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What Does Evolutionary Economic Geography Bring To The Policy Table? Reconceptualising regional innovation systems

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ABSTRACT

The article discusses the strategic roles of public policy and institutions and the way this effect to the efficiency of regional innovation systems in the landscape of evolutionary economic geography. It argues that the current emphasis on path dependency historically contingent preconditions has provided important insights into the interdependencies between industrial knowledge bases and routines, regional system dynamics and long-term development paths. Yet, it falls short of capturing the scope of policy intervention which follows logically from the evolutionary framework itself. Anchored in a renewed regional innovation systems approach, the article presents a policy intervention framework for constructing regional advantage in different contexts.

JEL: B52, O33, O38

Keywords: evolutionary economic geography, institutions, regional innovation policy, clusters, regional innovation systems

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Abstract

The article discusses the strategic roles of public policy and institutions and the way this effect to the efficiency of regional innovation systems in the landscape of evolutionary economic geography. It argues that the current emphasis on path dependency historically contingent preconditions has provided important insights into the interdependencies between industrial knowledge bases and routines, regional system dynamics and long-term development paths. Yet, it falls short of capturing the scope of policy intervention which follows logically from the evolutionary framework itself. Anchored in a renewed regional innovation systems approach, the article presents a policy intervention framework for constructing regional advantage in different contexts.

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Introduction

The evolutionary turn in economic geography has shed new light on historically contingent regional preconditions for innovation and economic growth, and revealed a weakness in established systemic approaches to innovation attributable to their often limited appreciation of these path dependencies (Boschma & Frenken, 2006; Uyarra, 2010) As explained by Martin (2010, p. 3), "the combination of historical contingency and the emergence of self-reinforcing effects" stemming from critical mass and spillovers is considered key in steering the "technology, industry or regional economy along one 'path' rather than another". Due to its interest in and focus on firms; their routines, knowledge bases and the self-sustaining development dynamics which may arise from their collocation it is not surprising to find that the evolutionary framework as it now stands has a rather poorly developed view of how policy intervention and institutions can work (pro) actively in favour of regional development in terms of path extension, renewal and new path creation.

In their pioneering work, Boschma and Frenken (2006) distinguish evolutionary economic geography explicitly from institutional economic geography. Others have voiced their concern about this divide. Notably, it has been pointed out that an overreliance on imported evolutionary frameworks (such as Nelson and Winter's theory of the firm and their lack of an explicit social ontology) may lead to a 'theoretical relegation' of institutions and social agency (MacKinnon, Cumbers, Pike, Birch, & McMaster, 2009). Others argue that the inclusion of institutions is essential for the development of evolutionary economic geography and that a sharp divide is not only artificial but even misleading (Essletzbichler, 2009; Grabher, 2009). While the discussion on the role of institutions in evolutionary

economic geography may have spilled over towards the question about policy relevance, it seems fair to say that the policy agenda in evolutionary economic geography has remained largely implicit. So far, direct policy implications originating from evolutionary economic geography are limited to an informative rather than prescriptive policy agenda: Avoidance of one-size-fits-all and picking-the-winner policies, sensitivity to the history of a region and the potentials and bottlenecks that follow from that and, finally, stimulating entrepreneurship both in terms of new business activity and policy experiments (Boschma & Martin, 2010). While there is nothing fundamentally wrong with these policy lessons (on the contrary), they hardly qualify as controversial or novel. Evolutionary economic geography's weak policy agenda becomes particularly evident in comparison with the strong policy agenda articulated in the literature on regional innovation systems (especially strengthened by the CRA approach) and other territorial innovation models (B. T Asheim, Smith, & Oughton, 2011; Moulaert & Sekia, 2003).

The purpose of this article is to revisit regional innovation policy, by way of investigating what evolutionary economic geography (implicitly and explicitly) brings to the policy table, and how policy could respond under different regional circumstances. The article starts out by identifying the conceptual foundation of and limitations of the evolutionary framework. It then proceeds to discuss the implications for policy which follow logically from the framework itself once it is extended to incorporate perspectives on local-global- interdependencies, different knowledge bases and different modes of innovation. On this basis, the article r re-conceptualizes the regional innovation system approach so that it is more explicitly geared towards analysing the role and impact of inter-industry knowledge flows and path-dependency. As part of this the article specifies a set of key policy areas with related institutional domains and discusses their implementation under various regional preconditions.

Knowledge spillovers and industrial development in EEG

The main ideas of evolutionary economic geography has centered on two interrelated issues: (1) path dependence, lock-in and lock-out, and (2) agglomeration economies, related variety and regional branching (Boschma & Frenken, 2006; Boschma & Martin, 2007; Coe, 2011; Hassink, 2010). In the following section we review how these contributions come to bear upon regional innovation policy and especially the way policy is pursued by a regional innovation systems approach. Recent RIS research has provided compelling evidence that the localized, path-dependent processes of knowledge generation emphasized by EEG should neither be seen as independent from local-global interlinkages nor treated as unaffected by different modes of innovation and knowledge bases. Different types of regions will therefore at any time be influenced by their characteristics of these parameters and hence possess various compositions of firms and industries, skills, global interlinkages, absorptive capacity, knowledge bases and modes of innovation that in turn will influence their potentials and capabilities in terms of innovation and economic performance.

Path dependence, lock-in and lock-out

A casual invocation of path-dependence may be interpreted as 'history matters'. A closer reading of evolutionary economics would however acknowledge the close relationship of this concept vis-à-vis (evolutionary) technological change (David, 1985). In this model, new technological pathways are created as a result of "historical accidents", "chance events" or "random" actions. Subsequently, a combination of self-reinforcing effects and contingency leads to the selection of certain pathways. Characteristic for this model is that it opens up for the possibility that the selected pathways may

very well be based on sub-optimal technologies, institutional or organisational arrangements. Because of these self-reinforcing effects, these pathways become ultimately locked-in, and the only way to break out of this seems to be through exogenous shocks. Initial work in evolutionary economic geography on the path dependence of spatial industrial evolution has adopted a parallel model to explain long-term stability in locational patterns of industry. In a similar vein, initial location of first firms in an industry is determined serendipitously while self-reinforcing processes are explained by agglomeration economies, i.e. critical mass (see below).

This emphasis on evolutionary development paths responds to an important critique raised against RIS to provide snapshots of successful regions detached from their time-space context (MacKinnon et al., 2002). According to Uyarra (2010) RIS analysis has often been characterized by "inventory-like descriptions of regional systems, with a tendency to focus on a static landscape of actors and institutions" (p. 129). Furthermore, evolutionary economic geography has pushed RIS away from a largely static perspective on the role of policy, focused on fixing the holes in the system (Benneworth, Coenen, Moodysson, & Asheim, 2009). Instead, Boschma and Frenken (2006) argue for regional policy based on a deep understanding of how historical trajectories affect change and how dynamic adaptation and persistent path-dependent generates disparities in growth rates. However, as argued earlier, this policy agenda can be seen as relatively implicit and largely informative (as opposed to prescriptive).

The emphasis on continuity associated with path-dependency may seem at odds with the ambition to understand and explain change in a non-deterministic and non-linear way which characterizes systemic approaches to innovation. The classic understanding of path-dependency in evolutionary economics (derived from the work by David and Arthur on technological pathways) lacks a satisfactory explanation of path renewal and new path creation resorting instead to exogenous shocks and serendipity respectively (Martin, 2010; Simmie, 2012). This critique could indeed be seen as indicative of the concern that institutions and social agency are being relegated at the expense of an overriding focus on explanations grounded in the micro-foundations of individual firms and their routines. It seems that this criticism has been answered in different ways by different 'schools' in evolutionary economic geography.

On the one hand, the Dutch school seems to maintaining a distinct divide between evolutionary and institutional economic geography and emphasizing an 'orthogonal' relationship between (territory-specific) institutions and organisational routines respectively. As such, Boschma and Frenken (2009) assert that "we expect the effect of (territory-specific) institutions to be small as firms develop routines in a path-dependent and idiosyncratic manner" (p. 153). This position is further qualified in the context of path-dependent spatial evolution of industries: "we do not expect that the spatial distribution of institutions can explain where a new industry will emerge and develop. What is crucial, though, is that such institutions are created deliberately to support and sustain the further growth of the industry in question. These supportive institutions often come into existence where the specific demand for them has emerged, that is, in those places where the new industry started to develop" (p. 155).

The UK school, on the other hand, seems more inclined to include institutions in the conceptualization of path-dependency to steer away from deterministic accounts and to recognize the broad range of alternative evolutionary paths found in the economic landscape. Martin (2010)

suggests an alternative path dependence model for regional industrial evolution which incorporates concepts of layering (institutions change gradually), conversion (re-orientation of an institution) and structured diversity and recombination (agents learn from other institutions) (see also Gertler (2010) for a similar categorization of institutional change in regional economies). Simmie (2012) takes this even one step further and calls attention to processes of collective agency to purposively create and steer pathways.

Agglomeration economies, related variety and regional branching

The theoretical advances in EEG on the relationship between agglomeration economies and regional development paths build on the classical notion of knowledge spillovers as determinants of economic growth. However, instead of focusing on the presence of R&D performers and the extent to which this R&D is associated with positive external effects (Griliches, 1979, 1992; Hall, Mairesse, & Mohnen, 2010; Møen, 2005), it focuses broadly on how the pre-existing industrial structure determines on the one hand the composition of spillovers with respect to knowledge content broadly defined, and, on the other, the ability of the regional system to effectively transform them into growth (Koen Frenken, Oort, & Verburg, 2007). This is largely assumed attributable to the degree of cognitive similarity, relatedness or distance between *industrial* knowledge resources and the organisational routines by which they are expressed, and where diffusion is assumed to occur from collocation. Thus, instead of attributing localized learning dynamics to interactive learning and spillovers associated with inter-organisational linkages, e.g. value chain linkages or links between research organisations and industry; it focuses on knowledge diffusion as essentially determined by localized labour market characteristics. The latter has traditionally been a neglected dimension of RIS (de Laurentis, 2006) and clusters (Malmberg & Power, 2005).

Conceptualizing localized learning as a process of continuous search, recombination, replication and transformation occurring at the intersection between the knowledge bases of firms, self-sufficiently driven by individuals (most intensively) mobile in regional labour markets (Fallick, Fleischman, & Rebitzer, 2006; Sturgeon, 2003), points to the importance of the specific industry structure which defines the characteristics of the knowledge available in the labour market and information available through the surrounding 'local buzz'. The basic idea behind agglomeration economies is that firms get advantages from locating close to each other, either because this provides privileged access to diverse knowledge and networks into very different industrial and technological domains (urbanization economies due to regional industrial diversity), or because it provides privileged access to the knowledge and industrial domains which constitute the core of individual firm activities (localization economies due to regional industrial specialization). Yet, urbanization economies are subjected to cognitive distance constraints, and may not materialize as such due to regional fragmentation of collaborative linkages and segmentation of labour markets (Tödtling and Trippl, 2005). Localization economies, by contrast, may be associated with both positive and negative technological locks-ins. In the RIS literature, these recognitions have traditionally legitimized institution building and policy intervention, e.g. in the form of lateral networking initiatives in urban regions (to compensate for fragmentation) or the establishment of educational programs and research institutes in specialized regions (to reinforce positive or break negative lock-ins).

In contrast, current evolutionary thinking focuses exclusively on the industrial conditions under which self-sustained localized spillovers emerge. To capture this, the concept of variety has been divided into related and unrelated variety (Boschma, Eriksson, & Lindgren, 2009; Koen Frenken, et

al., 2007; K. Frenken, van Oort, Verburg, & Boschma, 2004). It is built on the assumption that some sectors inherently are more easily cross-fertilized than others, and thus more easily form a critical mass of industrial activities which as such is able to reproduce or diversify itself. Related variety describes an ideal state of affairs in which self-sustained spillovers most effectively cross-fertilize those industrial firms which are present. This line of reasoning has also been linked to the maturity of the industry in question (Frank Neffke, Henning, Boschma, Lundquist, & Olander, 2008) and the notion of regional 'branching' processes through which specialized yet related organisational routines and technological capabilities are transformed into new industrial activities. Research has suggested that industry life cycles are strongly associated with the advantages of being located in various types of agglomerations. In particular, the results show that the more mature an industry is, the more likely it is to gain from specialized localization economies. Oppositely, the younger an industry is, the more it is assumed to diversify and to gain from Jacob's externalities and urbanization economies (Jacobs, 1969; Frank Neffke, et al., 2008). According to Boschma and Frenken (2011), branching into new activities can occur through knowledge-transfer mechanisms such as spin-off activities, firm diversification (e.g. within the firm in cases of setting up a new department), labour mobility or social networking (R Boschma & K Frenken, 2011). As in the case of cross-fertilization between firms, branching processes are therefore to a large extent shaped by those organisational routines and technological capabilities which are i) already present and ii) identified as (potentially) related by private sector actors, employees and entrepreneurs.

Limitations of the evolutionary approach

This line of reasoning has three fundamental limitations. First, it assumes that the main system components, firms, are 'given', either when paths are created through historical accidents, serendipitous events or external chocks which lead to the formation of new critical mass and thus new development paths; or as a result of historically contingent, place-specific processes of branching within the confines of a specific path.

Second, it assumes that it is primarily – or even only - the pre-existing regional resource base which influences the introduction and selection of variety. At the same time, other strands of literature has shifted away from the view of international collaboration and the presence of MNEs as a threat to regional economy dynamics (B.T Asheim & Herstad, 2005), towards a view of these as mechanisms by which the technological basis for localized learning may be expanded and diversified by external inputs through international networks (Balsvik, 2011; Ebersberger, Lehtoranta, & Herstad, 2012; Pesola, 2011).Thus, EEG is essentially ignoring that global innovation network linkages in their various forms can contribute to the renewal, extension or even transformation of the regional resource base. While such networks initially reflect the geographical contexts and cognitive domains of direct relevance to the pre-existing industrial base and the specialization of this base as a whole, the complex layers of indirect ties (Owen-Smith & Powell, 2004) into different cognitive and geographical domains entail that this neglect is highly problematic in a context when such networks are growing in importance (Kafouros, Buckley, & Clegg, 2012).

Third, by relying heavily on cross-fertilization by means of collocation it assumes that 'relatedness' is predetermined; empirically by statistical industry classifications (Boschma, et al., 2009; Koen Frenken, et al., 2007), patent classes (Nooteboom, Van Haverbeke, Duysters, Gilsing, & van den Oord, 2007) or by revealed labour mobility patterns (F Neffke & Henning, Forthc.); and substantially in that some technologies inherently are more related than others. This view fails to acknowledge

how the continuous exploration of novel combinations and subsequent redefinition of related and unrelated technologies is part and parcel of innovation and technological change itself (Katila, 2002; Katila & Ahuja, 2002). This is problematic because it a) assumes that firms, often forced by investors and the overall competitive environment to focus on core activities, collectively are able to identify and exploit the potential for growth and structural change at the regional level from novel combinations of resources already present, and b) that the regional knowledge diffusion mechanisms which are at play and beyond realm of individual firm control, contribute to the exploration of what is potentially related and not only reflected in what is already identified as such (Herstad & Brekke, 2012). Lastly, it is problematic because c) attention towards corporate or non-corporate extra-regional networks which follow from the globalization of innovation may come with reduced attention towards local interaction (B.T Asheim & Herstad, 2005; Blanc & Sierra, 1999). This may result not only in failure on the side of individual firms with respect to acknowledging and harnessing regional knowledge resources which remain relevant and valuable, but also in reduced reverse knowledge transfer effects at the level of the region through individual firm 'decoupling' from collaboration networks.

The above sections illustrate the magnitude of possible knowledge sources which, when brought together within territorial units, constitute a potential for the creation of competitive advantage. In evolutionary thinking spillovers reflecting the knowledge bases of individual firms and the (limited cognitive range of) extra-regional networks interact with the relative absorptive capacity of other firms in the region and define processes of cross-fertilization. As it all starts with what is already there as a result of past evolution (i.e. firms) and develops as a result of collocation (i.e. spillovers), not much room, by the share logic of the argument, is left for direct policy intervention.

Regional innovation systems as a framework for policy-making

The systemic perspective implies that regional innovation systems can be conceptualized in terms of (1) system components, (2) system linkages and (3) system boundaries (Asheim, Smith and Oughon, 2011). The system components refer to the private and public organisations involved in innovation processes as well as to the institutions guiding their behaviour. The system linkages refer to the relationships between the components which are part of a localized innovation network that allows for interactive learning to take place (Cooke, 1998). The boundaries of the RIS draw attention to the demarcation, overlap and relationships with extra-regional actors, networks and institutions.

It follows from a plethora of RIS studies that such systemic support for innovation does not occur automatically through market-based coordination but requires a variety of different governance arrangements. One of the main contributions of the RIS approach has been to specify what kind of innovation policy is needed contingent on different regional conditions. There is no single permanent 'best practice' policy, or mix of policy instruments, available for each and every situation, as regions and nations are very different. Thus, instruments and policy systems have to be context sensitive in being adapted to the needs and bottlenecks in different types of firms and regional circumstances. This context sensitivity is clearly articulated in the typology suggested by Tödtling and Trippl (2005) which builds on different system failures found in different types of regions. This typology distinguishes between systemic problems related to organisational thinness often found in peripheral regions, problems associated with technological lock-in characteristic for old industrial regions and, finally, problems connected with internal system fragmentation typically found in

metropolitan regions. According to Tödtling and Trippl (2005) these systemic problems require tailored policy support beyond 'one-size-fits-all'.

On a more general level, the discussion points to the policy rationale found in RIS, which is to address system failures. A system perspective on innovation goes beyond the neoclassical economic rationale that policy intervention is legitimate and needed due to market failure because of sub-optimal resource allocation by firms. Rather, it builds on the notion that innovation processes are social learning processes that take place in a context of networks and institutions. This implies that public intervention is legitimate and needed if the complex interactions that take place among the different organisations and institutions involved in innovation do not function effectively. Various authors (Klein Woolthuis, Lankhuizen, & Gilsing, 2012; Weber & Rohracher, 2012) have identified a number of system failures which inform and shape system-oriented public policy support for innovation:

- Capabilities' failure: The lack of appropriate competencies and resources at firm level may prevent access to and exploitation of knowledge.
- Hard institutional failure: Absence, excess or shortcomings of formal institutions such as laws, regulations, and standards (in particular with regard to IPR and investment).
- Soft institutional failure: Informal institutions such as social norms and values, culture, entrepreneurial spirit, trust and risk-taking that impede innovation
- Strong network failures: Intensive cooperation in closely tied networks leads to myopia and lack of infusion of new ideas
- Weak network failures: Too limited interaction and knowledge exchange with other actors inhibits exploitation of complementary sources of knowledge and processes of interactive learning.

Regional innovation system policy holds the potential for improved "on-the-ground" policy know-how about these specific conditions. As Nauwelaers and Wintjes (2002, p.205) observe: "the non-anonymous relations, the complementarity of activities and the historical setting are stressed in the regional context. […] Further, in order to find out and articulate what a particular region or firm needs, or what is lacking concerning innovation, regional proximity and communicative interaction may be needed to address the tacit and latent aspects of such needs" (Nauwelaers & Wintjes, 2002).

These arguments in part resonates with recent work on different modes of innovation (M. B. Jensen, B. Johnson, E. Lorenz, & B. A. Lundvall, 2007). The core of the "science-technology-innovation" (STI) mode of innovation is R&D departments of firms, linked to recruitment of highly skilled individual researchers, the use of academic communities and literature for search purposes and collaboration with science system actors. The outcome is explicit knowledge, which travels well but requires adaption to contexts of application before it transforms into commercial innovation (Herstad & Brekke, 2012). The strength of the STI mode lies in its ability to draw on and push disciplinary frontiers and explore fundamentally new knowledge independent of specific contexts of application. This is also its Achilles heel; as transformation into large-scale industrial application often requires specialized complementary capabilities developed by other modes of innovation than STI (Karlsen, Isaksen, & Spilling, 2011).

The core of the contrasting "doing-using-interacting" (DUI) mode of innovation is learning work organisations linked to external value chain actors in various forms. This model manages to mobilize

and link experience-based knowledge originating in different parts of the organisation and value chain; thus ensuring that a stock of knowledge which is context-specific and application-oriented continuously evolves. This sustains an on-going stream of incremental innovations along established technological development paths. For the same reason, it comes with the danger of lock-in. Thus, at both firm and regional levels it can be argued that science-based and experience-based knowledge are complementary (Ebersberger & Herstad, 2011; Milgrom & Roberts, 1995) as the full impact of either one on firm innovation (M. B Jensen, et al., 2007) or regional dynamics (Karlsen, et al., 2011) is dependent on the co-existence of the other.

Despite the disruptive potential of scientific and technological breakthroughs, a Schumpeterian understanding of innovation and industrial renewal capture the interdependencies between different forms of knowledge and modes of innovation. As suggested by a differentiated knowledge base approach, knowledge creation and innovation can take place in all kinds of industries but is done in different ways, and needs different kinds of knowledge and skills and requires different forms of innovation support (B. T Asheim, Boschma, & Cooke, 2011). The differentiated knowledge base approach makes a distinction between analytical (science), synthetic (engineering) and symbolic knowledge bases. A main theoretical value-added of this typology is connected with the possibilities of transcending the traditional dichotomy between codified and tacit knowledge as well as the common distinction in innovation research between "high-tech" and "low-tech" activities and sectors. In empirical terms, the EURODITE project has provided compelling evidence that innovative firms typically rely on combinatorial knowledge bases and that innovations are realized through integrating separated but interconnected interactions within the realm of different knowledge bases, learning communities and contexts (Manniche, 2012). Based on research carried out in the same project, Crevoisier and Jeannerat (2009) argue that production and innovation systems might experience negative "lock-ins" due to a too strong focus on one single knowledge base (Crevoisier & Jeannerat, 2009).

Thus, the interdependencies between different forms of knowledge and different modes of innovation in determining, sustaining and redefining technological development paths which follow from it, is increasingly recognized. This translates into a question of how certain regions serve as breeding grounds for the exploration and exploitation of linkages between scientific and industrial knowledge (M. B. Jensen, B. Johnson, E. Lorenz, & B. Å. Lundvall, 2007). This in turn questions how support infrastructures and policy can serve this kind of new knowledge exploration and exploitation, which transcend the limitations of traditional roles such as contractual R&D support at arm's length and linear technology transfer (Herstad & Brekke, 2012).

A tailored policy approach that addresses the specific needs of a region thus calls for a customized mix of policy instruments. In an international analysis of different regional innovation policies across Europe, Nauwelaers and Wintjes (2002) have classified existing policy tools into four types (Table 1). The typology distinguishes between, on the one hand, two principal modes of support and, on the other hand, between two different target levels. In terms of modes of innovation support, policy can either seek to address a perceived *lack of resources* (types A and C) or *organisational routines* related to innovation (types B and D). In case of the former mode of support, it is assumed that actors already have a (more or less clear) idea about which opportunities for innovation are present but that these opportunities cannot be pursued due to a lack of resources. In the latter case, the principle barrier to innovation relate to aspects such as organisational culture, strategy, management

and mentality. Support for innovation entails changing the mind-set of actors to make them more aware of the necessity and opportunity to innovate. In other words, policy support is directed to changing the *institutions* that guide the innovative behaviour of actors. Policy thereby seeks to help actors develop or acquire new behavioural routines that are more proactive and geared towards innovation.

A second distinction that can be made in classifying innovation support concerns the target level of the intervention (see column 1 in the table). Policy can either target specific organisation individually or focus on system level support. These distinctions provide a 2x2 matrix by which tools for innovation policy may be classified. Examples of all types of innovation policy can be found contingent on the specific regional situation.

Table 1 approximately here

Re-Conceptualizing regional innovation systems

Some of the critique from the evolutionary approach is clearly legitimate against the background of early regional development policy, heavily influenced by the cluster approach and attempting to target industrial development in terms of specialization in vertical value chains or by bridging public R&D and industry in a linear and narrow STI mode of innovation. Specifically, the RIS approach has traditionally distinguished between two regional subsystems, i.e. the knowledge exploration subsystem and the knowledge exploitation subsystem (Asheim and Gertler, 2005). The exploration subsystem has been viewed as consisting of universities, research institutes, etc. Firms in the region which are part of similar or related industrial sectors have on the other hand been considered as representing the exploitation subsystem which feed on and transforms knowledge developed within the exploration system into economic value through the process of innovating. A functioning regional innovation system has been considered to be in place when there are "interacting knowledge exploration and exploitation subsystems linked to global, national and other regional systems" (Cooke, 2004, p. 3). Yet, later developments within RIS have increasingly emphasized the importance of inter-industry dynamics and correspondingly how policy should also support such horizontal linkages (Cooke, Laurentis, Tödtling, & Trippl, 2007) based on the recognition that specialized knowledge is developed within such organisations. This reduces the clear distinction between the two subsystems and, instead, treats these as overlapping.

To replace a distinct knowledge exploration and exploitation subsystem, an EEG conceptualization of RIS would suggest a combined knowledge production and diffusion infrastructure. Thus, new combinations of knowledge originating in different cognitive domains (knowledge bases) and industry segments are systematically explored. Similarly, this is paralleled by a systematic exploration of linkages between STI and DUI modes of innovation. In essence, this conceptualization puts greater emphasis on firms as *the* loci of innovation and may tone down the role of universities and other types of knowledge organisations in the RIS as active agents in innovation processes. On the one hand, this may lead to welcoming a re-assessment in terms of what can be realistically expected from universities and research institutes. In the wake of the triple helix approach and rise of entrepreneurial universities, these expectations may have become somewhat overblown putting universities and research institutes in a misplaced driving seat to promote innovation. On the other

hand, EEGs emphasis on firms as primary agents for innovation may leave the impression that innovation solely takes place in firm-led and market-based environments.

In our opinion, the main contribution from EEG is a more explicit and empirically well-founded emphasis on the (traded and untraded) interdependencies which determine regional development paths, and the recognition that the specialized knowledge bases and organisational routines of the industrial base constitute the core of innovation systems – not university research and technology transfer schemes nor individual entrepreneurs operating in isolation. Due to the EEG approach these interdependencies, which can be conceptualized as system linkages in RIS, have taken a more pronounced cognitive character. In previous RIS work such linkages were to a large extent dominated by functional linkages (in clusters or industry-academia relationships of a triple helix) which were assumed to overlap with cognitive linkages.

EEG has directly contributed to a more explicit focus on regional knowledge diffusion mechanisms, which draw heavily on the notions of 'untraded' interdependencies (Storper, 1997) and thus the labour market mobility and interpersonal networks which are assumed to follow from co-location (Agrawal, Cockburn, & McHale, 2006; Eriksson & Lindgren, 2009; Fallick, et al., 2006; Singh & Agrawal, 2011). First and foremost, this marks a clear departure away from the notions of regional innovation systems as sets of localized user-producer linkages, towards a strong emphasis on the *cognitive* foundations of the system. It also points back to the individual firm level, in that it allows not only independencies but also contradictions between knowledge development at the individual firm level and knowledge diffusion at the regional level. These contradictions exist because diffusion through labour markets translates into weakened knowledge accumulation within firms. In turn, this may put constraints on the ability of regions to grow new critical mass. This suggests that policy intervention with the aim to expand and diversify the regional knowledge diffusion infrastructure must at the same time account for the fact that such initiatives, from the perspective of the individual firm, may come with appropriability problems and perceptions of increased vulnerability rather than potential improvements of innovative capabilities and competitive strength.

An additional contribution to RIS conceptualization in the wake of EEG concerns the importance and role of extra-regional linkages, which either expand as a result of established 'insideness' in global communities (Coviello, 2006; Johanson & Vahlne, 2009; Reihlen & Apel, 2007) – or are constrained by lock-in to specific geographical and cognitive domains (Narula, 2002). Admittedly, EEG has not yet explicitly incorporated the role of extra-regional networks and their intimate relationship with contexts of location (Fernhaber, Gilbert, & McDougall, 2008; Herstad & Ebersberger, 2012). At the same time, the attention paid to the industrial base, which represents the primary contact points of regional economies with such networks entail that it *implicitly* captures the role of this industrial base in determining the nature, geographical reach and cognitive diversity of extra-regional linkages. Furthermore, as it is regional knowledge diffusion processes which determine the impact of such networks on the development paths in question, it also implicitly points to the role of the industrial structure and the labour markets by which firms are linked in determining regional absorptive capacity (Balsvik, 2011; Boschma & Iammarino, 2009; Ebersberger, et al., 2012). This is a major supplement to the RIS line of reasoning. However, at the individual firm level global network linkages may come at the expense of regional networks and, thus, increase the problem of fragmentation, particularly in diverse regions. This in turn draws attention to the importance and role of functional

linkages in the RIS as determinants of the ability of regions to capitalize on the cognitive diversity introduced through global linkages.

Traditionally, regional innovation system thinking has put a strong emphasis on spatial contextualization, i.e. the need to develop and adapt policy 'packages' which are composed in a manner which directly reflect the circumstances at hand. With EEG, this perspective is 'opened up' to include historical contextualization. From the acknowledgement of the interdependencies (see above) – be it inter-industry or intra-industry, intra-regional or extra-regional, industry-university linkages – follows the recognition that regional innovation policies must not only adapt to specific objectives and specific regional circumstances; they must also operate at several, interdependent levels in a manner which reflect these preconditions and objectives by acknowledging the specific challenges they represent. In essence, they must either work with an evolutionary logic (path extension or path renewal), or accept the challenges involved in transcending it (new path creation).

In terms of policy rationales, EEG has drawn attention to the need to consider both the system and the firm levels in an interrelated way. From this follows that the classical market failure argument remains relevant in regions where the intensity of knowledge diffusion between firms through labour market may depress private returns from investment in new knowledge development, thus resulting in downward investment spirals and strong incentives to free-ride (Combes & Duranton, 2006). Intervention at the firm level may under these circumstances be necessary to ensure the commitment of key firms to contribute to knowledge development within the region and to the exposure of proprietary knowledge in relation to the regional mobilization and networking initiatives attempting to overcome the problem of fragmentation (Herstad, Pålshaugen, & Ebersberger, 2011; Tödtling & Trippl, 2005). Furthermore, it comes with an explicit recognition that organisational thinness or negative lock-in must be faced with policy geared to business start-ups and growth into critical mass in new areas. By the same token, the presence of seed and venture capital and labour market mobility which are shaped by higher education institutions are important in the context of variety creation, selection and subsequent growth to achieve a critical mass. However, besides institutions connected to labour markets, finance and education, EEG seems to underplay the role of institutions of RIS. Probably this is especially the case for informal institutions which have traditionally received a lot of attention in the RIS literature.

The numerous firm-oriented initiatives which are available to support the micro-level introduction and selection of variety include inward FDI attraction, the supply of public seed or venture funding, direct or indirect support for intramural R&D, demand-side intervention such as active public procurement policies and market regulation, dense coordination between private industrial owners and government, or direct public establishment and ownership of activities assumed to be critical for the transformative capacity of the economy. Furthermore, they may include system-level intervention such as specialized educational programs supplying competences not yet used and thus provided for the labour market of the established industrial base; university-industry collaborative linkages seeking to supplement the output of DUI-based industrial (application-oriented) knowledge development processes with STI-based (technological platform) knowledge which reflect their long-term needs. Lastly, such initiatives may also include measures by which pre-existing local demand and knowledge resource constraints are sought overcome by linking regional firms to extra-regional markets and providers of competences.

A dimension of institution-building which is neglected altogether by EEG concerns the active use of public research institutes, universities and even higher education organisations more broadly defined as 'third-party' actors placed at the intersection between various industrial activities which may or may not be identified by labour markets or traded linkages as related – and scientific research. The presence, or establishment, of such organisations with strong linkages to the industrial base thus contain the potential not only for 'externalizing' results of specialized knowledge developed in one industrial sphere, subjecting its scientific scrutiny before making it available to other actors either through collaborative R&D work or through education programs. It also contains the potential for achieving a potent interplay between technological platform development within the science system, based on the academic networks maintained by such institutions yet reflecting industry needs and drawing heavily also on local specialized knowledge; and on-going application development within the realm of industry. Yet, as this role is not exercised as linear technology transfer and assumes the existence of industrial resources with which to interact, it is primarily relevant within the context of path renewal and extension in specialized or urban regions.

Conclusion

The spatial contextualization provided by RIS approaches and the historical-cognitive contextualization provided by EEG through the notion of path dependencies represent, in our opinion, complementary perspectives on regional development. While the former explicitly focuses on policy institution building and consider the industrial base primarily in terms of knowledge exploitation, the latter has located both knowledge exploration in the domain of industry and knowledge inter-organisational exploitation solely in the domain of local buzz and labour market mobility, thus at the outset rejecting that intervention into exploration or exploitation can have any substantial role to play.

However, implicitly and by the share nature of the interdependencies between organisations at the micro-level and diffusion at the regional level which is emphasized by EEG, the approach does open up for intervention along the same basic dimensions as prior work on regional (Nauwelaers and Wintjes (2002) and national innovation systems (Herstad, Bloch, Ebersberger, & van De Velde, 2010) have focused on. Thus, by combining the RIS approach with core insights from EEG we arrive at a forceful tool for constructing regional advantage in a context where pre-existing regional conditions define not only the necessary objectives of the intervention but also the specific form – the sets of complementarities - of it. As regional circumstances evolve as a product of both intervention and (firm-based) evolution, so does the objectives of the intervention and the form it should take. In this perspective, the question becomes not so much of whether institutions pre-exist or follow from development paths already established, as a question of how agency and RIS influence positively or negatively on what is inevitably a process of co-evolution between institutions and the industrial knowledge base.

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Tables

Table 1 Two-dimensional classification of main policy instruments in regional innovation systems

	Aim of innovation support	
Target level of support	**Assign lacking resources to actors:** **Support the accomplishment of innovation ideas / re-active**	**Learning to innovate:** **Change organisational behaviour / pro-active**
Single actor oriented	Type A: Embed critical mass R&D subsidies and loans Risk capital	Type B: Business innovation centres Loans for competence development Mobility schemes
(Regional) system oriented	Type C: Subsidy for co-operative R&D	Type D Cluster policies Regional Innovation Strategies

Source: Nauwelaers and Wintjes (2002)

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