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## **The birth and the rise of the cluster concept**

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### **Abstract**

Why has the cluster concept proved so successful in this millennium? Which are the authors, the scientific areas, and journals that have helped to enliven the debate in this era? With this work, we have aimed to answer these research questions by adopting an evolutionary approach. By means of a bibliometric analysis based on descriptive statistics and social network analysis tools, we have identified the founders and the main disseminators of the cluster concept across time. The point of departure is an original database, created by the authors, consisting of 1586 academic articles about industrial clusters that have been published from 1989 to 2010 in international scientific journals (source: ISI Web of Science). Our claim is that the Porterian contribution on clusters opens up a global debate over a concept that was ?in the air? many years before. The cluster concept is rooted in the Marshallian tradition, and is strongly related to the

Italian and European literature, which is more familiar with the narrower concept of the industrial district. By relaxing some of the specific features that characterized the industrial district model, a more inclusive concept is promoted, which, in a prey-predator relationship, assimilates previous contributions. By now, the cluster concept has gained international recognition and been constantly sustained by a theoretical discussion that encompasses a variety of disciplines and approaches. Our evidence shows that this success can be attributed basically to the liquid properties we have identified: multi-disciplinary and cross-disciplinary qualities and global dimension.

## 1. Introduction

Born in the strategic management literature, the concept of clusters has spanned over time through a wide range of disciplines, changing, adapting, and gaining theoretical power by finding application to different fields (Porter, 1990, 1998). Today, several definitions of clusters coexist as well as several applications to different socio-economic contexts, each one of them stressing one or more of the particular features of the cluster. Therefore, we can consider the cluster concept as a puzzle made of different pieces either originally elaborated by the cluster literature or borrowed from other fields of study. In particular, two concepts have been dueling for a long time: the cluster and the industrial district (henceforth, ID). The latter stems from the economics literature; its modern history dates to the re-discovery and re-interpretation of the Marshallian contribution made by Becattini (1979). In his analysis of the evolution of the British industry, Marshall (1920) identifies the triad of external economies (labor market pooling, technological spillovers, and intermediate goods supply and demand linkages), which tends to lead to the local clustering of economic activity. The works of Becattini went beyond Marshall's economic analysis, stressing the need for an interdisciplinary approach. A large number of geographers, economic geographers, and scholars in regional science further contributed to refining the concept. A parallel stream of research, which focuses on the explanation of agglomerations and their impact on economic performance, is linked to the work of Paul Krugman (1991) and of the exponents of the New Economic Geography (NEG).

The literature on clusters has a lot in common with that on IDs. As stressed by Feser and Bergman (2000), Porter and Ketels (2009), and Ketels (2011), both concepts bring the analysis of location into that of firms' competitiveness and they share the same focus on the impact of agglomeration on economic performance. Some contributions, mainly from management scholars, use the term ID or cluster indifferently (among the others: Schmitz, 1995; Tallman et al., 2004; Bell, 2005), some others, more precisely, identify the ID as a particular kind of a more general category of clusters (Belussi, 2006; Bellandi, 2007; Porter and Ketels, 2009).

The cluster concept has become an increasingly popular topic for researchers and policy makers operating at different levels. Nevertheless, some authors have strongly criticized the cluster concept, characterizing it as fuzzy and chaotic (Martin and Sunley, 2003) because of the absence of a unique definition and the problems related to its measurability (see also Malmberg and Maskell, 2002).<sup>1</sup> Foss (2011: 100) criticizes the Porterian approach; he accuses Porter of applying a wrong form of eclecticism, of proposing "loose frameworks." In our perspective, the so-called fuzziness, as well as the chaotic nature of the cluster concept is at the very root of its evolutionary nature. The concept, in fact, has spanned over time through a wide range of disciplines, changing, adapting, and gaining theoretical power by finding application to different fields (from economics to management and organization studies, from sociology to economic geography and regional studies, from urban planning to innovation studies). We therefore stress the idea that the adaptation capability of the cluster concept has transformed a potential weakness into an opportunity. Certainly, some of the cluster features are ill defined, but we have to acknowledge that the cluster paradigm is successful, because it has been able to cross the bridge from the solid to the liquid modernity (Bauman, 2000).<sup>2</sup> The concept of liquid modernity was first proposed by the Polish sociologist Zygmunt Bauman, as a more apt term than postmodernity (Harvey, 1989) for making sense of changes as well as continuities in modernity, mainly driven by globalization. We draw from his works by suggesting

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<sup>1</sup> Nevertheless, some authors have successfully applied some techniques to measure the variety of interfirm relationships within a cluster; see for instance the social network analysis to map knowledge flows performed by McEvily and Zaheer (1999), and Giuliani and Bell (2005).

that some cluster features (*multidisciplinary, cross-disciplinary, and global dimension*) that we identified make it “liquid” and able to face the major change of our modernity, which more solid concepts, such as Marshallian IDs and innovative milieux, failed to capture (see also Cooke, 1990; Lazzeretti, 2006, 2007). Therefore, the main features to be checked about the concept will be the multidisciplinary, the cross-disciplinary, and the global dimension, which allow the generation and diffusion of new ideas inside and across diverse areas, as taught us by the lesson on the trespassing boundaries given by Hirshmann (1981).

By multidisciplinary, we refer to the fact that the cluster concept has been studied by scientists belonging to different disciplines, such as economic geography and new economic geography, management and innovation studies, and economic sociology. By cross-disciplinary, we refer to the contamination between the various disciplines, which borrowed theoretical frameworks and analytical tools from one another, enriching the notion of clusters in a co-evolutionary and trespassing process. By global dimension, we refer to the geographical extension of the concept, which can be captured from the academic affiliation of the authors that have published on the topic.

There is a substantial lack of empirical support in ascertaining the evolution of the concept of clusters, which is often depicted through qualitative methods. The purpose of this paper is to review cluster research and its evolution by considering the works of the most prominent researchers in the field over an extended period of time using bibliometric methods.

We add to previous work on the issue by proposing an interpretative key to the success of the cluster concept, and by strongly supporting our arguments by means of quantitative techniques. These methods tend to minimize the subjectivity of the analysis and to produce more reliable results, if compared to other more qualitative techniques. Our work offers an original and robust overview of the cluster concept. The theoretical discussion is empirically supported by a bibliographic analysis based on statistical analysis and social network tools. The point of departure is an original database, created by the authors, consisting of 1586 academic articles about clusters or IDs that were published from 1989 to 2010 in international scientific journals (source: ISI Web of Science).

We first identified the disseminators of the cluster concept, selecting the most-cited articles; second, we performed a backward citation analysis, in order to get information on the roots of the concept (the founders). Cruz and Teixeira (2010) embarked on a similar exercise, but, in search of the seminal works on the topic (the founders), they limited the analysis to contributions most cited by articles published only in one journal (*Regional Studies*) on industrial clusters (from 1962 to 2007), and more importantly, they did not try to give a specific theoretical explanation for the success and the evolutionary trajectories of the cluster concept.

The results of our work shed light on the cluster concept contextualized into liquid modernity. The concept is evolutionary in nature; it emerges in the realm of the economics of agglomeration and local competitive advantage studies and spans over and fertilizes through a variety of social and economic sciences.

The paper is structured as follows. Section 2 illustrates the theoretical base of the work, which explains why the cluster concept can be labeled as “liquid” and presents our research questions. Section 3 describes our research design and the method of data collection. Section 4 presents some descriptive statistics on the disseminators of the cluster concept. Section 5 illustrates the results of the backward citation analysis, reporting on the founders of the cluster concept. Finally, Section 6 incorporates our conclusive remarks.

### **3. Data and methodology**

Our data come from the ISI-Thomson Reuters Web of Science database (henceforth, ISI). The choice of ISI as the referring database is motivated by its widespread international use for rating the research output

of scientists in every discipline. Our database includes a set of articles<sup>3</sup> collected by ISI that have been published from 1989<sup>4</sup> to 2010 in international scientific journals. We have identified the articles pivoting on the topic of industrial clusters or IDs, performing an advanced search on a specific subset of subject categories included in the ISI database (i.e., economics, planning and development, geography, management, environmental studies and business and urban studies).<sup>5</sup> Concerning the boundaries of the disciplines, we delimited the topic by searching articles on the “industrial district\*” OR cluster\* (as topic in ISI). In our view, as previously discussed in the introduction, the cluster and the ID concept are interwoven. The contributions offered by McEvily and Zaheer (1999) and Porter and Ketels (2009), which describe IDs as a special form of clusters, strongly support our choice. In order to decide whether or not to include an article in the sample, we adopted the criterion of reading the abstract of each article, and, if this was not sufficient, the whole article. By doing so, we excluded all the articles that focused only on “cluster analysis” as a statistical procedure, clusters as a generic group of objects, clusters of population in urban economics and the district as an administrative unit.

Any study based on citations must start from a set of source authors or documents that make up the core of the discipline or approach being analyzed (Callon, Courtial, and Penan, 1993), from which citation analysis is obtained. The selection of those source documents is a critical stage in the process. The usual criterion to establish the core is relevance (most-cited works in the field). Citation analysis is based on the premise that authors cite works they consider to be important to the development of their research. As a result, heavily cited articles are more likely to have exerted a greater influence on the subject than those less frequently cited. In order to avoid the drawback of favoring the older documents to the detriment of more recent ones, which might have had a greater impact on theory, we selected as a criterion not the most cited, in absolute terms, but the average most cited per year. In this way, the analysis captures also the most recent trends in the theory.

Instead of using articles published in a specific journal, as is often the case in existing literature reviews (see, for instance, Cruz and Teixeira, 2010), we decided to group articles by subject categories. This takes into account the multidisciplinary nature of the concept and allows the production of a more objective view of the cluster research. There is, however, some bias involved in our choices. Some articles on clusters might have been published within other subject categories that, nevertheless, would represent a minority. We are, however, reasonably confident that the articles analyzed are a representative sample of cluster research.

Following this procedure, we collected a set of 1586 journal articles that have been published in 250 international journals. From this database, we have selected a relatively small group of 46 most-cited articles, which have collected more than ten citations on average (by year).<sup>6</sup> The 46 most-cited articles represent the “disseminators” of the cluster concept. They are recognized as the most significant contributions on the topic by the scientific community<sup>7</sup>.

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<sup>3</sup> We also searched for proceedings, because in ISI the articles that have also been published as proceedings have been recorded as belonging to both the categories. Including as a selection criterion only the articles, we would have kept all of them out of the sample.

<sup>4</sup> 1989 is the first year of data available in the ISI database.

<sup>5</sup> These categories were selected on the basis of the main field of analysis and application of the cluster concept, in accordance also with the contribution of Maggioni, Uberti, and Gambarotto (2009).

<sup>6</sup> Citations data are updated to November 2011.

<sup>7</sup> It is worth reminding here that the ISI database collects only the contributions published by ISI journals, mostly in English, and omits all the contributions published in books and other languages. The most-cited articles are consequently a subset of this group of contributions. Only when looking at the references cited by this subset

Starting from the selected group of most-cited articles, we explored the theoretical ground upon which they are based. In order to do so, we downloaded from the ISI database the backward citations of the 46 most-cited articles. The analysis of backward citations refers to all the articles, books, and book chapters that have been cited by the 46 observed articles. In the past, the monograph was the typical outcome of the work done by researchers, and the publication of a book was much more common than the publication of a journal article. Therefore, the inclusion of books proves to be a particularly appropriate choice for the study of the “founders” of the cluster concept.

Overall, the 46 articles cite 2066 different references. The web of relations between citing and backward-cited works, as well as that among backward-cited works, is analyzed with the help of social network analysis tools (Wasserman and Faust, 1994). In order to identify the most influential backward-cited works and authors, we refer to the simple concept of degree centrality, which measures the citation frequencies of articles and authors. In order to identify cohesive groups of backward-cited works, which can be representatives of meaningful scientific communities, we use a clustering algorithm that was developed by Palla et al. (2005).

#### **4. The rise of the cluster concept: The disseminators**

The number of articles on clusters augmented over the years, reaching up to 200 articles per year in 2010 (Figure 1). This result indicates how hot is the topic and the degree to which the scientific community is invested in deepening it.

INSERT FIGURE 1 ABOUT HERE

The cluster concept intermingled with different streams of literature, sometimes producing new topics and new fields of study. As we can see from Figure 2, the number of journals that published articles on clusters also grew exponentially from 1989 to 2010. The increasing variety of journals interested in publishing on this issue supports the idea that this concept is very multidisciplinary, and able to cross different communities of scientists.

INSERT FIGURE 2 ABOUT HERE

This idea is reinforced by Figure 3, which shows how the distribution of the journals per number of articles published resembles that of a long tail. Besides the few that dominate – mostly journals in the area of economic geography – we find a long tail composed of journals targeting a wide range of scientific disciplines.

INSERT FIGURE 3 ABOUT HERE

In order to investigate this issue more deeply over time, we listed the journals that published the most on clusters (which we named “best-publisher journals”), considering two time frames: 1989-1999 and 2000-2010. We did split the overall period of analysis into two decades, because we wanted to capture the time evolution of the concept, which is strictly linked to the types of journals interested in publishing on the topic. The results are shown in Table 2.

INSERT TABLE 2 ABOUT HERE

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(backward citations) can we collect information on contributions published in other journals, in books, and in languages other than English.

Whereas *Regional Studies* contains the original most-cited contributions over the issue, starting off as the leading journal during the first decade, *European Planning Studies* positioned itself at the top of the list in the second decade, narrowly followed by *Regional Studies*. It is also interesting to note that in recent years, *Research Policy* is among the top ten journals, together with *Technovation*, thus informing on the importance of the concepts in innovation-related studies.

Analyzing the most popular articles on clusters, the ones that try to sketch the pillars of the concept, we can underline some features that can be informative regarding the reasons behind the large consensus it received over time. From the list of the 46 most-cited articles (the disseminators), we have extracted the nine most-cited articles (yearly citations > 20), which are presented in Table 3.

INSERT TABLE 3 ABOUT HERE

As we can see in Table 3, the most-cited articles on the issue, on average (considering the average yearly citations), were published in 2004 in *Progress in Human Geography*. The article, titled "Clusters and knowledge: Local buzz, global pipelines and the process of knowledge creation", is concerned with spatial clustering of economic activity and its relation to the spatiality of knowledge creation in interactive learning processes. It is argued that the co-existence of high levels of buzz and many pipelines may provide firms located in outward-looking and lively clusters with a string of particular advantages not available to outsiders. Buzz refers to the knowledge exchange resulting from a variety of informal local relationships. The concept of buzz is strictly connected and comparable to the Marshallian industrial atmosphere (Marshall, 1920), to the mechanism of localized knowledge spillovers (Breschi and Lissoni, 2001), to the Japanese Ba (Nonaka and Konno 1998), and to the specific immaterial concept of the public good (Bellandi, 2006), only to cite the most well-known examples. The concept of buzz offers the opportunity to broaden other pre-existing concepts, more strictly related to the area of the industrial production system.

Michael Storper and Anthony Venables, in an article published in the *Journal of Economic Geography* in 2004, made an extensive argument about the role of buzz in the explanation of urban concentration. This concept was developed to describe the importance of face-to-face (F2F) contacts in metropolitan areas, and then extended to explain the agglomeration advantages of firms located in IDs and clusters. Bathelt et al. (2004) used the term buzz to describe a peculiar aspect of a form of industrial organization, the cluster, marking the transition from an urban to an industrial economics perspective. The global pipelines metaphor is used to illustrate the knowledge networks built upon formal distant business relationships. These relationships can, in fact, include the R&D collaborations of dynamic local companies (as spelled out by Powell, 1996; Owen-Smith and Powell, 2004) as well as the captive ties of a multinational with a subsidiary in the cluster (as spelled out by Bair and Gereffi, 2001; Humphrey and Schmitz, 2002; Cantwell and Iammarino, 2003).

The most-cited article, in absolute terms (considering the total citations), is "Clusters and the New Economics of Competition", published in 1998 by Michael Porter in the *Harvard Business Review*. The article explains how clusters, despite the era of global competition, foster high levels of productivity and innovation; in other words: locality still matters. In 2000, Porter published another highly cited article in *Economic Development Quarterly*, addressing the issue of the competitive advantages related to clusters and of the role of government in sustaining cluster upgrading through dedicated cluster policies.

It is worth noting that both the most-cited articles deal with the importance of proximity despite globalization. Alongside this perspective, Ann Markusen tackled the issue of the importance of "sticky places" in "slippery space," proposing one of the most-cited taxonomies of industrial spaces. In an article published in 1996 in *Economic Geography*, she introduced some new variables used to better classify

industrial agglomerations: the role of the state, the role of large firms, the firms' embeddedness, the structure of the major local industries, and the role played by the regional policy, together with a range of social welfare metrics. She proposed a theoretical taxonomy of industrial spaces, being inspired by the ID literature.

*The Journal of Economic Geography* in 2003 published the third most relevant paper, authored by Ron Martin and Peter Sunley. It is a conceptual paper, which tries to more properly define the cluster concept, and to analyze in detail its policy implications. Martin and Sunley (2003) are very critical about the business strategy approach of Porter, who proposes a vague definition of clusters and seems not to make any reference to the work done by the economic geographers on other related, but, unfortunately, less-fashionable concepts. As well explained by Martin and Sunley (2003: 9), the Porterian cluster metaphor is "highly generic in character, being deliberately vague and sufficiently indeterminate as to admit a very wide spectrum of industrial groupings and specializations (from footwear clusters to wine clusters to biotechnology clusters), demand-supply linkages, factors conditions, institutional set-ups, and so on." The cluster concept has been labeled as "chaotic," with a negative meaning.

In a similar vein, Ian Gordon and Philip McCann, in their article published in *Urban Studies* in 2000, consider the cluster as an umbrella concept. They admit that this formulation asks for a more fine-grained definition; they propose to distinguish between three ideal types of spatial industrial clustering. Unfortunately, the three models are not mutually exclusive, since a social network can be developed around a central firm or a group of firms, and thus resemble an industrial complex, or give rise to local rental values, as in the case of pure agglomeration. Their contribution confirms the impossibility to bundle the concept into one specific academic tradition, given its multifaceted nature. While Gordon and McCann (2000) adopted a structuralist approach in analyzing the mechanism of industrial clustering, Malmberg and Maskell (2002) focused on the cluster knowledge creation process along the vertical and horizontal dimension of interfirm cluster relationships. They describe the main features of the cluster building as a hybrid argument that lies between the Porterian and the ID approach, and finally acknowledge the absence of a satisfactory theory of the localized cluster, mainly because of the "conceptual elasticity" of the cluster concept.

Bill McEvily and Akbar Zaheer contributed heavily to celebrating the mutation of the cluster concept from an economic geography to a strategic management domain, writing a largely cited paper in *Strategic Management Journal*. Here the authors demonstrated through a structural equation modeling that the firm embeddedness in geographical clusters is an important source of variation in the acquisition of competitive capabilities.

## **5. The birth of the cluster concept: The founders**

### **5.1 Main backward-cited authors and works**

From the analysis of the backward-cited authors and works, we gain information on the founders of the cluster concept. Overall, the 46 articles cite 2066 different references, written by 1276 authors. A set of 437 works (that is, around 21% of the total backward citations) and 421 authors (around 33% of the total number of authors) has been repeatedly (more than one time) cited.

Table 4 presents the most backward-cited authors (BC\_AUT) and the most backward-cited works (BC\_WORKS).

On top of the list of the founders, we find, not surprisingly, Michael Porter, the father of the cluster concept. His books also rank among the most-cited works that we have examined. Together with these books, the list of BC\_WORKS includes other milestones of the cluster and district concepts, such as Paul Krugman, who has opened a new avenue of studies on agglomeration, and the works of Alfred Marshall



(1920). Also on the district concept, we find an article written by the Italian scientist who rediscovered and enriched the analysis of Marshall: the economist Giacomo Becattini. In his popular work, *Industrial Districts and Inter-firm Cooperation in Italy*, he published a chapter that presented a summary of his research on IDs and provided a first definition of this re-discovered socio-economic unit of analysis (Becattini, 1990).

The group of founders includes other authors who have coined new concepts that show some degree of relatedness to the cluster. One of the most important is Philip Cooke, who incorporated some pieces of the cluster and district literature within the broader concept of a regional innovation system; a concept that has gained great popularity both among the scientific community and among the EU policymakers. The related concept of a national innovation system (Lundvall, 1988; 1992) has also been widely cited. Besides the fathers of new concepts, the list of founders includes also a large group of geographers who have contributed either to the theoretical development of the cluster and district concepts or to their empirical application. The first in terms of citations received is Michael Storper, who has reflected upon the concept of an economic region and has elaborated the successful definition of "untraded interdependencies" (Storper, 1997, p. 5). These interdependencies, which are place-specific institutions that can fuel different paths of local development, also relate to the idea of "embedding" (Granovetter, 1985), which has also been widely cited. The list of founders also includes a number of sociologists such as Charles Sabel and Peter Dickens, who have further developed the concepts of embeddedness and that of social capital. Sabel's article on flexible specialization is, not surprisingly, among the small group of most-cited articles that we have listed in Table 4 .

Always in the field of geography or economic geography, a large bulk of research on the theme of the linkages between clusters and economic regions have been published by Allen J. Scott, Ash Amin, Meric Gertler, and AnnaLee Saxenian. Another group of geographers have focused on the knowledge implications of the cluster organization forms. Among the others, we recall Peter Maskell, Anders Malmberg, and Bjorn Asheim who have extensively explored the cognitive mechanisms featuring clusters and districts and their innovation capacity.

As for the most-cited articles or books, we find a number of contributions which focus on the theme of industry-specific spillovers as drivers of the agglomeration of economic activities. Among the most-cited works, we find the works written by the economists David Audretsch and Maryanne Feldman and Glenn Ellison and Edward Glaeser, who explores the motives for agglomerations, and the famous work written by Jaffe, Trajtenberg, and Henderson, which empirically proves the geographical concentration of knowledge by exploring the paper trails left by the knowledge spillovers. Another well-known innovation-related concept cited in the literature analyzed is that of "absorptive capacity" (Cohen and Levinthal, 1990), which explains the innovation differential among different IDs or clusters. The evolutionary approach put forward by Nelson and Winter (1982) is also widely cited.

INSERT TABLE 4 ABOUT HERE

## **5.2 The historical evolution of the cluster concept**

In order to trace the evolutionary trajectories of the cluster concept, we grouped the BC\_WORKS by year of publication (see Tab. 5). This analysis shows the theoretical background of the 46 most-cited articles (the disseminators). The number of citations received by each work informs us of the relative importance of each contribution. In so doing, the differences between subsequent time periods, together with the identification of the reference authors per period, gives us important information on two of the three main features of the liquid modernity of the cluster concept: multidisciplinary nature and global dimension. The analysis of the historical evolution of the concept connects our contribution to the recent debate on cluster

evolution (Iammarino and McCann, 2006; Boschma and Fornahl, 2011; Martin and Sunley, 2011) and cluster identity (Staber and Sautter, 2011).

Table 5 helps us in highlighting the roots of the cluster and district concepts, which, not surprisingly, date back to the seminal contribution of Marshall in 1920. The list of BC\_WORKS published before the '50s includes, together with Marshall (1920), a number of milestones such as the contributions of Adam Smith, Joseph Schumpeter, Alfred Weber, as well as a number of contributions coming from the side of economic geography on the location theory. The contribution of the economic geographers is relevant, also with reference to the subsequent periods.

During the '50s, the long-standing location economics tradition consolidates and François Perroux (1955) formulates the concept of "growth poles," which have had a strong influence both on the French school of the *milieux innovateurs* and on the Italian school of IDs. Other most-cited books or articles are those written by Penrose on the theory of the growth of the firm, or the Stiglerian reflection on specialization, which provides a ground for the explanation of the nature of the (external) economies of specialization.

From the literature of the '60s, the cluster concept borrows some reflections from Alfred Chandler on strategic organizational issues. In order to explain the nature of the learning processes taking place at the local level, the literature on clusters initially refers to the Arrowian processes of learning by doing. These are very common in the traditional sectors of the made-in-Italy goods, upon which most of the empirical research on IDs focuses. Most importantly, the Jacobian reflection on cities, and on what has been called Jacobs externalities, becomes a new point of reference.

In the '70s, it is the turn of the transactional theory of Williamson and the centrality of the network forms. In his original formulation of the ID, Marshall envisioned a locality of industry where the business is run by local entrepreneurs that are strongly embedded in local networks of production and exchange. In order to explain the particular features of these local inter-firm relations, the literature on clusters and IDs has made a large use of the framework set by the literature on transaction costs and social networks (see for instance Dei Ottati, 1991). The particular nature of the local transactions has been explained by referring to the role of local institutions, and to the concepts of "embeddedness" and "strength of weak ties," (Granovetter, 1973). The social and community dimension of the agglomeration economies is at the center of the reflections of Becattini, who in 1979 published a path-breaking article in an Italian journal of industrial economics and policy, which gave rise to the rediscovery of the ID. According to Martin (1999: 79), the Italian ID literature "has encouraged economic geographers to focus on the network of trust, cooperation, competition and governance that characterizes such areas."

In the '80s, Piore and Sabel (1984) launched a new industrial-technological paradigm, based on "flexible specialization", which is central for understanding the success of regional development, as spelled out by Scott (1988). In the same period, Nelson and Winter (1982) put forward their evolutionary theory of the firm, which is particularly suited for investigating the existence and functioning of local production systems. Analysis on the patterns of industrial development of large firms in the U.S. and in Europe, begin to confront and to contaminate with the analysis on small companies. Articles written by American economists and geographers have become a common reference. The European and American schools appear now as integrated, and thus contribute together to the development of a global dimension of the cluster concept.

The overall development of the cluster concept exploded in the '90s, thanks to the major contribution of Porter (1998, 1990), and has become a cross-disciplinary point of reference. During the '90s, the literature on clusters also intermingled with the contributions of the NEG, based on the work of Paul Krugman (1991), who constructed a theory of economic localization based on increasing returns. In particular after the contribution of the NEG school, a group of economists that focused on the investigation of the causes and

consequences of agglomeration. Special attention is given to the processes of R&D and knowledge spillovers (Jaffe et al., 1993; Audretsch and Feldman, 1996). It is in the '90s that the multidisciplinary nature of the concept becomes evident. Innovation studies become a new reference for cluster concept development: the geographical dimension of the phenomenon matches with the technological. Regions are perceived as the best geographical scale for an innovation-based learning economy (Cooke and Morgan, 1998; Malmberg and Maskell 1999).

The strong presence of Porter, Krugman, Saxenian, Storper, and other Americans in the '90s underlines the primacy of the U.S. not only in the realm of management studies, but also in the area of economic geography and sociology, where their contributions engage in a privileged dialogue with the northern European scholars, such as Cooke, Morgan, Malmberg and Maskell.

The success of the cluster as an organizational form of the new millennium is thus anchored on the important link between different disciplines (multidisciplinary), whose main representatives span over the US and Europe (global dimension), where the cluster poses the basis for its recent development also in the developing and emerging countries.

INSERT TABLE 5 ABOUT HERE

### **5.3 Co-citation analysis: A social network analysis approach**

In order to investigate more deeply the three main features of the liquid modernity of the cluster concept, and mostly its cross-disciplinary character, we conducted a social network analysis on the backward-cited works (BC\_WORKS). The set of 2066 backward-cited works can be viewed as a two-mode network where the citing articles are connected to the cited works. By transforming this two-mode network<sup>8</sup> into a one-mode one, we obtain a network that includes only the backward-cited works: two backward-cited works are here linked when they are cited by the same articles.

This kind of network leads us to the analysis of scientific communities (Crane, 1972; Verspagen and Werker, 2004) and the relationship between them. In fact, we consider that when two or more works are often cited together by the same sources, they form a cohesive group that can be interpreted as a scientific community. The relationship between communities (cross-disciplinary) is possible if there are members that have the property of multi-membership, belonging to more than one community and behaving as boundary spanners. We therefore apply an algorithm for the identification of particular communities (cohesive sub-structures) and boundary spanners (intercohesive nodes) from the network of backward citations.

In social network analysis, communities are groups of nodes that are more intensively connected to each other than to the rest of the network, identifying particularly cohesive sub-structures. As previously noted, in our network, "communities" of works may constitute meaningful groups of references that are somehow connected by the presence of a theme, an author, a concept that is linked to the literature on clusters. Communities in network analysis can be identified in several ways. The clique percolation algorithm (Palla et al., 2005), implemented in the Cfinder software, identifies groups of adjacent k-cliques (where a k-clique is a set of nodes each of which is connected to at least other k nodes): two k-cliques are adjacent if they have k-1 vertices in common. Each set of adjacent k-cliques is a community. The idea

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<sup>8</sup> This two-mode network is based on a two-mode matrix composed of 2066\*46 articles. The intersection of the rows and columns of the matrix tells us how many times an article has been cited by the 46 most-cited articles on cluster and district. This number will always be greater than 1, since we have already excluded the articles that are mentioned only once. The one-mode network is based on a one-mode matrix composed of 2066\*2066 articles. Two articles are here linked if they are cited by the same source(s).

underlying the identification of such communities is that, for a network sub-group to be cohesive, it is not necessary for all members of the group to interact with all others (as in a k-clique) but there can be cohesion even if some actors interact with only k-1 others.<sup>9</sup>

In social network analysis, boundary spanners can be discovered by looking at intercohesive nodes, which take parts in more than one community. This concept is similar to that of brokers. However, while brokers connect different communities but do not belong to any of them, an intercohesive node belongs to more than one community and hence belongs to different social groups at the same time. In our network of backward citations, intercohesive nodes are meaningful works that have been recognized as important, and cited, by several scientific communities. We apply the clustering algorithm to our data. As in any clustering algorithm, we define the criterion that allows us to choose the number of groups. We look for those communities that include at least 14 components (backward-cited articles); 14 is the threshold that allows us to identify communities that are composed of references cited by at least two different sources (among the 46 articles). In so doing, we identify communities that are not generated by the backward-citation made by a single article.

On the basis of this criterion, we identify ten communities of works, whose composition is displayed in Figure 4. Each community is composed of 15 works on average (minimum is 14 and maximum is 21), and it includes both intercohesive nodes (highlighted in black in Figure 4) and single-time participants (white nodes, belonging to a single community). Overall, there are 30 intercohesive agents. The strength of the link between works varies on the basis of the frequency of the co-citations: the more two backward-cited works are cited from the same sources, the more intense is the relationship that binds them.

The communities are identified in Figure 4 as groups of adjacent nodes.<sup>10</sup> The communities that are more clearly visible are those at the borders of the graph (the periphery). They are composed mainly of works that belong to only one community, and include a limited number of intercohesive nodes. Instead, the core of the graph is formed by intercohesive nodes that cross different communities, and give the pace of the cross-disciplinary feature of the cluster concept.

INSERT FIGURE 4 ABOUT HERE

Let us first focus on the periphery of the network. On the left side, the first is composed of works dealing with the topics of urbanization economies, authored mainly by economic geographers. Here we find the seminal contribution of Chinitz (1961) on the urban supply side, of Vernon (1960) on the metropolitan area of New York, and Jacobs (1960) on urban external economies. Large urban environments generate externalities from lower transaction costs (Williamson, 1975, 1985). Better matches in the labor market, availability of specialized machines in production, and skilled entrepreneurs reduce transaction costs and speed up economic development in cities and metropolitan areas. Proceeding clockwise, we find the community formed by Hirschmann, Arthur, Brusco, and Myrdal, economists who wrote on the externalities in the process of economic development, exploring the role of agglomeration and increasing returns in theories of economic growth. More to the right, the Nordic school of economic geography, led by

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<sup>9</sup> Palla et al. (2005) introduce an approach to analyze the main statistical features of interwoven sets of overlapping communities that form a network. Their basic assumption is that most of the actual networks are made of highly overlapping cohesive groups of nodes. Therefore, the existing methods used in order to find communities in large networks are not useful, since they find separated communities. Given that our exploratory analysis has revealed the presence of a high level of interconnections between the literature on clusters and that on industrial districts, we believe that the clique percolation is the method that best fits our data.

Malmberg and Maskell, worked on local processes of learning and innovation, fueled by networks of interconnected innovators, as in the case of the innovative milieus proposed by Maillat. Always moving clockwise, Capello and Camagni, inspired by the French school of the milieux innovateur, studied the processes of collective learning in innovative local systems. They are nodes of a community dedicated to evolutionary-based studies on innovation processes and innovation networks developing at the local scale (other members are Boschma, Von Hippel, Barabasi). This community is strongly linked to the following by the works of Lundvall and Asheim on national and regional innovation systems. The latter are the main focus of the bottom-right community, which includes Cooke, Asheim, Tödtling, Trippel and Doloreux. This community is mostly composed of European economic geographers. At the bottom of the network, we find the strategic management community, largely populated by Americans, whose work focuses on the analysis of firms' competitiveness, through the lenses of the resource-based view of the firm (Barney, Teece and colleagues are members). Finally, on the bottom left, Gertler, Sayer and Amin are members of a community focused on the spatial implications of Post-Fordism and flexible specialization. These peripheral communities are linked to the core of the network by boundary spanners, intercohesive nodes represented by cross-community contributions, which hybridize different disciplines in order to build a cross-disciplinary concept of clustering.

INSERT FIGURE 5 ABOUT HERE

The core is formed by strong linkages between intercohesive nodes, and it is shown in Figure 5, where the size of the nodes informs on their degree centrality (number of connections). The analysis of the degree centrality (DC) of the core nodes helps in understanding the logic behind their network position. Saxenian (1994) – DC = 97 – and Scott (1988) – DC = 91 – are the two contributions most largely cited by a variety of communities. They work as boundary spanners between different disciplines and geographical areas. The work on Silicon Valley and Route 128 by Saxenian lies at the intersection between economics, economic geography, business strategy, entrepreneurship, and innovation studies. Moreover, Saxenian connects European and American scholars focused on cluster research. Saxenian's book on the emblematic case of Silicon Valley became an international point of reference. The work on flexible production systems and regional development by Scott lies at the intersection between theories of economic growth and regional science. Scott's book on new industrial spaces in North America and Western Europe has a global reach (as promised by the title). Interestingly enough, both Scott and Saxenian elaborated their theory having in mind the model of Marshallian ID, more than that of the Porterian cluster.

The triad Scott – Marshall – Saxenian, well connected at the center of the network (both in Figure 4 and Figure 5), is key to understanding the cross-disciplinary aspect of the cluster concept. Without these nodes, the network would have collapsed in small isolated communities, where the two mainstream concepts of ID (in Europe) and cluster (in the US) would have never met.

## 6. Conclusions

This work aimed to give a rigorous picture of the origin and development of the cluster concept. We also attempted to offer an original interpretation of the mechanisms behind the rise and the progressive diffusion of the concept in a variety of disciplines from a pool of scholars that span over various countries. While many contributions stressed the negative qualities of the cluster concept, labeling it as "chaotic," we provide some evidence, through our bibliometric analysis, of its liquid modernity, which we consider at the very root of its international and interdisciplinary success. We maintain that the success of the cluster concept over time can be partially explained by its liquid nature, which allows adaptation to the challenges

of the second modernity and of globalization. Three important features characterize the liquid modernity of the cluster concept: *multidisciplinary* and *cross-disciplinary nature* and *global dimension*. In our view, these three aspects do not represent a threat, but an opportunity; they cannot be confined and reduced as responsible for its chaotic and fuzzy nature, indeed they contribute to make the concept evolutionary.

Our descriptive statistics based on a bibliometric analysis show the *multidisciplinary* character of the cluster concept, which proves to be a powerful concept that grows in multiple directions and generates new ideas and applications in a variety of fields. The study of the network of authors based on a backward-citation analysis shows the interconnections between different scientific communities, confirming the *cross-disciplinary* nature of the cluster concept. Finally, the concept is an example of a case of international success, thanks to its *global dimension*. The cluster, in fact, has proved an important tool for internationalization, being replicable and appropriable by diverse communities.

According to this perspective, the initial problem, evoked by many of the recent theoretical discussions, related to the vagueness of its boundaries, no longer exists. The vagueness can be seen not as a weakness but as a strength. The cluster concept has grown in the realm of political and industrial economy, in Europe, from neo-Marshallian origins. It spreads over, nurtured by the Italian experience on ID, in the business literature in the United States, and subsequently takes a prominent role worldwide, particularly thanks to the works of many North European and North American geographers and economic geographers who have investigated the local dimension of economic development and innovation.

Our work presents some limitations, due to the choice of the database, key words, and subject categories. Nevertheless, we believe that the results obtained are robust and give a complete and suggestive picture of the birth and rise of the cluster concept in liquid modernity.

The understanding of the origin and the natural development of the cluster concept provides a useful point of departure for designing the future, rejuvenating the concepts of clusters and IDs, and eventually pushing the conceptual trajectories toward a better fit to the liquid modernity. What will be the future directions of the concept? Will it expand in global reach? Will the number of disciplines interested in cluster studies increase or shrink? Will it survive the challenge of the liquid modernity or will it be substituted with another more liquid concept? These are only some of the possible ways to further develop the work we have started here.

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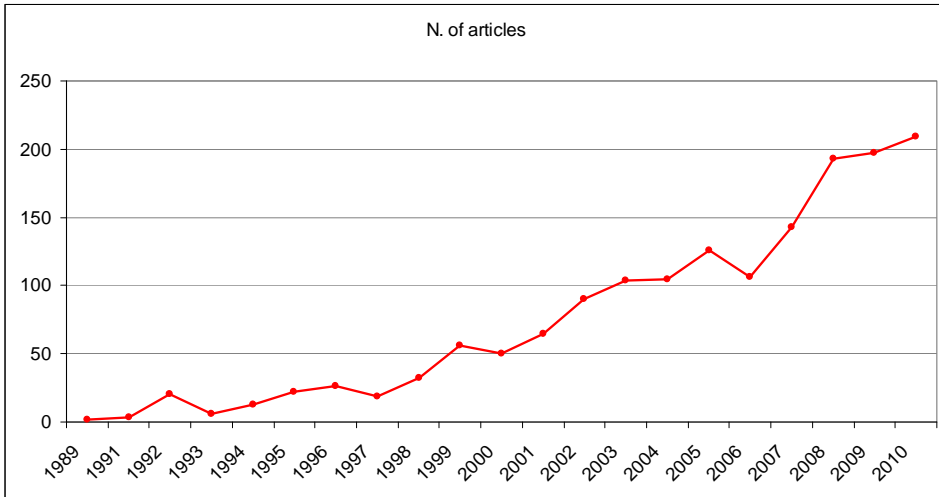
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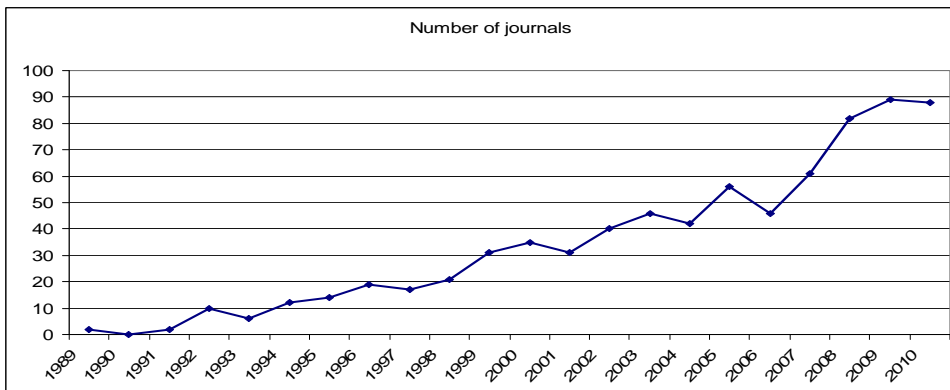
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Figure 1 – Number of articles on clusters in 1989-2010



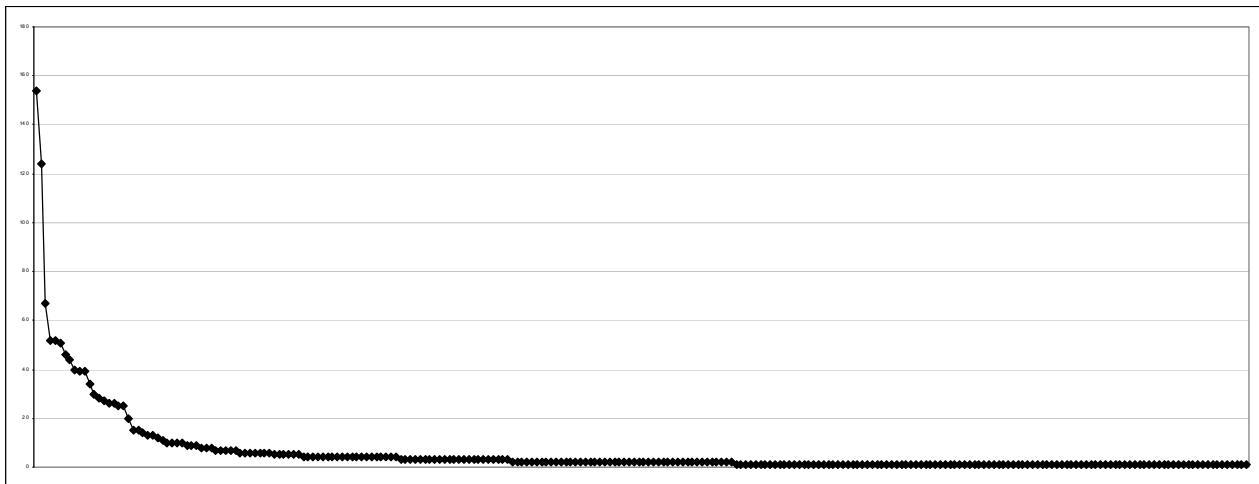
Source: Authors' elaborations based on ISI database

Figure 2 – Number of journals that published articles on clusters in 1989-2010



Source: Authors' elaborations based on ISI database

Figure 3 – The long tail distribution of journals in 1989-2010



Source: Authors' elaborations based on ISI database

Note to figure 3: The number of articles is displayed on the y axis. Labels identifying the 250 journals are not included for lack of space.

Table 2 – List of best-publisher journals by time frame.

<b>JOURNAL 1989 – 1999</b>	<b>ARTICLES</b>	<b>JOURNAL 2000 - 2010</b>	<b>ARTICLES</b>
REGIONAL STUDIES	<b>24</b>	EUROPEAN PLANNING STUDIES	<b>154</b>
WORLD DEVELOPMENT	<b>19</b>	REGIONAL STUDIES	<b>100</b>
RESEARCH POLICY	<b>11</b>	ENVIRONMENT AND PLANNING A	<b>59</b>
ECONOMIC GEOGRAPHY	<b>11</b>	ENTREPRENEURSHIP AND REGIONAL	
ENVIRONMENT AND PLANNING A	<b>8</b>	DEVELOPMENT	<b>52</b>
SMALL BUSINESS ECONOMICS	<b>7</b>	URBAN STUDIES	<b>46</b>
INTERNATIONAL JOURNAL OF URBAN		JOURNAL OF ECONOMIC	
AND REGIONAL RESEARCH	<b>7</b>	GEOGRAPHY	<b>44</b>
URBAN STUDIES	<b>6</b>	INTERNATIONAL JOURNAL OF	
IDS BULLETIN-INSTITUTE OF		TECHNOLOGY MANAGEMENT	<b>44</b>
DEVELOPMENT STUDIES	<b>6</b>	RESEARCH POLICY	<b>40</b>
CAMBRIDGE JOURNAL OF ECONOMICS	<b>5</b>	ECONOMIC DEVELOPMENT	
ECONOMIC DEVELOPMENT		QUARTERLY	<b>36</b>
QUARTERLY	<b>4</b>	TECHNOVATION	<b>33</b>
GROWTH AND CHANGE	<b>4</b>	ECONOMIC GEOGRAPHY	<b>28</b>
		TIJDSCHRIFT VOOR ECONOMISCHE	
		EN SOCIALE GEOGRAFIE	<b>27</b>

Source: Authors' elaborations based on ISI database

Table 3 – The top disseminators: most cited articles in 1989-2010

AUTHORS	YEAR	JOURNAL	YEARLY CITATIONS	TOTAL CITATIONS
Bathelt, H; Malmberg, A; Maskell, P	2004	PROG HUM GEOG	54,43	381
Porter, ME	1998	HARVARD BUS REV	46,31	602
Martin, R; Sunley, P	2003	J ECON GEOGR	43,63	349
Storper, M; Venables, AJ	2004	J ECON GEOGR	37,29	261
Porter, ME	2000	ECON DEV Q	28,45	313
Malmberg, A; Maskell, P	2002	ENVIRON PLANN A	26,11	235
Markusen, A	1996	ECON GEOGR	25,87	388
McEvily, B; Zaheer, A	1999	STRATEGIC MANAGE J	22,92	275
Gordon, IR; McCann, P	2000	URBAN STUD	21,36	235

Source: Authors' elaborations based on ISI database.

Table 4 – The top founders: most backward-cited authors and most backward-cited works.

Most cited authors (BC_AUT)	Total citations (>17)	Most backward-cited works (article, book chapter or book) (BC_ART)	Total citations (>8)
PORTER ME	66	KRUGMAN P 1991. Increasing Returns and Economic Geography, <i>Journal of Political Economy</i> , 99(3): 483-99.	24
STORPER M	52	PORTER ME 1998. <i>On Competition</i> , Boston: Harvard Business School	22
SCOTT AJ	45	SAXENIAN AL 1994. <i>Regional Advantage</i> . Cambridge, MA: Harvard University Press	21
KRUGMAN P	40	PORTER ME 1990. <i>The Competitive Advantage of Nations</i> , New York: Free Press	20
AMIN A	37	MARSHALL A 1920. <i>Principles of Economics</i> . London: Macmillan.	16
MASKELL P	31	JAFFE AB, TRAJTENBERG M, & HENDERSON R 1993. Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations, <i>Quarterly journal of Economics</i> , 577-598	15
SAXENIAN AL	30	SCOTT AJ 1988. <i>New industrial spaces</i> . London: Pion	15
COOKE P	29	AUDRETSCH DB & FELDMAN M 1996. R&D Spillovers and the Geography of Innovation and Production. <i>American Economic Review</i> , 86: 630-640	14
MARKUSEN A	26	STORPER M 1997. <i>The Regional World</i> . London: Guilford Press	14
MARSHALL A	26	COOKE P & MORGAN M 1998. <i>The Associational Economy</i> , Oxford: Oxford University Press	13
MALMBERG A	23	MALMBERG A & MASKELL P 1999. Localised Learning and Industrial Competitiveness, <i>Cambridge Journal of Economics</i> , Oxford University Press, 23(2): 167-85.	12
ASHEIM BT	22	PIORE M & SABEL CF 1984, <i>The Second Industrial Divide</i> . New York: Basic Books	12
GRANOVETTER M	22	STORPER M 1995. The Resurgence of Regional Economies, 10 Years Later, <i>European Urban and Regional Studies</i> 2(3): 191-221.	12
JAFFE AB	22	GRANOVETTER M 1985, <i>Economic Action and Social Structure: The Problem of Embeddedness</i> . <i>American Journal of Sociology</i> , 91: 481-510.	11
NELSON RR	21	MARKUSEN A 1996. Sticky Places in Slippery Space: A Typology of Industrial Districts. <i>Economic Geography</i> , 72(3): 293-313.	10
LUNDEVALL BA	19	COHEN WM & LEVINTHAL DA_90: Absorptive Capacity: A New Perspective on Learning and Innovation, <i>Administrative Science Quarterly</i> , 35(1): 128-152	9
DICKEN P	18	MASKELL P 2001. Towards a Knowledge-based Theory of the Geographical Cluster, <i>Industrial and Corporate Change</i> , 10(4): 921-943.	9
GERTLER MS	17	BECATTINI G 1990. <i>Industrial districts and inter-firm cooperation in Italy</i> , ed by F. Pyke, G. Becattini e W. Sengenberger, IILS, Geneva.	8
HARRISON B	17	ELLISON G & GLAESER E 1997. Geographic Concentration in U.S. Manufacturing Industries: A Dartboard Approach. <i>Journal of Political Economy</i> , 105(5): 889-927,	8
KEEBLE D	17	NELSON RR & WINTER SG 1982. <i>An evolutionary theory of economic change</i> . Cambridge, Mass.: Belknap Press	8
SABEL CF	17	SABEL CF 1989. Flexible specialisation and the re-emergence of regional economies," in P. Hirst and J. Zeitlin (eds.): <i>Reversing industrial decline? Industrial structure and policy in Britain and her competitors</i> Oxford: Berg	8

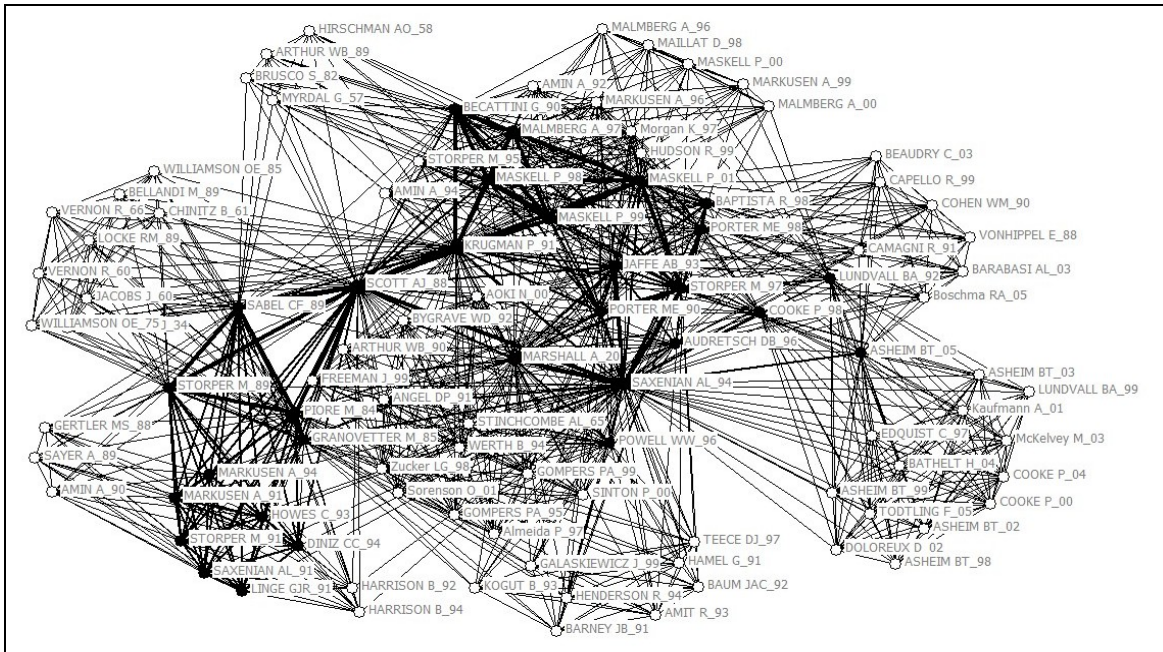
Source: Authors' elaborations based on ISI database.

Table 5 – Number of citations (cits) of the most backward-cited works, grouped by years of publication

pre – 1950	cits	1950s	cits	1960s	cits
Marshall A. 1920. Principles of Economics (Revised Edition ed.). London: Macmillan.	16	Penrose E.T. 1959. The Theory of the Growth of the Firm. New York: John Wiley & Sons.	3	Jacobs J. 1960. The economy of cities. New York: Random House	7
Coase R.H. 1937. The Nature of the Firm. <i>Economica</i> , 4(16): 386-405.	3	Hirschman A.O. 1958. The Strategy of Economic Development, New Haven, Yale University.	2	Arrow K.J. 1962. The Economic Implications of Learning by Doing. <i>Review of Economic Studies</i> 29: 155-173	6
Marshall A. 1927 Industry and Trade. Philadelphia: Porcupine Press.	3	Lösch A. 1954. The economics of location. Oxford: Oxford University Press.	2	Chandler A.D. 1962. Strategy and structure. Cambridge (MA): The MIT Press	4
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Source: Authors' elaborations based on ISI database.

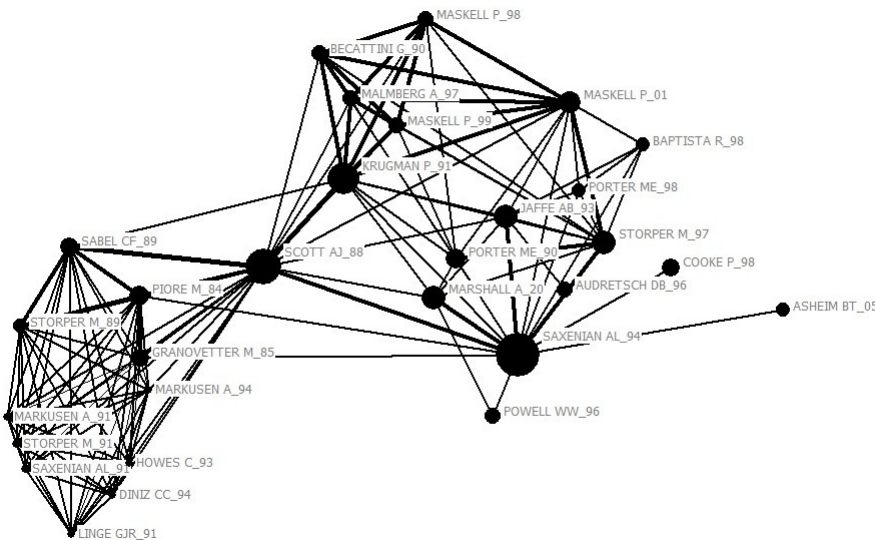
Figure 4 – The network of founders



Source: Authors' elaborations based on ISI database.

Note: Nodes are the backward-cited articles. White nodes belong to a single community, black nodes are intercohesive nodes. Lines are marked with different widths, depending to the intensity of the co-citation relation. The labels identify the name of the first author and the year of publication.

Figure 5 – The core of the network



Source: Authors' elaborations based on ISI database.

Note: The size of nodes informs on the degree centrality. The thickness of the lines depends on the frequency of co-citations. The labels identify the name of the first author and the year of publication.