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Through the magnifying glass: an analysis of regional innovation models based on co-word and meta-synthesis methods

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Abstract This paper performs a fine-grained analysis of regional innovation models discussed in the literature, using a combination of quantitative (co-word analysis) and qualitative (meta-synthesis) methods applied to 300 papers from the Scopus and Sage databases covering the period 1990–2013. The co-word analysis produced knowledge maps that identify the most frequently occurring regional innovation models and group them into three clusters: Cluster 1 (industrial districts, local production systems), Cluster 2 (industrial clusters and regional clusters), and Cluster 3 (innovative milieus, regional innovation systems, innovation networks and learning regions). The meta-synthesis analysis used for exploring the content of these models identified three main themes, each with several sub-themes, as well as distinct features of the regions implementing them. Based on these distinctions, a typology of regions was derived, distinguishing between Early Innovators, Transitional Innovators and Advanced Innovators, which can serve as a useful instrument for academic researchers, policy-makers and practitioners involved in regional innovation.

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1 Introduction

An innovation performance analysis at national level (Lundvall 1992; Nelson 1993; Freeman 2002) can sometimes provide inaccurate results if applied to specific regional contexts, because of the heterogeneity of and frequent lack of coherence between regions in many nation states, especially large and developing ones (Evangelista et al. 2001; Acs et al. 2002; Fritsch 2002; Edquist 2005). Growing business and technology internationalization, international competition and use of information technologies reduced the importance of national borders and extended technological capabilities beyond national territories, while also increasing the popularity of regional innovation, especially among academics and policy-makers (Enright 2001). Regionalisation processes at technological, economic, political or cultural levels have been building up within the national borders of many countries.

Much of the popularity of regional innovation models such as, for example, regional innovation systems, comes from the emergence of regional economic nodes or clusters and the more recent focus on regional innovation policies to sustain innovation-based economies (Doloreux and Parto 2005). Localized capabilities such as resources, institutions and shared common social and cultural values are key drivers of regional innovation (Maskell and Malmberg 1999). Regional innovation has a variety of definitions in the literature (e.g. Storper 1995; Doloreux and Parto 2005) and is also closely associated with regional development in intricate and complex ways that are socially determined by particular groups and/or interests in specific places and time periods (Pike et al. 2010). Just as there is no single understanding of regional innovation, there is no best policy implementation approach in a region (Cooke et al. 2000; Isaksen 2001; Nauwelaers and Wintjes 2003), as the implementation approach is highly context-specific. A mix of regional visionary capability and concrete tools and institutional settings are needed for enhancing knowledge creation and management and for enabling planning for the future (Uotila et al. 2005). Regional innovation capacity is also influenced by factors like the regional production and innovation environment, the local university system, public administration and private enterprises (Buesa et al. 2006).

The literature provides a plethora of regional innovation models, e.g. industrial clusters (Porter 1990, 1998), regional clusters (Saxenian 1994), industrial districts (Bagnasco 1977), new industrial spaces (Storper and Scott 1988), high-tech areas (Keeble and Wilkinson 2000), clusters of knowledge-based industries (Cooke 2002), local production systems (Doloreux and Parto 2005), etc., but a comprehensive categorization and clustering of main themes in these models is lacking.

This paper attempts to fill this gap by using quantitative and qualitative methods (co-word analysis and meta-synthesis, respectively) which have been applied to a selection of 300 regional innovation papers covering the period 1990–2013 in order to identify the most frequently occurring regional innovation models and their main themes. The co-word analysis of regional innovation models produced 2D knowledge maps (bibliometric maps) of four different types: (i) label view, (ii) density view, (iii) cluster density view, and (iv) scatter view, based on selected keywords and a similarity matrix. The label and density view maps converge in identifying regional innovation systems, innovative milieus and learning regions as the most frequently occurring regional innovation models. The cluster view map groups regional innovation models in three clusters: Cluster 1 (industrial districts, local production systems), Cluster 2 (industrial clusters, regional

clusters), and Cluster 3 (innovative milieus, regional innovation systems, innovation networks and learning regions). The meta-synthesis identified three main themes in regional innovation models, each with own sub-themes: (i) *the development level of regions, especially in terms of institutions,* with sub-themes as: development of institutional systems, industrial infrastructure, human resources and local markets; (ii) *a decreasing direct role of government, especially in the interaction with industrial organizations and companies,* with sub-themes including: the role of governance systems in the market, local government objectives, impact of WWII and Cold war; and (iii) *globalization and increase in international relations,* with sub-themes as: international cooperation, networks among regions, national and international levels, globalization and modern communication technology.

The novelty of the paper consists of the application of this combined set of qualitative and quantitative research methods, the identification of the most frequently-occurring regional innovation models discussed in the literature and of their main themes, as well as the construction of a typology of regions that distinguishes between Early Innovators, Transitional Innovators and Advanced Innovators.

The structure of this paper is as follows: Sect. 2 reviews the regional innovation literature. Section 3 provides a description of the methodological approach adopted in this paper. Section 4 discusses the results of the quantitative (co-word analysis) and qualitative (meta-synthesis) methods and their convergence, and provides a typology of regions, based on the innovation models that characterize them. Section 5 summarizes the findings, draws some conclusions and discusses limitations of the research, as well as directions for further advancement of this study.

2 Literature review

The importance of innovation in regions and specific implementation mechanisms have been highlighted in a variety of regional innovation models (Cooke 2001; Enright 2001; Doloreux and Parto 2005; Asheim and Coenen 2006; Zygiaris 2009). Innovation occurs in institutional, political and social contexts that are deeply embeded within a regional economic context (Doloreux and Parto 2005). Interactions among the parts of a region may be technical, commercial, legal, social and financial, and are aimed at the development, protection, financing or regulation of new technology and innovation (Ferrara et al. 2012).

Innovation is fundamentally a geographical process, where localized capabilities such as resources, institutions and shared common social and cultural values are key drivers (Maskell and Malmberg 1999; Doloreux and Parto 2005). Regions can ensure a sustainable growth in a medium-long term perspective by making substantial changes in the way they manage their innovation (Ferrara et al. 2012).

Industrial districts (Bagnasco 1977), local production systems (Bouchrara 1987; Moulaert and Sekia 2003), innovative milieus (Aydalot 1986), industrial clusters (Porter 1990, 1998), regional clusters (Saxenian 1994), regional innovation systems (Cooke 2002; Doloreux and Parto 2005; Asheim and Coenen 2006), learning regions (Morgan 1997), innovation networks (Rycroft 2003) are some of the most important regional innovation models identified in the literature. While all of them reflect economic, political, social and other aspects, different theoretical and economic roots can be distinguished (Fig. 1).

The industrial district model is rooted in Marshall's approaches of partial equilibrium and flexible manufacturing systems (Piore and Sabel 1984) that can increase pro-

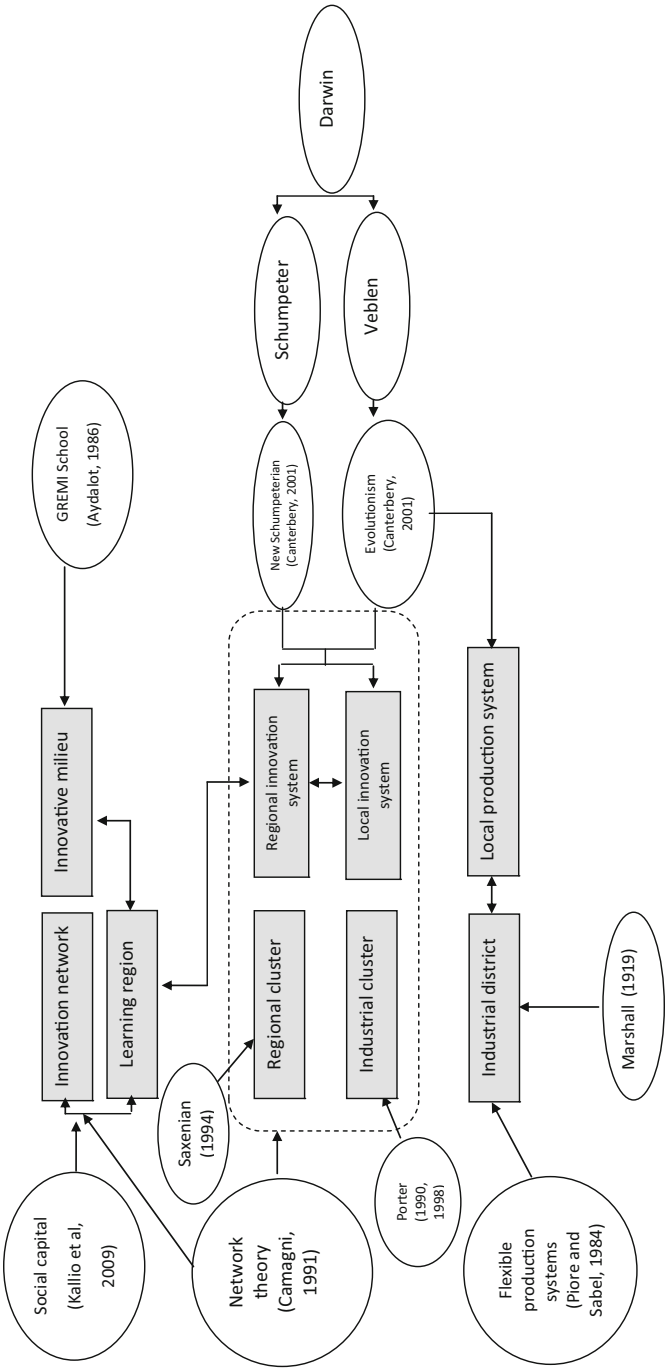


Fig. 1 Regional innovation models and some of their main roots

ductivity (Storper and Scott 1988; Canterbery 2001; Moulaert and Sekia 2003). Flexible manufacturing systems also served as one of the origins of the new industrial space concept, similarly to the industrial district. The main features of these models are the concentration on the innovation capacity of industrial firms and filling gaps in the regional value chain in specific industries based on trust and interaction of key players.

The local production system model is close to the industrial district model and considers industrialization as a key process in a region (Bouchrara 1987; Moulaert and Sekia 2003). The regional cluster approach is often related to Saxenian' s (1994) study of Silicon Valley, where she pointed out the importance of regional institutions and culture for development. Porter (1990, 1998) proposed the industrial cluster concept with emphasis on market and competition, rather than on networking and social aspects (Enright 2001).

Several other regional innovation models—regional innovation systems (Cooke 2002; Doloreux and Parto 2005; Asheim and Coenen 2006), learning regions (Morgan 1997), innovation networks (Rycroft 2003)—are a translation of the evolutionist and institutionalist view of economic development (Moulaert and Sekia 2003; Carlsson 2007). Network theories, social capital, learning and the relationship among the players play important roles in regional innovation development in these approaches. Innovation in the regional innovation system approach is a creative process resulting from the interactions between agents of the process in a region (Edquist 1997; Autio 1998; Moulaert and Sekia 2003).

In the 1990s, especially after the introduction of the National Innovation System concept, new regional theories were promoted by academics and policy-makers. These new approaches consider regional development as an evolutionary process which does more than filling gaps in the regional value chain and is based on social, economic and institutional contexts. Systematic approaches, such as regional innovation systems (RIS) are rooted in the neo-Schumpeterian and institutionalism approaches (Uyarra 2008).

In the learning region model (Morgan 1997; Cooke 2002; Asheim and Coenen 2006), knowledge is the most important strategic resource and learning is the most important process. The innovation network model (Rampersad et al. 2010; Rycroft 2003) involves continuous collaboration relationships among governments, businesses and research centers to achieve innovation. International collaboration for innovation development is one of the key themes in this model. Table 1 summarizes the characteristics of regional innovation models discussed above.

Figure 2 shows the evolution over time of regional innovation models promoted especially in European countries and the US, reflecting changes in their regions and innovation environment.

The increasing spread of regional innovation policies has also influenced the industrial policy orientation of some governments, in the sense of a gradual shift from selective to functional measures. 'Functional' and 'selective' policies (sometimes called 'horizontal' and 'vertical' in economic theory) are important instruments for regulating the economic environment. Functional (horizontal) policies are those aimed at improving "the framework in which firms and industries operate and where market mechanisms ultimately determine survival and prosperity" (EBRD 2008, p. 80). In this category can be included the improvement of the legal framework for business, and incentives for research and development. Selective (vertical) policies, in contrast, favour certain activities over others and are typically implemented through trade protection and subsidies in the form of tax incentives or soft loans, targeted at specific firms, regions or sectors (Altenburg 2011).

Table 1 Regional innovation models and their features

Model	Features
Industrial district (Bagnasco 1977)	Importance of the innovation capacity of SMEs in an industry and region
	Formal and informal social, economical and political relations are fundamental for innovation in a region
	Value chain completion based on SMEs is the core of innovation in a region
	Importance of technological innovation
Local production system (Bouchrara 1987; Moulaert and Sekia 2003)	Provides a generalization of the industrial district view
	Local production systems bridge local diffuse industrialization rooted within a local community and national and international economic pressures
	Importance of local social and cultural context in regional development
Innovative milieu (Aydalot 1986)	Importance of a supportive environment in a region for innovation
	Importance of institutions (universities, firms, governments, etc.) in the research and innovation process
	Apprenticeship is a key part of learning and innovation in a learning region
Industrial cluster (Porter 1990, 1998)	Emphasis on market and competition
	Importance of networking and knowledge agglomeration for innovation
Regional cluster (Saxenian 1994)	Importance of institutions, culture, industrial structure for innovation
	Networking and social interactions are the core of innovation
Regional innovation system (Edquist 1997; Autio 1998; Moulaert and Sekia 2003).	Systematic interactions among institutions such as universities, firms, governments are the core of innovation
	A supportive environment and infrastructure are important for innovation
	Innovation is more than technological advancement, it is an organizational process
	Innovation is a cumulative and interactive process which is path dependent
Learning region (Morgan 1997; Cooke 2002; Asheim and Coenen 2006)	Innovation is an interactive process
	Importance of evolution of technology and institutions in innovation
	Importance of networking and social interactions for innovation
	Learning is the key to innovation
Innovation network (Rampersad et al. 2010; Rycroft 2003)	Importance of the cooperation between research organizations, universities, governments and businesses for technology cooperation
	Innovation networks are the new paradigm to meet the requirements of globalization
	Innovation is an interactive and cumulative process

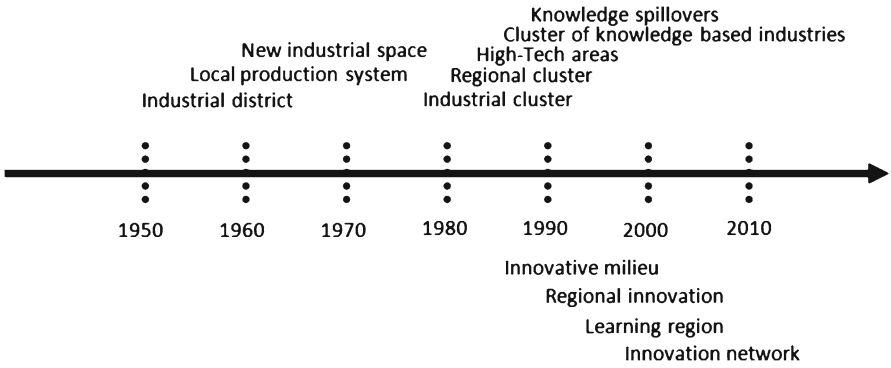


Fig. 2 Evolution over time of regional innovation models

3 Research method

This paper adopted a multiple methodology or multi-methodology research, which couples in-depth, contextualized qualitative research with quantitative research in order to provide more comprehensive evidence and answer questions that cannot be answered by either approach alone (Creswell 2003). The methods adopted in this paper in order to identify the main themes of regional innovation models include:

- *Co-word analysis*, a quantitative content analysis technique which allows analyzing and following the main themes in a field and their relations (Garfield 1994). A number of 300 papers on regional innovation from 1990 to 2013 collected from Sage and Scopus databases (Sage 2013; Scopus 2013) were submitted to an analysis of co-occurring keywords, terms extracted from titles, abstracts and/or full text, subject headings or cited authors (Noyons et al. 1999). Co-word analysis has been used to explore the main themes and concepts in different fields, such as plant biology (De Looze and Lemarie 1997), condensed matter physics (Bhattacharya and Basu 1998), consumer behavior research (Muñoz-Leiva et al. 2011), medicine (Onyancha and Ocholla 2005), etc. A four-step co-word analysis (Fig. 3) based on the integration of full-text based techniques was applied, and the mining process and calculations followed the process proposed by Weiss et al. (2005). The output of co-word analysis is a *knowledge map of regional innovation models*, which groups the main regional innovation models into several clusters and shows their relationships and number of uses.
- *In-depth analysis using the meta-synthesis method* This qualitative method is focused on creating new knowledge based on interpretation of literature (Paterson et al. 2001; Sandelowski and Barroso 2007), in a process of translation (Noblit and Hare 1988). In this study, the meta-synthesis was used as a systematic qualitative method for in-depth analysis and interpretation of the main themes of regional innovation models, in corroboration with the findings of the knowledge maps. A seven-step meta-synthesis methodology (Sandelowski and Barroso 2007) was used (Fig. 4).

The research methodology steps associated with the co-word analysis and meta-synthesis methods applied in this analysis are presented in Fig. 5.

A brief description of the three methodological blocks described in Fig. 5 is given below.

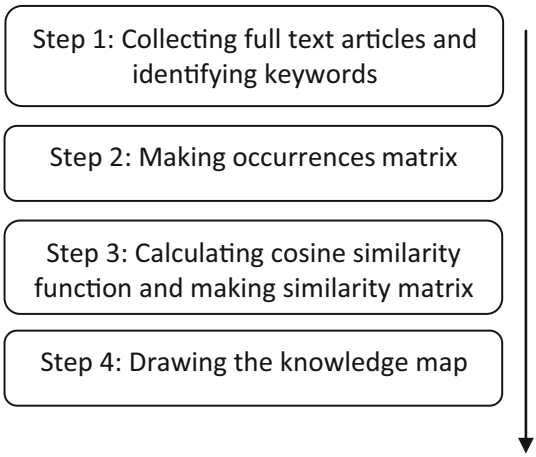


Fig. 3 The 4 steps of the mining process by co-word analysis

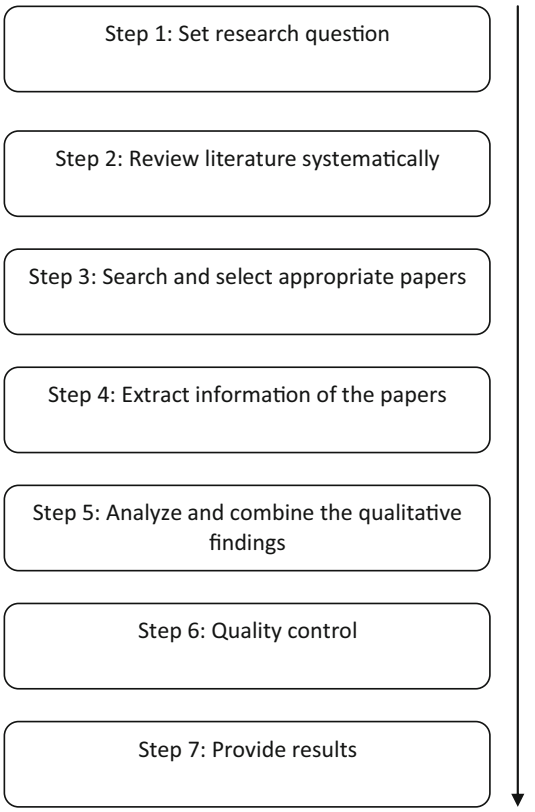


Fig. 4 The 7 steps of the meta-synthesis method

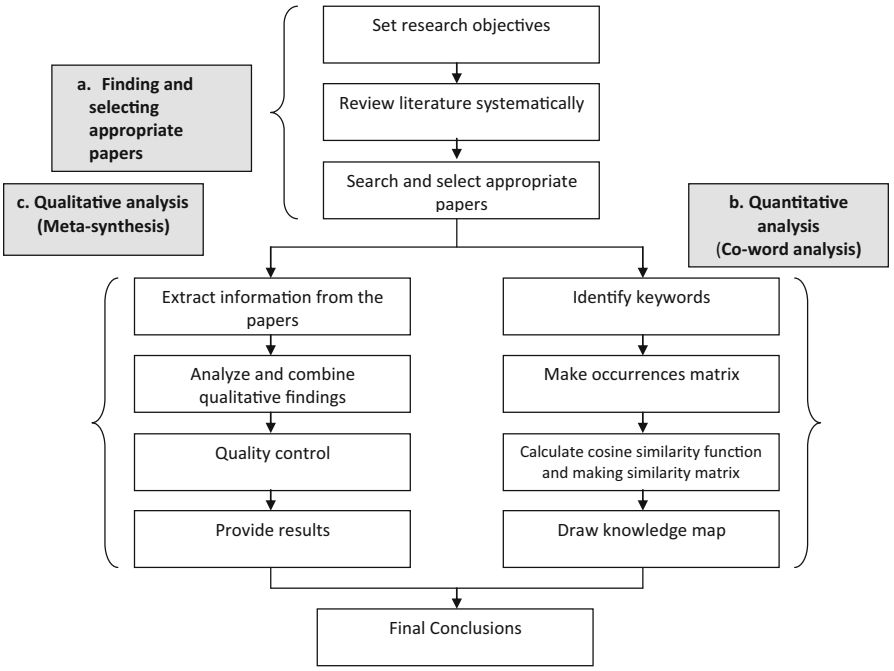


Fig. 5 Research methodology steps followed in the analysis

3.1 Finding and selecting appropriate papers

3.1.1 Set research objectives

In this first step, the research objectives of the paper were defined as identifying the regional innovation models most frequently occurring in the literature (identified through the quantitative co-word analysis), then analyzing their content/themes (identified through the qualitative meta-synthesis analysis). This dual purpose explains the need for a multiple research methodology.

3.1.2 Review literature systematically/search and select appropriate papers

The paper selection included regional innovation papers and related papers identified from their references. The Sage (2013) and Scopus (2013) databases were searched by keywords such as regional innovation, territory, local innovation, etc. After reviewing the abstracts of these papers, a final selection of 300 papers published between 1990 and 2013 and related to the research objectives of the study was submitted to the co-word analysis as the quantitative part of the study. Thereafter, 51 papers out of the 300 have been selected for qualitative in-depth analysis, based on the highest numbers of citations and related papers. The 51 papers were assessed for quality, initially using the COREQ 32-item check-list. Annex 1 shows the papers included in the meta-synthesis method with the results of the quality assessment based on COREQ 32-Item (Tong et al. 2007). Scores of 28 and higher were considered to represent high-quality papers, and scores between 22 and 27 average quality papers. The quality of the papers was strictly related to the research objectives of this study and is not applicable

to other studies with different objectives. Two authors assessed each paper and decided on its selection. Of the 51 papers, 36 had average quality and 12 papers had high quality. Three out of the 51 papers were excluded due to an overall rating of minor quality, especially in scope and purpose, study design, analysis and findings, and relevance. Thus, 48 papers were finally selected for the meta-synthesis method in view of identifying main themes. The final 48 papers were reviewed in full text format.

3.2 Quantitative analysis (co-word analysis)

3.2.1 Identifying keywords

After the literature review, 36 keywords were identified in the first screen, and only eight of them remained as keywords in the second screen (dictionary of regional innovation models for co-word analysis). These eight keywords are: learning region, innovative milieu, industrial district, local production system, regional innovation system, regional cluster, industrial cluster and innovation network. Although these keywords cover most models and concepts in regional innovation, they can be changed in other studies based on the researcher's preferences and criteria. The 300 papers from 1990 to 2013 identified from the Scopus and Sage databases were then used for drawing the regional innovation models knowledge map as an output of co-word analysis.

3.2.2 Making the occurrences matrix

In this step, the occurrences matrix results from the dataset gathered in the previous step. The number of rows in the matrix is equal to the number of keywords, and the selected documents are placed in columns. If one keyword has been used in a document, the content of this cell is equal to the number of uses of that keyword in the document. In this study, the mining of full texts, instead of just titles and abstracts, has been employed. Mining full texts introduces extra difficulties and noise, but it is preferred if the full text is available (Glenisson et al. 2005). Due to this fact, full text papers were exploited in order to increase the reliability of conclusions.

3.2.3 Calculating cosine similarity function and making the similarity matrix

One of the information retrieval approaches to comparing documents is cosine similarity. The word count and bonus approach is a variation of computing tf-idf. For cosine similarity, only positive words shared by the compared documents are considered, but the frequency of word occurrence is also valued. The cosine similarity formula (Weiss et al. 2005) is presented below.

$$w(j) = \mathrm{tf}(j) * \log_2(N/\mathrm{df}(j)),$$
$$\mathrm{norm}(D) = \sqrt{\sum w(j)^2},$$
$$\mathrm{cosine}(d1, d2) = \sum (w_{d1}(j) * w_{d2}(j))/(\mathrm{norm}(d1) * \mathrm{norm}(d2))$$

- $w(j)$: The weight of a word in a document,
- j is the j-th word in the dictionary,

- tf(j) is the j-th word frequency in the document,
- N is the number of documents in the (training) collection,
- df(j) is the number of documents in which the word appears,
- The tf-idf measure can be normalized to a unit length of a document D as described by norm (D) in Equation.

Weiss et al. (2005) note that "the cosine distance multiplies the weights of the shared words of the two compared documents, which is similar to a logical AND operation requiring a word to be present in both documents. The measures of individual words are summed over all words according to Equation, resulting in a measure of overall similarity between two documents." The similarity matrix (Table 2) was made based on cosine similarity calculations, for which a software programme was written by the paper authors.

3.2.4 Drawing the knowledge map

For this step, the VOSviewer_1.2.1, a software tool specifically designed for constructing and visualizing bibliometric and knowledge maps[1] was used. Minimizing a weighted sum of squared Euclidean distances between all pairs of items through an optimization process is the main idea of the VOS mapping technique (Cobo et al. 2011). The similarity matrix and the keywords identified previously are used in VOSviewer_1.2.1 as input data. VOSviewer_1.2.1 shows 2D maps, of four different types: (i) label view, (ii) density view, (iii) cluster density view, and (iv) scatter view, based on the selected keywords and the similarity matrix used as inputs.

In our study, the following regional innovation knowledge maps were drawn:

(i) *In the label view* (Fig. 6) each element is represented by a label and a circle. The size of the label and circle shows the importance of each item. Each cluster has a special color. *In the label view, regional innovation system, innovative milieu and learning region appear as the most important labels.*

(ii) *In the density view* (Fig. 7), according to Cobo et al. (2011), "each point in the map has a color that depends on the density of items at that point, which depends both on the number of neighboring items and on the weights of these items. VOSViewer calculates the density of each point according to the equation defined by Eck and Waltman (2010), which uses a Gaussian kernel function". The red color represents the highest density and the yellow and green colors represent lower densities of concepts. *In the density view, the highest densities can be found for regional innovation system, innovative milieu and learning region.*

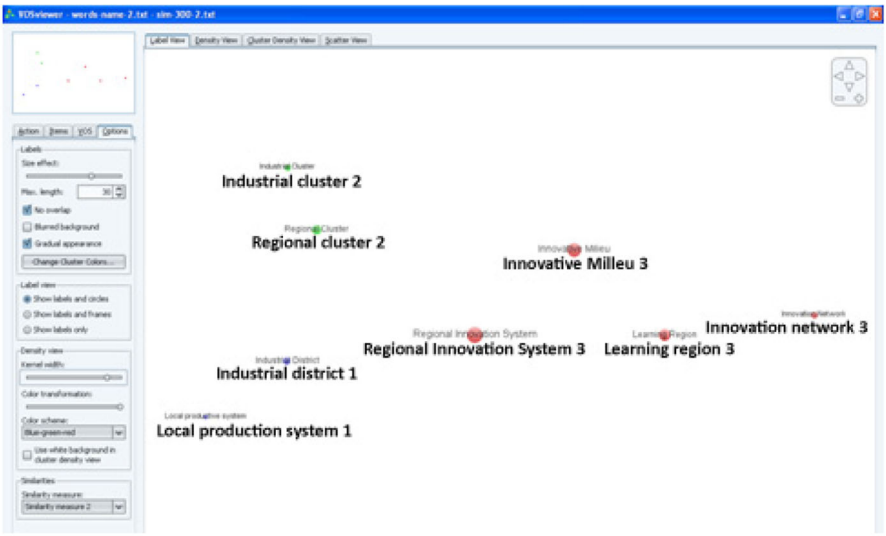
(iii) *The cluster density view* (Fig. 8) displays items separately for each cluster. Figure 8 shows three clusters: the first includes industrial district and local production system, the second includes industrial cluster and regional cluster, and the third covers the regional innovation system, innovative milieu, learning region and innovation network.

(iv) *The scatter view* is a simple view in which items are indicated by a small circle and no labels are displayed. However, because of the small size of the image, this view is not presented.

[1] The software tool was developed by the Centre for Science and Technology Studies (CWTS) at Leiden University in the Netherlands.

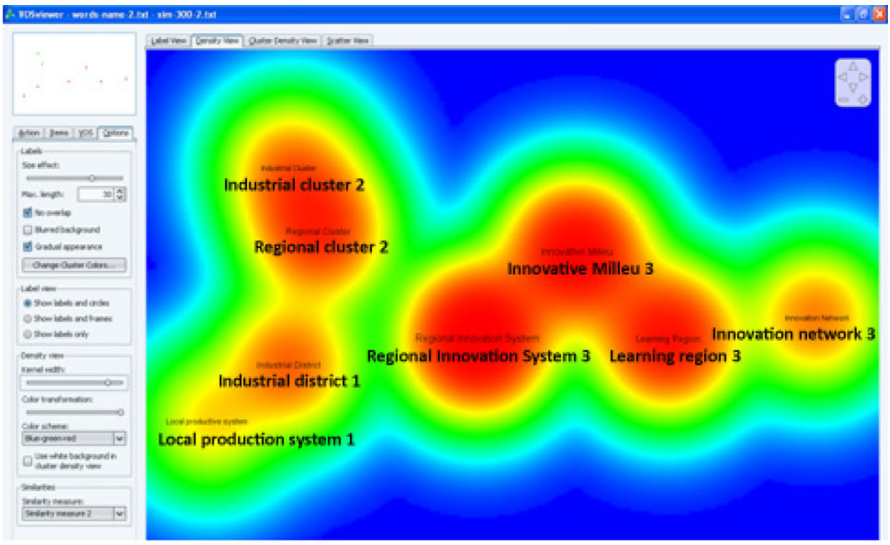
Table 2 Similarity matrix

	Learning region	Innovative milieu	Industrial district	Local production system	Regional innovation system	Regional cluster	Industrial cluster	Innovation network
Learning region	215	0.204603081	0.062480747	0.005495713	0.20681571	0.048669984	0.02004182	0.109056896
Innovative milieu	0.204603081	61	0.088144344	0.00824758	0.252637825	0.054780372	0.08163854	0.095897422
Industrial district	0.062480747	0.088144344	560	0.07354141	0.040908026	0.030329311	0.054652476	0.00754492
Local productive system	0.005495713	0.00824758	0.07354141	24	0.073231644	0.024196696	0.004270269	0
Regional innovation system	0.20681571	0.252637825	0.040908026	0.073231644	275	0.233024747	0.048061227	0.091120405
Regional cluster	0.048669984	0.054780372	0.030329311	0.024196696	0.233024747	28	0.107149478	0.005626864
Industrial cluster	0.02004182	0.08163854	0.054652476	0.004270269	0.048061227	0.107149478	107	0.001986075
Innovation network	0.109056896	0.095897422	0.00754492	0	0.091120405	0.005626864	0.001986075	60



- The numbers (1, 2, 3) represent three clusters.

Fig. 6 Label view of the regional innovation knowledge map

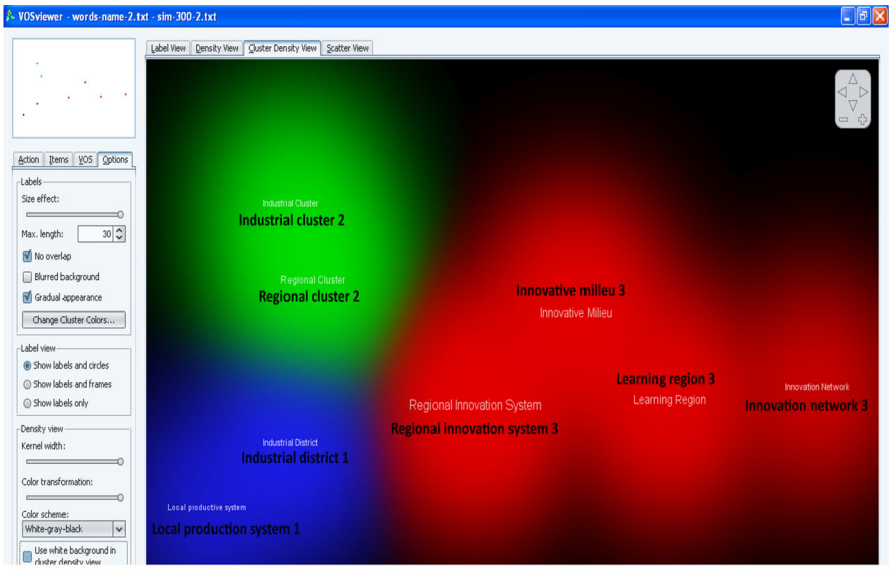


- The numbers (1, 2, 3) show three clusters.

Fig. 7 Density view of regional innovation models knowledge map

3.3 Qualitative analysis (meta-synthesis)

For the meta-synthesis method, the statistical population included 48 regional innovation studies from 1990 to 2013 collected from Sage and Scopus databases. The data were of qualitative type, and thus the Open Coding method was used, as one of the best known methods of qualitative data analysis. Open Coding is the first step of data coding which is



- The numbers (1, 2, 3) show three clusters.

Fig. 8 Cluster density view of regional innovation knowledge map

used in grounded theory method (Strauss and Corbin 1990). The codes are extracted from text and then another coding is applied on them to form concepts and categories (text-code-concept). One of the main challenges of the meta-synthesis is to find, classify and integrate findings from qualitative studies using multiple methods from several analytical and theoretical perspectives (Bondas and Hall 2007). Each paper was investigated based on authors, methodology, approach, references and quality.

The papers were divided in three categories: Theory, Case Study, and Review. Theory papers propose a framework for a regional innovation concept or investigate some factors and theoretical aspects of such concept. Case Study papers refer to the industrial and innovation context in different regions around the world. Most of the regions analysed were in Europe (e.g. furniture industry in Salling, Denmark; wireless communication industry in North Jutland, Denmark; innovation regional planning in Algarve, Portugal; innovation analysis in British regions; functional food industry in Scania, Sweden; product innovations and export entrepreneurship by firms in Swedish regions; food industry in Rogaland, Norway and electronics industry in Horten, Norway; biotechnology in regions of Germany; regional innovation system in the Lahti region of Finland and innovation in Emilia Romagna, Italy), while others were in the United States and Australia, with a few cases also from China (such as Guangdong province and the Pearl River Delta). Review papers refer to discussions of different regional innovation models.

The results show that 29 papers focused on factors and frameworks of regional innovation models (Theory), 17 papers explained innovation experiences of regions (Case study) and only two papers reviewed several regional innovation models (Review). The convergence of themes across the papers was explored systematically. In the last step the themes were synthesized. Three main themes, each with own sub-themes, were identified and were found convergent and compatible among the papers (Noblit and Hare 1988). Annex 2 shows the codes of selected papers related to themes and sub-themes. 48 high and average papers were

codified by code A#. Annex 2 also presents the themes and sub-themes covered by the selected papers. For instance, code A2-31 means paper no. 2 pointed out the first sub-theme of third theme.

Three themes were identified by the findings of meta-synthesis method (code, sub-theme, theme):

(i) *Theme 1: The development level of regions, especially in terms of institutions,* with sub-themes as: development of institutional systems, industrial infrastructure, human resources and local markets.
(ii) *Theme 2: A decreasing direct role of government, especially in the interaction with industrial organizations and companies,* with sub-themes including: the role of governance systems in the market, local government objectives, impact of WWII and Cold War.
(iii) *Theme 3: Globalization and increase in international relations*, with sub-themes as: international cooperation, networks among regions, national and international levels, globalization and the modern communication technology.

A detailed account of the meta-synthesis results by theme is presented in the next section.

4 Discussion of results

A combination of quantitative (co-word analysis) and qualitative (meta-synthesis analysis) methods was used in this paper to identify and characterize key regional innovation models in the literature.

4.1 Co-word analysis results

The co-word analysis produced 2D knowledge maps, of four different types: (i) label view, (ii) density view, (iii) cluster density view, and (iv) scatter view, based on selected keywords and the similarity matrix used as inputs. The label and density view maps converge in identifying regional innovation systems, innovative milieus and learning regions as the most frequently occurring regional innovation models. The cluster view map groups regional innovation models in three main clusters: Cluster 1 (industrial districts, local production systems), Cluster 2 (industrial clusters, regional clusters), and Cluster 3 (innovative milieus, regional innovation systems, innovation networks and learning regions).

4.2 Meta-synthesis results

The meta-synthesis analysis supports this clustering and adds further relevant insights regarding the main themes and sub-themes of the key regional innovation models, as follows:

- *Theme 1: The development level of regions, especially in terms of institutions*

Regional innovation models started to be explored after WWII, when regional and institutional development was needed to fix damages and weaknesses in the institutional structures that had been affected by the war, especially in European countries (Moulaert and Sekia 2003). After the 1960s, because of these weaknesses and the declining performance of some traditional production regions, the need for reconstruction and investment in the industrial development of regions became an important issue. Different development models emerged,

Table 3 Characteristics of expert-, experience- and efficiency-driven businesses

Business/characteristic	Kind of the problem	Problem-solving method	Competitive advantage
Expert-driven	New	New	Innovation
Experience-driven	New	Current or routine	Adaption to current problem-solving methods and techniques
Efficiency-driven	Current or routine	Current or routine	Ability to reduce costs in products or services

Source: Gottschalk (2005)

based on completing the value chain of regions in one or several industries. Concepts like industrial districts (Bagnasco 1977), new industrial spaces (Storper and Scott 1988) and local production systems (Doloreux and Parto 2005) were proposed for filling gaps in the value chain of regions confronted with different problems.

These regional innovation models consider specific industries with limited players, who exploit the regional capacities for industrial development and value chain completion. Institutional development, as well as other regional aspects, improved gradually, especially in regions in Western countries. Universities and industries underwent significant reconstruction and improved their capacity to implement innovation. Also, governments transferred some of their traditional responsibilities to private or non-governmental institutions (Canterbery 2001; Cooke 2001; Moulaert and Sekia 2003). Businesses moved from efficiency-driven models to experience-driven and expert-driven ones (Table 3), where the role of innovation is more important (Allee 1997; Fritsch 2002; Asakawa and Lehrer 2003; Gottschalk 2005; Arvanitis and Jastrabsky 2006; Uyarra 2008).

Following these developments, new innovation models, like industrial clusters (Porter 1990, 1998), regional clusters (Saxenian 1994) and systematic approaches such as the regional innovation systems (Cooke 2002; Doloreux and Parto 2005; Asheim and Coenen 2006), learning regions (Morgan 1997) and innovation networks (Rycroft 2003) started to be used in the regions. Much of the efficiency and effectiveness of systematic approaches was related to the maturity of institutions (Cooke 2001; Asheim and Coenen 2006; Andersson and Johansson 2008).

- *Theme 2: A decreasing direct role of government, especially in the interaction with industrial organizations and companies*

The government role is fundamental in investigating the roots and the characteristics of regional innovation models (Oughton et al. 2002; Gerstlberger 2004; Clark et al. 2009). Government interaction with other institutions typically increases in crisis situations or wars, so that enhanced government intervention in organizations and institutions was visible after WWII. Most regional markets were state-regulated (Moulaert and Sekia 2003; Moulaert et al. 2005). Some regional innovation models that emerged after WWII and the Cold War such as industrial districts (Bagnasco 1977), new industrial spaces (Storper and Scott 1988) and local production systems (Doloreux and Parto 2005) take into consideration the state-regulated markets and the role of SMEs. In these models, governments use selective policies that promote local advantages and proximity for selecting priorities. In this period, regional innovation models focus on endogenous development to solve their problems, and the main goal of governments is the reconstruction of the regional economy (Bagnasco 1977; Storper and Scott 1988; Moulaert and Sekia 2003; Doloreux and Parto 2005).

Later on, especially after the Reagan and Thatcher programmes for reducing government power, the role of government gradually moved towards that of an institution for policy-making and provision of infrastructure, rather than for regulating the market (Enright 2001; Nauwelaers and Wintjes 2003). Thatcher's privatization and Reagan's deregulation policies transferred economic power from the state into private hands (Starr 1988; Canterbery 2001). Therefore, the government role in newer regional models such as industrial clusters, regional clusters and systematic approaches such as regional innovation systems, learning regions and innovation networks has decreased.

- *Theme 3: Globalization and increase in international relations*

Globalization and some infrastructure (e.g. IT) as regional development enablers changed regional policies in Western countries. Many regions evolved from a local economy based on a regional advantage to an international economy based on global networks and knowledge-based industries (Archibugi and Iammarino 1999; Tödtling and Trippl 2005). In these regions, non-linear and network-based innovation models, such as industrial clusters (Porter 1990, 1998) and regional clusters (Saxenian 1994) started to be applied, characterized by factors like institutional development, privatization, decreasing role of governments in the economy, etc.

The 1990s was an important time for new theories in developed regions. In this decade and thereafter, most regional innovation models became more systematic. The considerable increase of international relations due to IT, stronger institutions in the developed regions, globalization, the variety of innovation players were the main incentives for using systematic approaches in the regions (Trippl 2008; Zygiaris 2009). The globalization of innovation can be categorized in three groups: (a) the international exploitation of technology produced nationally; (b) the global generation of innovations; (c) global technological collaborations (Archibugi and Iammarino 1999). Recent regional innovation models such as learning region or innovation network pertain more to the second and third groups (Asheim and Coenen 2006; Buesa et al. 2010; Krishna et al. 2012). New regional innovation models provided some answers to new requirements for global competitiveness. In some of the new models such as the innovation network, the concept of network extends from local to international networks (Archibugi and Iammarino 1999; Rycroft 2003; Uyarra 2008).

Based on these themes and the dominant regional innovation model, a typology of regions can be derived (Table 4). Thus, regions where Cluster 1 innovation models operate can be considered as *Early Innovators*, which have limited international relations, need infrastructure support from their governments, and have predominantly state-regulated markets, where local advantage and proximity play an important role in selecting priorities. They have a local economy with a limited number of players, among which SMEs account for a large share, and apply selective policies. Regions operating under Cluster 2 innovation models can be considered as *Transitional Innovators*, as they are typically in a transition from a local economy based on regional advantage to an international economy based on global networks and knowledge industries, where networks and social interactions are important. These regions are also shifting from state-regulated market to self-regulated markets, which is a prerequisite for global competitiveness. Regions operating under Cluster 3 innovation models can be considered as *Advanced Innovators*, which are characterized by a decreasing direct role of government in the economy and a gradual shift of government regional policies from selective to functional. Such regions aim to enhance networking and social capital, and build new capacities in firms for improving learning capabilities, especially for global competitiveness. Such regions provide a supportive environment for

Table 4 Typology of regions based on the innovation models they apply

Region	Models	Features
Type 1 region: Early innovators	Cluster 1 models: industrial districts, local production systems	Limited international relations
		Need infrastructure support from government
		Predominantly state-regulated markets
		Strong role of SMEs
		Important role of local advantages and proximity for selecting priorities.
		Selective policies
		Local economy with limited players
Type 2 region: Transitional innovators	Cluster 2 models: industrial clusters, regional clusters	Shift from a local economy based on regional advantage to an international economy based on global networks and knowledge industries Important role of networks and social interactions
		Shift from state-regulated market to self-regulated markets
		Focus on networking and social interactions
Type 3 regions: Advanced innovators	Cluster 3 models: innovative milieus, regional innovation systems, innovation networks and learning regions	Decreasing direct role of government in the economy
		Gradual shift of government regional policies from selective to functional
		Focus on networking, social capital, new learning capacities in firms
		Focus on global competitiveness
		Supportive environment
		Innovation in different fields (technological, organizational, etc.)
		Self-regulating markets

Innovation in different fields (technological, organizational, etc.) and have self-regulating markets.

4.3 Convergence of co-word and meta-synthesis results

The co-word analysis as a quantitative method and the meta-synthesis as a qualitative method show convergent results. The co-word analysis grouped similar regional innovation models in three clusters, while the meta-synthesis has provided an in-depth analysis of models' contents and confirmed the similarities between the models grouped in each cluster of the knowledge map.

It is relevant to note here some important differentiations among the clusters of regional innovation models identified by the co-word analysis, which were further clarified by the results of the meta-synthesis.

- The meta-synthesis identified a shift from a local economy based on regional advantage in Cluster 1, to an international economy based on global networks and knowledge industries, with a key role of networks and social interactions in Cluster 2 and Cluster

3, and a shift from state-regulated market to self-regulated markets, as a requirement for global competitiveness.

- The meta-synthesis also identified a change in the role of governmental policies in Cluster 1 to that in Cluster 2 and Cluster 3. This change consists of decreasing direct role of governments in the economy and a gradual shift of government regional policies from selective to functional, with increased emphasis on networking, social capital and building new capacities in firms for improving learning capabilities, especially for global competitiveness.
- Finally, the meta-synthesis highlighted a shift from a focus on value chain completion and selective innovation policy-making in Cluster 1 to a systematic approach in Cluster 3, which includes functional innovation policies and a more limited role of government. The regional development level and the government role in regional economies and international relations are important in this shift and also in selecting the appropriate theory for policy-making in a region.

4.4 Relevance of the results

The clustering and in-depth analysis of the most frequently occurring regional innovation models, the discussion of main themes that characterize them and of the main features of the regions where these models operate can offer useful insights to academics, policy-makers and practitioners engaged in regional innovation development. In particular, the typology of regions that can be Early Innovators, Transitional Innovators and Advanced Innovators can increase awareness of these distinct features and facilitate the choice of an appropriate innovation model for a given region, subject to the characteristics, learning capabilities and production capacities of the region, the maturity of its institutions, local and/or international market connections, the stronger or weaker role of the government in the region, etc.

This typology can also serve as a useful instrument for understanding the specific aspects and suitability of different innovation models to different types of regions. This is particularly relevant in situations where regional policy-makers seeking rapid transformation and renewal in Early Innovator regions, such as in some developing countries, with incipient regional innovation ecosystems, look at the experience of Advanced Innovators and aim to implement policies specific to advanced innovation ecosystems in regions where innovation infrastructure is not very advanced and the relationships between key innovation stakeholders are not well consolidated. Such policy choices can lead to expensive, but ineffective experiments.

This typology is also compatible with other regional qualitative categorizations currently available. For example, the 2011 categorization of OECD regions using socio-demographic, economic and innovation-related variables (see Ajmone Marsan and Maguire 2011) provides three macro categories: *knowledge hubs* (regions with the highest levels of wealth and innovation performance, which develop strategies oriented on capitalising on their current advantages), *innovation production zones* (regions with different production characteristics that face specific restructuring and transformation challenges to keep up with the moving innovation frontier) and *non-S&T-driven* (peripheral regions that need to build up knowledge absorption capacity and knowledge generation assets to catch up with more advanced OECD regions). These macro regional categories are largely compatible with the categories defined in this study: Advanced Innovators, Transitional Innovators, and Early Innovators, respectively. The typology is also compatible with Cooke 's (1998) Localist, Interactive, and Globalised categorization of regions, Tödtling and Trippl's (2005) Metropolitan, Mature industrial, and Peripheral regions, and Asheim's (2007) Territorially embedded, Regional networked, and Regionalised national regions.

5 Conclusions and directions for further development

A combination of co-word and meta-synthesis methods of quantitative and qualitative research was applied in this study to a selection of 300 papers from the Scopus and Sage databases covering the period 1990–2013 in order to identify the most frequently occurring regional innovation models and categorize their main themes.

The label view and the density view knowledge maps produced by the co-word analysis converge in identifying regional innovation systems, innovative milieus and learning regions as the most frequently occurring regional innovation models, while the cluster view map groups regional innovation models in three main clusters: Cluster 1 (industrial districts, local production systems), Cluster 2 (industrial clusters, regional clusters), and Cluster 3 (innovative milieus, regional innovation systems, innovation networks and learning regions).

The meta-synthesis analysis confirmed this clustering of the key regional innovation models and took a step further, identifying three main themes and sub-themes, as follows:

- *Theme 1: The development level of regions, especially in terms of institutions,* with sub-themes as: development of institutional systems, industrial infrastructure, human resources and local markets.
- *Theme 2: A decreasing direct role of government, especially in the interaction with industrial organizations and companies,* with sub-themes including: the role of governance systems in the market, local government objectives, impact of WWII and Cold War.
- *Theme 3: Globalization and increase in international relations*, with sub-themes as: international cooperation, networks among regions, national and international levels, globalization and modern communication technology.

Based on these themes and the dominant regional innovation model, a typology of regions was derived, which distinguished between *Early Innovator regions,* operating with Cluster 1 innovation models, *Transitional Innovator regions,* operating with Cluster 2 innovation models, and *Advanced Innovator* regions, operating with Cluster 3 innovation models. The specific features of these regions were discussed.

Both the methodology used in this study and the regional typology that emerged from applying this methodology could provide valuable insights in further research. First, the methodology, which has coupled quantitative research with in-depth, contextualized qualitative research, can be further used for identifying mainstream models and associated themes in other innovation fields, or indeed other social sciences areas, that require coverage of comprehensive evidence over longer time periods and aim to answer questions that cannot be addressed by either method alone. One example could be the Triple Helix studies, which are closely related to regional innovation and development, as the partnerships between university, industry and government as innovation drivers usually provide the most visible impact at the regional level. The combination of co-word and meta-synthesis analysis could be a valuable tool to explore themes and sub-themes usually addressed in Triple Helix studies, such as academic technology transfer and research commercialization, academic spin-offs, academic entrepreneurship, etc., or the connections of the Triple Helix model with other models like Mode 1/Mode 2 of knowledge production or Open Innovation. Secondly, the regional typology of Early, Transitional and Advanced Innovators can be a useful instrument for regional innovation policy-makers, academics and practitioners, in the choice of a suitable innovation model as a foundation for a regional innovation strategy, as such process requires a comprehensive understanding of the specific characteristics of the region, its innovation environment assets and challenges. In general, regions are confronted with innovation challenges that vary from one region to another, and no single one-size-fits-all practice can be

adopted. This makes the regional policy-making a complex task, which requires thorough awareness of different regional innovation models.

One limitation of this study comes from the selection of papers used in the co-word and meta-synthesis analyses, which were published in the period 1990–2013. An expansion of the paper selection to include papers published before 1990 can be useful to better understand the vision on regional innovation models that was in place in those decades.

Some directions for further research could include an analysis of regional innovation models in specific regions and time periods, in order to deepen the understanding of success (or failure) factors of different models in different regions. Also, the regional typology developed in this study, which distinguishes between Early, Transitional and Advanced Innovator regions, could be further developed based on new evidence provided by regional innovation reports or books resulted from academic research, or from the work of regional innovation policy-makers and practitioners. In connection with this latter aspect—regional innovation policy-making and practice, it is important to note that regional mechanisms, dynamics and policies for innovation have become a priority in many countries of the European Union, where about three quarters of EU legislation is implemented at local or regional level, and representatives of these levels can have a say in the development of new EU laws through the Committee of the Regions[2]. Possible connections between the different types of regions and the regional innovation indicators currently in use (e.g. in the Regional Innovation Scoreboard) could yield interesting results. Also, the evidence provided by the Regional Innovation Monitor Plus (RIM Plus), the new instrument for regional innovation policy analysis developed in the context of European Commission's Europe 2020 strategy, specifically under the Innovation Union flagship initiative, to inform regional administrators, researchers and other stakeholders about main innovation policy measures and trends in some 200 EU regions, could be successfully used to provide more depth to the typology proposed in this study.

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