Identification of regions with less developed research and innovation systems

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Abstract

The aim of this working paper is to contribute to the debate on how to identify regions with less developed research and innovation systems. We look at both conceptual and empirical approaches that figure prominently in scholarly work on regional innovation systems. Based on a critical review and discussion of the literature we shed light on a large number and variety of barriers and weaknesses that may hamper regional innovation and industrial change. It is shown in this paper that the regional innovation system concept can essentially inform the current debate on the design and implementation of smart specialisation strategies. It offers rich insights into various dimensions of regional innovation systems that may be weakly developed and allows for the development of typologies that capture the heterogeneity of these systems. We also demonstrate that empirical approaches to identify regions with less-developed research and innovation systems fall short of taking account of the conceptual advances made in the recent past.

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1 Introduction

Smart specialisation has become the new innovation policy paradigm in the European Union. This policy concept "is about placing greater emphasis on innovation and having an innovation-driven development strategy in place that focuses on each region's strength and competitive advantage. It is about specialising in a smart way, i.e. based on evidence and strategic intelligence about a region's assets and the capability to learn what specialisations can be developed in relation to those of other regions" (European Union, 2011, p. 7).

Smart specialisation shares a number of commonalities with and has been inspired by other modern and influential policy concepts such as the Constructing Regional Advantage (CRA) approach (European Commission, 2006; Asheim et al., 2011a; Asheim, 2014; Boschma, 2014a): It considers knowledge and innovation as key determinants of regional development and emphasizes the need to avoid imitation of successful policies pursued in other regions and "one-size-fits all" strategies (Tödtling and Trippl, 2005). Smart specialisation strategies are place-based policy strategies that aim to promote economic diversification of regions (McCann and Ortega-Argiles, 2013; Boschma, 2014a) taking into account their unique characteristics and assets. Specialised diversification or diversified specialisation (Asheim 2014) should thus rank high on policy agendas. The identification and selection of prioritised areas for policy intervention are suggested to be the outcome of an "entrepreneurial discovery process", a notion that has been heavily debated in the recent past (Foray and Goenaga, 2013; Foray and Rainoldi, 2013; Asheim, 2014; Boschma, 2014a). There seems to be an agreement, however, that an inclusive approach to the identification of policy priorities (that is, inclusive governance structures that allow for the involvement of regional stakeholders in selecting promising areas for innovation policy) is important for the success of smart specialisation.

A key question is if smart specialisation strategies are applicable to any type of regions. It has been argued that regions with less-favoured research and innovation systems have a low potential to diversify into new industrial areas due to unfavourable economic structures and a weak endowment of knowledge organisations (Boschma, 2014b, Isaksen and Trippl, 2014a). In addition, some less-developed regional research and innovation systems suffer from weak policy and governance capacities, which could curtail the effective use of Cohesion policy funds (Charron et al. 2014) and may form major barriers to the successful formulation and implementation of smart specialisation strategies (Rodriguez-Pose et al., 2014).

This working paper is part of Work Package (WP) 3 of the project "Smart Specialisation for Regional Innovation" (funded by the European Commission in the context of the seventh framework programme). One of the key goals of this project is to gain new insights into the nature, opportunities and challenges for smart specialisation strategies in a large variety of regional settings. WP 3 focuses specifically on regions with less-developed research and innovation systems. The objectives of this WP are (1) to identify regions with less-developed research and innovation systems; and (2) to get a better understanding of the challenges for these systems to maximize the impact of smart specialisation strategies, focusing on the roles of economic structures, knowledge organizations and governance and strategy design.

The aim of this working paper is to contribute to the first objective, that is, to identify regions with less-developed research and innovation systems. It would be beyond the scope of this paper to engage in a discussion of how the specific elements of these systems influence the opportunities for smart specialisation or how the challenges faced by these regions might be overcome to enhance the impact of smart specialisation strategies (for insights into these issues see the other working papers generated in the context of WP 3 as well as the empirical reports on a number of case studies that will be published at a later stage of the project). This working paper paves the way for these analyses by discussing several conceptual and empirical contributions to identify regions with less-developed research and innovation systems, focusing in particular on key barriers and missing elements that may be found in these systems. For the sake of clarity, it is important to note that in the following parts of this paper only the notion "regional innovation system" (RIS) will be used, because we consider the regional research system as a subsystem of RIS.

The remainder of this working paper is organised as follows. Section 2 reviews the conceptual debate on RIS, system failures, organisational and institutional thinness, knowledge bases and regional industrial path development and demonstrates how these concepts can contribute to identifying various types of regions with less-developed RIS. In section 3, we provide a critical discussion of empirical approaches to categorise less-developed RIS based on measurements of their innovation performance. Finally, section 4 concludes and outlines some key issues that should receive due attention in future research.

2 Conceptual Approaches

Research on RIS has grown significantly since the notion's first articulation and development in the early 1990s (for an overview on the theoretical antecedents and origins of the RIS approach, its development over the past two decades and recently made advances see Asheim et al. 2011b). RIS come in many shapes and various typologies have been suggested to capture this variety (see, for instance, Asheim and Isaksen, 2002; Cooke, 2004; Asheim and Gertler, 2005; Asheim and Coenen, 2006). In this section we focus on those conceptual ideas (and the typologies that emanate from them) that are most relevant for identifying less-developed RIS. We review contributions on system failures, organisational and institutional thinness, knowledge bases and new regional industrial path development to shed light on potential factors and dimensions in RIS that can restrain regional innovation and change.

2.1 System failure approaches

A well-known conceptual approach for identifying less-developed innovation systems draws attention to various types of system deficiencies or system failures that result in low levels of innovation activities. Several typologies of system failures exist (see, for instance, Lundvall and Borras, 1999), enabling us to spot various dimensions of innovation systems that may be less-developed or not working adequately. Klein Woolthuis et al. (2005), for example, distinguish between infrastructural failures, institutional failures (hard and soft institutional problems), interaction failures (strong and weak network failures) and capability failure. Recent work on transformational system failures (Weber and Rohracher, 2012) has further advanced the debate, pointing to a set of factors that limit a system's capacity to undergo processes of transformative change towards sustainability. A distinction between four types of transformational failures can be drawn: i) directionality failure, ii) demand articulation failure, iii) policy coordination failure, and iv) reflexivity failure (Weber and Rohracher, 2012). In the context of this debate, innovation systems might be referred to as "less developed" if they exhibit a weak capacity to foster transformative change. These insights are highly relevant for smart specialisation as the promotion of sustainability and social innovation are often seen as one of the key aims of such strategies.

Tödtling and Trippl (2005) have applied the system failure approach to the regional level to analyse various deficiencies of RIS. The authors propose a typology that distinguishes between three forms of system deficiencies, namely, organisational thinness, negative lock-in, and fragmentation (Table 1).

Table 1: RIS failures

System failure / deficiencies	Type of region
Organisational thinness: crucial elements of a RIS are missing: low levels of clustering & weak endowment with key organisations	Peripheral regions
Negative lock-in: over-embeddedness & overspecialization	Old industrial areas
Fragmentation: lack of interaction between RIS elements	Metropolitan regions

Source: Tödtling and Trippl (2005)

This provides the foundation for discerning three main types of less-developed RIS (Tödtling and Trippl, 2005; Martin and Trippl, 2014):

- *Organisationally thin RIS* are systems in which essential elements are only weakly developed or even missing. Examples include the lack of a critical mass of innovative firms, a weak endowment of other key organisations and institutions and low levels of clustering. Organizationally thin RIS are often present in peripheral areas. These regions are characterised by insufficient levels of R&D and innovation due to the dominance of SMEs in traditional sectors, the lack of assets to nurture new industries, a weak capacity to absorb knowledge from outside the region, and a thin structure of supporting organisations (Doloreux and Dionne, 2008; Karlsen et al., 2011).

- *Locked-in RIS* are characterized by an over-embeddedness and over-specialization in mature sectors and out-dated technologies. Locked-in RIS often prevail in old industrialised areas. The capacity of firms in these areas to generate radical innovation is limited and the supporting organisations tend to be too strongly oriented on traditional industries and technologies. Various forms of negative lock-in (functional, cognitive and political ones) keep these regions in ancestral development paths (Grabher, 1993; Trippl and Otto 2009; Hassink, 2010).

- *Fragmented RIS* suffer from a lack of connectivity due to a suboptimal level of networking and knowledge exchange between actors in the system, leading to insufficient levels of collective learning and systemic innovation activities. Fragmented RIS can frequently be found in metropolitan areas (Blazek and Zizalova, 2010; OECD, 2010). In this type of region fragmentation is often the outcome of too much diversity and a lack of related variety, resulting in levels of regional knowledge exchange and innovation below what could be expected given the often rich endowments of knowledge exploration as well as exploitation organisations found in metropolitan regions.

The application of the system failure approach to the regional level has provided important insights into potential misconfigurations of RIS, pointing to a variety of elements that might be less developed or functioning inadequately. However, the key notion of "thickness" is defined in a rather simple way (number of organizations) and remains poorly conceptualized. In particular the role of institutions for regional development and innovation (Gertler, 2010; Rodriguez-Pose, 2013; Charron et al. 2014), that is, the institutional dimension of thickness is only insufficiently captured.

More recently, an attempt has been made to elaborate on the notions of thickness and thinness of RIS. Based on a comprehensive review and critical discussion of the respective literature, Zukauskaite et al. (2014) advocate a clear distinction between the organisational and institutional dimension of thinness. Organisational thickness (thinness) refers to the presence (absence) of a critical mass of firms, universities, research bodies, support organizations, unions, associations, and so on. Institutional thickness (thinness) is defined as the presence (absence) of both formal institutions (laws, rules, regulations) and informal institutions (such as an innovation and cooperation culture, norms and values) that promote collective learning and knowledge exchange.

Departing from this clear-cut distinction, we advance the argument that RIS may suffer from institutional thinness, organisational thinness or a combination of both dimensions of thinness. This leads us to distinguish between three types of less-developed RIS (see Table 2):

Table 2: Organisational and institutional thickness / thinness of RIS[1]

	Organizational thickness	**Organizational thinness**
Institutional thickness	Metropolitan / city regions in Northern & Western Europe	Industrial districts in the Third Italy, Nordic peripheral regions
Institutional thinness	Larger cities in Southern and Eastern Europe; OIA in Western Europe	Southern and Eastern peripheral regions

Source: own compilation

- Institutionally thick *but* organisationally thin RIS: Good examples for this type of RIS are industrial districts in the Third Italy and regions in the North of Europe. Italian districts are well known for a pronounced culture of cooperation (institutional thickness) but they lack specific RIS elements such strong research organizations or science-based firms (organisational thinness) that are essential for the generation of more radical forms of innovation. Nordic peripheral regions benefit from a high quality of government institutions (institutional thickness) but are only poorly endowed with innovation relevant organizations (organisational thinness).

[1] This matix is based on an idea by Björn Asheim, outlined in a project application for the Marianne and Markus Wallenberg Foundation.

- Organisationally thick *but* institutionally thin RIS: This type of RIS can often be found in larger cities in Southern and Eastern Europe but also some old industrial areas in Western Europe may fall under this category. These places are characterized by the existence of a critical mass of firms as well as research, educational and other supporting organizations (organizational thickness). However, innovation activities are seriously curtailed by the absence of an innovation and cooperation culture as well as a low quality of government institutions (institutional thinness).

- Institutionally thin *and* organisationally thin RIS: Such constellations tend to prevail in peripheral regions located in the South and East of Europe. More often than not, these areas are poorly endowed with innovation-relevant organisations (organisational thinness) and suffer from an institutional set-up that is not conducive to innovation (institutional thinness).

2.2 Knowledge base approach

The literature on differentiated knowledge bases (Asheim and Gertler, 2005; Asheim et al., 2011a) has sharpened our view that all industries and not only high-tech ones can be innovative and it has provided the analytical tools for explaining inter-sectorial variations of innovation patterns. Three types of knowledge bases can be distinguished: analytical, synthetic and symbolic (see Table 3). Scholarly work on knowledge bases clearly challenges old approaches that equate innovation with R&D and high-tech activities. Innovation systems that are characterised by lower levels of R&D and a dominance of mature industries (that often are knowledge intensive but not high-tech) cannot automatically be categorised as less developed ones.

Table 3: Differentiated knowledge base approach

	Analytical (science based): genetics, biotech, IT, nanotech.	**Synthetic (engineering based): industrial machinery, shipbuild.)**	**Symbolic (arts based): film, TV, design, fashion**
Rationale for knowledge creation	Developing new knowledge about natural systems by applying scientific laws	Applying or combining existing knowledge in new ways	Creating meaning, desire, aesthetic qualities, affect, symbols, images
Development and use of knowledge	Scientific knowledge, models	Problem solving, custom production	Creative process
Actors involved	Collaboration within and between research units	Interactive learning with customers & suppliers	Experimentations in studios, project teams
Knowledge types	Strong codified knowledge content, highly abstract, universal	Partially codified knowledge, strong tacit component, more context specific	Creativity, cultural knowledge, sign values; strong context specificity
Importance of spatial proximity	Meaning relatively constant between places	Meaning varies substantially between places	Meaning highly variable between place, class and gender

Source: Asheim et al. (2011a, p. 898; own modification)

An analytical knowledge base prevails in research-intensive industries such as biotechnology or nanotechnology where innovation is driven by scientific progress. Radically new products and processes are developed in a systematic manner involving mainly basic but also applied research. Firms usually invest heavily in intramural R&D, but rely also on knowledge generated at universities and other research organisations. Linkages between firms and public research organisations are thus pivotal and occur more frequently than in other industries. The "science-technology-innovation" (STI) mode clearly dominates in analytical industries, whilst synthetic and symbolic sectors rely more on the "doing-using-interacting" (DUI) mode of innovation (for a detailed discussion of the STI and DUI modes of innovation, see Lorenz and Lundvall, 2006; Jensen et al., 2007; Asheim, 2012).

A synthetic knowledge base is dominant in mature industries operating in fields such as industrial machinery or food processing. Innovation is often more incremental in nature, based on the use and new combination of existing knowledge and learning by doing, using and interacting (mainly along the value chain, that is, with customers and suppliers). Linkages between university and industry are relevant, but occur more in applied research and education, and less in basic research.

The symbolic knowledge base is present in creative and cultural industries (advertisement, fashion, new media and design). Innovation is devoted to the creation of intangible dimensions such as aesthetic value and images. Symbolic knowledge is highly context-specific; the meaning and the value associated with it can vary considerably across places. More often than not, innovation occurs through experimentations in studios and the formation of temporary project teams.

A key question that follows from the discussion about knowledge bases concerns the relation between RIS configurations and different knowledge types. Arguably, different types of knowledge bases require different types of RIS. Asheim and Gertler's (2005) distinction between narrowly defined and broadly defined RIS is eminently important in this regard (Table 4). A *narrowly defined RIS* is constituted by two subsystems and the systemic interaction between them to support the STI mode of innovation: the knowledge exploration and diffusion subsystem (universities, technical colleges, R&D organizations, technology transfer agencies, business associations and finance organisations) and the knowledge exploitation subsystem (firms in regional clusters and their support industries). A *broadly defined RIS*, in contrast, also benefits the DUI mode of innovation. It includes the wider setting of organisations and institutions (like a specialized labour market that provides experienced workers, applied research centres, non-R&D-based business services, local technical culture, and so on) that support knowledge creation, learning and innovation and their interactions with firms located in the region.

A narrowly defined RIS forms an adequate setting for analytical industries and the STI mode of innovation. Although synthetic and symbolic sectors may also benefit from some elements of a narrowly defined RIS (in particular applied research), they need a broader defined RIS (a wider set of organisations and institutions) that supports the DUI mode of innovation to prosper and innovate. If a RIS is weakly developed (and what specific RIS elements are missing) can thus only be determined in relation to knowledge bases and modes of innovation. An innovation system can be considered as "less-developed", if one or more of the above mentioned elements are absent or if the existing ones are not "fine-tuned" to the knowledge bases that dominate in the region. The theoretical advancement made by the differentiated knowledge base approach and insights offered on modes of innovation clearly challenge too “one dimensional” definitions of RIS and narrow policy approaches that put too much emphasis on R&D only and ignore other important sources of regional innovativeness and competitiveness.

Table 4: Knowledge bases and RIS configurations

Knowledge bases	**RIS**
Analytical knowledge base (basic research); synthetic and symbolic knowledge bases (applied research)	Narrowly defined RIS (linkages between universities; R&D institutes, TTOs and firms in the region)
Synthetic and symbolic knowledge bases	Broadly defined RIS (systemic interactions between wider system of organisations supporting learning and innovation and firms)

Source: Asheim and Gertler (2005)

The approaches discussed above have shed light on various elements and dimensions of RIS that may be weak or even missing. They have also allowed for the development of different typologies of less-developed RIS and they have led to valuable policy suggestions (see Tödtling and Trippl (2005) for policy implications following from RIS failures and Asheim et al. (2011a) as well as Martin and Trippl (2014) for policy conclusions drawn from the knowledge base approach).

The RIS concept, however, has also been criticized for providing a rather static perspective. Uyarra (2010, p. 129), for instance, notes that many analyses of RIS are “inventory-like descriptions of regional systems, with a tendency to focus on a static landscape of actors and institutions”. Recent scholarly work, however, has essentially contributed to the development of a more dynamic view. Advances in evolutionary economic geography and the literature on related variety (Frenken et al. 2007, Boschma and Frenken 2011) and combinations of knowledge bases (Asheim et al., 2011a, 2013; Strambach and Klement, 2012) have enhanced our understanding of key sources of regional industrial change. Isaksen and Trippl (2014a) integrate RIS in the analysis of such change processes and explore conceptually the link between different types of RIS and various forms of regional path development (see below). This is highly relevant for the purpose of this paper. Regional economies and innovations systems increasingly face the challenge to renew their industrial structures and embark on new growth paths. Promotion of such regional industrial renewal processes is one of the core aims of smart specialisation strategies.

2.3 Regional innovation systems and new path development

Recent work on regional industrial path development provides important insights into the ways regions change over time. This work moves beyond traditional approaches of path dependence, which are primarily concerned with illuminating the continuation and persistence of regional industrial structures and restrictive lock-ins, and seeks to explain economic renewal and new path development in regions. A distinction between three main forms of regional industrial path development is drawn (Asheim et al., 2013; Tödtling and Trippl, 2013; Isaksen, 2014; Isaksen and Trippl, 2014a).

- *Path extension* occurs through mainly incremental innovations in existing firms and industries. However, such *intra-path changes* may in the long run lead to stagnation and decline due to a lack of renewal (Hassink 2010). Regional industries are then locked into innovation activities that take place along existing technological paths limiting their opportunities for experimentation and space to manoeuvre into radical innovation. Ultimately, this erodes regional competitiveness and can lead to *path exhaustion*.

- *Path renewal* takes place when existing firms and industries located in the region switch to different but possibly related activities and sectors. This is in line with the notions of regional branching and related diversification (Boschma and Frenken, 2011; Boschma, 2014b) as well as combinatorial knowledge bases and the integration of STI and DUI modes of innovation (Jensen et al., 2007; Asheim et al., 2011a, 2013; Manniche, 2012, Strambach and Klement, 2012; Grillitsch and Trippl, 2014).

- *New path creation* corresponds to unrelated diversification (Boschma, 2014b) as it refers to the establishment of firms in entirely new sectors or to the introduction of products new to the market (i.e. radical innovations) (Martin and Sunley, 2006; Tödtling and Trippl, 2013) New path creation is often research-driven and requires active policy interventions (Asheim et al., 2013) and the creation of supportive institutional structures.

Several scholars have argued that macro-institutional structures have a major influence on directions of regional change. Storper (2011) claimed that path renewal is typical for Europe whilst the US has a stronger tendency for radical innovations and new path creation. Boschma and Capone (2014) provided empirical evidence that national institutions in liberal market economies promote unrelated diversification (new path creation) while coordinated market economies encourage related diversification (path renewal), as their less flexible institutions do not allow them to move in more unrelated fields of activities. However, such tendencies found in coordinated market economies can be compensated by strong pro-active policy interventions as is seen, for example, in Sweden by VINNOVA's (Swedish Governmental Agency for Innovation Systems) centre of expertise policy of building regional innovation systems or strong regional research and innovation milieus. This perspective has important implications for the potentials of a smart specialisation strategy as well as for how to design and implement such a strategy.

Recent conceptual work that points to varying capacities of regional economies (Boschma, 2014b) and RIS (Isaksen and Trippl 2014a) to renew their economic structures is highly relevant given the purpose of this paper. Boschma (2014b) argues that regions characterized by industrial diversity, weak ties and a loosely coherent institutional structure have better chances to develop new growth paths. Isaksen and Trippl (2014a) explore the relation between RIS configurations and various forms of regional industrial path development. They distinguish between three different types of RIS: organizationally thick and diversified systems; organizationally thick and specialized systems; and organizationally thin systems. Through a conceptual analysis it is demonstrated that these three RIS types differ enormously in their capacity to promote new path development (Table 5).

Table 5: RIS types and regional industrial path development patterns and challenges

	Characteristics	**Typical development patterns**	**Weak RIS structures for …**
Organizationally thick and diversified RIS	Wide range of heterogeneous (but related) industries and knowledge bases → high potentials for cross-sectoral knowledge flows & recombinations of knowledge; strong research organizations → high potentials for commercializing research; bridging (& bonding) social capital	Path renewal and new path creation	… path extension (too little exploitation) → lack of industrial focus; emerging paths may not achieve critical mass; instability in institutional arrangements (fragmentation)
Organizationally thick and specialized RIS	Narrow industrial base, specialized knowledge & support structure; bonding (& bridging) social capital	Path renewal Path extension (positive lock-in) Path exhaustion (negative lock-in)	… switching to new growth paths (lack of industrial and organisational variety; too little exploration)
Organizationally thin RIS	Weakly developed clusters, poor endowment with knowledge & support organizations, bonding social capital	Path exhaustion	… new path development (lack of critical mass of actors, little variety)

Source: own compilation based on Isaksen and Trippl (2014a)

Thick and diversified RIS offer excellent conditions for path renewal and new path creation due to the presence of related variety, combinatorial knowledge dynamics, academic entrepreneurship and a favourable set-up of knowledge generating organisations. Organisational thick and specialized RIS, in contrast, tend to support path extension but face the risk of path exhaustion if positive lock-in turns into negative lock-in. However, some RIS belonging to this group benefit from a sufficiently large generic competence in their field of specialisation, which may form the basis for path renewal processes. Investment into the region's research infrastructure to strengthen and widen the exploration capacity of the RIS can essentially enhance such processes (Asheim and Grillitsch, 2014). Path renewal may also be triggered by the inflow of non-local knowledge and its combination with the highly specialized assets available within the region. Organisationally thin RIS have a limited capacity of promoting path extension and thus they have to deal with the danger of path exhaustion (although for different reasons than organisationally thick ones).

Both organisationally thick specialised regions and especially organisationally thin regions have thus weakly developed RIS structures for supporting new regional industrial path development. The main development challenge for these RIS types is to avoid being caught in the "path exhaustion trap". Organisationally thick and diversified regions, in contrast, may suffer from weak structures for path extension mainly due to a reduced industrial production (exploitation) capacity. A too strong focus on and use of assets and resources for knowledge exploration and new path development can lead to a too rapid decrease in knowledge exploitation capacity, causing fragmentation problems.

2.4 Summary

To summarise, the system failure approach, the notions of organisational and institutional thinness, the knowledge base concept as well as recent work on the relation between RIS types and new path development offer many insights into what exactly might be less developed in RIS. A RIS can be seen as less developed if it is ill equipped to generate innovations along existing industrial and technological paths (static view). However, it might also be less developed in the sense that it lacks the capacity to support the renewal of the regional economy over time (dynamic view). Given the fact that smart specialisation strategies aim at initiating regional transformation, it is the latter aspect that should deserve more attention in future research. Key issues that remain poorly understood include amongst others the role of exogenous sources (external connectedness of regions) of regional change (Isaksen and Trippl, 2014b) and how multiscalar institutional frameworks shape path renewal and new path creation (Gertler, 2010).

3 Empirical Approaches

This section takes a closer look at three empirical approaches to measure innovation activities in regions and to identify less developed RIS. The approaches selected for a critical examination include the Regional Innovation Scoreboard (European Commission, 2014), the Regional Innovation Monitor (European Commission, 2013) and the typology of regions suggested by the OECD (2011).

3.1 Regional Innovation Scoreboard

The Regional Innovation Scoreboard provides a comparative assessment of 190 regions within the European Union, Norway and Switzerland and is complementary to the Innovation Union Scoreboard, which benchmarks innovation performance at the national level. The latest Regional Innovation Scoreboard was completed in 2014, using the same methodology as the Innovation Union Scoreboard. Due to problems of data availability, however, it is based on fewer indicators (see Table 6). Three main groups of variables with regard to innovation are considered: enablers, firm activities and outputs (European Commission, 2014).

In the Innovation Union Scoreboard three types of **enablers** are covered: human resources; research systems; and finance and support. Due to a lack of regional data, they are only considered to a limited extent in the Regional Innovation Scoreboard. Only two indicators are included, namely ‘percentage of population aged 25-64 having completed tertiary education’ as a measure for human resources, and ‘R&D expenditure in the public sector as % of GDP’ as an indicator for finance and support. No indicators for measuring the openness and attractiveness of research systems are available. Indicators for **firm activities** are grouped into firm investments, linkages & entrepreneurship and intellectual assets. Firm investments are measured by ‘R&D expenditures in the business sector as % of GDP’ and by ‘non-R&D innovation expenditures as % of turnover’ in SMEs. The latter indicator is based on CIS data and is supposed to indicate the diffusion of new production technology and ideas by measuring, for example, investments in equipment and machinery or the acquisition of patents and licenses. Data from CIS is also used for the two indicators on linkages and entrepreneurship, to measure the share of SMEs that have innovated in-house and are involved in innovation co-operation with others. Intellectual assets are covered by the number of EPO patent applications in relation to regional GDP.

Table 6: A comparison of the indicators included in the Innovation Union Scoreboard and the Regional Innovation Scoreboard (data availability in parenthesis)

Innovation Union Scoreboard	**Regional Innovation Scoreboard**
ENABLERS	
Human Resources	
New doctorate graduates (ISCED 6) per 1000 population aged 25-34	Regional data not available
Percentage population aged 30-34 having completed tertiary education	Percentage population aged 25-64 having completed tertiary education (94.9%)
Percentage youth aged 20-24 having attained at least upper secondary level education	Regional data not available
Open, excellent and attractive research systems	
International scientific co-publications per million population	Regional data not available
Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country	Regional data not available
Finance and support	
R&D expenditure in the public sector as % of GDP	Identical (71.8%)
Venture capital (early stage, expansion and replacement) as % of GDP	Regional data not available
FIRM ACTIVITIES	
Firm investments	
R&D expenditure in the business sector as % of GDP	Identical (75.1%)
Non-R&D innovation expenditures as % of turnover	Similar (only SMEs) (55.3%)
Linkages & entrepreneurship	
SMEs innovating in-house as % of SMEs	Identical (60.9%)
Innovative SMEs collaborating with others as % of SMEs	Identical (64.2%)
Public-private co-publications per million population	Regional data not available
Intellectual assets	
PCT patent applications per billion GDP (in PPS€)	EPO patent applications per billion regional GDP (PPS€) (87.6%)
PCT patent applications in societal challenges per billion GDP (in PPS€)	Regional data not available
Community trademarks per billion GDP (in PPS€)	Regional data not available
Community designs per billion GDP (in PPS€)	Regional data not available
OUTPUTS	
Innovators	
SMEs introducing product or process innovations as % of SMEs	Identical (64.5%)
SMEs introducing marketing or organisational innovations as % of SMEs	Identical (63.3%)
Employment in fast-growing firms of innovative sectors	Regional data not available
Economic effects	
Employment in knowledge-intensive activities (manufacturing and services) as % of total employment	Employment in medium-high/high-tech manufacturing and knowledge-intensive services as % of total workforce (91.8%)
Contribution of medium-high and high-tech product exports to the trade balance	Regional data not available
Knowledge-intensive services exports as % of total service exports	Regional data not available
Sales of new to market and new to firm innovations as % of turnover	Similar (only SMEs) (49.6%)
License and patent revenues from abroad as % of GDP	Regional data not available

Source: European Commission (2014, p. 9)

The indicators of innovation **outputs** aim to measure the innovative outputs of firms (the innovators) and the regional effects. Based on CIS data, two indicators are used for measuring the performance of innovators: the share of SMEs introducing product or process innovations, and the share of SMEs introducing marketing or organisational innovations. As regards economic effects, the Regional Innovation Scoreboard considers the share of employment in knowledge-intensive activities and the sales of new-to-market and new-to-firm innovations in relation to turnover.

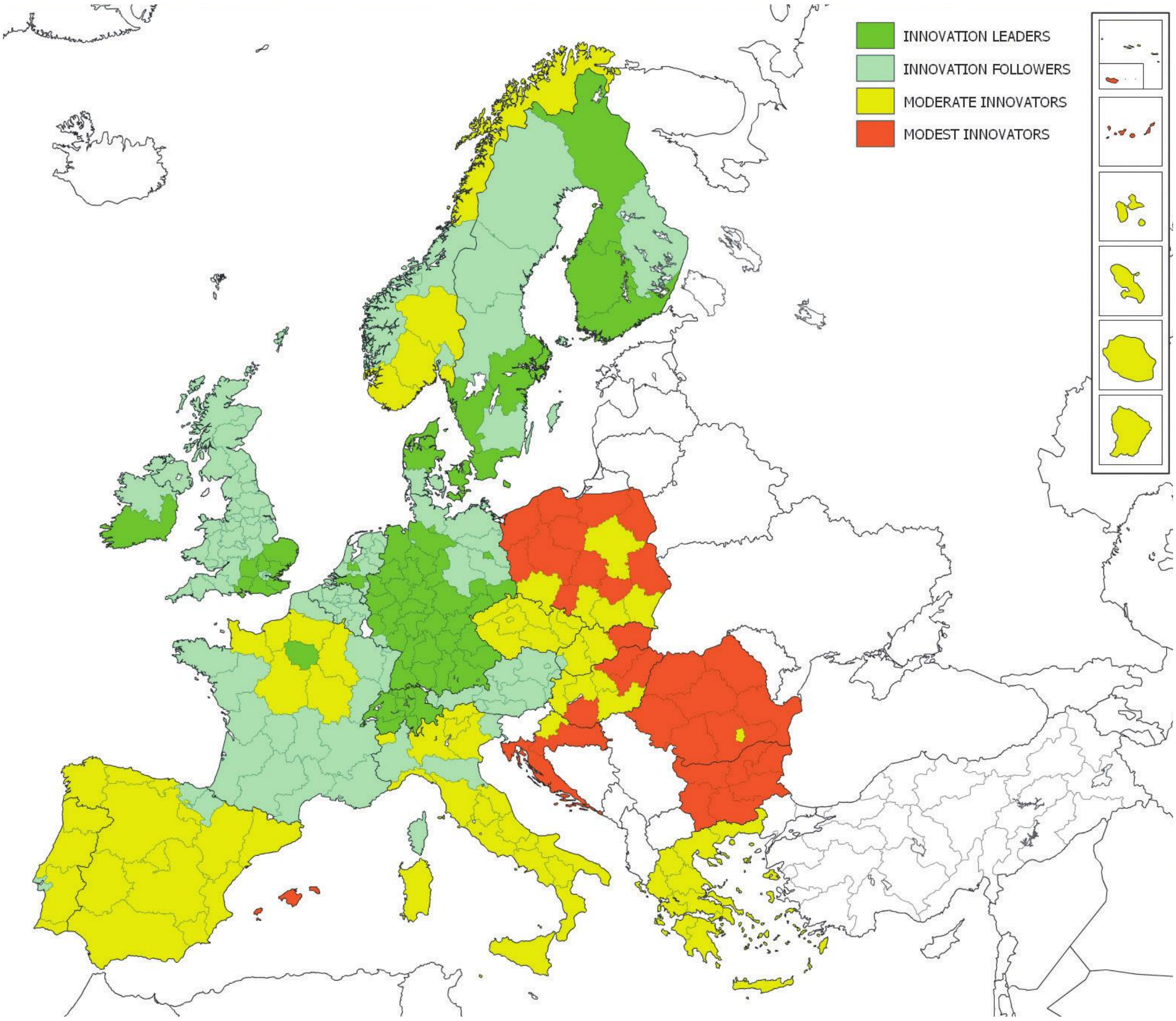
In addition to the lack of regional data for a number of indicators (see Table 6), almost 30% of data for the indicators included in the Regional Innovation Scoreboard is missing. For some of the indicators, such as ‘sales of new-to-market and new-to-firm innovations’ and ‘non-R&D innovation expenditure’, data availability is only around 50%. Furthermore, data availability differs between countries. In Bulgaria, the Czech Republic and Slovakia, the availability is 100% whilst in Denmark, Croatia and Switzerland it is below 30%. To increase data availability a technique for regionalization has been adopted from CIS, followed by a number of imputation practices for the remaining missing CIS data and for the indicators using other data (primarily Eurostat) (European Commission, 2014).

Using the Regional Innovation Scoreboard, regions in Europe can be categorized in four categories based on their relative performance, with thresholds at the same levels as in Innovation Union Scoreboard. **Innovation Leaders** are those regions performing 20% or more above the EU average. In the Regional Innovation Scoreboard 2014, these regions have the highest performance in all indicators except the share of SMEs involved in innovation co-operation with other companies. Among the key strengths of innovation leaders are business activities and higher education. **Innovation followers** are regions at levels between 90% and 120% of the EU average. They are performing well on indicators measuring SMEs co-operation in innovation activities and share of SMEs innovating in-house but less well on indicators related to the performance of their business sector. **Moderate innovators** are performing between 50% and 90% of the EU average and **modest innovators** perform below 50% of the EU average, the latter with low scores on all indicators except being equipped with a relatively well-educated population (72% of the EU average).

Following the map laid out in Figure 1, we can observe that the regions belonging to the modest innovators are largely to be found in the post-socialist transition economies. Others are to be found in Croatia and the islands off the Mediterranean coast of Spain. Moderate innovators are more broadly distributed across Europe, with significant groupings in the southern member states (Spain, Portugal, Italy and Greece) the Czech Republic, and parts of Slovakia, Hungary and Poland. Furthermore, there are pockets of moderate innovators in countries that generally exhibit higher levels of performance, such as northern France (surrounding Ile de France) and Norway.

The features that characterize these modest and moderate innovators vary across regions and national context, and we suggest that the patterns illustrated above provide the basis for identifying three key categories: first, regions and countries experiencing post-socialist transitions; second, regions and countries located in southern Europe; and third, regions underperforming in comparison with their surrounding context.

Figure 1: Regional performance groups in the Regional Innovation Scoreboard 2014



Source: European Commission, 2014, p. 16

In a comparison of the initial performance levels and the change in performance between 2004 and 2010 for all regions in the Regional Innovation Scoreboard, no 'catching-up' processes can be observed. Less-performing regions are not growing faster than well-performing ones during this time period. However, most regions have improved their innovation performance during the observation period. In regions located in southern Europe and regions underperforming in comparison with their surrounding context, a decrease in innovation performance is seen in some regions such as the east coast of Spain, but the main pattern is that innovation performance is increasing. In regions experiencing post-socialist transitions innovation performance growth is more divergent, most notably with groups of decreasing regions in Eastern Poland, Croatia and Western Romania. Here we have a number of less-performing regions experiencing a relative decline of innovation performance over time.

The Regional Innovation Scoreboard suffers from several shortcomings. As already mentioned above, it is based on a rather low number of indicators and data is missing for many regions. For some indicators, survey data is used, whilst others are based on register data. Another problem is that the Regional Innovation Scoreboard sometimes corresponds to NUTS1 and sometimes to NUTS2 regions. Among the indicators in the Regional Innovation Scoreboard, there is a bias towards measuring R&D-driven innovation activities and even though non-R&D activities are targeted (for example through non-R&D expenditure as % of turnover in SMEs), it remains obscure what is covered in this regard. Whilst some indicators are broad and can include a wide variety of innovations, most are more narrow and targeted towards measuring analytical knowledge, the STI mode of innovation and narrowly defined RIS. Neither does the Regional Innovation Scoreboard consider the degree of regional specialisation, neglecting, for instance, the possible dependence of regions on an industrial mono-structure, fragmentation problems or a lack of positive lock-ins. Thus, it fails to identify what system failures or system deficiencies are prevailing in the region. Moreover, it does not offer insights into problems of organisational and institutional thinness, nor does it capture the capacity of regions to support regional industrial change.

3.2 Regional Innovation Monitor

The Regional Innovation Monitor (RIM) provides information on regional innovation policies for 20 EU Member States[2]. The aim is to provide intelligence on innovation policies in some 200 regions across these member states, and to offer easy access and a comparative overview of regional innovation policies. Information and analysis of policy documents, governance structures and existing innovation policy initiatives are collected at NUTS1 and NUTS2 levels. The RIM repository gives a comprehensive overview of the state of development of regional innovation policies and strategies as well as the state of the implementation of these, in all 200 regions. In addition to this, 80 in-depth regional reports (RIM Plus) have been prepared since 2011 (European Commission, 2013).

In these in-depth regional reports, the focus is on identifying areas for improvement or challenges in the RIS, regardless of the regions' innovation performance. The policy governance and policy instruments are analysed and conclusions for future policy making are drawn. Through qualitative analyses the RIM Plus reports seek to provide insights into how to address the prevailing challenges in the region. However, they do not provide a clear-cut way of identifying less-developed RIS.

Each region in the RIM repository has been categorized in one of three categories: world-class performers, regions with strong focus on industrial employment and regions with a focus on the service sector and public R&D. The classification has been made using the regional distribution of employment and R&D expenditure. If these categories are related to the Regional Innovation Scoreboard (see above), we find that a majority of world-class performers are labelled innovation leaders in the scoreboard. About two thirds of the regions that have been classified as modest and moderate innovators in the scoreboard, are categorised as regions with strong focus on industrial employment in the RIM analyses (European Commission, 2013). In summary, the RIM focuses primarily on the policy and governance dimension of RIS. It could be used as a tool for identifying what deficiencies, especially with regard to the policy subsystem, are dominant in less-developed regions.

[2] Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden and the United Kingdom.

3.3 OECD approach

By using data from the OECD Regional Database, Ajmone Marsan and Maguire (2011) suggest a categorisation of regions with the aim of capturing the regional socio-economic and production structure as well as variables associated with innovation activities. This is the approach used to categorise regions in the report "Regions and Innovation Policy" (OECD 2011). Based on the availability of data in the OECD Regional Database, twelve variables are selected to reflect the regional socio-economic structure, industrial structure and some input- and output-indicators "commonly associated with an innovation-friendly environment" (Ajmone Marsan and Maguire, 2011, p. 11). When selecting variables, there was a trade-off between the breadth of variables and the number of countries with available data, in an effort to maximise the number of regions for the analysis[3]. Three broad categories are identified and are divided into eight sub-categories (see Table 7). A majority of regions (60%) were identified as **industrial production zones**, characterized by an industrial structure that faces specific challenges for restructuring and transformation. The highest wealth levels and best performance on science- and technology based innovation-related indicators are found in the **knowledge hubs**, constituting 15% of all regions. Finally, 24% of all regions are **non-S&T-driven regions**, sharing a peripheral location and are lacking knowledge absorption and generation capacity to keep up with other OECD regions.

Table 7: Variables and categorisation of OECD regions

Variables (Ajmone Marsan and Maguire (2011)
Gross Domestic Product (GDP) per capita
Population Density
Unemployment Rate
Percentage of the labour force with tertiary education
Gross domestic expenditure on R&D as share of GDP
Business R&D expenditure as a share of total R&D expenditure
PCT patent applications per million inhabitants
Share of employment in the primary sector
Share of employment in the public sector
Share of employment in manufacturing
High & medium-high technology manufacturing as a & of total manufacturing
Knowledge-intensive services as % of total services

Categorization of OECD regions (OECD 2011)
Knowledge hubs (38 regions)
Knowledge intensive city/capital districts
Knowledge and technology hubs
Industrial production zones (145 regions)
US states with average S&T performance
Service and natural resource regions in knowledge-intensive countries
Medium-tech manufacturing and service providers
Traditional manufacturing regions
Non-S&T-driven regions (57 regions)
Structural inertia or de-industrialising regions
Primary-sector-intensive regions

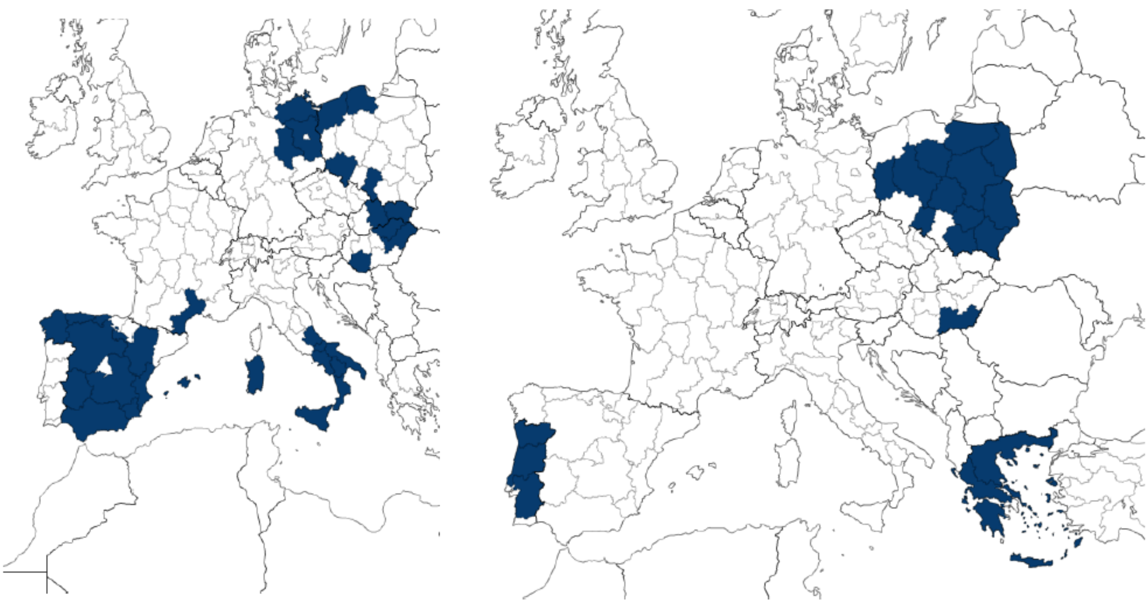
Sources: Ajmone Marsan and Maguire (2011), OECD (2011)

The non-S&T-driven regions are divided into 'structural inertia or de-industrialising regions' and 'primary-sector-intensive regions' and account for only 8% of the sample GDP (compared to 14% of the population). These are regions that face processes of de-industrialisation or experience structural inertia and regions with a significant share of their economies in primary sector activities or low-technology manufacturing, located across primarily Eastern and Southern Europe. The primary-sector-intensive regions are lagging behind all other groups, in terms of GDP per capita and innovation-related indicators. As seen

[3] All OECD countries except Australia, Chile, Estonia, Iceland, Israel, Japan, Mexico, New Zeeland, Turkey, Slovenia and Switzerland are included in the analysis.

in Figure 2, these regions largely correspond to regions experiencing post-socialist transitions and regions in southern Europe and are considered by Ajmone Marsan and Maguire (2011) to capture the peripheral economies in Europe. However, with the exception of two regions in southern France, no regions underperforming compared to their surrounding context are found. This probably relates to the methodology used, measuring the industrial structure by the share of employment in broad sectoral terms (primary, public, manufacturing and service sectors), leading to a spatial clustering of regions within the same category.

Figure 2: Structural inertia or de-industrialising regions (left) and primary-sector-intensive regions (right)



Source: Ajmone Marsan and Maguire (2011, pp. 25-26), own modification

The indicators proposed by Ajmone Marsan and Maguire (2011) are useful for identifying regions with weak economic structures as well as weak innovation capabilities. Measurement of innovation is, however, restricted to variables such as R&D and patenting intensity that may capture activities in analytical sectors and the STI mode of innovation but are inadequate to assess the performance of other knowledge bases, innovation modes and broadly defined RIS (see below). Furthermore, these indicators are mainly targeting the current economic state of the region and, as the authors themselves acknowledge, are lacking a dynamic dimension. The OECD typology do not consider what factors are determining the transformative capacity of a RIS, or what factors are resulting in a lack of such capacity. Moreover, as already stated above, the indicators used in the OECD typology approach to proxy the innovation environment are mainly measuring analytical knowledge and narrowly defined RIS. Neither do they cover the degree of specialisation in the regional industrial structure. In addition, even though non-S&T-driven regions are identified as less-performing regions, the OECD approach does not take into consideration the heterogeneity existing within this group. This issue is also seen in the case with regions categorised as industrial production zones, where this approach acknowledges that these regions are facing challenges for restructuring and transformation but treats these challenges as specificities to each region, failing to provide insights into more general innovation and transformation problems that might curtail development in these regions.

4 Conclusions and Outlook

The critical review and discussion of conceptual and empirical approaches to identify less-developed RIS has shed light on a large number and variety of barriers and weaknesses that may curtail innovation and regional industrial change. The RIS concept offers many insights in this regard and allows for the development of useful typologies of less-developed RIS that are highly relevant for the current debate on the design and implementation of smart specialisation strategies.

There are several challenges for future research. First, future conceptual research should further advance our understanding of opportunities and challenges for regional industrial change in different types of RIS. Recent work on the relation between RIS configurations and new path development has made an important contribution in this regard. The focus has thus far been on how the degree of organisational thickness and the degree of specialisation of industrial structures shape the direction of regional industrial change. The institutional dimension of RIS has received less attention in this work. A key issue of future research is thus to explore how institutions at various spatial scales and institutional change affect new path development in different RIS types. Another core question that deserves due attention in future work concerns the role of exogenous sources of regional industrial change. New path development has thus far been conceptualised as a process that builds on endogenous assets. The role of global innovation networks and other forms of exogenous development impulses (and their interplay with locally available knowledge) have been underplayed in the literature and remain poorly understood. There is thus a need for systematic analyses of how extra-regional knowledge flows and external connectedness affect the extension, renewal and creation of regional industrial paths. Third, little is known about the nexus between RIS transformation and regional industrial change. Future research should thus address the question of how various RIS types transform themselves as a result of path renewal and new path creation.

Second, existing empirical approaches fall short of taking account of conceptual insights into system failures, organisational and institutional thinness, misconfigurations of RIS in relation to knowledge bases and weak RIS structures for different forms of path development. In other words: advances that have been made in conceptual debates on specificities of less-developed regions are only partly reflected in existing empirical approaches. There is still a tendency to measure narrowly defined RIS, analytical (R&D based) knowledge and the STI mode of innovation and build typologies based on the findings of these exercises. There is a need to consider in particular recent findings on the role of different types of knowledge bases and innovation modes (as well as their combination) and broadly defined RIS in empirical research that aims at revealing misconfigurations of RIS. In addition, the transformative potential of RIS, that is, their capacity to support new path development, is hardly captured. There is a need for developing new measures and indicators to be used in quantitative research as well as new designs for qualitative case studies that take into consideration the issues raised above. Building on the analytical insights provided in this working paper, current research in the context of the project "Smart specialisation for regional innovation" could make a valuable contribution to enhance understanding of how diversified specialisation or specialised diversification can be achieved among the heterogeneity of European regions.

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