A bibliometric review on innovation systems and ecosystems: a research agenda

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Abstract
Purpose The ecosystem perspective on innovation and business has emerged as the secret sauce of innovative organizations. While its theoretical foundations are premised on innovation system literature, the broad adoption of the ecosystem concept has resulted in conceptual ambiguity. This study tackles the ambiguous use of innovation ecosystem terminology and structures a conceptual frame for the field, identifying definitions of an innovation ecosystem and how the concept has been established in previous literature.
Design/methodology/approach This paper examines the ambiguous use of terminology by reviewing the literature with bibliometric coupling and co-citation analysis through which thematic differences in ecosystem literature were identified. The study gathered scientific publications from Thomson Reuters Web of Sciences Core Collection (n=4681) from 1990 to 2015.
Findings Six major bibliometrically coupled clusters were identified of which the three largest clusters are innovation system studies, regional innovation studies, and technological innovation studies. In addition, further analysis shows an emerging cluster that is focused on ecosystems that has its roots in eight seminal papers. This ecosystem research cluster includes seven sub-clusters such as innovation ecosystem studies, business ecosystem studies, and studies focusing on ecosystem development.
Research limitations/implications Our approach highlights that much of the recent ecosystem studies actually belong to previous, well-developed research streams. However, there is also a separate, emergent research stream that includes the innovation and ecosystem studies. The paper's research implications are connected with the research agenda for further studies presented at its conclusion.

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Originality/value While the literature on innovation systems and ecosystems is extensive, no studies have captured the emergence of the ecosystems approach and its relation to the systems of innovation literature.
Keywords Innovation, Strategy, Bibliometric, Ecosystems

Introduction

The ecosystem perspective on innovation and business has emerged as the secret sauce of innovative organizations. Ecosystems offer a systemic approach on innovation by focusing on how a network of actors create and sustain competitive advantage independently and as a participant in a system of actors who are not hierarchically managed (Jacobides et al. 2014), but rather act towards their own goals. The broad adoption of the ecosystem concept has resulted in conceptual ambiguity in what are meant by innovation ecosystems and how, if in any way, these differ from the existing systems approaches to innovation (Freeman 2004, Lundvall 1985). While to some, the construct represents a departure from the extant literature on innovation and strategic management of the governance of industrial and innovative effort (de Vasconcelos Gomes, et al., 2016), others have expressed a critical voice on the value the ecosystem approach adds to the already existing systemic treatment of innovation (Oh et al. 2016).

There is a plethora of published work taking an alternative, systemic approach on innovation. This body of literature constitutes several innovation systems streams such as national innovation systems (Freeman 2004, Lundvall 1992, Nelson 1993), regional innovation systems (Asheim et al. 2011, Cooke et al. 1997), sectoral and technological innovation systems (Carlsson & Stankiewicz 1991, Malerba 2002) – and on the level of corporate dynamics on clusters (Porter 2004), value networks (Li & Whalley 2002), innovation networks (Chesbrough & Rosenbloom 2002) and business ecosystems (Gawer & Cusumano 2002, Iansiti & Levien 2004*b*, Moore 1993). Several published papers have also reviewed these streams of literature. Studies have structured research in the field, for example, through bibliometric analysis of service innovation systems (Zhu et al. 2013), discussion papers on the research direction of innovation systems (Lundvall 2007), and literature reviews on science policy and innovation studies (Martin 2012), business ecosystems (Mäkinen & Dedehayir 2012), innovation ecosystems (de Vasconcelos Gomes, et al., 2016), regional innovation systems (Doloreux & Parto 2005), open innovation (West & Bogers 2014), and survey-based reviews on innovation systems (Fagerberg & Verspagen 2009).

Even with this extensive literature, including de Vasconcelos Gomes and colleagues' (2016) detailed examination, no studies have captured the emergence of the ecosystems approach, particularly in relation to the innovation systems literature, which establishes the core theoretical premise of innovation ecosystems (Oh et al. 2016). In response to Ritala et al.'s (2017) recent call for more refined conceptualization of the ecosystem notion, this study tackles the ambiguous use of innovation ecosystem terminology and structures a conceptual frame for the field, identifying definitions of an innovation ecosystem and how the concept has been established in previous literature. The work offers a view on the foundations of innovation ecosystem literature, enabling scholars to have a stronger and more holistic viewpoint of the systems approach to innovation.

We focus on a single research question; what are the shared theoretical foundations of innovation ecosystems and innovation systems literatures? To answer this question, our study follows the literature review approach, based on a robust empirical bibliometric analysis followed by a qualitative analysis of the core documents. Using well-established bibliometric methods, bibliographic coupling and co-citation analysis, we identify thematic differences within ecosystem literature and highlight points of departure from the extant literature. The bibliometric analysis is in turn used as a basis for a qualitative analysis of the core literature, which is used to create the narrative for this study.

Related key concepts

Inter-organizational networks that cultivate innovation have been studied through different theoretical lenses. For instance, when we are concerned with the immediate business environment of a given organization, with an emphasis on the "geographic concentrations of interconnected companies and institutions in a particular field" (Porter 1998), we may profit from looking through the lens of 'clusters'. When the focal question is on the value that is co-created by a myriad of actors, irrespective of their geographical locations, we may alternatively opt to study innovation through the 'value networks' framework(e.g. Maine et al. 2012, Overholm 2015). Furthermore, when our intention is to underline the contribution of governance, universities, and the industry in creating innovation and economic development, we may view such networks as 'innovation systems'(Carlsson & Stankiewicz 1991, Cooke et al. 1997, Freeman 2004, Malerba 2002). And the "business ecosystem" perspective is insightful when our intention is to examine the cooperative and competitive activities of multiple organizations, that belong to different industries (e.g. Moore, 1993; 1996). These and similar conceptual models provide stylized perspectives on the complex inter-organizational network phenomenon, each offering different advantages to the comprehension of real-world issues. Inevitably, these perspectives overlap and some may be considered as fully subsuming the other. Below we provide a brief overview of a few major conceptualizations of inter-organizational networks.

Clusters as predecessors

Clusters are "critical masses – in one place – of unusual competitive success in particular fields" (Porter 1998). Examples of such clusters include the Silicon Valley, Boston's Route 128 corridor, North Carolina's Research Triangle Park, Hollywood, Wall Street, and the Californian Wine Cluster (e.g. (Bresnahan et al. 2001, Porter 1998)). The concentration of organizations embedded in these geographic regions include suppliers of products and services, providers of complementary products and services, customers, governmental institutions, and providers of infrastructure, research, education and technical support (Porter 1998). Given the large constellation of actors that define them, clusters often emerge as cross-industry entities, harbouring collaboration as well as competition among their constituents (e.g. Baglieri et al. 2012)). These defining characteristics reveal some level of conceptual overlap with the notion of regional innovation systems.

Clusters are important for regional competitiveness and economic performance, with the co-location of businesses increasing the productivity of companies, driving innovation, and stimulating the formation of new businesses (e.g. Casper 2007, Porter 1990). Cities across the globe are increasingly interested in cluster-based economic development strategies and the factors that lead to their success. Indeed, the locus of academic and policy interest has hitherto centred on the artificial creation of entrepreneurial clusters, such as the imitation of Silicon Valley as a prolific exemplar Bresnahan et al. (2001).

Notwithstanding this focus, the emergence of many contemporary clusters in different regions and sectors, as well as the formation of the Silicon Valley cluster itself in the 1960s, suggest that clusters come into existence equally through natural processes, without the direct intervention of policy. In this manner, Casper (2007) underlines the futility of direct government policy, given the naturally emergent labour market mobility that has initiated successful cluster formation. In a comparative study of two maritime regions in Norway, Karlsen (2005) similarly shows the important roles of socio-cultural differences and path dependence in the manifestation of contrasting cluster formation trajectories. Nevertheless, evidence suggests that some cluster contexts may benefit from active governance. In their study of the granite-mining cluster in Brazil, Silvestre & Neto (2014) support this position by arguing that BOP (Bottom of the Pyramid) clusters, by comparison to others, face additional barriers to technology diffusion that is catalysed by inadequate coordination and policy.

Value networks: wider view on value creation

The value chain of a given firm is part of a larger system of related and interdependent value chains, which can be collectively referred to as a value network (Li & Whalley 2002, Lusch et al. 2010). While the value chain is characterized by a linear flow of value in “dyadic relationships from raw material providers to manufacturers to suppliers to customers”, the value network is a multilateral construct, with a “myriad of B2B, B2C, and C2C relationships” (Basole & Rouse 2008).

The value network is a complex, interconnecting web of direct and indirect ties among a group of actors (potentially spanning the globe), which create (or co-create) value for customers through the products and services that are manufactured (Basole & Rouse 2008, Lusch et al. 2010). The network can also be seen as a nested, hierarchical system of manufacturers and markets, which produce as well as purchase the corresponding nested hierarchy of components, products, and holistic systems (Christensen & Rosenbloom 1995, Christensen 1997). The value generated by the network refers to the economic, technical, service and social benefits derived from the holistic product acquired by the customer. According toDosi (1982), this value is premised on the dominant technological paradigm in the system of use in the value network. Hence, the technological paradigm and the corresponding technological trajectories help define the extent of a given value network, and thereby the context within which firms exist, by engaging in competition, and providing solutions to customers’ needs and problems (Christensen 1997, Newey & Zahra 2009).

The actors constituting the value network originate from a range of industries, and include component and sub-assembly suppliers, distributors and retailers, as well as third-party product suppliers such as competitors and logistics providers (Dedrick & Kraemer 2005). The core capabilities of these organizations are complementary, and are integrated to deliver holistic value for the customer. At the same time, by coming into partnership, organizations share the ownership of the costs and risks associated with developing and marketing products and services.

The degree of partnership between network members can range from arm's-length interchanges to integrated operations. Unlike in value chains, where value is created from the level of satisfaction a customer derives from a given product, it is through these transactions and exchanges among network partners that value is created in value networks (Fjeldstad & Ketels 2006, Stabell & Fjeldstad 1998). Aided by these interactions, the process of value creation often involves the conversion of one type of value – for instance, intangible assets such as the knowledge obtained from basic scientific research – into tangible outputs such as components and sub-assemblies, or final products and services (Tian et al. 2008).

Different views on innovation systems

This body of literature studies technological innovation from a systemic view, centering on the generation, diffusion, and utilization of technology within a particular context. The focus of this research stream is on the interconnectedness and relationship among different agents of innovation, manifest in the communication between and transfer of technology and knowledge among different systemic actors (Carlsson et al. 2002). In this manner, the technical elements of the system are assigned little emphasis, while the social aspects of the system take front stage. Innovation systems have been studied in the literature with respect to different geographical or physical contexts; as national, regional, sectoral, and technological systems of innovation.

National innovation systems (Freeman 2004, Lundvall 1992) establish the boundary of the system to align with the boundary of the nation under analysis. The roles of firms, institutions (e.g. universities and other research institutions) and the national government in motivating technological innovation are the main focal areas of this research stream. In this light, dong Lee & Park (2006), for instance, demonstrate the significance of government financial support in the early stages of R&D in their analysis of the Korean electronics and mechanical industries, while Baglieri et al. (2014) underline the difference in technology policies enacted by the governments of China (pursuing an anchor-tenant model) and Japan (driving an industry-oriented model) in promoting their respective nanotechnology innovation systems.

Regional innovation systems study innovation systems from a sub-national point of view, in an effort to reduce the complexity and diversity of studying innovation systems at a national level (Cantner et al. 2010, Cooke et al. 1997). The aim of regional studies is to understand how different sectors or clusters, within a particular geographic (e.g. culturally or administratively delineated) region, interact with regional governance, innovation support infrastructures, and the national and global levels of innovation (Fernández-Esquinas et al. 2016, Melkas & Harmaakorpi 2008, Trigkas et al. 2012). The importance of the regional study of innovation systems spawns from the fact that specific regions possess a certain social order, culture, and institutional routines, as well as norms and values, which impact the manner of interaction among actors(Buesa et al. 2006, Cooke et al. 1997). Studies focusing on regional spaces highlight for example the role of critical mass (Georghiou et al. 2014) and other local conditions (Majava et al. 2016) that allow for a region to be competitive.

A sectoral innovation system, on the other hand, refers to "a set of products and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products" (Malerba 2002), within certain sectors or industries. The agents, here, may be individuals and organizations at various levels of aggregation, the interaction (e.g. communication, exchange, co-operation, and competition) of which is shaped by institutions . Importantly, the study of sectoral systems of innovation centres on the notion that different industries or sectors operate under different technological regimes, rather than focusing on the interdependence between different industries (Breschi & Malerba 1997, Carlsson et al. 2002).

Finally, technological innovation systems are dynamic networks of agents, which interact to create, diffuse, and utilise technology inside a particular economic or techno-industrial area (Carlsson & Stankiewicz 1991). Technological systems of innovation can be relatively large-scale international networks, whereby borders extend beyond a single national system, or relatively small-scale local systems such as the Silicon Valley (Carlsson & Stankiewicz 1991).

Value creation in business ecosystems

The notion of a business ecosystem, as first proposed by Moore (1993) and later elaborated by other scholars, offers yet another theoretical lens through which the phenomenon can be studied. Like many concepts that are used pervasively in the management literature (and the social sciences in general), the business ecosystem is an analogy taken from the natural sciences. Hence, the essential characteristics of the business ecosystem conceptualization of inter-organizational networks, and aiding its differentiation from already existing frameworks, are its ecological science origins. The latter enable us to observe organizations positioned in complex networks to perform particular functions, akin to species that reside in natural ecological systems. Viewed in this way, the business ecosystem will constitute populations of different species, whereby competition will be anticipated within populations, whilst symbiotic relationships will be anticipated between populations.

Much of the related literature has aimed to understand the dynamics of competition in business ecosystems, exploring 'predator and prey' relationships (Iansiti & Levien 2004*a*) or assuming an internal perspective through the dynamic capabilities framework (Teece 2007). A notable percentage of these contributions focus on the decisions actors make to share knowledge or provide value in ecosystems (Jacobides & Tae 2015, van Gils & Rutjes 2017), but also on the role of new entrants towards innovation (Spender et al. 2017).

This paper centres on the overlap that exists between the conceptualization of inter-organizational networks such as innovation systems and innovation/business ecosystems, as recently addressed by Oh et al. (2016). Scholars have attempted to define the latter as collaborative networks of firms that create value through the development of new products and services (e.g Adner 2017), at times emphasizing the presence of an interlocking platform that brings these actors together (Li 2009). Despite the obvious overlap that exists between the two constructs given their ‘systems’ focus (Oh et al. 2016), innovation ecosystems can be argued to be distinct from innovation systems on account of their lack of confinement to a particular nation, geographic region, or industry. Nevertheless, the theoretical foundations, the point of departure from existing literature, and the definition of innovation ecosystems remain little understood and subsequently forms the focus of this study.

Materials and methods

The research follows a design whereby two datasets and methods are used to answer the research question stipulated above. One of the datasets focuses on the broader view on innovation and business systems while the other on innovation and business ecosystems. Methodologically, co-citation analysis is used to understand the origins of both datasets, and bibliographical coupling is employed to provide a contemporary view. The process, further described below, is visualized in Fig 1.

Overview

The set of scientific publications to be used in our review was downloaded from the Thomson Reuters Web of Science database in December 2015. The first publication in the dataset is from 1990, thus providing data that temporally spans from 1990 until 2015. First, a dataset was compiled by searching with one of the terms ”innovation ecosystem”, ”business ecosystem”, ”innovation system”, or ”business system” in either singular or plural form being used in the title, abstract, author keywords or the Thomson Reuters Web of Science enhanced metadata Keywords Plus field. The search was limited to articles, book chapters and proceedings papers. This first dataset (Dataset1) consists of 4681 publications and was used to explicate the shared knowledge bases between the streams of innovation systems literature, and to highlight the point of departure for ecosystems research. By approaching the analysis with a focus on “systems” we aim to capture the long–standing scholarly work on systems of innovation and business – arguing that the ecosystem approach is a particular systems approach. Dataset1 enables us to show the structure of the broader systems literature and clarify the departure point of the ecosystem literature.

To specifically understand the structure of the ecosystems approach with greater depth, the second dataset was compiled by limiting the search only to ”innovation ecosystem” or ”business ecosystem”. This second dataset (Dataset2) comprises 427 publications. As shown in Table 1, the majority of documents in the two datasets are articles and proceedings papers, with the latter comprising close to two thirds of Dataset2.

TABLE 1
Document types and numbers for each dataset.

Dataset 1			**Dataset 2**		
Type	Count	%	Type	Count	%
Article	2521	51.44 %	Article	161	37.01
Proceedings	2370	48.36 %	Proceedings	268	61.61
Book chapter	8	0.16 %	Book chapter	5	1.15
Review	2	0.04 %	Review	1	0.23

When examined temporally, both datasets indicate a steady increase in numbers from the early 1990s with a strong surge in 2007 (Fig 2). The increase in publication volume is significant if compared with the overall yearly increase in science publishing (2% yearly). Since 2007, the numbers of articles included in the analysis has remained fairly stable. We attribute the decrease in article numbers in 2015 to the time of our data collection, which was undertaken prior to the completion of that year (i.e. in December 2015). Even with recent additions to the ecosystem debate, the literature gathered represents a large collection of the central papers which create the foundations for future research. The dataset is significant in size and in temporal range, thus allowing in-depth analysis of the historical foundations and contemporary pathways of ecosystem research.

The articles in both datasets are relatively concentrated in a few data sources. For Dataset1, the 10 highest citing sources account for nearly 17% of publications in the dataset (see Table 2), while for Dataset2 this concentration is even higher, at 30% (see Table 3). We also note a significant thematic difference in the titles of publication sources when comparing Tables 2 and 3. In Dataset1, we predominantly see highly ranked journals from a number of fields, such as policy, technology management and bibliometrics, with the exception of Lecture Notes in Computer Science, an outlet that publishes papers from scientific conferences and those focusing on mobile and software ecosystems. By comparison, Table 3 shows a limited number of journal titles, with conference proceedings forming the majority. This finding may suggest that the field is continuing to grow, under the assumption that ground-breaking or early scientific research is generally published in conferences prior to other sources such as journals.

Bibliographic coupling and co-citations

To analyse the datasets, two separate bibliometric methods were used to structure the literature. The methodological differences of the approaches are seen in Fig 3. Bibliographic coupling (BC) was firstly used to study the shared intellectual background of the publications (Kessler 1963). BC is a well-established approach for measuring the shared intellectual background among documents, where a strength value is calculated between each document in the sample based on the number references the two documents share. Kessler (1963) elaborates that "...a single item of reference shared by two documents is defined as a unit of coupling between them" and if multiple items share the same reference, it increases the weight of the coupling. The BC approach suggests that the more

TABLE 2

Ten highest citing sources for Dataset1.

Title	Count	%
Research Policy	167	3.57
European Planning Studies	130	2.78
Technological Forecasting And Social Change	79	1.69
Lecture Notes in Computer Science	78	1.67
International Journal of Technology Management	65	1.39
Scientometrics	59	1.26
Energy Policy	57	1.22
Technovation	56	1.20
Regional Studies	55	1.18
Technology Analysis and Strategic Management	48	1.03

shared references, the stronger the theoretical foundation shared by the two documents.

Glänzel & Czerwon (1996) showed that BC highlights hot topics and, with a longer analysis period, underscores topical citing papers. BC is capable of linking documents with similar research focus (Jarneving 2007), creating the knowledge structure of a field. By calculating the BC strength for all the documents in our datasets, we were able to cluster and visualize networks of shared knowledge. These calculations were made using documents as the unit of analysis and by employing a full counting method.

Secondly, we used co-citation (CoC) analysis (Small 1973) to identify the shared background of the publications in our datasets. In CoC, two documents are co-cited if there are one or more documents that cite both articles. The weight of co-citation is based on the count of articles that co-cite the two documents. CoC creates a network of cited documents rather than linking the documents in the dataset (Garfield 2001). The CoC analysis was made by using the cited references as the unit of analysis. Full counting was used for these calculations. Using BC and CoC analysis in parallel allows us to structure both the theoretical background and the current challenges of research. In the analysis, CoC serves as a historical view of the origins and BC as a "contemporaneous representation of knowledge" (Youtie et al. 2013).

We used the VOSviewer software (van Eck et al. 2010) to pre-process the WoS data and calculate the bibliographic coupling and co-citation weights. VOSviewer also transformed the original data into network data, created on the basis of bibliographical links between the documents. The network data was imported to Gephi software for further analysis. Using the OpenOrd layout algorithm (Martin et al. 2011) embedded in Gephi, we visually analysed the proximities among documents or references. The visual analysis was supported by the tabular information extracted and clustering done using the VOSviewer software. Key metrics were also extracted for each network cluster, namely the count of documents in each cluster, cluster density, cluster degree and document eigenvector centrality.

Elaborating on the key metrics used, density is a measure of the interconnectedness of a network. The density score is the ratio of the number of connections in the network

TABLE 3
Ten highest citing sources for Dataset2.

Title	Count	%
IEEE International Conference on Digital Ecosystems and Technologies	43	10.07
2007 Inaugural IEEE International Conference on Digital Ecosystems and Technologies	27	6.32
Lecture Notes in Business Information Processing	9	2.11
2008 2nd IEEE International Conference on Digital Ecosystems and Technologies	9	2.11
International Journal of Technology Management	7	1.64
International Federation for Information Processing	7	1.64
IFKAD 2014 9th International Forum on Knowledge Asset Dynamics	7	1.64
Procedia Social and Behavioral Sciences	6	1.41
Harvard Business Review	6	1.41
Technovation	5	1.17

to the total possible number of connections. In a totally connected network the density is one. The degree represents the number of direct connections that a node has. The cluster's degree is the average of the degree values of nodes in the cluster. Both the degree and density give indications of the interconnectedness of the network. Eigenvector centrality measures the influence of a node in the network. The eigenvector centrality of a node measures a relative score based on the fact that connection to high-scoring nodes is more valuable. Central documents are identified, not only by their degree, but also by evaluating how valuable the connections of the node are. For each main stream of ecosystem literature, five publications were selected for qualitative evaluation. Documents were selected by ranking documents based on citation scores and selecting the five highest in each cluster, excluding review-type documents.

The clusters in different phases of analyses are labeled according to the following procedure. Through individual reading of the documents in each cluster, the authors independently determined labels, and then worked towards a consensus until agreement was reached on the label for a particular cluster. In the labeling process, the researchers used all documents in a cluster and could take advantage of the network measures to evaluate the weight of individual documents.

Results

Systems of Innovation

From the total of 4,681 documents comprising Dataset1, we analysed 3,652 connected documents, excluding 1,029 documents that had limited connections to the core sample. In our analysis, we created a network constituting 3,652 documents as nodes and 664,242 edges connecting these nodes. The BC analysis revealed ten clusters of literature, six of which are substantial in volume, comprising over 300 documents. The main streams of research identified through a qualitative evaluation of the clusters were platforms (n=1,172 documents), triple-helix (n=526 documents), regional clusters (n=522 documents), national innovation systems (n=465 documents), technology innovation systems (n=405 documents), and organizational capabilities (n=315 documents). The network statistics for the clusters are seen in Table 4. Cluster number 4, on national innovation systems, is the densest cluster, which can also be viewed as the most coherent thematic cluster. By contrast, Cluster 1 is the sparsest cluster with a significant volume of isolated documents. The low degree and density values suggest there to be underlying patterns and outliers in the cluster, which may warrant the identification of sub-labels within this highly aggregated label, through qualitative evaluation.

TABLE 4
Descriptive values for the six major BC-based clusters with researcher assigned labels. The full document clustering is available as Appendix I.

#	Count	Degree	Density	Top BC-weighted	Label
1	1,172	17.697	0.015	de Jong & Kalvet (2010), Savory & Fortune (2015), Lehtola & Ståhle (2014)	Platforms
2	526	42.629	0.081	Leydesdorff (2010), Huggins & Johnston (2008), Ivanova & Leydesdorff (2015)	Triple–Helix
3	522	101.757	0.195	Liu & Rong (2015), Belussi et al. (2010), Hervas-Oliver et al. (2012)	Regional clusters
4	465	189.894	0.409	Ylinenpää (2009), Kyrgiafini & Sefertzi (2003), Balzat & Hanusch (2003)	National innovation systems
5	405	67.052	0.166	Bleda & Del Rio (2013), Nilsson & Moodysson (2015), Meelen & Farla (2013)	Technology innovation systems
6	315	31.61	0.101	Coenen et al. (2004), Hage & Hollingsworth (2000), De Laurentis (2006)	Organizational capabilities

Moving from the contemporary view to look at highly referenced articles, we employed CoC analysis to analyse theoretical origins. This analysis showed that Dataset1 has in total 101,578 cited references. This volume of references is too large for any practical analysis of the key theoretical origins. By setting a requirement that the minimum number of citations of the cited reference should be at least 20, the analysis was limited to 375 cited core references that meet the threshold. The analysis of citation linkages resulted in a network with 375 cited references as nodes and 32,414 edges connecting

TABLE 5
Descriptive values for the six major CoC-based clusters with researcher assigned labels.The full document clustering is available as Appendix I.

#	Count	Degree	Density	Top eigenvector centrality	
1	126	48.262	0.772	Cooke et al. (1997), Porter (1990), Braczyk et al. (1998)	Regional clusters
2	83	25.651	0.626	Lundvall (1992), Nelson (1993), Edquist (1997)	National Innovation systems
3	66	20.076	0.618	Cohen & Levinthal (1990), Nelson & Sidney (1982), Powell et al. (1996)	Dynamic capabilities
4	60	22.95	0.778	Carlsson et al. (2002), Malerba (2002), Carlsson & Stankiewicz (1991)	Sectoral and/or technological innovation systems
5	40	13.35	0.685	Etzkowitz & Leydesdorff (2000), Kline & Rosenberg (1986), Gibbons (1994)	Triple-Helix

the cited references. The graph density is observed as 0.462 with an average degree of 86.437. In turn, clustering the network resulted in five clusters, as elaborated in Table 5.

The largest cluster, visualized in Fig 4 in blue, highlights the core literature on regional cluster policies. Central to this blue cluster are the works of Cooke extending the national innovation systems concept to a subnational level. Cluster 2, highlighted in purple, is the national innovation system stream driven by Lundvall (1992) and Nelson (1993). Cluster 3, shown in red in Fig 4, highlights the company level focused literature in the networks. Highlighted by the documents central to the network, the literature focuses on company capabilities to adapt, collaborate and innovate. In addition to the dense centre of the nodes, this cluster has two isolated areas seen at the bottom of Fig 4. The nodes highlighted in the orange circle focus on varieties of capitalism while the nodes highlighted in the green circle focus on ecosystems. This suggests that there is a departure point in Cluster 3, from which two lines of thought diverge; one around varieties of capitalism and the other on ecosystems. The two outlier clusters are interesting in that they do not have significant linkages between them, despite the linkages between Teece (2007) and other authors.

The ecosystem literature, as structured in the green highlighted area in Fig 4, consists of eight key publications. Moore's (1993,1996) seminal works on the predator and prey relationship in competition is central to this structure of eight publications. With a significant time difference, other articles focus on platform dynamics and leadership (Gawer & Cusumano 2002) and the role and advantage of keystone actors in ecosystems (Iansiti & Levien 2004*a*,*b*). Adner (2006) meanwhile highlights the role of complementarities and the fact that ecosystems "allow firms to create value that no single firm could be able to create alone". In a similar sentiment, Teece (2007) emphasises the open regimes of trade, investment and knowledge that require companies to be able to morph and absorb new information.

Cluster 4, in light green on the upper right region of the figure, departs from the national innovation systems literature to focus on sectoral and/or technological innovation systems. Central to the cluster is the literature by Carlsson (e.g. Carlsson & Stankiewicz 1991), describing the nature and structure of technological systems that are cross-national. And the focus of Cluster 5, shown in green, is the Triple-Helix concept (Etzkowitz & Leydesdorff 2000). Interestingly, this cluster appears to contain publications that are not clearly in line with this central document.

Ecosystems

We next analyzed Dataset2, which comprises the literature specifically mentioning ecosystems. The results show that 83.6% of Dataset2 records belong to the platform cluster and equally distributed among the other clusters identified for Dataset1. From this we may draw the conclusion that the broader theoretical background of the ecosystem literature is drawn from the platform cluster identified from Dataset1. This directs our attention towards analysing the difference in the theoretical foundations of the two datasets.

Analysing Dataset2 with BC, we identified the largest set of connected items to be 329 documents from the total of 427 that formed the dataset, thus excluding some 98 documents that had limited connections to the core sample. This reduces the sample of documents to create a network where the remaining 329 documents are nodes, connected by 10,024 edges. The network has an average degree of 30.5 and a density of 0.19. In turn, clustering the BC network resulted in 17 clusters. The descriptive statistics for the network and the seven most prominent clusters are shown in Table 6 with their given descriptive labels.

The CoC analysis provides the historical view of the field, and showed that Dataset2 has a total of 10,115 cited references. Again, this volume of references is too large for any practical analysis of the key theoretical origins. By setting a requirement that the minimum number of citation of the cited reference should be at least 3, we limited the analysis to 375 cited references that meet the threshold. From the 375 documents, the largest set of connected components consists of 374 and thus we omit only one isolated document from further analysis. The analysis of citation linkages resulted in a network with 374 cited references as nodes and 10,673 edges connecting the cited references. The graph density is 0.15, with an average degree of 28.6, and clustering the network resulted in nine clusters, as shown in Table 7.

The CoC analysis identifies that the literature draws from nine different streams of literature; 1) dynamic capabilities, 2) co–opetition, 3) networks, 4) platform markets, 5) case studies on platforms, and four additional clusters with less than 30 co-cited documents in each, rendering them difficult to label as coherent areas. Cluster 1 on dynamic capabilities refers to the stream of literature focusing on organization capability to purposefully adapt its resource base (Teece et al. 1997). The co–opetition literature meanwhile draws from the analysis of firm behavior that is based on cooperative competition. Networks in turn focus on the analysis of interdependent relationships among firm actors, while clusters 4 and 5 focus on platform markets. Cluster 4 is founded in the literature of Two-sided markets (e.g. (Rochet & Tirole 2003), but then extended to platform businesses (e.g. (Gawer

TABLE 6
Descriptive values for the network identifying seven major BC-based clusters. The full document clustering is available as Appendix I.

#	Count	Degree	Density	Top BC-weighted	Label
1	55	13.982	0.518	Gawer & Cusumano (2014), Brusoni & Prencipe (2013), Adner & Kapoor (2010)	Innovation ecosystem
2	43	3.070	0.146	Hellström et al. (2015), Li (2009), Faucheux & Nicolaï (2011)	Knowledge ecosystem
3	42	4.310	0.210	Pilinkienė & Mačiulis (2014), Shang & Shi (2013), Zhao & Liu (2009)	Digital business ecosystem
4	32	9.562	0.617	Weber & Hine (2015), Kang et al. (2011), Zhang et al. (2008)	Business ecosystem
5	28	7.250	0.537	Kukk et al. (2015), Yue (2013), Scarlat (2007)	Case studies on ecosystems
6	27	2.630	0.202	Karhu et al. (2014), Gao et al. (2013), Gatautis & Audrone (2014)	Platforms, architecture and design of ecosystems
7	27	13	1	Rong, Wu, Shi & Guo (2015), Basole & Karla (2011), Hu et al. (2014)	Development of ecosystems

& Cusumano 2002, Iansiti & Levien 2004*b*), seen in Appendix I). Meanwhile, Cluster 5 is focused on case studies, with a strong platform focus. The method arguably places much weight on a few case study methods references (e.g. (Yin 2009, Eisenhardt 1989))which are central to the formation of this cluster.

As shown in 5, visualizing the co-citation network for ecosystem research, a more coherent network structure can be seen with stronger links between clusters compared to Dataset1. In this figure, the clusters are hard to partition clearly, and the structure of the network is defined by a few key documents with a high co-citation value.

Discussion

Streams of systems of innovations research

A vast amount of practical and scholarly attention has been and is still being paid to different types of ecosystems. Largely these discussions go back and forth without precise definitions and therefore the concept of ecosystem has been accused of being one more buzzword without a real meaning. However, this paper shows to what extent this conceptual ambiguity truly exists in scholarly works.

TABLE 7
Descriptive values for the identified theoretical background clusters in Dataset2. Four clusters with under 30 co-cited documents are excluded. The full document clustering is available as Appendix I.

#	Count	Degree	Density	Top eigenvector centrality	Label
1	95	12.305	0.262	Teece et al. (1997), Zollo, M., Winter (2002), Zahra et al. (2002)	Dynamic capabilities
2	62	20.919	0.686	Tiwana et al. (2010), Teece (1986), Ulrich (1995)	Co-opetition
3	52	4.731	0.186	Moore (1993, 1996), Tian et al. (2008)	Networks
4	49	12.571	0.524	Wernerfelt (1984), West (2003), Rochet & Tirole (2003)	Platform markets
5	38	13.5	0.730	Williamson & De Meyer (2012), Yin (2009), Power & Jerjian (2001)	Case studies on platforms

The paper firstly explicates the theoretical foundations of innovation systems research, thus confirming the links between national innovation systems, technological innovation systems, business ecosystems and innovation ecosystems literature. The critique by Oh et al. (2016) can be supported concerning several of the conceptual frames mentioned above. The forward-looking BC analysis showed a large cluster on platforms that outweighed other thematic areas in research by size. This cluster was home to the ecosystem literature, as shown by the high embeddedness of ecosystem literature in the cluster. Turning to the historical view, our results clearly identify national, regional and technological systems of innovation literature as well as corporate competitiveness literature as distinct clusters. From the competitiveness literature, we identified two diverging streams of literature, one being the actual ecosystem stream. This ecosystem approach clearly has different origins and is thus conceptually separate from the national, regional, technological and innovation system (including innovation ecosystem) studies.

Value added of ecosystems

Core concepts within the ecosystems approach relate to a confined space (ecosystem) where actors interact with each other and with the ecosystem. Adner (2006) argues that an ecosystem allows actors (firms) to create value that no single actor in the system would be able to create and that this additionality comes from the complementing nature of the actors. As Moore (1996) notes, ecosystems require actors to convince others to work with them, upgrading everyone's abilities, resulting in what Moore describes as the "death of competition". The ecosystem's shared environment highlights the fact that there needs to be evolution and that companies are required to co-evolve (Moore 1996), and further, that there is a clear understanding of a shared fate Iansiti & Levien (2004*b*) drawn from the shared environment. Scholars also highlight the role of keystone actors (Iansiti & Levien 2004*b*, Jacobides & Tae 2015), but even more important is the implicit notion of roles: some shared, some complementary. Finally, Teece (2007) adds the dynamic capabilities approach to explain the nature of co-evolution (Moore 1996), highlighting how the open regimes of trade, investment and knowledge require a high-level of adaptation to changes in the environment. He also argues that actors are required to "semi-continuously morph" to maintain their position in the system. The central literature on ecosystems highlights the capability of ecosystems to create value larger than that which any single organization could create. This process of value creation requires co-evolution, where actors enhance each other's capabilities, but also governance of the dynamics of the endevour (Wareham et al. 2014). These capabilities need to be dynamic, enabling the adaptability of the "semi-continuous morph[ing]" of the actor. This dynamic capability comes from actors embracing their physical surroundings (ecosystem), its dispersion of resources and collective properties.

Research agenda for ecosystem research

By accepting the concept of ecosystems as a value-adding framework, we should understand and highlight a path towards a more rigorous theory called for by recent contributions (e.g. Ritala & Almpanopoulou 2017). Currently the theory of ecosystems is underdeveloped and mostly focused on what ecosystems are and how they operate (Jacobides et al. 2018). Theory development rests heavily on a few seminal works, but both empirical and conceptual advancements are needed before a coherent theory of ecosystems can emerge. At the same time, its competition theory foundations allow the innovation ecosystem literature to bring together the competition and systemic views on innovation.

Tables 8 and 9 extract and highlight the changes between historical studies and contemporary research on both innovation systems and ecosystems. The tables illustrate trajectories of current research – where scholars have seen spaces to contribute to the discussion. For the system level, Table 8 shows that research has moved forcefully towards platform studies. This raises the question, if the foundation of the research is solely driven by literature on national, sectoral, technological, or regional innovations systems (with the exclusion of the dynamic capabilities discussion), is there a strong foundation for platform studies?

For the ecosystems literature, in Table 9, the changes in literature streams are much broader. Previous studies highlight the elements of ecosystemic view, dynamic capabilities to change, co-opetitive work in multirole environments, and creation of a value adding network that have two or more groups. Contemporary streams of scientific literature are thus moving to answer "what ecosystems are and how they operate", simultaneously losing sight on the "when and why" the issue (Jacobides et al. 2018).

Columns, in Table 9, should be observed in a holistic manner where the left column highlights the intellectual foundation and the right underscores the current debate. Thus, the labels should not be seen as pairs, where for example the dynamic capabilities literature would have transitioned to innovation systems. It is clear that the contemporary

TABLE 8
Changes in Innovation systems literature by size based on the number of articles in the cluster.

#	**Historical view by CoC**	**Contemporary view by BC**
1	Regional clusters	Platforms
2	National innovation systems	Triple–Helix
3	Dynamic Capabilities	Regional Clusters
4	Sectoral and/or technological innovation systems	National innovation systems
5	Triple–Helix	Technological innovation systems
6	*	Organizational capabilities

* CoC analysis concluded in five larger clusters that could be assigned a label.

TABLE 9
Changes in Ecosystems literature by size based on the number of articles in the cluster.

#	**Historical view by CoC**	**Contemporary view by BC**
1	Dynamic capabilities	Innovation ecosystem
2	Co–opetition	Knowledge ecosystem
3	Networks	Digital business ecosystem
4	Platform markets	Business ecosystem
5	Case studies on platforms	Case studies on ecosystems
6	*	Platforms, architecture and design of ecosystems
7	*	Development of ecosystems

* CoC analysis concluded in five larger clusters that could be assigned a label.

literature applies the foundations to different domains, and also to detailed case studies seen in Cluster 5 of the BC analysis. Indeed, what separates Cluster 5 from the others domain specific clusters is its empirical case study focus[1]. In addition to the articles cited in Table 6, the cluster includes publications focusing on building Internet-of-Things-based ecosystems (Rong, Hu, Lin, Shi & Guo 2015) and partnership ecosystems in the electronics industry (Siripitakchai et al. 2015), among others.

Particularly for domain specific clusters, the current research in ecosystems literature focuses on innovation ecosystems, knowledge ecosystems, (digital) business ecosystems, and platforms. A review of the most cited contributions in these clusters reveals the blurriness of boundaries and overlaps between them. We anticipate the main reason being the nascence of the research domain. For the future development of these strands of literature that have recently emerged, we may suggest a research agenda that enables the gradual strengthening of boundaries between these sub-topics marked by more distinct research programs. Some of core questions for this research agenda are presented in four thematic groups –innovation, knowledge, business, and platform ecosystems – as follows:

[1] Highly cited case study method publications such as (Eisenhardt 1989) can link case study work strongly in the BC analysis.

Innovation ecosystems that address the value creation of actors as they collaborate for innovation (de Vasconcelos Gomes et al. 2016):

- How do innovation ecosystems emerge and how do they evolve?
- What are the coupling mechanisms that help bring about an effective constellation for innovation in a bibliometric review on innovation systems and ecosystems innovation?
- How do historical relationships between actors influence their collaboration for innovation?
- How can business models be redesigned to allow for better cooperation in innovation ecosystems? (Adner & Kapoor 2010, Brusoni & Prencipe 2013, Gawer & Cusumano 2014).

Knowledge ecosystems that focus on the knowledge interactions between actors in their endeavour to collaborate towards innovation in a pre-competitive setting (Järvi et al. 2018):

- What are the mechanisms of knowledge exchange?
- How does boundary spanning facilitate the creation of an ecosystem?
- How can actors develop appropriate business models to harness knowledge exchange for innovation?
- What are the strategies available to actors to exchange and acquire knowledge in the ecosystem - particularly from different technological fields (e.g. patents, mergers and acquisitions) (Li 2009, Hellström et al. 2015).

Business ecosystem that enable value creation and capture value as actors engage in transactions during the innovation process (de Vasconcelos Gomes et al. 2016):

- What are the types of relationships that exist in business ecosystems?
- How can partner selection schemes be developed to increase the success likelihood of business ecosystems?
- What are the critical factors (e.g. bottlenecks and their resolutions) for the long term sustainability of business ecosystems?
- How do different business ecosystems interact? (Zhang et al. 2008, Kang et al. 2011, Weber & Hine 2015).

Platform ecosystems that consider how actors organize around a platform (Jacobides et al. 2018):

- How does competition and collaboration within platform ecosystems change over time? What new, systemic value generation mechanisms necessitate information and data sharing, data management and ownership?

- How can the upcoming era of platform economy (Parker et al. 2016) change innovation processes and practices?
- Why have so few innovation platforms been successful? How can ecosystems and platforms change bottleneck locations (Jacobides et al. 2014)?
- How can these changes influence power balance, ownership, and revenue sharing?
- How do digital platforms transform present ecosystems? How can industry and firm architectures change due to the digitizing process?
- What are the new capabilities and skills needed to manage platforms and their ecosystems? (Karhu et al. 2011, Gatautis & Audrone 2014, Pilinkienė & Mačiulis 2014, Shang & Shi 2013, Zhao & Liu 2009, Gao et al. 2013).

Conclusion

This paper has presented the results of a literature review, based on a robust empirical bibliometric analysis followed by a qualitative analysis of the core documents. There are two limitations that a reader should consider. First, the dataset was gathered from the Thomson Reuters Web of Science, which although includes a good coverage, does not capture the comprehensive scholarly literature. In addition, the conference publications are updated on the database with a considerable delay, and yet, as Table 3 suggests, a lot of recent development is reported particularly in the conference proceedings. Second, the method focuses on citations, and is therefore reliant on the practices through which scholars give credit to their peers. This method does not take into account the reasoning nor the strength (importance) of a particular citation. Furthermore, the general increase in the number of references in academic literature may have created some biases in the results. To conclude, we suggest that scholars should clearly distinguish and acknowledge the intellectual roots of their concepts. We would like to welcome scholars to honestly expose their theoretical groundings, without marketing buzz and any superficial decoration. At the same time, a lot of intriguing research questions in the field of ecosystems deserve scholarly attention.

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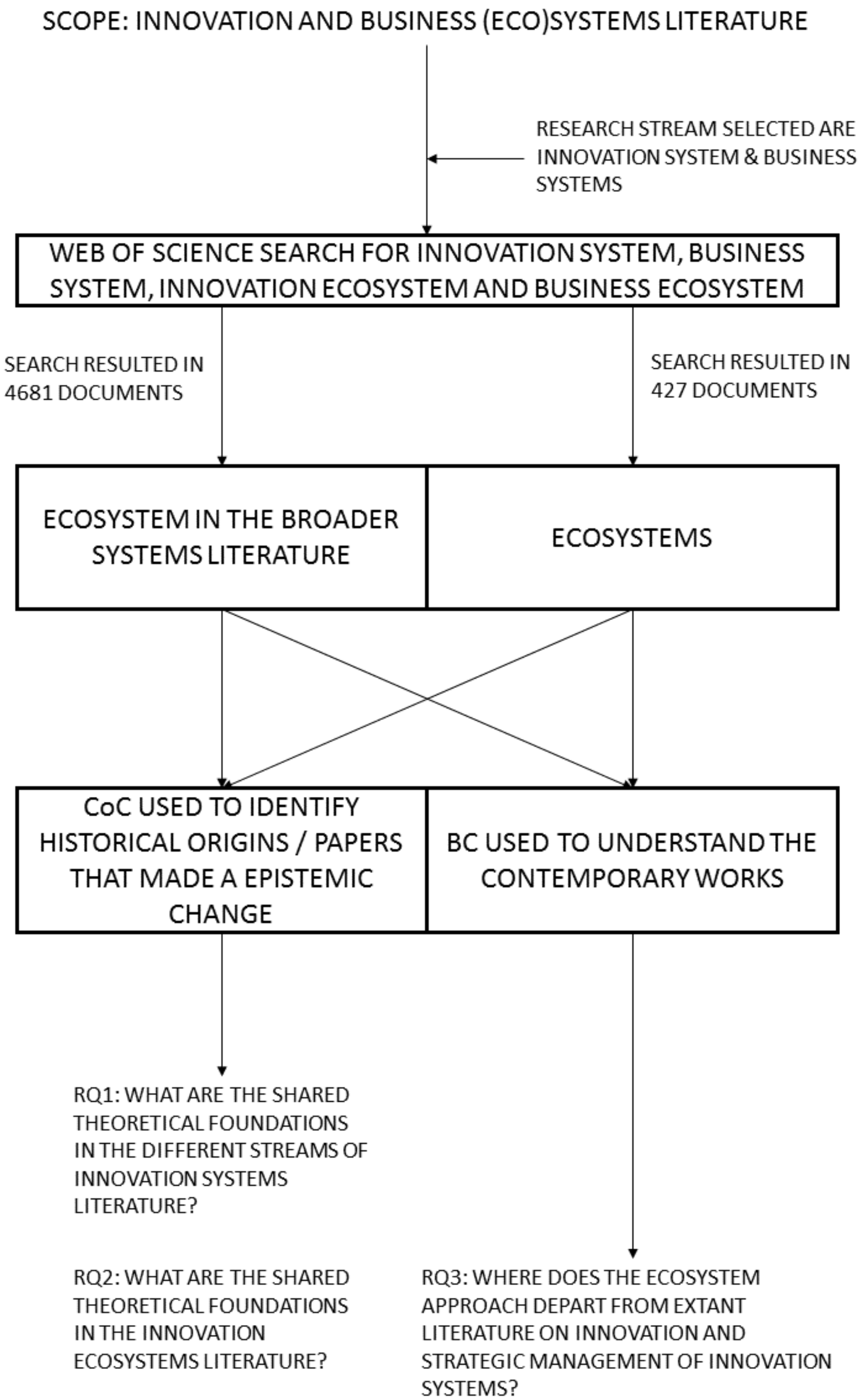

FIGURE 1: **Research design for the study.** The design uses two datasets and two different methods to answer three research questions.

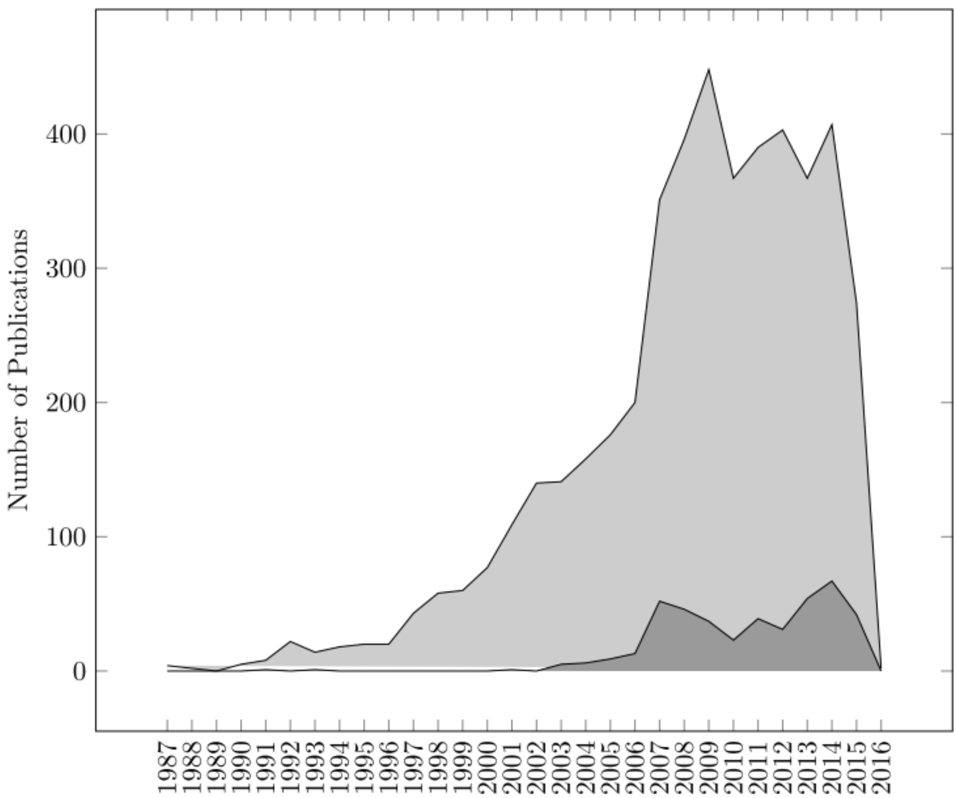

FIGURE 2: **Number of scientific publications.** The figure shows the number of publications by year in both datasets. Dataset on is given in light grey and Dataset 2 in dark gray.

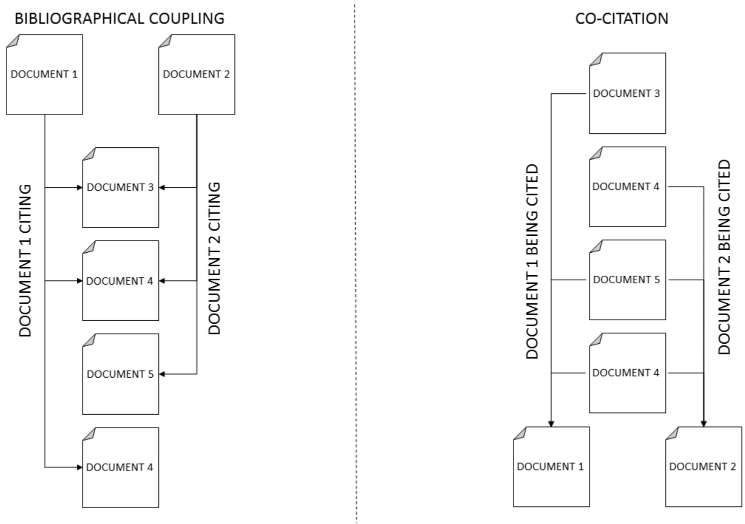

FIGURE 3: **Methodological differences between BC and CoC analysis.** CoC is a historical view of origins and BC a contemporary view.

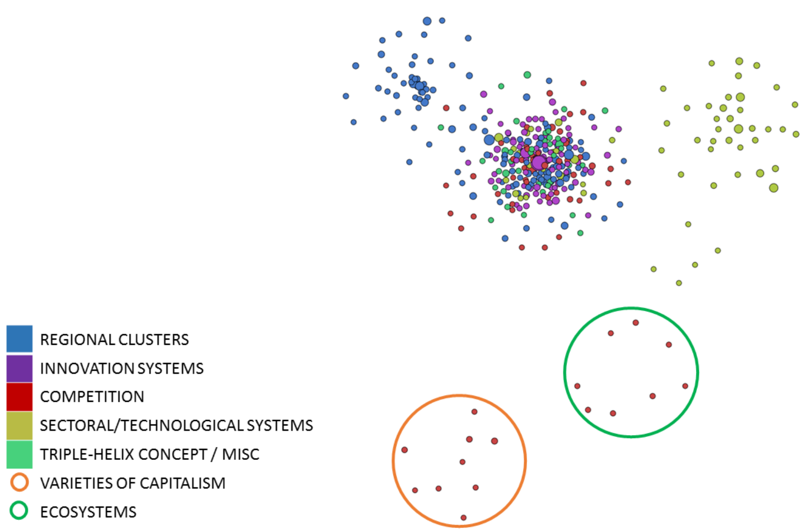

FIGURE 4: **Network graph created from the co-citation analysis of Dataset1.** Colours represent clusters. Nodes are sized based on co-citation weights. Edges are omitted for clarity. The graph is available online at https://tinyurl.com/gwyo2k4

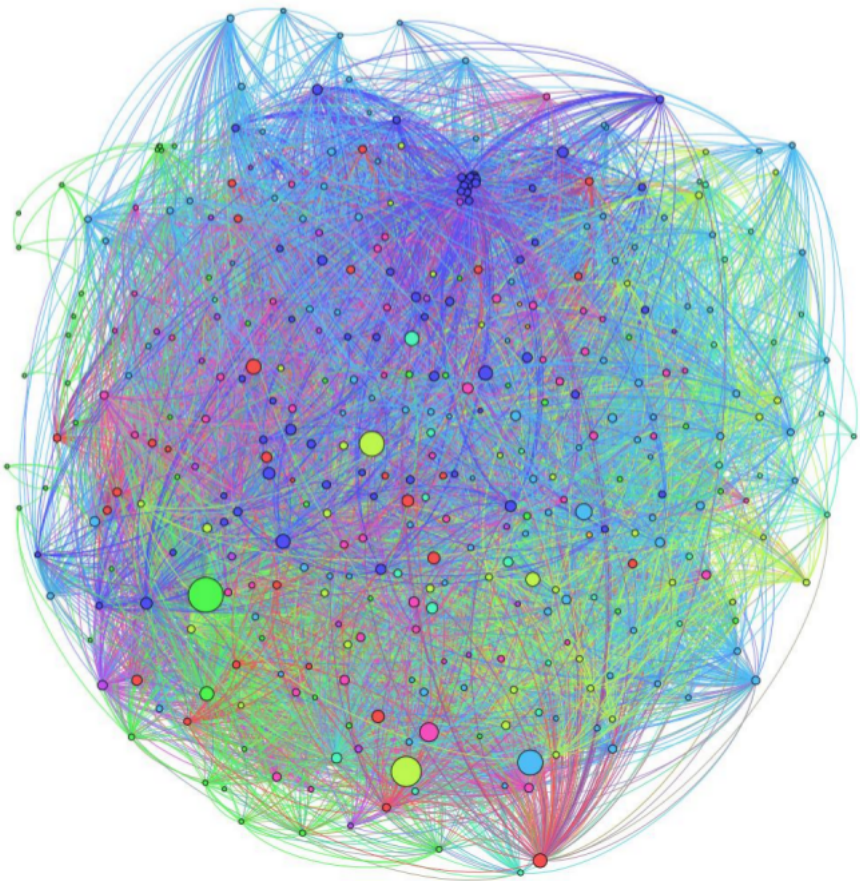

FIGURE 5: **Network graph created from the co-citation analysis of Dataset2.** Colours represent clusters. Nodes are sized based on co-citation weights. The graph is available online at https://tinyurl.com/zea49cw