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System Failures, Knowledge Bases and Regional Innovation Policies

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Abstract: Regional innovation strategies rank at the top of public policy agendas today. There is a widespread consensus in both academic and policy circles that standardized "best practice" innovation policy models suffer from severe limitations and major shortcomings. The recent literature is replete with claims that regional innovation policies should be place-based and context-sensitive, taking into consideration the specificities of regions and their distinctive preconditions and capacities for innovation. Various conceptual approaches and theories support such a view. This paper discusses two concepts that have a particularly strong potential for informing customized regional innovation policies: the regional innovation system (RIS) approach and the knowledge base concept. The RIS literature highlights the importance of the organizational and institutional setting of a region and suggests that system deficiencies or failures should constitute the starting point for designing regional innovation policies. The differentiated knowledge base approach stresses that regional industries can differ strongly in their underlying knowledge bases and, as a consequence, in their policy needs. We elaborate on the policy implications that originate from these concepts and argue that tailor-made regional innovation policies should consider both region-specific institutional set-ups and knowledge bases. Focusing on peripheral regions, we outline how such an integrated framework can inform customized regional innovation policies.

1 Introduction

Regional innovation strategies have become a key priority for policy actors in many countries and regions (OECD 2011). A growing body of work suggests that there is no standardized "one-size-fits all" innovation policy approach that could be applied to all types of regions. Indeed, there is widespread agreement in the scientific community (Isaksen 2001; Nauwelaers, Wintjes 2003; Tödtling and Trippl 2005; Boschma 2009; Asheim et al. 2011a; McCann, Ortega-Argilés 2013) and in policy circles (in particular in the form of the smart specialization strategies advocated by the EU (2011) and the OECD (2011)) that policies should be customized and place-based, taking into account the specificities of regions and their respective innovation potential and capabilities. What remains less clear is what such a context-sensitive regional innovation policy approach should look like. Scholarly contributions to this debate are based on various theoretical frameworks including, among others, insights from evolutionary and institutional schools of thought, leading to somewhat different conclusions about the nature of customized innovation policies.

The aim of this paper is to contribute to the debate about the nature of tailor-made regional innovation strategies by examining in a more general way which policy implications can be drawn from two core concepts: the regional innovation system (RIS) approach and the notion of knowledge bases. Furthermore, we intend to briefly discuss, specifically for the peripheral regions that are the center of interest in this special issue, sound policy options that emanate from these theories. Both the RIS and knowledge base concepts have advanced the understanding of the complexity of innovation processes, moving the discussion beyond the too simple views that have dominated innovation theory and policy discourses in the past. The RIS literature has shown that not only well-developed and institutionally dense core areas, but other types of regions can also be innovative, albeit in different forms. The knowledge base concept has sharpened our view that all industries – not only "high tech" and R&D-based ones – are engaged in innovation processes and it has provided the analytical tools for grasping inter-industrial variations of innovation patterns. These insights are highly relevant for peripheral regions, which are often characterized by thin institutional structures and non-R&D-based economic and innovation activities.

Both the RIS and the knowledge base notions are conceptually well equipped for transcending "one size fits all" formulas in innovation policy. The RIS concept puts due emphasis on the organizational and institutional setting of a region and emphasizes that system failures (or deficiencies) should constitute the basis for le-

gitimatizing and designing regional innovation policies (Tödtling, Trippl 2005). The differentiated knowledge base approach highlights that industries differ strongly in their underlying knowledge bases (Asheim, Gertler 2005) and, as a consequence, in their policy needs (Martin et al. 2011). The two concepts offer complementary perspectives, which, when brought together, provide some opportunities for constructing a valuable framework for the design of customized regional innovation policies.

The remainder of this paper is structured as follows: Sections 2 and 3 discuss the RIS and knowledge base concepts in more detail, outlining their core arguments and setting out in a more general way which perspectives they offer for the scope and objectives of customized regional innovation policies. Section 4 advances the idea that regional innovation policies should respond to the innovation challenges and opportunities associated with the institutional structures of a RIS and the specificities of the knowledge bases prevailing in the region. Focusing specifically on peripheral regional economies, we highlight how such an approach can add to the formulation of appropriate innovation policy interventions.

2 Institutional Configurations and Failures of Regional Innovation Systems as a Policy Framework

The RIS concept figures prominently in contemporary discussions about the importance of regions as loci of knowledge creation and innovation processes. Research on RIS has grown enormously since the concept's first articulation and development in the early 1990s (for an insightful discussion of the theoretical antecedents and origins of the RIS approach, its development over the past two decades and recent advances, see Asheim et al. 2011b).

A RIS is commonly understood as a set of several components (or elements) that are embedded in a common region-specific socio-institutional and cultural setting (Cooke 1992, Asheim, Gertler 2005). RIS components include all private and public organizations that are involved in innovation processes, i.e., companies, public research institutes, technology transfer centers, educational and training bodies, workforce mediating organizations and finance providers. In addition, regional policy actors are acknowledged to be an important component of RIS as they can play an essential role in shaping and facilitating innovation. This holds particularly true for political-administrative contexts, in which regions possess wide-ranging powers, i.e. sufficient legal authority and financial resources to design and implement their own innovation policies. Institutions, both "hard" ones such as laws and regulations and "soft" ones like norms, conventions and routines, are viewed as highly relevant as they influence the behavior of innovation-relevant actors and the relationships between them. Ideally, there are numerous connections between the elements of a RIS, facilitating a continuous flow of knowledge, human resources and skills at the regional level and giving rise to systemic innovation activities. Finally, it is also emphasized that a RIS is not a self-sustaining entity, but is usually linked to various national and international actors and innovation systems.

The general outline of the "architecture" of an ideal RIS as suggested above does not hide the fact that such systems come in many shapes (see Cooke et al. 2004). In recent years, several typologies have been developed to capture the heterogeneity of regions and the variety of RISs that exist (for an overview, see Tödtling, Trippl 2011). The RIS literature has shed light on differences between regions in terms of innovation potential, organizational and institutional settings, network structures and innovation capabilities. One of the main strengths of the RIS concept is its strong policy agenda and capacity to articulate important ingredients and directions of regional innovation policies that are tailor-made for the respective specificities, challenges and needs of various types of regions (Asheim et al. 2013).

Tödtling and Trippl (2005) argue that a differentiated regional innovation policy approach should not only be built on market failures (undersupply of private funding for research and development due to uncertainties about the outcome of such activities and knowledge spillovers; see also Lundvall, Borras 1997) but also on system failures. Focusing on the latter, Tödtling and Trippl (2005) distinguish between three main types of RIS failures (or RIS deficiencies): organizational thinness, lock in, and fragmentation. Organizational thinness refers to situations in which crucial parts of an innovation system are weakly developed or even missing. Low levels of clustering or a weak endowment with key organizations and institutions are typical examples in this regard. Lock-in (or more precisely, negative lock-in) points to innovation problems that are related to an over-embeddedness and over-specialization in mature, declining industries and out-dated technolo-

gies. Finally, fragmentation refers to lacking interaction and knowledge flow between the organizations in an innovation system, resulting in low levels of systemic innovation activities.

Although regions can feature combinations of RIS deficiencies, some system failures are more important than others in specific types of regions. Organizational thinness is often the dominant innovation problem in peripheral regions. These areas suffer from low levels of R&D and innovation, brought about by the dominance of SMEs operating in traditional industries, the absence of key assets for the development of new sectors, a low absorption capacity for knowledge from extra-regional sources, and a thin, less specialized structure of support organizations (Doloreux, Dionne 2008; Karlsen et al. 2011). Lock-in is usually a typical characteristic of many old industrial regions. These areas face the problem of an overspecialization in mature industries experiencing decline. Innovation activities in old industrialized areas frequently follow out-dated technological trajectories and the capacity of companies in these regions to engage in more radical innovation activities is rather weak. Functional, cognitive and political lock-ins suppress innovation and keep the region in existing development paths (Grabher 1993; Trippl, Otto 2009; Hassink 2010). Finally, fragmentation can frequently be found in metropolitan areas (OECD 2010; Blazek, Zizalova 2010). This particular type of RIS deficiency might result from too much industrial diversity and a lack of related variety (Frenken et al. 2007; Asheim et al. 2011a) or major barriers to interaction, leading to low levels of intra-regional knowledge flow and innovation.

The heterogeneity of regions and the variety of RIS failures and deficiencies sketched out above clearly challenge the idea of an "ideal, best practice model" of innovation policy that can be applied in a similar way across all kinds of areas. The RIS concept provides a framework for tailor-made policy interventions that address the specific innovation opportunities and problems prevailing in different types of regions. The basic principles and key characteristics of such a differentiated regional innovation policy approach are summarized in Table 1 and have been discussed in detail in previous work (Tödtling, Trippl 2005). In the context of this paper, it is thus sufficient to briefly recapitulate the main strategic orientation and key elements of innovation policies for different types of regions.

As shown in Table 1, customized regional innovation policies for peripheral, old industrial and fragmented metropolitan regions should differ, among other aspects, regarding the promotion of intra-regional versus extra-regional networking, the orientation on endogenous versus exogenous firms and knowledge providers, and the strategic orientation on incremental versus radical innovation (see Tödtling, Trippl 2005). Innovation policies for peripheral areas should focus on upgrading the regional economy and promoting technological and organizational processes of "catch-up" learning. Accessing extra-regional knowledge is viewed as highly important for this type of region (Lagendijk, Lorentzen 2007; Rodriguez-Pose, Fitjar 2013). Such a strategy might include attracting innovative companies and research organizations from outside the region and linking domestic firms to external knowledge providers and innovation systems at higher spatial scales.

Policy challenges in old industrial regions differ strongly from those in peripheral areas. Breaking path dependency and facilitating the restructuring of the regional economy are considered pivotal for these areas. Facilitating industrial and technological diversification processes and fostering renewal and change of existing companies, network structures and institutions are viewed as sound elements in this regard (Trippl, Otto 2009). Fragmented metropolitan regions, in contrast, benefit from policy strategies and actions that aim at stimulating the dynamic development of science-based industries, "knowledge-intensive" services, and radical innovations. Of key importance are policy interventions that enhance interactive learning and knowledge circulation within the RIS to overcome the fragmented state of the system.

To summarize, the RIS concept provides valuable insights into the sources of regional disparities in innovation, stressing that regions vary strongly with respect to their endowment with innovation-relevant organizations, institutional set-ups and networks. Moreover, the RIS concept offers a useful framework for "diagnosing" specific innovation problems and system failures that tend to prevail in different types of regions. Identification of RIS failures provides a legitimization of public policy action and a starting point for developing innovation policies that are tailored to the specific organizational and institutional set-up of regions. The RIS approach, however, does not sufficiently take into account that major differences exist between regional industries in terms of innovation patterns and challenges. In the next section, we will demonstrate that the knowl-

Policy action area	Peripheral regions – organizational thinness	Old industrial regions – lock in	Metropolitan regions – fragmentation
Network initiatives	Promote links between companies and knowledge providers (within the region and, even more importantly, beyond)	Promote networking with respect to new sectors and technologies on regional, national and global scales	Promote regional inter-firm networks and university-industry links
Research and education infrastructure	Attract branches of national research organizations with relevance to regional firms and industries; establish technical colleges, engineering and management schools (provision of medium level skills)	Establish research organizations and universities in new and related fields; establish technical colleges and universities (provision of new skills)	Establish high-quality universities and research organizations in relevant fields; establish universities and schools for highly specialized qualifications and skills
Firms and regional industries	Strengthen potential clusters in the region; link firms to clusters outside the region; attract innovative firms; form new firms	Support clusters in new/related industries and technologies; restructure old sectors; diversify; form new firms; attract cluster related FDI	Support emerging clusters related to the region's knowledge base; develop specialization advantages to achieve synergies and international visibility; attract cluster related FDI, Support start-ups and spin-offs in knowledge- based sectors
Overall / main innovation strategy	Strengthen/upgrade regional economy; catch-up learning (organization, technology); improve strategic and innovation capabilities of SMEs	Renew regional economy; innovation in new fields / trajectories; product and process innovation for new markets	Improve position of regional economy in global knowledge economy; science-based and radical innovation, new ventures; enhance interaction between industry and knowledge providers

Tab. 1: Regional Innovation Policies for Different Types of Regions and RIS Failures. (Source: Tödtling, Trippl (2005), author's modifications)

edge base concept is a powerful approach for capturing such inter-sector variations. The notion of a differentiated knowledge base allows a fine-grained analysis of the specificities of the industrial and economic structures of a RIS and its particular policy needs.

3 Differentiated Knowledge Bases as Policy Frameworks

Recent work on the geography of innovation stresses the need to draw more attention to industry-specific differences that exist within RIS. One way of addressing sector variation in RIS is by referring to the knowledge dynamics that underlie innovation activities. The differentiated knowledge base approach argues that industries can be classified based on the type of knowledge that is critical for innovation (Laestadius 1998; Asheim, Gertler 2005). Three types of knowledge base can be distinguished: analytical, synthetic and symbolic. These differ in various respects such as the rationale for knowledge creation, the development and use of new knowledge, the actors involved and the spatial configuration of innovation networks (Asheim et al. 2011a).

An analytical knowledge base is dominant in industries where innovation is primarily driven by scientific progress. Examples mentioned in the literature are biotechnology, life sciences and information and communication technology (ICT), which are often regarded as

"high-tech" industries (Asheim et al. 2011c). In these industries, new products and processes are developed in a relatively systematic manner involving basic and applied research. Firms usually invest heavily in intramural R&D, but also rely on knowledge generated by universities and other research organizations. Links between private firms and public research organizations are pivotal and take place more frequently than in other sectors. Since analytical industries deal with knowledge stemming from the academic sphere, they depend to a large extent on codified forms of knowledge contained in scientific publications and patents. Codified knowledge is relatively easy to transfer over long distances. Therefore, knowledge sourcing takes place on a wide geographical scale, often within globally configured networks and epistemic communities (Plum, Hassink 2011a; Martin, Moodysson 2013).

A synthetic knowledge base prevails in industries that innovate through the use and new combination of existing knowledge with the intention of solving concrete practical problems. Examples for synthetic industries are plant engineering, industrial machinery or food processing, sometimes also regarded as "traditional" industries (Trippl 2011). In these industries, innovation is driven by applied research or incremental product and process development, whereas formal R&D is of minor importance. Links between university and industry are relevant, but occur more in applied research and education, and less in basic research. Tacit forms of knowledge are crucial, due to the fact that new knowledge often results from experience gained through learning by doing, using and interacting. Synthetic industries require know-how, craft and practical skills, which are often provided by professional and polytechnic schools or by on-the-job training. In comparison with analytical industries, knowledge networks are less globally configured, and knowledge sourcing takes place within national or regional boundaries, be it through cooperation between firms or mobility of employees. At the same time, many synthetic firms are involved in international user-producer relationships (Asheim, Coenen 2005; Broekel, Boschma 2011).

The symbolic knowledge base is a third category that is receiving increasing attention because of the growing importance of cultural production. It is present in a variety of industries such as advertising, music, fashion, new media and design, sometimes also labeled "the cultural and creative industries" (Power, Scott 2004; Scott 2006). What these industries have in common is that innovation is devoted to the generation of aesthetic value and images and less to physical, tangible goods (Asheim et al. 2007). Symbolic knowledge can be embedded in material goods, such as clothing or furniture, but the impact on consumers and the economic value as such arise from its intangible character and aesthetic quality. Symbolic knowledge is highly context-specific as the interpretation of symbols, images, designs and cultural artifacts is tied to a deep understanding of the norms and conduct of specific social groupings. Therefore, the meaning and the value associated with it can vary considerably from one place to another. This also reflects the spatial dispersion of knowledge networks, which are, due to the context specificity of symbolic knowledge, predominantly locally configured connecting partners that share a similar sociocultural background (Martin, Moodysson 2011; Sotarauta et al. 2011).

In correspondence with previous findings on the geography and organization of innovation as outlined above, industries with different knowledge bases are also supposed to differ with regard to how regional innovation policy should be designed and implemented. Recently, Martin et al. (2011) have shown that industries with different knowledge bases vary strongly in their need and requirement for innovation policy, while existing policy initiatives, at least in the case of southern Sweden, tend to neglect those differences in favor of rather generic policy measures. We claim that policies should take the variety of knowledge bases in a regional innovation system into account and provide appropriate support that is attuned to the differentiated nature and geography of innovation (Hassink, Plum 2011b; Isaksen, Karlsen 2011). Table 2 provides an overview of key elements of a regional innovation policy approach that is customized to the needs and characteristics of analytical, synthetic and symbolic industries.

Access to new knowledge is essential for innovation, regardless of the knowledge base of an industry, whereas the geographical spread and the actors involved in knowledge networks differ between industries (Martin, Moodysson 2013). Analytical industries are more predisposed to university-industry collaboration on a global scale, while inter-firm collaboration on the regional and local scale is more common to synthetic and symbolic industries. Research and education arrangements that are conducive to innovation in analytical knowledge bases include university education in the natural and

Policy action area	Analytical	Synthetic	Symbolic
Network initiatives	Promotion of university-industry partnerships; promotion of international networks	Promotion of inter-firm collaboration and user-producer partnerships; promotion of national and regional networks	Promotion of project-based collaboration between firms and with public and private customers; promotion of regional and local networks
Research and education infrastructure	Higher education in fields of natural and formal sciences, e.g. chemistry, physics, mathematics;support of top research milieus and global centers of excellence	Higher education in engineering based fields and applied sciences, e.g. mechanical and electrical engineering; support of polytechnic schools and technical colleges with focus on applied science	Higher education in creative and arts based fields, e.g. architecture and design, visual and performing arts, humanities; support of cultural and creative infrastructure, e.g. theatres, concert halls, exhibitions
Innovation support for start-ups and SMEs	Science and technology parks; technology brokers and transfer agencies; public-private partnerships for innovation; industrial PhDs	Innovation vouchers; life-long learning schemes; schemes for worker participation in innovation	Business support and coaching; provision of meeting places, e.g. conferences, fairs Public procurement
Mobility and talent attraction schemes	Attraction of star scientists through promotion of business and people climate	Promotion of business climate, e.g. laws, regulations, tax incentives, etc.	Promotion of people climate, e.g. diversity, tolerance, quality of place, etc.; regional branding and place marketing
Anchoring projects	Big science projects and large scale research facilities	Attraction and retention of large anchor firms	Architectural landmarks and urban planning projects

Tab. 2: Regional Innovation Policies for Analytical, Synthetic and Symbolic Industries. (Source: author's compilation)

formal sciences, as well as research centers of excellence that provide access to global knowledge flows. Higher education for synthetic industries includes engineering training provided by universities and technical colleges with a focus on applied science. Symbolic industries can be supported by creative and art-oriented education in combination with a well-developed cultural and creative regional setup. With regard to supporting start-ups and SMEs, typical science, technology and innovation-oriented (STI) policy instruments, such as science parks and technology transfer agencies are most suitable for analytical industries, while synthetic industries benefit from policy instruments designed to promote doing, using and interacting (DUI) modes of innovation, such as innovation awards and life-long learning schemes. Innovation support for symbolic industries includes the provision of physical and temporary meeting places such as conferences and exhibitions and should be attuned to the project-based organization of innovation.

As regards mobility and talent attraction schemes, talented people with different knowledge bases tend to have different location preferences (Asheim, Hansen 2009). While a diverse and tolerant socio-economic environment, i.e. a good people climate, is particularly important for knowledge workers in symbolic industries, synthetic industries benefit most from a well-developed business climate. The attraction and retention of high-profile "star" scientists who can play a key role for innovation in analytical industries (Trippl, Maier 2010, 2011; Trippl 2013) can be facilitated by both a good business and people climate (Asheim, Hansen 2009). Furthermore, investment in large anchoring

projects attuned to the requirements of different industries may be favorable. Large-scale research facilities can strengthen the analytical knowledge base of a region, whereas architectural landmarks and urban development projects can positively affect the symbolic knowledge base of RIS.

The policy approaches outlined above are customized to the requirements of different knowledge bases and can be applied to foster innovation in analytical, synthetic and symbolic industries. However, this does not imply that regional innovation policies should promote one single knowledge base in order to secure long-term growth. Depending on the institutional preconditions of the respective RIS, customized regional innovation policies can take advantage of cross-fertilizing effects that occur at the intersection of knowledge bases (Manniche 2012). Grounded on the principles of related variety and differentiated knowledge bases, such "platform polices" should stimulate innovation and knowledge exchange both within and between sectors (Asheim et al. 2011a). In that way, they allow dynamic combinations and shifts of knowledge bases along the evolution of a RIS, and can contribute to breaking negative lock-in in regional development (Martin and Trippl 2013).

4 Towards an Integrated Policy Framework for Peripheral Regions

The literature on the geography of innovation offers a rich conceptual basis for developing context-sensitive, tailor-made regional innovation strategies. This article has outlined policy implications from two interconnected concepts, namely the RIS approach, which constitutes an essential theoretical underpinning of contemporary innovation policy strategies (OECD 2011; McCann, Ortega-Argilés 2013), and the knowledge base approach (Asheim, Gertler 2005), which is increasingly acknowledged for extending and further developing the RIS literature in essential ways.

A key issue that emanates from the discussion above is how to integrate the two approaches and design policy strategies that take into account both the institutional characteristics of RIS and industrial knowledge bases. A first step towards such an integrated policy approach is to gain awareness of the institutional conditions that characterize the respective RISs. As argued in Section 2, policy interventions should be focused on mitigating or overcoming the most pressing innovation problems and RIS deficiencies. The way this is done and the choice of policy tools will depend on the challenges related to the prevailing knowledge bases in the region. A second step is to recognize the different needs for innovation policy resulting from knowledge base specificities, as argued in Section 3. Such specificities should be taken into account by policies geared towards RIS transformation and the creation of more favorable support structures for innovation. Since an elaboration on customized innovation policy for every possible regional setting is beyond the scope of this paper, we apply these insights to the case of a peripheral region dominated by a synthetic knowledge base.

Peripheral regions mainly suffer from institutional and organizational thinness. The key policy challenge is to turn thin structures into thicker ones and to strengthen and rebuild the RIS. Sound policy measures in this regard include adding missing RIS elements, such as educational bodies, support organizations, etc., attracting innovative firms from outside the region and supporting incumbent ones to improve their innovation capabilities, as well as promoting the formation of knowledge links within and across the boundaries of the region. The question of how to choose priorities in this regard requires a focus on the knowledge bases prevailing in the region. Peripheral areas are often specialized in traditional economic sectors drawing on synthetic knowledge, although analytical and symbolic sectors may also be present (see Karlsen et al. 2011; Martin 2012; Mayer 2013). Synthetic industries located in an organizationally thin RIS will benefit from establishing new RIS elements, enlarging the ensemble of innovative players in the region. This includes setting up research centers and educational facilities with a focus on applied science and supporting new firm formation in the region and attracting larger innovative firms from abroad. Furthermore, the promotion of company engagement in DUI learning activities, the typical innovation mode in synthetic industries, is high in demand. This includes policy support for on-the-job and life-long learning activities and fostering knowledge links to customers and suppliers. In general, knowledge links in synthetic industries tend to be regionally and nationally configured. The RIS deficiency of organizational thinness in peripheral regions, however, implies that promotion of extra-regional knowledge connections, in addition to regional ones, should be high on the policy agenda (see Lagendijk, Lorent-

zen 2007). Finally, in addition to upgrading the existing knowledge base, peripheral regions might also benefit from policy measures that facilitate knowledge circulation across knowledge bases. Supporting firms to get access to and use knowledge input from other knowledge bases can trigger diversification processes and more substantial forms of innovation.

To sum up, it is argued in this paper that a nuanced understanding of institutional structures, system failures and industrial knowledge bases is necessary to design policy approaches that can account for the complexity and diversity of regional innovation systems. The concepts of RIS and differentiated knowledge bases complement each other. A framework that considers both perspectives can provide valuable implications for the development and implementation of regional innovation policies in the context of peripheral regions. It is important to note that the policy strategies outlined in this article have been derived from conceptual arguments. Arguably, each peripheral region faces the challenge to adapt them to its own circumstances. A key issue for future research is to elaborate on customized innovation policies, not only for synthetic industries located in peripheral regions, but for all types of regions and knowledge bases and to explore the opportunities that are provided by integrating the RIS concept and the knowledge base approach in this regard.

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