</i>	2012	Supply chain resilience	1
<i>Scholz, R.W., Blumer, Y.B., Brand, F.S.</i>	2012	Resilience definition	1
<i>Vlachos et al.</i>	2012	Supply chain resilience	1
<i>Abdullah, N.A.S., Md Noor, N.L., Ibrahim, E.N.M.</i>	2013	Business continuity management	1
<i>Boin, A., van Eeten, M.J.G.</i>	2013	Resilience: definition and case study	1
<i>Leat, P., Revoredo-Giha, C.</i>	2013	Resilience in agri-food supply chain	1
<i>O'Hare, P., White, I.</i>	2013	Resilience definition	1
<i>Akgun, A.E., Keskin, H.</i>	2014	Organizational resilience capacity	1
<i>Edgeman, R., Williams, J.A.</i>	2014	Assessment of organizational resilience	1
<i>Gilly, J.P., Kechidi, M., Talbot, D.</i>	2014	Organizational resilience and territorial resilience	1
<i>Jonkeren, O., Giannopoulos, G.</i>	2014	Modelling of resilience	1
<i>Mamouni Limnios et al.</i>	2014	Resilience framework	1
<i>Mari, S.I., Young H.L., Memon, M.S.</i>	2014	Sustainable and resilient supply chain	1
<i>Torabi, S.A., Soufi, H.R., Sahebjamnia, N.</i>	2014	Business continuity management	1
<i>Golgeci, I., Ponomarov, S.Y.</i>	2015	Firm innovativeness and supply chain resilience	1
<i>Liu, Y., Liang, L.T.</i>	2015	Resource based resilience in manufacturing industries	1
<i>Longstaff, P.H.</i>	2008	Resilience of networked industries	2
<i>Erol, O., Mansouri, M., Sauser, B.J.</i>	2009	Framework for creating organizational resilience	2
<i>Trim, P.R. J., Jones, N.A., Brear, K.</i>	2009	Security management	2
<i>Yao, H., Jingshan, L.; Holloway, L.E.</i>	2009	Resilience of manufacturing network	2
<i>Briano et al. (a)</i>	2010	Resilience in fashion goods' supply chain	2
<i>Briano et al. (b)</i>	2010	Resilience in short life cycle products' supply chain	2
<i>Erol, O., Sauser, B.J., Mansouri, M.</i>	2010	Framework for investigating into organizational resilience	2
<i>Sydnor-Bouso et al.</i>	2011	Resilience in tourism industry	2
<i>Teigão dos Santos, F., Partidário, M.R.</i>	2011	Resilience framework	2
<i>Carvalho, H., Azevedo, S.G., Cruz-Machado, V.</i>	2012	Conceptual framework for resilience analysis	2
<i>Carvalho, H., Maleki, M., Cruz-Machado, V.</i>	2012	Resilience strategies for supply chain	2
<i>Ishfaq, R.</i>	2012	Logistic strategy for supply chain resilience	2
<i>Papapanagiotou, K., Vlachos, D.</i>	2012	Supply chain resilience	2
<i>Xiao, R., Yu, T., Gong, X.</i>	2012	Supply chain resilience	2
<i>Bhattacharya et al.</i>	2013	Resilient shock absorber for supply chain	2
<i>Boone et al.</i>	2013	Inventory management for resilience	2
<i>Harrison et al.</i>	2013	Supply chain resilience	2
<i>Johnson, N., Elliott, D., Drake, P.</i>	2013	Social capital and supply chain resilience	2
<i>Lee, A.V., Vargo, J., Seville, E.</i>	2013	Measuring organizational resilience	2
<i>Marwa, S.M., Milner, C.D.</i>	2013	Enhancement of corporate resilience	2
<i>Rose, A., Krausmann, E.</i>	2013	Framework for resilience index	2
Teixeira, E.d.O., Werther, W.B.	2013	Resilience strategies	2
<i>Whitman et al.</i>	2013	Assessment of organizational resilience	2
<i>Wieland, A.</i>	2013	Supply chain resilience	2
<i>Azadeh et al.</i>	2014	Supply chain resilience factors	2
<i>Carayannis et al.</i>	2014	Business model innovation	2
<i>Costantino et al.</i>	2014	Replenishment policy for resilience	2
<i>Gong et al.</i>	2014	Supply chain resilience	2
<i>Jaaron, A.A.M., Backhouse, C.J.</i>	2014	Resilience in service organizations	2
<i>Markman, G.M., Venzin, M.</i>	2014	Resilience of banks	2
<i>Prior, T., Haggmann, J.</i>	2014	Measuring resilience	2
<i>Rajesh, R., Ravi V., Venkata Rao, R.</i>	2014	Resilience in electronic supply chain	2
<i>Scholten, K., Scott, P.S., Fynes, B.</i>	2014	Supply chain resilience	2
<i>Fiksel et al.</i>	2015	Supply chain resilience	2
<i>Aleksić et al.</i>	2013	Assessing resilience potential in SMEs	3
<i>Lampel, J., Bhalla, A., Jha, P.P.</i>	2014	Resilience in employee owned firms	3
<i>Pal, R., Torstensson, H., Mattila, H.</i>	2014	Resilience in SMEs	3
<i>Davies, S.</i>	2011	Regional resilience of European countries in 2008-2009	4
<i>Elzarka, S.M.</i>	2013	Impact of Egyptian revolution on supply chains	4
<i>Urciuoli et al.</i>	2014	Resilience in energy supply chains	4

