Regional innovation systems revisited: networks, institutions, policy and complexity

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... In that Empire, the Art of Cartography attained such Perfection that the map of a single Province occupied the entirety of a City, and the map of the Empire, the entirety of a Province. In time, those Unconscionable Maps no longer satisfied, and the Cartographers Guilds struck a Map of the Empire whose size was that of the Empire, and which coincided point for point with it. The following Generations, who were not so fond of the Study of Cartography as their Forebears had been, saw that that vast Map was Useless, and not without some Pitielness was it, that they delivered it up to the Inclemencies of Sun and Winters.

Introduction
Since the 1980s the region has been central to discussions about innovation and competitiveness and understanding the dynamics of innovation at regional level a concern for scholarly research and for practitioners seeking to improve regional economic prosperity. Concepts such as regional innovation systems have been coined to convey the idea that firms interacting locally and adequately supported institutionally are able to achieve higher rates of innovation, and ultimately generate quality jobs and growth in the region. The presence, characteristics and performance of such regional configurations have been of key interest for academics and policy makers, in parallel with the emergence of an agenda for regionalisation of industrial policy and economic development policy in many countries in Europe since the 1990s.

Despite the popularity of the concept ‘regional innovation system’ (RIS) in the academic literature and in policy practice, multiple interpretations and uses of the term coexist. For instance while some scholars view RIS as subsystems of national or sector-based systems presenting particular spatial features, other portray them as smaller-scale versions of national systems (Lagendijk, 1999; Howells, 1999; Iammarino, 2005, Uyarra, 2010). Doloreux & Parto (2005) identify three dimensions of regional innovation systems, namely: the interactions between different actors in the innovation process, the role of institutions, and the use of regional innovation systems analysis to inform policy decisions. More generally, Werker & Athreye (2004) differentiate between micro and meso approaches explaining regional innovation; while the former concentrate on the entrepreneurial behaviour of innovative firms, the latter focus on the structural elements manifested in the institutional set-up of regional and industrial systems. Boschma & Frenken (2006) distinguish between institutional and evolutionary views to innovation and geography as alternatives to neoclassical views. Related literature on national innovation systems (NIS) is no less heterogeneous,

1 Chapter published in Herrschel, T. and Tallberg, P. (eds.) The Role of the Regions, Networks, Scale, Territory.
with numerous usages and interpretations (Miettinen, 2002; Balzat & Hanusch, 2004; Sharif, 2006; Lundvall, 2007). Despite the popularity of the concept ‘innovation system’ in the academic literature and in policy practice, the term itself remains ambiguous (Doloreux & Parto 2005; Uyarra, 2010). This fuzziness (Markusen, 2003), even ‘black boxing’ of the term, may have obscured certain aspects influencing regional development while overstating others (Uyarra & Flanagan, 2010).

This chapter draws from contemporary literature on the region and from innovation studies in order to critically examine different interpretations that have over time been associated with the use of the term ‘regional system of innovation’. The chapter attempts to critically discuss these changing views, while at the same time connecting the literatures on RIS and NIS. The chapter therefore commences with a glance at firm network approaches to regional innovation systems, which put the emphasis on dense and closely collaborating communities of firms that are found to be characteristic of successful agglomerations. The chapter then continues with an examination of scholarly accounts that use the term ‘system’ as a metaphor to reflect the key role played by institutional and governance structures in economic development. The third section critically considers how recent literature views innovation systems as an artefact and as a target for policy action. The chapter suggests that this use of the concept has led to an instrumental view of innovation and regions at odds with the ideas that originally inspired the concept. Recent contributions from evolutionary and complexity economics are reviewed in the fourth section as alternatives to understanding evolutionary, diverse, and multi-level dimensions of regional systems. However, questions remain in relation to methodology, ontology and policy. Finally, some conclusions are drawn in the last section.

**Systems as networks: local interactive learning**

A key feature of innovation system approaches is an understanding of innovation as an interactive and dynamic process that relies on learning and networking. It recognises that firms rarely innovate in isolation but rather in networks of related actors. Networks act as coordinating devices enabling inter-firm learning and diffusion of know-how, facilitating access to complementary assets and providing an organisational platform to combine different competences required for innovation (Oerlemans et al, 2007). Pressured by increasing global competition, rapid technological change and shortening product life-cycles, firms increasingly rely on innovation-related cooperation with a variety of partners such as customers, competitors, suppliers and universities. Stressing the importance of interactive learning and knowledge sharing for innovation, particularly in relation to user-producer interactions, Lundvall (1992) thus defined innovation systems as “the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge”. These micro-foundations place interactive learning and knowledge at the centre of analysis and are the starting point of discussions on the bottom-up dynamics of regional innovation systems (Cooke et al, 1997; Howells, 1999). Relationships and networks among regional components are a key defining feature of RIS, and localized processes of learning and knowledge accumulation an explanatory factor of higher levels of regional competitiveness (Cooke, 1998; Koschatzky & Sternberg, 2000).

The localised nature of innovation networks has been the focus of ‘knowledge spillovers’ studies, which demonstrate that firms benefit from the proximity of private and public R&D activities, the more so the more knowledge intensive firms are (Audretsch & Feldman, 1996). With the assumption that knowledge is either codified (and thus readily transferred) or tacit, such studies suggest a
A typical distance decay function in communication (Howells, 1999). Other accounts have stressed to a greater extent the relational and cultural underpinning, or embeddedness, of such networks. Post-Marshallian accounts of industrial districts in Italy and elsewhere (see e.g. Pyke et al., 1990), depict geographically localized productive systems, characterized by a large number of small firms specialized in different phases of the production and distribution processes of an industrial sector. Related literature on the ‘innovative milieu’ (Aydalot, 1986) and ‘new industrial spaces’ (Scott, 1986) reiterated the symbiotic relationship between innovation, networks, and proximity. Innovation surveys mapping knowledge flows within regional innovation systems sought to identify different patterns of collaboration between actors (notably between firms and universities and public research organisations) and across sectors, technologies and regions (Koschatzky & Sternberg, 2000; Freel, 2002).

Such accounts, mainly based on case studies of successful agglomerations, emphasize localized processes of learning and knowledge accumulation as sources of regional competitiveness. Regional economies displaying dense networks of inter-firm and public-private interactions are associated with better than average growth performance (Cooke & Morgan, 1993). Linked together by reciprocity, trust, cultural and social ties, these local networks are seen to generate a coordination system that outperforms other coordination mechanisms such as the market (Oerlemans et al, 2007), creating an environment that facilitates the sharing of tacit knowledge. However, straightforward explanations based on attributing geographical dimensions to degrees of knowledge tacitness have recently been challenged (Cowan et al, 2000). It has also been argued that other types of proximity (cognitive, social, institutional, organizational) are able to act as partial substitutes for physical proximity (Boschma, 2005). Furthermore, and despite the interest in social interaction in networks, network concepts and methods have rarely been applied to understand such mechanisms (Cantner et al, 2010). While social and culturally embedded networks are considered a key property of successful agglomerations, the structural properties of such localized networks and their impact on innovation outcomes are given less attention in the literature (Grabher, 2006; Oerlemans et al, 2007), an issue to which we will return in the final section of this chapter. From a policy design view, there is a risk of uncritically adopting a ‘networks are good, more networks are better’ approach, potentially overestimating external factors of innovation vis-à-vis internal capabilities (Freel, 2002) and underplaying variety in the drivers, structure and impact of collaboration.

Discussions on inter-firm relationships have generally focused on the institutional context in which actors are embedded, rather than on networks per se. The so-called ‘institutional turn’ within economic geography has emphasized the role of institutions in influencing firms’ behaviour, particularly in relation to inter-firm networking and industrial relations (Martin, 2000). Cooke & Morgan (1993, p. 555) note that local innovation networks are enabled by a “number of institutions of a private, semipublic, and public nature which act as a ‘life-support’ system, especially for SMEs”. Notions such as the ‘network paradigm’, ‘institutional thickness’ and ‘learning regions’ are used to refer to such “microregulatory networks of institutions which give spatial definition to interfirm networking” and serve to connect firm-network innovation approaches and social capital to the problem of regional development (Cooke and Morgan, 1993; see also Florida, 1995; Amin & Thrift, 1995; Asheim, 1996; Morgan, 1997). Connecting these contributions to the general literature on systems of innovation, the concept of ‘regional systems of innovation’ takes the learning region further by focusing on the governance of systemic institutional interrelations characteristic of successful regions. The next section explores this issue further.
Systems of innovation as an heuristic concept

Institutions are considered in the innovation systems literature to be key determinants of the rate and direction of technological change. For Freeman (1995: p.20), institutional differences in the mode of “importing, improving, developing and diffusing new technologies, products and processes” are instrumental to understanding the variation in technological capabilities across countries and regions. Pioneered by Freeman’s (1987) study of Japan, a number of scholars (notably the contributions to the edited volume by Nelson, 1993) sought to examine the extent to which the presence (or absence) of macro-level institutions mattered for innovation in different countries. These studies provided a comparative-historical narrative to explain the influence on innovation of various kinds of interactions and interdependencies between organisations and institutions. National innovation systems were perceived as a “historically grown subsystem of the national economy” in which institutions would interact and influence the carrying out of innovative activity (Balzat & Hanusch, 2004; p.197).

The motivation of comparative analyses of national and regional systems of innovation was to contrast diverse settings (and therefore learn from diversity and differences) rather than to provide any form of general explanation of how systems function. It did not provide a “sharp guide to what exactly should be included in a system of innovation” Edquist (1997; 27). Systems of innovation thus conceived become a useful metaphor or loose framework for empirical research rather than a clearly articulated term. And, although aimed to inform policy, these analyses made no presumption of what constituted a ‘right’ or ‘efficient’ configuration of systems (Miettinen, 2002). While a national domain was early on adopted on the basis that many institutions influencing innovation have a national character, other appropriate levels (local, sectoral) at which to study the innovation system were also suggested (Lundvall, 1992). To some, the regional level was viewed as the natural level from which to develop innovation policies and institutions to support innovation and the development of industrial clusters. Cooke et al (1997; p. 479) considered the region as an appropriate unit for the analysis of innovation systems, for some of the “basic characteristics which distinguish a state can sometimes be distinctive in certain regions”. It is not surprising that early uses of the notion of RIS were associated with dynamic regions with strong autonomous governments such as Baden Wurttemberg or the Basque Country, or with regions with ambitions to achieve similar levels of autonomy. Such regions were seen to feature strong institutional density, or ‘thickness’ (Amin & Thrift, 1995) and a strong social and cultural embeddedness of interrelations. The regional institutional infrastructure supporting innovation is therefore a key defining feature of regional innovation systems.

These top-down views stress the presence of institutions that deliberately promote innovation and knowledge, as well as the wider socio-economic system in which political and cultural influences and specific modes of governance determine innovation structures and performances (Howells, 1999). For Cooke (2001), an ideal institutional configuration includes issues such as autonomous taxing and spending, influence on infrastructure, and university-industry strategy; a cooperative culture and consensus, and organizational aspects such as harmonious labor relations at the firm level and inclusivity, networking and consultation at the policy level. Based on this characterisation, the existence of a RIS would be a special case, a rare event, characteristic only of a small number of regions (Cooke, 2001). Elsewhere, the national system of innovation would be dominant, as it is
generally at the national level where scientific priorities are set, and where basic research and university training are funded (Cooke, 2005).

Fløysand & Jakobsen (2010) and Lundvall (2007) criticise what they perceive as a narrow definition of innovation systems, biased towards science based innovations and towards formal knowledge vis-à-vis contextual and informal knowledge. This bias “rules out most rural contexts where certainly innovation can also be observed” (Fløysand & Jakobsen, 2010,p.2). It could also be argued that this characterization of regional systems suffers from a ‘structuralist’ bias whereby the configuration of actors and institutions becomes the key explanatory factor of innovation performance and economic development, underplaying the dynamics of actors’ routines and interactions (Uyarra & Flanagan, 2010). RIS are thus interpreted as smaller-scale versions of national systems, or as national systems ‘writ small’. According to Iammarino (2005), such a ‘shift’ of NIS features down to the regional scale, although providing the necessary conditions to distinguish RIS, it is not by itself sufficient. Finally, while regional institutional structures are important for understanding differential patterns of economic activity, they tell us relatively little about the nature of institutional change and about the dynamics of system evolution: How are institutional structures created? How do they change? Can successful regional innovation systems be sustained over time?

**Systems as artefacts: RIS as policy tool**

The interest in systems of innovation has over time led to a more instrumental view that suggests ways to create well-functioning innovation systems. Indeed the idea of an ‘innovation system’ has morphed into a policy tool, a trend that can be observed not just in the national systems of innovation literature but also in some regional policy approaches. ‘Systems of innovation’ have shifted from a heuristic device or metaphor to understand variations across different institutional settings to a ‘model’ that regions or countries should aspire to build if they want to succeed in the knowledge economy. This use of the innovation system concept implies a structure or mechanism that can be nurtured and supported. Systems are considered as a tool, a target, and often an outcome of policies, a machine or artefact performing certain ‘functions’, whose performance can be improved or fine-tuned through the right policy levers. Similarly, performance comparisons or benchmarking across systems have taken centre stage, while less attention has been placed on systemic dissimilarities and context, country and history-specific structures and elements of particular systems (Balzat & Hanusch, 2004). Contrary to the institutional interpretation of systems, the existence of systems is here presupposed, even if they are weak or underperforming. Fløysand & Jakobsen (2010, p.2) thus note that “with the development of strong linkages between research and policy, the [system] approach has been reconstructed as a standardized model for best innovation practice and used instrumentally for adjusting system failures within national, regional and even local innovation systems”.

Some innovation systems approaches have thus moved away from detailed empirical studies of ‘real’ systems, trying instead to identify all the general determinants of innovation—namely the factors (actors, functions, relationships) that have an impact on innovation. In this sense, Hekkert et al (2006; p.414, my emphasis) define innovation systems as a “heuristic attempt, developed to analyse all societal subsystems, actors and institutions contributing in one way or the other, directly or indirectly, intentionally or not, to the emergence or production of innovation”. If we can understand all the determinants of innovation, system approaches automatically become a useful “conceptual framework for government policy making” (Edquist, 1997; 16). In other words,
understanding the activities that foster or hamper innovation, i.e. how innovation systems ‘function’, allows us to “intentionally shape innovation processes” (Hekkert et al, 2006). The question that concerns scholars is therefore the identification of the set of functions3 that are (or should be) fulfilled by the different actors or components. The performance of the system depends on “how well the functions are served within the system” (Hekkert et al, 2006). Thus the performance of the ‘system’ becomes a causal explanation of innovative activity and the identification of its determinants makes its management and improvement feasible (Miettinen, 2002; 46).

A tendency towards a normative use of systems can equally be perceived in policy oriented regional development studies. Christopherson & Clark (2007) consider the shift from firm-network innovation systems to an effort to make the learning region ‘real’ through policy initiatives to be a critical turning point. The shift from networks to learning regions and regional innovation systems has moved the discussion into the arena of policy-making, focusing on the rationale for investing collective monies in nurturing innovation systems. In order to favour development, it is argued that investment is needed in the institutional infrastructure supporting innovation in regional systems. As Freel (2002; p.633) notes, such policies are “premised on the belief that there exist, or may exist with sufficient encouragement or facilitation, distinct regional innovation systems within Europe”.

I have argued elsewhere (Uyarra & Flanagan, 2010) that the influence of RIS as a normative concept favours the diffusion and adoption of a simplistic view in relation not only to the presence of a ‘regional innovation system’ in all regions but also to the implicit assumption that such systems are unproblematically amenable to regional policy intervention. Furthermore, the reverse causality is often implied: that RIS are the result of regional innovation policy and therefore that we can evaluate or assess regional policies by measuring the performance of the RIS. Besides the obvious problems of attributing cause and effect, it is important to remember that systems approaches tend to draw inspiration from ‘best practice’ regions whose development has often had little or nothing to do with regional innovation policy (Hospers et al, 2008).

These policy-oriented considerations also raise important questions about legitimacy and governance. For instance about how regional governance structures are shaped, about accountability, decision-making and monitoring, inclusion and exclusion. In essence it raises questions about “whose interests are represented in processes of institutionalisation, in strategy development, in policy design and implementation” (Lagendijk, 1999). According to Christopherson & Clark (2007; p.11) “new regionalism is an effort to manufacture a scale – the region – in which local actors believe they can act effectively regardless of the political and economic realities operating on them” (See also Bristow, 2005; Lovering, 1999). The region is conceived as an ‘actor’ interacting with and competing in the world economy, rather than the firms themselves, somehow providing a blurred and misleading distinction between regions and firms. Agency and power seem to be absent in regional innovation systems in relation to the role of firms. Christopherson & Clark (2007; p.6) state that firms, particularly large ones, “actively shape the conditions in which they make choices through political as well as economic action at all geographical scales”. This means that firms’ capacities are embedded in political territories, but they are also shaped by firms’ strategies.

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3 Broad functions are for instance knowledge producing, knowledge using, intermediating or policy-making functions.
across scales as they attempt to construct markets. We have argued elsewhere (Flanagan et al, 2011) that by reducing actors to the ‘functions’ they perform in the system, they are seen as passive targets of public policy to be transformed by policy-induced learning into exhibiting behavioural changes, and are therefore denied agency in relation to public policy and the shaping of the system.

Finally, a fixation with the regional scale as the natural unit of analysis for innovation has lead to a view of regions as ‘islands of innovation’, underestimating the importance of non-local relationships and overstating the incidence and benefits of lasting proximate relationships. Cooperative, trust-based relations in local inter-firm networks may be the exception rather than the rule, and where they are strong they may even lead to cognitive lock-ins and reduce adaptability of regions (Grabher, 1993, Oinas, 2002). A closed view of the region presupposes that not only are innovation networks largely local, but also that the innovation in products & services and the benefits they generate are also local. The presumption is therefore that invention and innovation take place in the same region, which justifies policy efforts to couple the supply of and demand for innovation in the region, in a sort of input-output model of regionally bounded knowledge transmission.

Ultimately, instrumental approaches to systems of innovation sit uncomfortably with the idea of innovation as a complex, uncertain, contingent and heterogeneous phenomenon, which prevents a complete identification of the factors influencing technological change. According to Rosemberg (1992, p.186), “the essential feature of technological innovation is that is fraught with many uncertainties. This uncertainty [...] has a very important implication: the activity cannot be planned. No person, or group of persons, is clever enough to plan the outcome of the search process, in the sense of identifying a particular innovation target and moving in a predetermined way to its realization.” All-inclusive attempts to understand systems run the risk of confusing the map with the territory (Nelson, 1977), the system with ‘real regions’, and ‘operational’ with ‘conceptual’ innovation systems (Cooke, 1998). The behaviour of the ‘system’ cannot be explained by the individual attributes or ‘functions’ of the actors, no more than decoding the 3 billion ‘letters’ of the human genome has helped us understand the behaviour of living systems.

Evolutionary and complexity views of innovation systems
Recent scholarly contributions, mainly from evolutionary economic geographers, have sought a dynamic explanation of the evolution of regional systems (Boschma & Frenken, 2006; Journal of Economic Geography, 2007; Economic Geography, 2009; Boschma & Martin, 2010). Such approaches are distinguished from institutional views that attribute spatial variations in economic activities to institutional differences among territories (Boshma & Frenken, 2009). Centred on a consideration of the economy as a dynamic, irreversible and self-transformational system, evolutionary approaches are less concerned with how systems should look than with the adaptation, resilience and change of system configurations. Discussions have shifted from the economic growth and performance of regions to a broader focus on the adaptation and resilience of places against endogenous and exogenous shocks (Pike et al, 2010, Hassink, 2010, Pendall et al, 2007). To do so, they employ concepts and metaphors are employed such as variety, selection, adaptation, emergence and self-organisation derived from evolutionary biology (Frenken & Boschma, 2007, Essetlzbichler & Rigby 2007;), complexity theory (Martin & Sunley 2007), and network science (Glückler 2007).

Despite the use of different concepts and methodologies, these approaches share the common feature of trying to link the micro-economic behaviour of agents (firms, individuals) that operate in
terrestrial contexts with the spatial evolution of industries and networks at the meso-level of the economy (Boschma & Frenken, 2006; Boschma & Martin, 2007). They therefore provide an integrative, micro to macro, view of regional innovation systems (Dopfer et al, 2004; Werker & Athreye, 2004; Iammarino 2005; Boschma & Frenken 2006).

Characteristic features of evolutionary approaches include a consideration of boundedly rational actors and their routines as the unit of analysis; the role of diversity in development processes; the non-linear, dynamic and path-dependent nature of economic development; and the dynamics of adaptation and coevolution of economic, technological and institutional environments. Evolutionary economic geographers have sought to demonstrate how place matters in such evolutionary processes, in other words “how the spatial organization of economic production, distribution and consumption is transformed over time” (Boschma & Martin, 1997, p.3). There is clearly a link between geography and evolutionary processes such as path-dependency, as evidenced by the quasi-fixity of geographical patterns of industrial activities and their evolution over time (David 1985). As Martin & Sunley (2006; p. 427) note, economic history shows that “there are some areas and regions that have repeatedly been the site of path-forming innovations or new industrial sectors”.

However, the use of metaphors such as variety, selection and retention derived from evolutionary biology poses questions in relation to their interpretation. For instance: what is it that evolves? (what is the ontological unit of enquiry?) At what spatial level does selection operate? How does co-evolution of spatial structures, institutions and micro-economic behaviours take place and how does it vary spatially? How do path-dependence and lock-in manifest and at what spatial levels? (Boschma & Martin, 2007; see also Martin & Sunley, 2006; Essletzbichler & Rigby, 2007; Hassink, 2010).

Some scholars have explicitly defined systems of innovation as complex systems (e.g. Katz, 2006; Metcalfe & Ramlogan, 2008). The characteristics of complex systems include a dynamic structure with interdependent constituents that interact in complex and non-linear ways. ‘Limited functional decomposability’ implies that macro-level functioning of systems cannot be deduced from knowledge about the system components. Complex systems are open, with boundaries that are difficult to identify, and structures that span many scales. Such openness contrasts with the ‘operational closeness’ implicit in many system approaches (Martin & Sunley, 2007). They also exhibit emergent properties or behaviour, arising out of micro-level behaviour and interactions and which cannot be predicted by the properties of the system constituents or the system itself. Finally, complex systems are able to self-organize, and emergent properties may change structures or create new ones. This has implications in terms of trying to predict innovation outcomes in conditions of uncertainty and complexity. Change is non-linear, discontinuous and probabilistic rather than deterministic. As a result, cause-and-effect relations are “distributed, intermingled […] and not directly controllable, so policymakers need to become more comfortable with strategies that aim to influence rather than control” (OECD, 2009: p.13).

These systemic characteristics would preclude any attempt to manipulate, let alone create, systems. An implication of this view is that there is no clearly identifiable ‘system’ with clear boundaries, and therefore systems are linked to a problem or purpose, and that they are therefore not stable but transient. Rather than a holistic explanatory framework for understanding all determinants of innovation, innovation systems are more useful to understand specific (or “local”) innovation
problems (Metcalfe & Ramlogan, 2008). Problem oriented accounts of systems introduce a dynamic dimension, as opposed to the static orientation of most case studies of regional innovation networks, as they are underpinned by a theory of firm path dependency and of industry evolution (Christopherson & Clark, 2007).

The role of geography in underpinning complex adaptive systems is not clearly understood. However a point of connexion between relational economic geography, evolutionary and complexity theory can be found in the study of knowledge and connectivity in networks and interactions (Martin & Sunley, 2007). Economic development is perceived to be triggered by the emergence and exchange of knowledge, which evolves in multiple connections of networks (Martin & Sunley, 2007; Metcalfe & Ramlogan, 2008). While networks have been a common feature in the analysis of regional innovation, and are considered key determinants of economic development, their use to explain the spatiality of relations has been rather selective (Bunnel & Coe, 2001; Lagendijk, 2002; Grabher, 2006). Grabher (2006; p.165) argues that economic geography, while recognising the importance of networks, has not taken a “systematic interest in the behavioural consequences of network configuration”. This selective view of networks, associated with the embeddedness-network paradigm, emphasizes strong, locally embedded, cohesive networks, while neglecting weak, extra-local networks and links based on uneven power relations (Grabher, 2006). It therefore tends to neglect dominant positions of certain actors within networks. New theoretical perspectives in graph theory and statistical physics, Grabher (2006) argues, justify a re-examination of the properties of complex networks and their link with geography. Such developments have revealed properties associated with certain network configurations, with important implications for the creation and diffusion of knowledge as well as for the vulnerability or robustness of networks.

For instance, research by Albert & Barabási (2002) revealed that many networks have scale-free properties, with significant implications for network dynamics. The distribution of links in such networks follows a power law, which implies that the majority of nodes are relatively poorly connected, while a few exhibit extremely high connectivity. This is due to a particular pattern of growth of the network, which is not random or strictly proportional to the time of entry as previously assumed. It is likely that relationships with new nodes are based instead on ‘preferential attachment’, whereby new nodes would choose to connect with the nodes in the network that have greater connectivity. This generates a scale-free network characterised by the coexistence of a small number of hubs capturing most links and a majority of nodes having few links. Such configurations are found to be common in the internet, in citation networks among scientists, and in some innovation networks (Barabási, 2001). Scale-free networks influence performance in terms of knowledge diffusion, generating small world effects (Watts & Strogatz, 1998). The properties of high connectivity with the short average path length (small world effect) make them well suited for the evolutionary articulation of complex knowledge and the high speed of knowledge diffusion (Pyka, 2007).

Geography influences such network trajectories and, in turn, localized network evolution would influence regional innovation. According to Glückler (2007), the combination of preferential attachment, local embedding and multi-connectivity constitute cumulative retention mechanisms that induce path-dependence in networks, mechanisms that are themselves often mediated by geography. Frenken (2006) stresses the role of geography in the emergence of small worlds network effects. Since geography often acts as a constraint on search behaviour, he argues, its effect may to
some extent counteract the effect of preferential attachment. Co-location, or ‘being there’, may also constitute a strategy to increase the propensity of contact due to spatial proximity (Glückler, 2007). Firms (particularly SMEs) may find it advantageous to locate in ‘information rich’ and contact intensive innovation agglomerations (Howells, 1999). It may be such local processes of search and scanning, and not just the effect of ‘local’ institutional embeddedness, what explains the localised nature of networks (Freel, 2002). The degree of local connectivity, and the benefits of those connections, differ among local firms in clusters and along the life cycles of clusters (Giuliani, 2007; Menzel & Fornahl, 2009). The interplay between network topologies and geography leads to a diverse landscape of spatial network typologies, rather than to a dichotomous one of local clusters vs global links. Glückler (2007) suggests a fourfold typology of global bridging networks (between densely local networks and extra regional clusters), local bridging networks (between different but co-located clusters), local brokering (whereby only the weak ties are co-located), and mobile brokering (interconnected but geographically distributed actors who meet repeatedly in temporary clusters).

Certain properties of networks also make them more resilient and robust. In network theory, a scale free topology implies that a significant fraction of nodes can be randomly removed from any scale-free network without them breaking apart. Barabási (2000) thus notes that “most systems displaying a high degree of tolerance against failures share a common feature: their functionality is guaranteed by a highly interconnected complex network“. However, despite such apparent robustness, they also present vulnerability around key positions, as external shocks affecting key hubs, i.e. highly connected actors, can lead to cascading failures due to their high degree of interconnectivity. Mainly employed in the study of communication infrastructure and disaster studies, the idea of resilience is increasingly used in relation to the adaptability of regions to external shocks. Although its contribution to our understanding of regional economic adaptability has been questioned (Hassink, 2010), it is clear that relations between agents are integral to the concept of regional resilience (Pike et al, 2010). Grabher & Stark (1997) frame this debate in terms of legacies, linkages and localities. They emphasize the presence of a rich diversity of organizational forms, and of strong and weak ties between social actors within social networks. Loose couplings that indirectly connect social agents, often bridging structural holes (Burt, 1992) between relatively isolated groups of actors, are crucial for the adaptability of networks. Research on ‘related variety’ (Frenken et al, 2007) also suggests that diversified regions, presenting a variety of generic competences and open to extra local links would be more likely to adapt to changing conditions and would be less susceptible to lock-in effects. As Pike et al note (2010, p.65), “diversified economies are more adaptable because they act as a ‘shock absorber’, dissipating negative effects across and array of economic activities and places rather than concentrating and reinforcing them.”

Recent departures in evolutionary economic geography are helpful to understand the evolutionary, diverse, and multi-level dimensions of regional systems. Concerns have however been raised in terms of the limitations of selectively importing theoretical frameworks and concepts from physical sciences (Grabher, 2006). Indeed, Martin & Sunley (2007) question the extent to which a single, unified, ‘meta-theory’ of complexity can be equally applicable to diverse phenomena. Also problematic in Martin & Sunley’s view is the strong reliance of complexity theory on formal modelling vis-à-vis ontological foundations, which leads them to suggest a social-ontological approach that analyses how complexity is spatially distributed, spatially embedded and spatially emergent. Coe (2011; p.87) in turn laments that certain methodological tools used in evolutionary
and complexity theory remain, for many economic geographers, “alien and largely impenetrable, and the inbuilt assumptions and conceptualizations of space in EEG models will continue to be troubling”.

Other authors have questioned the usefulness of distinguishing between institutional and evolutionary economic geography, and critique the treatment of institutions, social agency, and power relations of the ‘evolutionary turn’ in economic geography (McKinnon et al, 2009; Essletzbichler, 2009). McKinnon et al (2009) consider that evolutionary approaches downplay the influence of the spatial context on firms routines and suggest the need to reassert place-specific institutional environments and arrangements within and beyond the firm (albeit not restating the primacy of territorial institutions in influencing economic geographies). They argue that the analytical lens should go beyond organizational routines and situate evolutionary concepts within the broader conception of geographical political economy. Boschma & Frenken (2009) justify the distinction between institutional and evolutionary economic geography since the latter considers that the influence on firms’ routines of territory-specific institutions is less significant. They suggest that “territorial institutions are [. . .] orthogonal to organizational routines” (p.152). Institutions may explain some interregional variety of routines, however they are more likely to be the outcome of processes of routine replication among firms through spinoffs and labor mobility. In their view, variance in innovative patterns of firms may be explained by sectoral, rather than regional, specificities (see also Malerba, 2002).

Linked to the treatment of institutions, Uyarra (2010) and Flanagan et al (2011) perceive a gap in evolutionary approaches and in general in innovation studies, in relation to the understanding of policy processes. Attention to policy is at best restricted to suggesting what policy makers ought to do (normative analysis), while being less concerned with what policy makers actually do (Wohlgemuth 2002) and how that conditions the dynamics of innovation. Assumptions in relation to policy are based on an evolutionary understanding of the economy, but not of the political process, which tends to be treated as a ‘given’ (Kay 2006). The impact of a policy is influenced not only by a changing economic landscape (the objective of innovation policy is always a moving target) or on the processes of co-evolution or mutual learning between the policies and the socio-economic system, but also on when it is implemented and on the path previously followed. Public policies, just like innovations, are complex and uncertain and display irreversibility and path-dependency effects: they are adopted not on a tabula rasa but in a context of pre-existing policy mixes and institutional frameworks which have been shaped through successive policy changes (Uyarra, 2010). Past policy decisions clearly constrain the range of options available for current decision makers (Kay, 2006; Bardach, 2006). Successful policies (or actors) become institutionalised and thereafter form part of the foundation for the beliefs of actors. They are ‘legacies’ that gradually institutionalise, and as institutions they restrict or enable options for future policy makers (Kay, 2006). Thus, when formulating policies, regions should not only take the knowledge and institutional base of the region as starting point, but should also consider existing policy mixes and past policy history, for they will enable or constrain new policy goals (Uyarra, 2010).

When acknowledged, discussions of policy complexity are generally accompanied with recommendations for more and better coherence and more effective coordination. Such attempts are however assumed to be unproblematic. Indeed co-ordination problems can never be completely solved by new co-ordination mechanisms as those new mechanisms inevitably contribute further to
the complexity they seek to manage, a problem exacerbated by the fact that it is rather easier to create new mechanisms than it is to remove existing ones. The absurd but logical outcome is that additional coordinating mechanisms will periodically have to be created to coordinate the older ones, and so on and so forth in an infinite regress\(^4\) which is, again, predicted by the ‘map and the territory’ metaphor\(^5\).

**Conclusion**

The discussion about the use and interpretation of the regional innovation system concept provides us with an opportunity to review different approaches to the spatial embedding of innovation and the different views that, over time, have stressed different factors influencing prosperity and resilience of places, as well as different conceptualisations and methodological approaches. Discussions of regional innovation and competitiveness have shifted from privileging locally and culturally embedded networks towards highlighting other explanatory dimensions such as the strength of institutional support for innovation, the presence or absence of specific functions in systems, and degrees of connectivity enabling adaptation and resilience of places.

The concept of systems of innovation has emerged out of the interplay of academic discussions and policy efforts to drive and coordinate economic development policies (particularly in supranational organisations such as the OECD). However, an instrumental view of systems tends to dominate in the sphere of innovation policy analysis, which has devalued its relevance to inform policy. It privileges a closed view of systems and a simplistic view of the policy process, not to mention *politics*. Regions as ‘spaces’ are clearly subject to the effects of policies made and implemented at multiple levels, they are not closed systems governed solely by their own regional innovation policies. Recent contributions from evolutionary and complexity economics that advocate a more open and dynamic view of regional systems, complemented by a more nuanced interpretation of the role of institutions and policy in regions open a more promising avenue of research.

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\(^4\) The author wishes to thank Kieron Flanagan for this comment.

\(^5\) Any map of a territory would, to be truly accurate, have to contain a representation of itself representing the territory, including a map representing the territory, and so on, in infinite regress.
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