

# Visualized Bibliometric Mapping on Smart Specialisation: A Co-Citation Analysis

Katharina Fellnhöfer  
Research and Innovation Management GmbH  
Marktplatz 7A, 3371 Neumarkt an der Ybbs, Austria  
Email: [info@research-and-innovation-management.com](mailto:info@research-and-innovation-management.com)

Lappeenranta University of Technology  
School of Business and Management  
P.O. Box 20, FI-53851 Lappeenranta, Finland  
Email: [katharina.fellnhofer@lut.fi](mailto:katharina.fellnhofer@lut.fi)

## Bibliographical notes:

As owner of a small and medium sized company in Austria Katharina Fellnhöfer is engaged in a European Union's Horizon 2020 project entitled ONLINE-S3. Additionally, she works in the field of Entrepreneurship Education as a Research Visitor at the Lappeenranta University of Technology. She holds a Ph.D. in economic sciences from the University of Innsbruck, Austria.

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**Abstract** The primary purpose of this bibliometric study is to systematically explore the multidisciplinary, multilevel and multicontextual dimensions of smart specialisation strategies. Quantitatively based co-citation analyses, including qualitative aspects, are used to map the emerging and multifaceted S3 phenomenon. Data from Web of Science and Scopus shape the background of these visualizations, including 297 peer-reviewed documents and 8,173 cited references from 5,659 co-cited sources of 5,806 co-cited authors linked to 298 organisations and 45 countries. Additionally, co-authorship and bibliographic coupling maps are illustrated. As one of the first studies with such a focus, the outcomes emphasize the need for more research in this discipline to improve our familiarity with smart specialisation strategies. Thus, this effort highlights not only potential research avenues with a recommended step-by-step approach, but also valuable implications for theory and practice based on the previous work discussed in the course of clustering the co-citation analyses.

**Keywords:** bibliometric study, science mapping, smart specialisation, co-citation analysis, knowledge-based policy advice, e-policy platform, online mechanism policy advice.

## 1 INTRODUCTION

Europe's development of economic policy is currently guided by a search for a smart, sustainable and inclusive economy. Despite facing long-term challenges, at its heart as a collective actor, the European Union (EU) is bridging strategic approaches to boost national and regional research and innovation potential with a Europe 2020 strategy (EC, 2010). The intention is to build and feed the basis for smart specialisation strategies (S3), which is smart, sustainable and inclusive. S3 is embedded in the nature of the Europe 2020 policy framework and therefore plays a crucial role. At its heart, S3 is an approach to facilitate research and innovation (R&I) in the course of economic growth. As defined in the guide to R&I Strategies for Smart Specialisations (RIS 3),

... national/regional research and innovation strategies are integrated, place-based economic transformation agendas that (1) focus policy support and funding on key priorities, challenges, and needs for knowledge-based growth, including ICT-related procedures, (2) build on strengths, competitive advantages and potential for excellence, (3) foster both technological and practice-based innovation to stimulate private sector investment, (4) as well as involve stakeholders fully to encourage innovation and experimentation while being (5) evidence-based including comprehensive monitoring and evaluation schemes (EC, 2012, p. 8).

All five R&I strategies listed above take the national/regional level carefully into consideration. Consequently, raising understanding and awareness of this concept at the level for which it is originally intended—the national/regional level—will direct growth towards the overall objectives at the European level.

As an orientation document, this bibliometric analysis intends to highlight essential previous knowledge of the skeleton structure and features in the context of S3. Articles from special issues dedicated to smart specialisation (e.g. Battaglia, 2014; Lerro and Jacobone, 2014; Presenza *et al.*, 2014; Romano *et al.*, 2014a; Yigitcanlar, 2014) have been taken into consideration. An organised examination of the current state of research enriches our understanding of the phenomena related to S3 across different regions and contexts. As the initial groundwork for such an approach, this structural synopsis of scientific relationships between authors, sources, organisations and territories aims to stimulate four future research streams. By systematically mapping the research dedicated to S3 so far, the core purpose of this study is to bridge ideas to unlock future crucial research avenues by exploring past research

clusters. Accordingly, four future research suggestions are discussed to elucidate the value and relevance of knowledge in S3 research, including a call to research initiatives.

This study is structured as follows. First, the methods section describes the applied processes and techniques. Subsequently, the results of diverse analyses are presented to serve as a vital basis for the discussion section. Finally, the concluding remarks bridge the outcomes to shape a call to systematic research with respect to the limitations of this study. Finally, our implications for theory and practice close this contribution.

## 2. METHODS

### 2.1 Applied processes and techniques

This study takes advantage of the different statistical measurements for bibliographic examinations of a scientific discipline (Braun, 2005; Van Leeuwen, 2004). Quantitative techniques are applied to map bibliometric information visually (Börner *et al.*, 2003; Teixeira, 2011; van Eck and Waltman, 2009). In particular, the most accurate measures, such as the more forward-looking co-citation analysis and the more retrospective bibliographic coupling have been applied (Boyack and Klavans, 2010; Gmür, 2003) to map the intellectual data of the S3 research field in a structured way (Bayer *et al.*, 1990; White and Griffith, 1981). Co-cited documents are accumulated and mathematically scaled in a matrix depicting visualized current knowledge relationships to identify crucial influential topics (Cronin, 2001; Ding, 2011; Moya-Anegón *et al.*, 2004; Pilkington and Teichert, 2006). Overall, while co-citation networks present intellectual links and similarities for indicating valid and reliable relationships (White and Griffith, 1981) in order to identify “invisible colleges” (Gmür, 2003), we applied the following four process steps with a quantitative and qualitative orientation. First, a *data and document collection* was conducted. The dataset consists of documents enclosing the search terms “smart specialisation” or “knowledge-based policy advice” or “e-policy platform” or “online mechanism” and “policy advice” in the topic or title from the primary database Web of Science (WoS). The characteristics of this collection are described in the next section. Second, *quality checks* were performed. The dataset was compared to other results in the Scopus databases. In addition, the results of EBSCO, ProQuest and ScienceDirect were scanned to detect potential crucial missing papers in the field under investigation. Third, different *networking maps* were visualized. Diverse networks were drawn from the dataset in VOSviewer<sup>1</sup> (VOS stands for visualization of similarities) and CitNetExplorer software<sup>2</sup>. While co-citation maps of

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<sup>1</sup> Accessible via <http://www.vosviewer.com>

<sup>2</sup> Accessible via <http://www.citnetexplorer.nl>

documents, sources and authors present the centre of the analysis, additional co-authorship and bibliographic coupling maps of organisations and regions provide further information for discussion next to the rankings. Based on guidelines and prior contributions (van Eck and Waltman, 2014b; van Eck and Waltman, 2009; van Eck *et al.*, 2010b; Waltman and van Eck, 2013) the applied algorithm in the software shapes the figures, stressing reliable and valid results. Fourth and finally, *qualitative-based clusters* were identified. With qualitative interpretation of the closed connected clusters in the drawn maps (van Eck and Waltman, 2009), common similar contextual thoughts form *an overview* that helps discover trends and lead to a better understanding of the S3 research stream (Orlikowski and Baroudi, 1991).

The methodology recommended by Tranfield *et al.* (2003) has been implemented in this study. Overall, a systematic mapping method was applied, which is a secondary study for exploring prior research to gather the research field. The search terms within a systematic mapping study are more general in order to provide a balanced perspective. The systematic mapping study appears to be appropriate if only a few reviews—with a focus on visualized mapping and clustering techniques—have been provided.

## **2.2 Characteristics of the dataset**

The data from the primary databases' WoS core publication yielded 297 documents in the topic or title, whereas Scopus only found 35 records in the title or abstract or keywords, using the search terms “smart specialisation” or “knowledge-based policy advice” or “e-policy platform” or “online mechanism” and “policy advice” for all years, including 2015. The selection of the search terms is based on a previous literature review (Fellnhöfer, 2017) in which 131 articles concerning smart specialisation were reviewed from databases such as Scopus, EBSCO and ScienceDirect. This review relied only on the search term *smart specialisation*, which supported identifying further search terms most used in a second step in this context. An alternative choice would be only using *smart specialisation* as a search term, which would lead to broader results. The identified data have gone through a quality check to identify missing documents or depict crucial documents. In addition, the EBSCO, ScienceDirect and ProQuest databases have been investigated. Overall, the dataset is based on the Social Science Citation Index provided by the Institute for Scientific Information (ISI) Web of Knowledge (Garfield and Merton, 1979; ThomsonReuters, 2015). Although several disadvantages have been expressed in relation to this index (Glänzel, 1996a; Glänzel, 1996b; Hicks, 1999; Nederhof, 2006;), in particular its low reliability when different languages and geographies are involved (Harzing and Van Der Wal, 2009; Kousha and Thelwall, 2008; Nederhof, 2006), we rely on

Franceschet (2010), who found that citation-based analyses taking both sources and authors into consideration are not significantly different between WoS and Google scholar. The underrepresentation of the research discipline in Scopus should draw our attention to the fact that this discipline deserves more attention. All the results from Scopus are also included in the WoS dataset. Finally, all 297 WoS records were considered for the bibliometric analyses, as exemplified in Table 1.

**Table 1.** Search strategy of this study

Field	Strategy
Search terms in all documents	“smart specialisation” or “knowledge-based policy advice” or “e-policy platform” or “online mechanism” and “policy advice”
Time frame	1996–2015
<i>Results in the databases</i>	
WoS – core publication	297
in title or topic	
Scopus	35
in abstract or title or keywords	

### 2.3 Applied analysis tools

The broad scope of this analysis and the emerging attention to S3 require special attention. Only a few contributions dedicated to this research domain have applied bibliometric methods (e.g. McMillan *et al.*, 2016), and visual presentations created with Pajek software<sup>3</sup>—which was used by McMillan *et al.* (2016)—dominate. However, larger maps require tailor-made mapping techniques, such as those implemented in VOSviewer and CitNetExplorer, for comprehensive coverage of the literature (van Eck and Waltman, 2009). The freely available plug-in VOSviewer (available at no charge at [www.vosviewer.com](http://www.vosviewer.com)) constructs bibliometric information on different maps (van Eck and Waltman, 2009; Waltman *et al.*, 2010; Waltman *et al.*, 2011a; 2011b) and has demonstrated acceptable performance in previous discussions (van Eck *et al.*, 2010a). Unlike Pajek, VOSviewer is able to graphically depict large bibliometric maps with functions such as zooming and multidimensional scaling (van Eck and Waltman, 2009). Generally, VOSviewer has been applied successfully in prior papers on the subject of economic policy (e.g. Rafols *et al.*, 2012; Su, 2012; Wallace and Rafols, 2015; Zuccala and Van Eck, 2011).

This investigation is based on distance-based term maps that visually portray three-dimensional relationships between different expressions. In this way, imperative consensuses

<sup>3</sup> Accessible via <http://mrvar.fdv.uni-lj.si/pajek/>

discussed in conjunction are depicted through co-citations, co-occurrences and co-authorships from past research. Analysing co-citations permits discourse on the intellectual foundation of a research discipline by means of the works cited, whereas bibliographic coupling displays the research facades by detecting the cited references that are common between two documents (Jarneving, 2005; Persson *et al.*, 2009; Schiebel, 2012). A single co-occurrence is counted if the search terms arise in the abstract, title or keywords in a document. The power of the terms “smart specialisation” or “knowledge-based policy advice” or “e-policy platform” or “online mechanism” and “policy advice” is measured by the sum of the abstracts, titles or keywords in which they appear. To put it another way, the more times the search terms co-occur, the greater the impact. Additionally, the distance between different terms on the three-dimensional map is an indication of the degree of connection. Overall, the shorter the distance between different terms on the map, the stronger the association between these expressions. Based on the fragmented mapping of terms, cluster topics of highly related terms are identified. Closely based clusters indicate a close field relationship. Based on this information, the clusters can be interpreted (Hair *et al.*, 2006). As a consequence, both a quantitative approach with text mining techniques and a qualitative approach based on the interpretation of visualized bibliographic maps through the interpretation of clusters are applied.

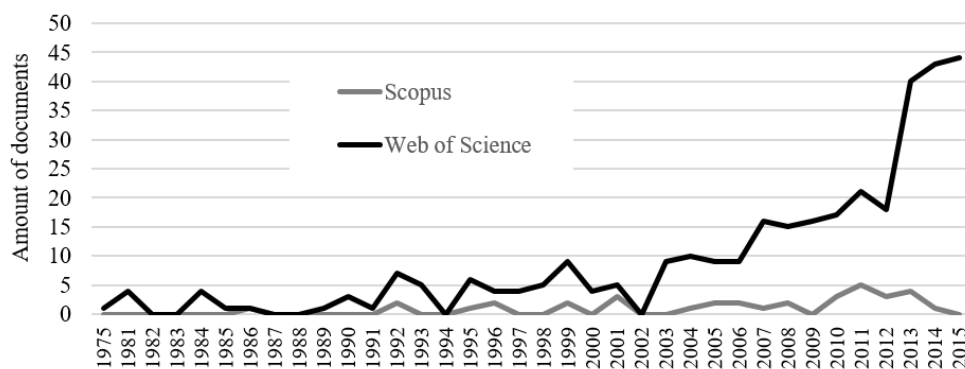
The software CitNetExplorer (available at no charge at [www.citnetexplorer.nl](http://www.citnetexplorer.nl)) is a web-based instrument for visualizing citation networks of scientific works in order to analyse the development of a research field (Hong, 2014; van Eck and Waltman, 2014a). In this context, the abbreviation stands for “citation network explorer”. Exploring the development of any research field, van Eck and Waltman’s (2014a) contribution is supporting in terms of illuminating the impact on emerging research disciplines.

### **3 THE CURRENT BODY OF LITERATURE**

#### **3.1 The timeline of transformation**

First, a descriptive introduction to the evolution of the research discipline dedicated to S3 aims at highlighting the increasing research trend in this domain. As outlined in Figure 1, the first document dedicated to this research topic was published in the agricultural sector by Mauldon (1975) with his work on “Agricultural Policy Advice and Public Inquiry Process”, Campbell and Ross (1981) with their debate on “The Utilitarianism of Smith Adam Policy Advice,” and in three documents regarding “On Setting the Agenda for Pennsylvania School-Finance Reform - An Exercise in Giving Policy Advice” (Inman, 1981) followed, according to the WoS results. As mentioned previously, Scopus only returned 35 records for our search

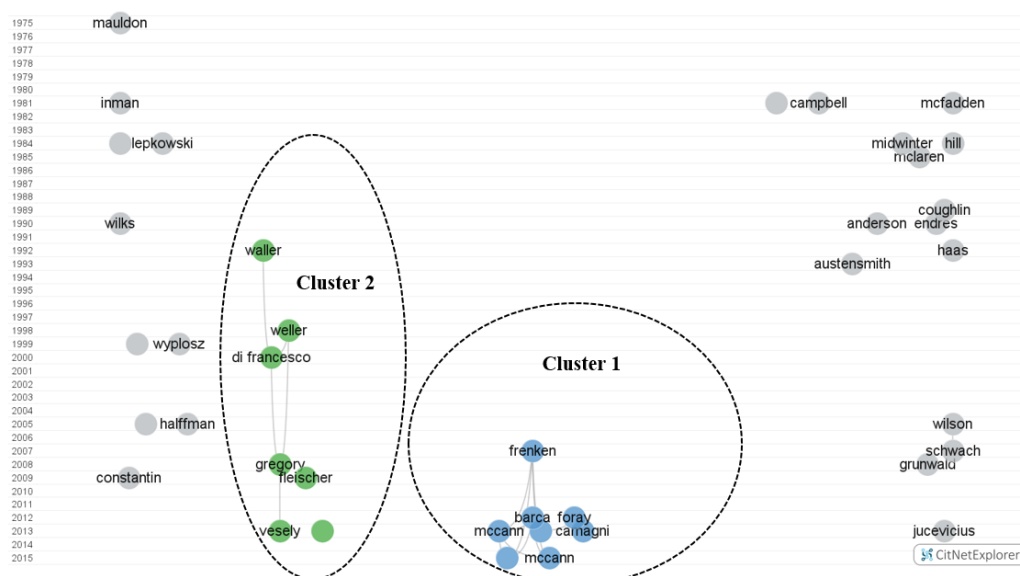
terms, the first of which was Taylor and Weaver's (1986) "Knowledge Elicitation: The Problems of The Alvey Dhss Large Demonstrator Policy Application", followed by Jones (1992) and Labat and Futersack (1992). Despite fluctuations in the early years between 1975 and 2002, the volume of documents has been increasing, reaching its highest level in 2015, with almost 45 published documents related to S3. Overall, Figure 1 includes all the documents in the domain, including the characteristics of interdisciplinary, multi-functional, multidisciplinary and multicontextual.



**Figure 1.** Evolution of the S3 research discipline

Figure 2 presents the contributing authors who have been cited at least 10 times based on WoS data derived from CitNetExplorer. As indicated in Figure 1, the initial works are wide-ranging contributions illustrating the current wide spectrum in this diverse research field. Since 1990, several papers dedicated to S3 have been published, and two main clusters have been identified by WoS: a European cluster (Cluster 1) and an Australian cluster (Cluster 2).





**Figure 2.** Evolution of S3 research from 1996–2015, according to contributing author

*European Cluster 1* originated with Frenken *et al.*'s (2007) article "Related Variety, Unrelated Variety and Regional Economic Growth". Based on this foundation, Foray *et al.* (2012) delivered the essential "Guide to Research and Innovation Strategies for Smart Specialisation (RIS 3)". Soon after, a publication with the title "Smart Specialisation: Opportunities and Challenges for Regional Innovation Policy" by Foray (2015) became available. Barca *et al.* (2012), with "The Case for Regional Development Intervention: Place-based versus Place-neutral Approaches", also contributed significantly to this cluster. McCann and Ortega-Argilés (2013a) published "Modern Regional Innovation Policy" and, not long later, "Smart Specialisation, Regional Growth and Applications to European Union Cohesion Policy" (McCann and Ortega-Argilés, 2015). Their most current work is dedicated to issues and challenges for a results-oriented EU regional policy with respect to entrepreneurship and small- to medium-sized enterprises (SMEs) (McCann and Ortega-Argilés, 2016). Thissen *et al.* (2013d) opened a discussion with "Regional Competitiveness and Smart Specialisation in Europe: Place-Based Development in International Economic Networks", which also contributed to this cluster. Camagni and Capello (2013) raised a debate in "Regional Innovation Patterns and the EU Regional Policy Reform: Toward Smart Innovation Policies".

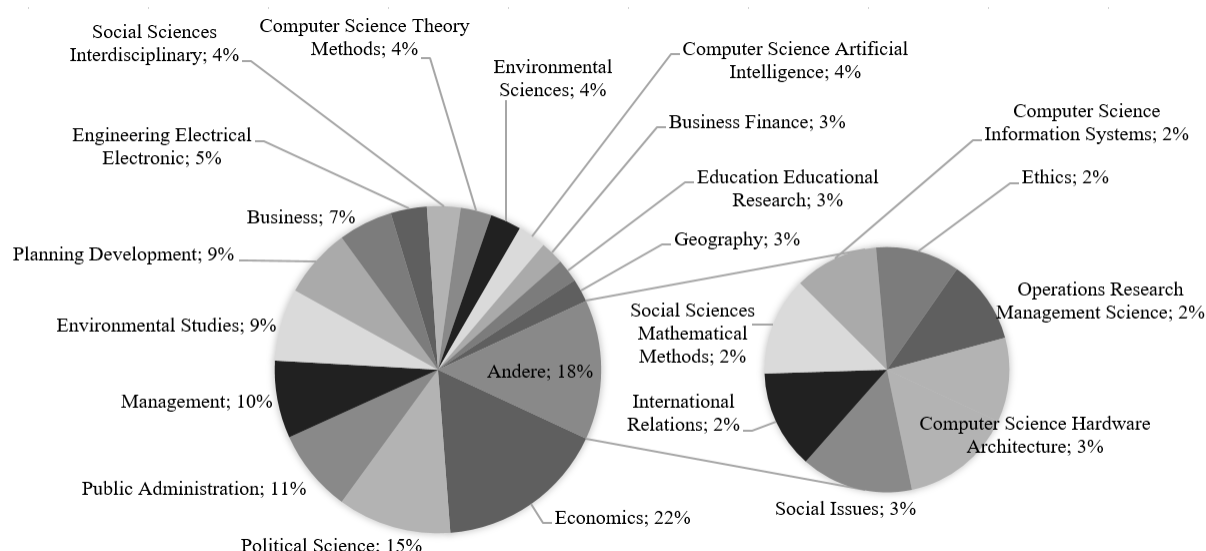
*Australian Cluster 2* was introduced by Waller (1992) with "Evaluating Policy Advice" and Weller and Stevens (1998) with "Evaluating Policy Advice: The Australian Experience". This cluster was also formed by Di Francesco's (2000) "An Evaluation Crucible: Evaluating Policy Advice in Australian Central Agencies" and later, Gregory and Lonti's (2008) "With Chasing



Shadows? Performance Measurement of Policy Advice in New Zealand Government Departments”.

However, at this stage it is clear that the definition of “smart specialisation” is rather new-fangled. As such, this innovative research stream calls for more research. Therefore, based on a well-defined description of smart specialisation by the EC (2012), we move this interdisciplinary, multi-functional, multidisciplinary and multicontextual research topic forward.

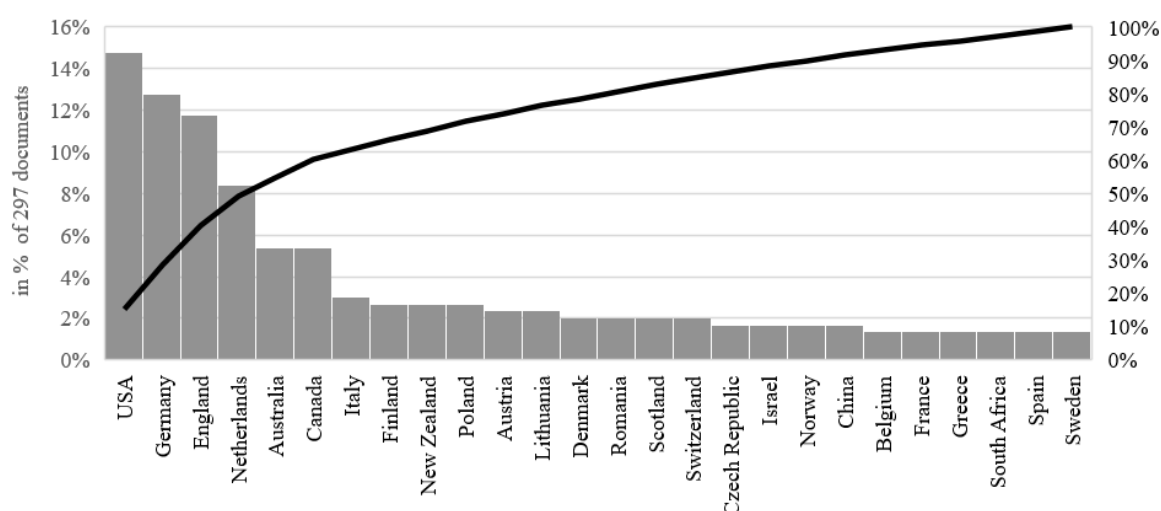
When viewing the subject areas of the published documents, the diversity and broad range of this research domain are obvious. As illustrated in Figure 3, S3 is present in diverse disciplines. Overall, economics (22%), political science (15%), public administration (11%) and management (10 %) dominate. All of the other subject areas account for less than 10%.



**Figure 3.** Subject areas of the published documents

With a Pareto distribution diagram—also called a Pareto chart—as one of the seven basic tools of quality control, areas of possible development and improvements, and trends and issues that require further attention can be identified (Kiremire, 2013; Sokovic *et al.*, 2005). Such a Pareto diagram is used for the following graphic depiction number 4 below, to illustrate data regarding the relative importance of various countries to S3 and highlights the dominating contributing countries, displaying documents per territory based on relative frequency. Here, interestingly, the Pareto principle, which would predict that approximately 80% of the contributions come from 20% of the contributing countries, does not hold true. Although we found an exception to the law of the vital few, also known as the 80-20 rule with respect to the

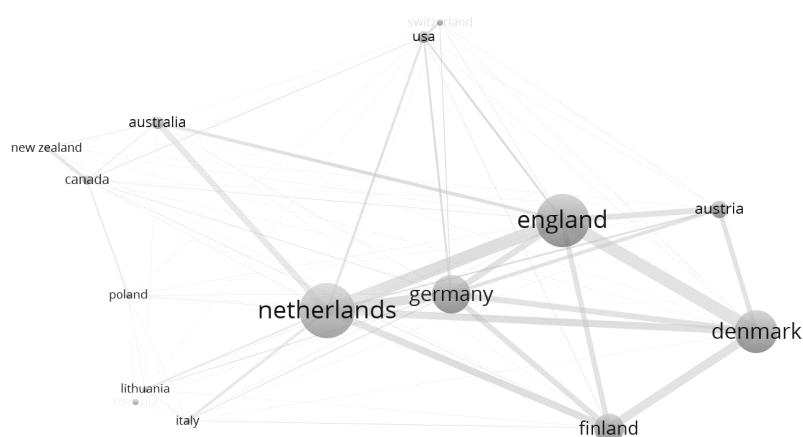
principle of factor sparsity (Kiremire, 2013), Figure 4 stresses regional fragmentation as a characteristic of the smart specialisation topic. Out of 45 contributing countries, just 16 (approximately 45%) provided approximately 82% of all contributions, based on the number of documents dedicated to the search terms in the research field of smart specialisation. As presented in Figure 4, the United States (US), Germany, England (UK), Netherlands and Australia represent the top five countries.



**Figure 4.** Documents per territory

A descriptive analysis of the universities affiliated with these territories indicates that Harvard University (USA) is ranked first, having the greatest cumulative effect on the research field (7 documents), followed by Kaunas University of Technology (6 documents), and Tel Aviv University and the University of Twente, with 5 documents each. Finally, Aalto University and University Groningen have delivered 4 documents from each. All of the other contributing organisations have provided fewer than 3 documents to the S3 research domain.

Based on a bibliometric coupling analysis, out of 45 involved countries, 15 exceed the threshold of at least 6 documents. As illustrated in Figure 5, Netherlands (bibliometric coupling score of 901), England (bibliometric coupling score of 871), Denmark (bibliometric coupling score of 697), Germany (bibliometric coupling score of 628) and Finland (bibliometric coupling score of 491) lead this list.



**Figure 5.** Results of a bibliometric coupling analysis based on countries

Table 2, below, shows the results of a bibliographic coupling analysis highlighting that the University of Toronto, with a bibliometric coupling score of 129, Simon Fraser University, with a bibliometric coupling score of 123, Rijksuniversiteit Groningen, with a bibliometric coupling score of 57, Universiteit Utrecht, with a bibliometric coupling score of 36, and finally, Kaunas University of Technology, with a bibliometric coupling score of 20, represent the most influential organisations in this sphere. Overall, out of 298 organisations, only 13 meet the threshold of at least 3 documents dedicated to the field of S3.

**Table 2.** Results of a bibliometric coupling analysis based on organisations

Organisation	Document Weight	Bibliometric coupling Weight
University of Toronto	3	129
Simon Fraser University	3	123
Rijksuniversiteit Groningen	4	57
Universiteit Utrecht	5	36
Kaunas University of Technology	6	20
Aalborg Universitet	3	11
Harvard University	7	7
University of Twente	5	7
The University of Auckland	3	1
University of Salento	3	1

After this descriptive introduction of the results, in the next step the outcomes of different co-citation analyses based on references, sources and authors are presented.

### 3.2 Results of diverse co-citation analyses

As demonstrated in Table 3 below, out of 5,659 sources, 18 meet the threshold of a minimum of 20 citations. *Regional Studies*, *American Economic Review*, *Journal of Economic Geography* *Advance Access* and *Research Policy* represent the leading journals for smart specialisation.

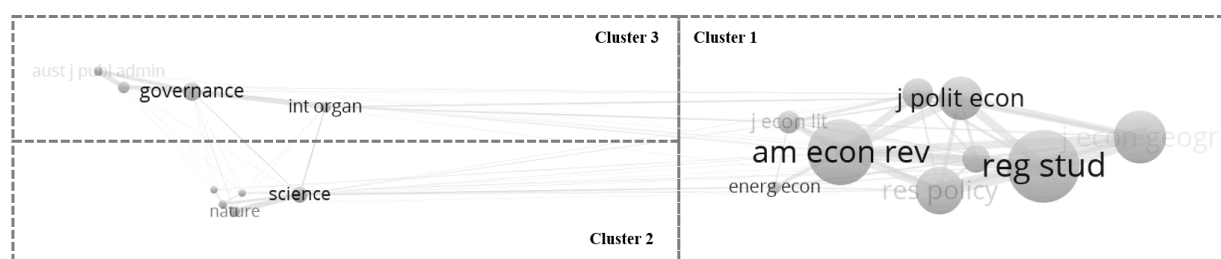
Highly prestigious journals based on the SCImago Journal Rank Indicator (SJR), such as *Quarterly Journal of Economics* (SJR = 22.541), *Nature* (SJR = 17.313), *Journal of Economic Literature* (SJR = 11.259), and *Science* (SJR = 10.107) are also among the most important journals for this emerging research discipline. The SJR, developed by SCImago from the algorithm of Google PageRank™, is a measurement of a journal's prestige, impact or influence. It calculates the average number of weighted citations from 2014 based on the papers published in journals in the previous three years. This information is based on the Scopus database to assess scientific domains (Scimago, 2016).

**Table 3.** List of the top sources

Source	SJR	H index	Citation Weight	Co-citation Weight	Cluster
Regional Studies	1.094	74	82	660	1
American Economic Review	9.543	185	74	600	1
Journal of Economic Geography	2.462	62	35	475	1
Research Policy	2.317	142	63	434	1
Journal of Political Economy	13.477	128	39	394	1
Journal of Economic Perspectives	0.115	2	46	284	1
Quarterly Journal of Economics	22.541	171	26	254	1
Journal of Economic Literature	11.259	119	20	211	1
Governance	1.337	48	31	166	3
Science	10.107	851	34	150	2
Energy Economics	2.58	76	20	120	1
Public Administration	1.281	57	30	111	3
The Review of International Organisations	1.932	16	29	99	3
Nature	17.313	890	25	98	2
Australian Journal of Public Administration	0.26	25	23	90	3
Global Environmental Change	3.006	90	20	76	2
Science and Public Policy	0.444	37	20	35	2
ICES Journal of Marine Science	1.121	83	24	19	2

Figure 6 is a visualized map of the co-citation analysis clustered according to sources. In particular, three main clusters of sources are detected. While co-citations are often seen together in sources such as *American Economic Review*, *Regional Studies*, and *Journal of Political Economy*, representing the dominating cluster one, cluster two is led by *Science* and *Nature*, indicating the natural science focus. The third cluster is shaped by *Governance* and *The Review of International Organizations*. The idea of smart specialisation in these three main clusters are shared. In addition, some journals, such as the *International Journal of Knowledge-Based Development*, have published a special issue dedicated to smart specialisation with fruitful articles (e.g. Battaglia, 2014; Lerro and Jacobone, 2014; Presenza *et al.*, 2014; Romano *et al.*,

2014a; Yigitcanlar, 2014) and many more papers (e.g. Gadille and Siarheyeva, 2014; Grant and Chuang, 2012; Kim *et al.*, 2016; Komninou, 2016; Maeng and Nedovic-Budic, 2010; Martinus, 2012; Secundo *et al.*, 2015). Overall, based on Table 3 and Figure 6, it becomes clear that leading entrepreneurship journals are missing, which highlights potential room for improvement.



**Figure 6.** Co-citation analysis by sources

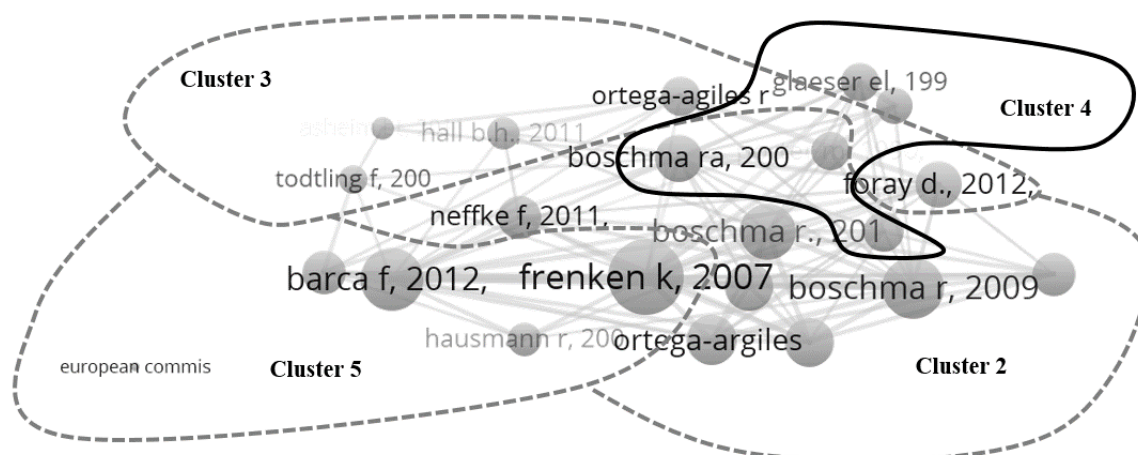
While Table 4 below lists the 10 top-cited references based on co-citation, Figure 7 maps the co-citation analysis based on references. Out of 8,173 analysed cited references, 33 meet the threshold of a minimum of 5 citations. Frenken *et al.* (2007), with his article “Related Variety, Unrelated Variety and Regional Economic Growth”, leads the list with a co-citation weight of 89. Barca *et al.* (2012) follow with the article, “The Case for Regional Development Intervention: Place-based versus Place-neutral Approaches”, which has a co-citation weight of 75. Boschma and Fritsch (2009) are in third place with “Creative Class and Regional Growth: Empirical Evidence from Seven European Countries”, which has been co-cited 73 times, followed by Boschma *et al.* (2012) with “Related Variety and Regional Growth in Spain” (67 co-citations), and Boschma (2005) with “Proximity and Innovation: a Critical Assessment” (56 co-citations). Ortega-Argilés (2012) discussed “The Transatlantic Productivity Gap: A Survey of the Main Causes” and OECD (2009) published a contribution on the “Focus on Citizens: Public Engagement for better Policy and Services”. McCann and Acs (2011) provided an in-depth view on “Globalization: Countries, Cities and Multinationals”. Finally, Foray *et al.*’s (2012) “Guide to Research and Innovation Strategies for Smart Specialisation (RIS 3)” and Barca’s (2009) “Agenda for a Reformed Cohesion Policy” close the top 10 list of most co-cited references.

**Table 4.** List of the 10 top-cited references based on co-citation

Cited reference	Citation Weight	Co-citation Weight	Cluster
Frenken <i>et al.</i> , 2007	10	89	5
Barca <i>et al.</i> , 2012	9	75	5
Boschma and Fritsch, 2009	8	73	2

Boschma <i>et al.</i> , 2012	7	67	2
Ortega-Argilés, 2012	5	59	2
OECD, 2009	5	58	2
McCann and Acs, 2011	5	57	2
Boschma, 2005	8	56	4
Foray <i>et al.</i> , 2012	11	55	3
Barca, 2009	8	52	5

In the next step, the co-citation analysis is performed based on references with a threshold of 5 cited references, which was met by 33 out of 8,173 citations, and is illustrated and is illustrated in Figure 7 below, based on co-citation weight. This citation map highlights the leading references, such as Frenken *et al.* (2007) and Barca *et al.* (2012), forming cluster 5. Ortega-Argilés (2012) and Foray *et al.* (2012) with the well-known “Guide to Research and Innovation Strategies for Smart Specialisation (RIS 3)” form cluster 3. Cluster 2 is led by Boschma and Fritsch (2009) and Boschma *et al.* (2012). However, the map stresses the intertwining and close connections that characterize the multifaceted S3 research domain.



**Figure 7.** Co-citation analysis by references

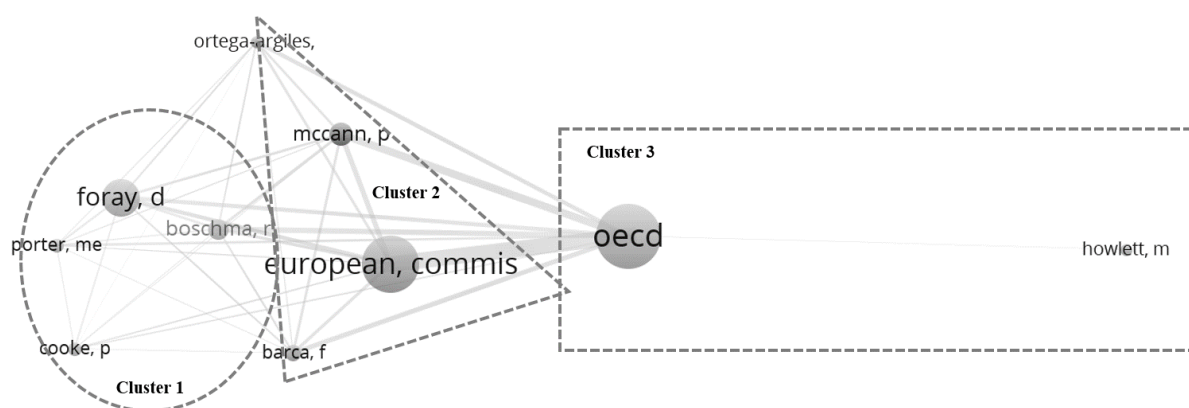
Table 5 presents a list of the 10 most co-cited authors; a co-citation map illustrates this list in Figure 8. Out of 5,806 authors, 10 meet the threshold of 16 citations, and leading institutions such as OECD and the European Commission occupy the top places. These dominant contributors become obvious when viewing Figure 8. McCann has been already co-cited 621 times and Foray has been cited 495 times. Although Boschma’s citation and co-citation weights are in the top 10, his publications have been only co-cited 481 times and his colleague, Barca, has been cited 414 times. Ortega-Argilés follows with 365 co-citations and Porter has 249 co-citations. Interestingly, Howlett received only 9 co-citations, but appears to build a “remote” foundation according to Figure 8. In other words, although his work is positioned rather far

away from the other articles in the co-citation map, the impact of his contributions is rather high according to Table 5.

**Table 5.** List of the top 10 co-cited authors

Author	Citation Weight	Co-citation Weight	Cluster
OECD	90	1177	3
European Commission	80	932	2
McCann, P	30	621	2
Foray, D	52	495	1
Boschma, R	29	481	1
Barca, F	23	414	2
Ortega-Argilés, R	17	365	2
Porter, ME	20	249	1
Cooke, P	20	185	1
Howlett, M	17	9	3

Figure 8 outlines the 3 clusters of the 11 most co-cited authors. Cluster 1 is built by Foray, Boschma, Porter and Cooke. Porter set the foundation with his cluster methodology. Cluster 2 is dominated by the European Commission, McCann, Barga and Ortega-Argilés. Finally, cluster 3 is shaped by the OECD and Howlett. At this stage, it is clear that besides the institutional impact and its importance to S3, Foray has contributed to this research discipline significantly, which might be based on his “Guide to Research and Innovation Strategies for Smart Specialisation (RIS 3)” (Foray *et al.*, 2012).



**Figure 8.** Co-citation analysis based on author



Based on the results of these analyses, in the next step the discussion feeds the conclusion of this bibliometric study, describing four recommendations for further research avenues based on the identified gaps and distances on the visualized maps.

#### **4 DISCUSSION**

In the European context, the purpose of S3 is to provide a path with agendas that increase European global competitiveness (EC, 2012; Lorentzen *et al.*, 2011; Thissen *et al.*, 2013b) through regional policies (McCann and Ortega-Argilés 2013b) and place-based development in economic networks (Thissen *et al.*, 2013a; 2013c). In this regard regional innovation patterns and step-by-step policy reforms showing directions (Camagni *et al.*, 2014). Guidelines (e.g. Foray, 2015) and design suggestions (Trajtenberg and Foray, 2015a; 2015b; 2015c; 2015d) provide dialogues regarding both opportunities and challenges for regional innovation policy within S3. Based on these fundamental goals, this bibliometric study deducts four central suggestions for future research to enhance our understanding of smart specialisation.

First, remembering the descriptive analysis of the documents per territory (Figure 5) with the US at the top of the list, followed by Germany, England, Netherlands and Australia, it becomes clear that European countries need to put more effort into S3, in particular because of Europe's diversity. However, the descriptions are supported by the bibliometric coupling analysis in which only European countries, such as Netherlands, England, Denmark, Germany and Finland lead the top list. Nevertheless, there are only a few studies dedicated to a specific analysis per region (e.g. Ignat *et al.*, 2009; Sandu, 2012). For instance, Szmaj and Tanger (2014) discussed the knowledge infrastructure for the innovation ecosystem in the Silesian province in Poland, while stressing that implementing S3 requires research related to knowledge-based regions, regional innovation ecosystems and specialisations. Paliokaite *et al.* (2015) focused on methods of developing S3 in Lithuania. Further, Tatjana *et al.* (2014) reviewed the legal fundamentals regarding the local scientific environment for developing advanced technologies in Latvia, emphasizing that the EU's smart specialisation platform is neglecting Latvia as a priority region. Another study provided insights from the Basque case and its reliance on policies fostering S3 (Valdaliso *et al.*, 2014). Karo and Kattel (2015) highlighted that S3 shows great potential to make a difference in the sphere of economic development in Central and Eastern European countries. Another study provided further details and demonstrated that Southern Europe benefits much more than Eastern Europe from S3 (Kroll, 2015). Furthermore, Muscio *et al.* (2015) empirically examined the differences in regional economic growth between Eastern and Western European regions based on European funding. To conclude, there

are specific regions that require more examination when it comes to S3. Thus, we propose the following for future research:

*Research suggestion 1: How can specific regions be better prepared to implement sustainable S3 effectively and successfully?*

Based on this bibliometric analysis, the majority of the well co-cited references focus on economic issues. For instance, Frenken *et al.* (2007) concentrated on the variety of regional economic growth. Barca *et al.* (2012) considered the case of interference in regional development. Boschma (2005) started with a critical assessment of proximity and innovation, Boschma and Fritsch (2009) discussed the creative course and regional growth and, a few years later, Boschma *et al.* (2012) focused on Spanish-related variety and regional growth. Additionally, Ortega-Argilés (2012) acknowledged the main causes of a productivity gap. The OECD (2009) focused on public engagement for better policy from the perspective of citizens. As a consequence, a dissemination of best practice case studies would enhance the literature base. There are already several best practices available that would require further academic groundwork to circulate them and expand our familiarity with implementation practices related to multi-level and multidisciplinary S3. For instance, the following examples could serve as a motivation: “Vision 2023: Turkish Technology Foresight” (JRC, 2005g), “Futur” in Germany (JRC, 2005c), “Eforesee Malta” (JRC, 2005b), “Eforesee Cyprus” (JRC, 2005a), “OPTI” in Spain (JRC, 2005f), “Greek Technology Foresight” (JRC, 2005e) and “FutuRIS” in France (JRC, 2005d). From a European perspective, the literature base would greatly benefit from a multi-country comparison referencing different pilots, experiments and best practice analyses, not only to stress the learning-from-each-other approach, but also to guide the regions to facilitate European bottom-up knowledge-based policy advice. Following this line of argumentation, we recommend the following second area for future research:

*Research suggestion 2: Despite the uniqueness of each territory and its connected circumstances, are there any common drivers and indicators in different case studies that lay the foundation for successful implementations of projects dedicated to smart specialisation?*

As recommended by Foray *et al.* (2012), the identification of specialisation patterns in regions through cluster mapping analysis represents major groundwork for every action heading toward S3. In particular, this concept of clusters provides a useful tool. This cluster mapping

exercise was funded by the European Commission's Directorate-General for Enterprise and Industry and has become a powerful strategic cluster-related reporting system (Protsiv, 2007). Despite the challenges in considering policy implementation in this sphere (Rosiello *et al.*, 2015, *performing benchmarking activities while learning from the US and Australia*, which represent two dominant international role models according to this analysis, will support us to better understand the further research required on S3. Regions that have already gained experience and know-how in designing and implementing S3 could provide a helping hand in peer-reviewing processes to improve the outcomes and help overcome barriers to surviving engagement challenges. The empirical contribution by Boschma and Fritsch (2009), with a focus on regional growth from 7 European countries, the debate on the subject of countries, cities and multinationals throughout globalization by McCann and Acs (2011) and “Guide to Research and Innovation Strategies for Smart Specialisation (RIS 3)” published by Foray *et al.* (2012) provide vital groundwork. Based on this, we propose the following suggestion for further research:

*Research suggestion 3: What can we learn from international role models such as the United States and Australia in linked areas of smart specialisation?*

Based on the descriptions dedicated to the different research disciplines involved (Figure 4), multidisciplinary becomes clear; this characteristic stresses the importance of fostering the links between the areas involved. In particular, when examining the top journals, the majority of journals that emphasize the impact of smart specialisation are located in the fields of policy or natural science. At this stage, it is important to place more attention on the relationships between S3 entrepreneurship as entrepreneurship is a driver of (regional) innovation (McCann and Ortega-Argilés, 2016). Moreover, there is evidence that sustainable innovation ecosystems represent innovative entrepreneurship fertilization in which knowledge creation, diffusion and absorption by diverse stakeholders facilitate long-term knowledge-based regional development within the European strategy for S3 (Romano *et al.*, 2014b). In particular, existing online tools for changing policy with a focus on entrepreneurship and SMEs, show great potential for fostering the link to the entrepreneurship research discipline (e.g. EC, 2016a). For instance, an early warning tool for entrepreneurs could serve as a starting point (EC, 2016b). Moreover, studies regarding entrepreneurship education present a model for implementing entrepreneurship at an early stage. A case of Estonia has already been discussed (Paes *et al.*, 2014), which might also feed tools and databases of good practices, such as EuroMed.

Nevertheless, further input is required from several regions (EC, 2016c). Finally, action research and experience-based methods in entrepreneurship research stress the potential to improve the efficacy of policymaking (Santini *et al.*, 2016). This research gap is also highlighted by prior entrepreneurial studies (e.g. Danson and Burnett, 2014; Ryan and Giblin, 2012).

*Research suggestion 4: How and where is the facilitation of innovative entrepreneurship most effective within S3?*

After proposing our four recommendations for further research, we conclude and close our co-citation analyses hereafter.

## **5 CONCLUSION**

Smart, sustainable and inclusive growth represent crucial and primary objectives of the EU while implementing initiatives, actions and strategies at regional, national and pan-European levels in order to reach short-, medium- and long-term goals (EC, 2012; Carayannis and Rakhmatullin, 2014; Thissen *et al.*, 2013b). The primary goal of this bibliometric study was to explore the multidisciplinary, multi-level and multicontextual dimensions of S3 in a systematic way in order to absorb details from the big picture for future required research avenues. Quantitative-based co-citation analyses and qualitative interpretation of the drawn maps, in particular with identified (research) gaps and distances, served as the basis for calling for more research in the emerging and multifaceted S3 phenomenon. A comprehensive dataset from WoS, double-checked with Scopus results, formed the basis of our visualizations. All in all, 297 peer-reviewed documents and 8,173 cited references from 5,659 co-cited sources of 5,806 co-cited authors, linked to involve 298 organisations and 45 countries, have been inspected with co-citation, co-authorship and bibliographic coupling maps. To the best of our knowledge, this mapping study is the first to be designed with a focus on S3. As such, it enhances our familiarity with this novel approach. In the foregoing sections, the deducted research avenues were outlined. The most powerful S3 literature was investigated, viewed, analysed and interpreted and the following four research suggestions were derived:

*Research suggestion 1: How can specific regions be better prepared to implement sustainable S3 effectively and successfully?*

*Research suggestion 2: Despite the uniqueness of each territory and its connected circumstances, are there any common drivers and indicators in different case studies that lay the foundation for successful implementations of projects dedicated to smart specialisation?*

*Research suggestion 3: What can we learn from international role models such as the United States and Australia in linked areas and interconnected sections of smart specialisation?*

*Research suggestion 4: How and where is the facilitation of innovative entrepreneurship most effective within S3?*

## **5.1 Limitations**

To the best of our knowledge, this bibliometric study is the first one apply both quantitative and qualitative analyses using cluster mapping. As such, it cannot guarantee full comprehensiveness despite careful and well thought out research designs. However, based on the implemented structural methods and quality controls, the risk of incompleteness is rather low. Thus, the possibility that essential work that would lead to other research suggestions might have been missed, is minor. Nevertheless, citations do not always show positive correlations. Negative meaning is not taken into consideration here. Through reading all the essential top-listed references, negative citations that might have changed our recommended avenues for further research are also comparatively irrelevant. Nevertheless, further bibliometric analysis with different tools, such as SPSS, Pajek and SCImagojr, should be performed as a basis for further empirical work.

## **5.2 Implications for theory and practice**

As a final remark, this work concludes with vital implications for theory and practice. First, it is worth mentioning that all the research recommendations were prepared with both practical and theoretical underlining views. Therefore, at this stage, these considerations are presented step-by-step hereafter.

Our first research suggestion regarding the question of how S3 could be most effectively implemented in specific regions is based on the theoretical discussions of prior works with a focus on quadruple and quintuple innovation helixes (e.g. McCann and Ortega-Argiles, 2013a; Carayannis and Rakhmatullin, 2014). Linking to practices answering this research question will provide further best practices designed for measuring both the short-term and long-term impacts of successful implementation. In this regard, prior doubts could be incorporated (e.g.

Dziemianowicz and Peszat, 2014). Furthermore, these implications are also correlated to our second research suggestion referring to the uniqueness of each territory and its connected circumstances. In this regard, common drivers and indicators of previous case studies will lay the foundation for successful implementations of projects dedicated to S3. Prior theoretical debates on a case-by-case basis (e.g. Carayannis *et al.*, 2015; Koumparou, 2013; McCann and Ortega-Argilés, 2014) and practical stories (e.g. Gadille and Siarheyeva, 2014; Guisson and Van Leeuwen, 2014) will be built up and enhanced in a different light. Obviously, our third research suggestion, which recommends including lessons learned from international role models such as the US and Australia, will enhance the theoretical basis of the area of cluster mapping by Porter (e.g. Clar and Sautter, 2014; Protsiv, 2007; Vence *et al.*, 2013) as well as regional cases or certain sectorial studies (e.g. Danson and Burnett, 2014; Piotrowski *et al.*, 2014; Todeva, 2015) serving as the European path in related areas and interconnected sections for implementing S3. Finally, our fourth research suggestion regarding the effective facilitation of innovative entrepreneurship within S3 will enrich entrepreneurial theories focused on micro-level dynamics to offer a base for experimentation (e.g. Benner, 2014) or discussion on innovation ecosystems as dynamic knowledge-creation environments with multi-actors for diffusion. Absorption within diverse communities will foster sustainable innovative entrepreneurship in knowledge-based regional development (Romano *et al.*, 2014b). It will also boost innovative entrepreneurial regional practices and experience for fostering entrepreneurship and innovation with pioneering entrepreneurial discovery mechanisms (e.g. Bečić and Švarc, 2015; Rosiello *et al.*, 2015) or identification processes, spillovers and agglomeration effects through entrepreneurial discovery (e.g. Boschma and Boschma, 2014; Grillitsch, 2016). Overall, this study concludes with a call to action to approach Europe 2020 on an innovative path that includes research that can improve our lives (EC, 2010).



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