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Innovation Policy for Grand Challenges. An Economic Geography Perspective

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Abstract

Grand challenges such as climate change, ageing societies and food security feature prominently on the agenda of policymakers at all scales, from the EU down to local and regional authorities. These are challenges that require the input and collaboration of a diverse set of societal stakeholders to combine different sources of knowledge in new and useful ways – a process that has occupied the minds of economic geographers looking at innovation in recent decades. Work in economic geography has informed innovation policies that tackle infrastructural, capabilities, network and institutional failures that may be found in different types of regions. How can these insights improve researchers' and policymakers' understanding of the potential for innovation policies to address grand challenges? In this paper we review these insights and then identify areas that push economic geographers to go beyond their previous focus and interests, notably by considering innovation policy in light of transformational rather than mere structural failures.

JEL codes: O38; Q01

Keywords: Innovation policy; grand challenges; economic geography; innovation systems failures; transformational systems failure

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Introduction

Grand challenges are increasingly becoming the focus of policymakers at various levels: it is in particular advocated by supranational organisations such as the OECD and the European Union (EU), but is gradually also taken on board by local and regional authorities (Cagnin, Amanatidou and Keenan 2012). In a European context, the Lund Declaration (2009) played a key role in highlighting the importance of finding solutions to problems associated with ageing societies, pandemics, public health, security, global warming and the increasingly difficult access to sources of energy, water and food. Since then, grand challenges have progressively become a policy discourse, most often tightly coupled to the need for development and diffusion of new innovations. At the EU level, this link is particularly evident through the emphasis on “responsible research and innovation” in current research and innovation policy (European Commission 2012). Attention for grand challenges has even found its way into EU’s new 2020 growth strategy which emphasises the importance of *“exploring new development paths to generate smart, sustainable and inclusive growth ... Various long-term challenges such as globalization, pressure on natural resources and an ageing population are intensifying. If we are to adapt to this changing reality, Europe can no longer rely on ‘business as usual’”* (European Commission 2013, p. 3). Thus, there is a generally increasing attention to the ability of innovation policy to facilitate transformative change, i.e. radical, long-term alterations in both production and consumption that significantly modifies the functioning of society (Grin, Rotmans and Schot 2010).

Innovation and innovation policy has been a topic of central concern for economic geographers (Feldman 2000). Especially at the regional level, economic geographers and scholars from cognate fields of study, have been quite successful in informing and influencing the policy agenda through approaches such as Regional Innovation Systems (RIS) (Cooke, Uranga and Etzebarria 1997, Asheim and Gertler 2005), Learning Regions (Morgan 1997) as well as other kinds of territorial innovation models (Moulaert and Sekia 2003). More recently, the community has also started to engage intensively with the rapidly proliferating EU policy notion of smart specialisation (McCann and

Ortega-Argilés 2013, Boschma 2014). In light of this lineage, this paper considers how insights from the literature on the economic geography of innovation can improve researchers' and policymakers' understanding of the potential for innovation policies to address grand challenges. Additionally, it also considers if the character of grand challenges poses questions that challenge economic geographers to go beyond their existing understanding of innovation and innovation policy. Firstly, however, the rationale for and focus of innovation policies are briefly considered.

Innovation policy – from structural to transformational failures

To study spatial dimensions of innovation, economic geographers have drawn heavily on the Innovation Systems approach. The Innovation System (IS) approach (Freeman 1987) analyses conditions for promoting innovation and investigates which actors/organisations are involved in the innovation process, to what extent and how these are connected in networks, and which institutions enable or inhibit network formations and innovation processes. Besides providing a rich conceptual framework, the IS literature consists of a substantial body of mainly case-based empirical research, which has had a major influence on innovation policy (Doloreux and Parto 2005, Asheim, Boschma and Cooke 2011). As a policy rationale, an IS perspective 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 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 (Laranja, Uyarra and Flanagan 2008). Thus, the main focus of innovation policy and rationale for policy intervention has been on correcting what Weber and Rohracher (2012) call structural innovation system failures (see e.g. Georghiou and Metcalfe 1998, Jaffe, Newell and Stavins 2005). A taxonomy of such structural innovation systems failures has been proposed by Klein Woolthuis, Lankhuizen and Gilsing (2005), who distinguish between four types of failures:

- *Infrastructural failures*: insufficiencies in existing physical infrastructures needed to enable innovation activities

- *Capabilities' failures*: The lack of appropriate competencies and resources at the firm and organisational level may limit and/or prevent the generation of, access to, and exploitation of knowledge.
- *Network failures*: Intensive cooperation in closely tied networks leads to myopia and lack of infusion of new ideas or too limited interaction and knowledge exchange with other actors inhibits exploitation of complementary sources of knowledge and processes of interactive learning.
- *Institutional failures*: Absence, excess or shortcomings of formal institutions such as laws, regulations, and standards, in particular with regard to IPR and investment and lack of informal institutions such as social norms and values, culture, entrepreneurial spirit, trust and risk-taking that impede collaboration for innovation

One of the main contributions of the RIS approach has been to specify what kind of innovation policy is needed to fit and address place-based characteristics and challenges. 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 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 of specialized, old industrial regions; and, finally, problems connected with internal system fragmentation typically found in diverse metropolitan regions. According to Tödtling and Trippl (2005) these systemic problems require tailored policy support beyond 'one-size-fits-all'.

While the relevance of these types of failures is generally accepted, the literature on structural innovation systems failure has been criticised for neglecting the challenges related to other types of

policy priorities beyond innovation-based competitiveness and growth (Alkemade, Hekkert and Negro 2011). This reflects a growing concern and interest in the innovation studies field towards considering effects of innovations at the broader societal level (Lundvall and Borrás 2005, Fagerberg, Martin and Andersen 2013). To exemplify, Soete (2013) argue that many innovations cause decreases in total welfare due to for instance negative environmental effects. It is therefore designated as a key challenge for innovation studies to move beyond analysing innovation for economic growth to innovation for sustainable development (Martin 2013).

Responding to this criticism, Weber and Rohrer (2012) argue that in order for innovation policy to facilitate transformative change and effectively move beyond the incrementalism of business-as-usual found in mainstream innovation policy (Steward 2012), focus should not merely be on correcting structural innovation system failures, but also on four types of transformational systems failures:

- *Directionality failures*: inability to steer innovations towards a particular direction of transformative change
- *Demand articulation failures*: lack of capacity to understand user needs which inhibits the uptake of innovations
- *Policy coordination failures*: absence of coherence between different types of policies
- *Reflexivity failures*: insufficient monitoring and adjustment of the development towards transformational change

In the following section we will review and discuss how studies in economic geography on innovation, often conducted in regional contexts, relate to and inform the above 'system failure' rationales for innovation policy.

Economic geography and innovation

Departing from the distinction between structural and transformational system failures introduced in the previous section, one can summarise the insights from the economic geography literature on

innovation as being primarily related to the structural type. Economic geographers have repeatedly argued that regional characteristics and interactions at the regional scale are particularly important for knowledge creation and innovation processes. Theories on regional innovation systems, innovative milieus, learning regions and industrial districts all stress the role of localised capabilities and relations around innovation and production processes. Related to this point, as contextual factors shape the innovativeness of firms, economic development policies ought to reflect regional characteristics (Tödtling and Trippl 2005, Farole, Rodriguez-Pose and Storper 2011). In sum, the regional scale is considered the adequate scale for implementing innovation policies that target structural innovation system failures (Asheim, Boschma and Cooke 2011), and in the following, we summarise the main contributions of economic geographers for these four failure types.

Firstly, the condition of a region's physical, as well as knowledge and scientific infrastructure is often considered to form the basis of its innovative potential. This includes well-connected transportation systems that allow a region to be integrated in global networks of production and innovation (Saxenian 2007). It is therefore no surprise that Rodriguez-Pose and Fratesi (2004) find that addressing *infrastructural failures* is the subject of a majority of programs under the European Cohesion Policy, even if they find that effects of these investments are highly questionable (see also Crescenzi and Rodríguez-Pose 2012). In the context of innovation, however, greater emphasis is placed on the presence of knowledge infrastructure such as higher education institutions, ICT infrastructure, laboratories and science parks (Feldman 1994, Feldman and Francis 2003, Smith and Bagchi-Sen 2006). These require long-term investments too large for single firms to bear, and which therefore depend on the public sector. As Trippl and Otto (2009) illustrate in their work on old industrial regions, these knowledge infrastructural investments are of central importance for allowing regions to successfully transition into new industries. Taking this one step further however, policymakers are drawing up an increasing number of research infrastructure "roadmaps" to secure the provision of long-term and basic knowledge production in the future (such as the ESFRI, the

European Strategy Forum on Research Infrastructures), and regions make investments to ensure they are included and featured on these (Stahlecker and Kroll 2013).

Secondly, related to capabilities failures, the economic geography literature highlights that the characteristics of the regional environment are significantly affecting the development of capabilities in firms and, thus, their ability to develop innovations. Building on the seminal work of Marshall (1890), economic geographers have in particular given significant attention to the role of agglomeration economies for the innovativeness of firms. Firstly, the availability of a pool of skilled labour is positive associated with innovativeness. Matching skill demands and labour supply is easier in thick labour markets, where firms have access to highly specialised labour (Moretti 2012), thus, innovativeness and creativity are higher in firms located in clusters with large employment concentrations (Baptista and Swann 1998, Andersson, Quigley and Wilhelmsson 2005). Secondly, knowledge spillovers, i.e. unintended flows of knowledge from one actor to another, have been shown to be geographically localised (Jaffe, Trajtenberg and Henderson 1993, Sedgley and Elmslie 2004). The vehicles for such knowledge spillovers range from gossip, rumours and the possibility to observe competitors (Pinch and Henry 1999, Henry and Pinch 2000) to the mobility of labour (Almeida and Kogut 1999). On the former, economic geographers highlight the importance of geographical proximity for such informal knowledge flows (Maskell 2001, Dahl and Pedersen 2004), and it has similarly been shown that the mobility of researchers is limited, thus, they have low propensity to relocate in space, and knowledge spillovers are therefore also primarily geographically localised (Breschi and Lissoni 2009). Most recently, specific attention has been given to the type of labour mobility that facilitates knowledge spillovers. Boschma, Eriksson and Lindgren (2009) find that relatedness in mobility, i.e. inflow of new employees with skills that are related – but dissimilar – to existing competencies, have particular positive effects. This points to the importance of having related industries at the regional scale (see also Boschma and Wenting 2007).

Thirdly, economic geographers have made contribution of great relevance for understanding network failures. A key insight is that the interactive character of innovation processes implies that collaborations between partners located in geographical proximity have a number of advantages. As pointed out in a seminal paper by Storper and Venables (2004), geographical proximity facilitates easy face-to-face contact, which in turn allows for efficient communication, creation of trust, and loss of anonymity that makes monitoring and evaluation of collaborators possible. However, it does not necessarily follow that geographical proximity is indispensable for collaborations concerned with innovation processes: Boschma (2005) suggests in a conceptual paper that proximity along social (strong social ties), organisational (common ownership), cognitive (similarity in knowledge bases) and institutional (shared formal and informal institutions) dimensions allow for collaborations between partners separated by long distances; and an empirical analysis indeed confirms the possibility for substituting non-spatial proximity for geographical proximity (Hansen 2015). Still, these insights do not question the proposition that, all things equal, collaborations between partners located in geographical proximity is easier than collaborations between distanced collaborators. As highlighted by Morgan (2004) and Hansen (2014), geographical proximity is particularly valuable in highly complex innovation projects, where the exchange of tacit knowledge is necessary. At the same time, studies have shown that firms cannot rely only on proximate network ties. Following the seminal 'local buzz, global pipeline' paper of Bathelt, Malmberg and Maskell (2004) there has been a wealth of contributions that point to the interplay and complementarity of local and global knowledge ties in innovation networks even in highly specialized and geographically concentrated clusters (Gertler and Levitte 2005, Giuliani 2007). Here, Giuliani and Bell (2005) have pointed to the importance of gatekeeper organizations as critical linkpins between global and local networks.

Fourthly, related to *institutional failures*, economic geographers point out that an important regional characteristic that influences the innovativeness of firms is cultural aspects. As famously stated by Saxenian (1994), the culture in Silicon Valley facilitated innovation to a much greater extent than in Route 128, due to a higher degree of openness among firms which allowed for members of

communities of practice distributed across different firms to exchange knowledge and engage in processes of learning through joint problem solving. According to Saxenian (1994) such 'culture' of knowledge sharing and exchange was far less developed among the more vertically integrated firms in Route 128. In a similar fashion, Storper's (1997) emphasis on the presence of 'untraded interdependencies' points to the importance of shared conventions embedded in the territory through the positive externalities generated by local institutions. Empirically Storper, Kemeny, Osman and Makarem (2015) explain the substantial difference in innovativeness and industrial renewal between Los Angeles and San Francisco since the 1970s by referring to a more widespread culture of risk taking and experimentation in San Francisco, which allowed for continuous adaptation of the industrial complex. More generally, economic geographers have tended to focus on the role of 'institutional thickness' as a driver of regional economic development. Institutional thickness can be understood as a *"combination of features including the presence of various institutions, inter-institutional interactions and a culture of represented identification with a common industrial purpose and shared norms and values which serve to constitute 'the social atmosphere' of a particular locality"* (Amin and Thrift 1995, p. 104). Institutional thickness, consisting of an interplay of formal and informal institutions, is thus considered to help the capacity of any region to adapt to changing conditions and generate and assimilate innovation (Rodríguez-Pose 2013).

The bulk of contributions made by economic geographers on conditions for innovation have primarily addressed dimensions related to structural innovation system failures. It should however be acknowledged that some attention has been given in recent years to transformational system failures. This research is particularly focused on the geography of sustainability transitions (see Hansen and Coenen 2015 for a review), i.e. primarily relevant for the grand challenges of climate change, resource scarcity and environmental degradation. A main contribution of this literature is to highlight how regional contextual factors influence the possibilities for overcoming *directionality failures*. Here, a particularly important factor concerns the presence of historical regional industrial specialisations, as regional innovation policies have started to combine environmental goals with

economic competitiveness and therefore often relate to the existing industrial and knowledge base present in the region (Späth and Rohrer 2010, Carvalho, Mingardo and Van Haaren 2012, McCauley and Stephens 2012). Work on *demand articulation failures* remains on the other hand very limited. Nonetheless Dewald and Truffer (2012) demonstrate that engaged local end-users are central to local market creation and institutional entrepreneurship. This study shows how geographical proximity has enabled learning between users and producers for the built up of suitable institutional configurations (i.e. a feed-in tariff) that allow for the diffusion of emerging renewable energy technologies. In order to understand the risks of *policy coordination failures*, some important contributions can be found, which point to the contested nature of sustainability oriented policies, due to processes of negotiation, translation and struggle between multiple public, quasi-public and private regional actors (Monstadt 2007). Importantly, contestation between actors may also take place vertically, between actors at different scales. To exemplify, Coutard and Rutherford (2010) describe how local and national authorities in the case of energy transitions in the Île-de-France region form alliances against regional authorities. Lastly, work on *reflexivity failures* has not really been picked up by economic geographers' work on innovation and innovation policy even though the notion of 'regional experimentalism' partly alludes to this challenge (Henderson and Morgan 2001, Coenen and Asheim 2006). Here, regional development strategies "*work in small-scale repeated interactions in an attempt to (re)define regional development support services and priorities in a collective manner, establish specific targets and responsibilities, and monitor outcomes in a way that facilitates learning on the part of those in a position to respond*" (Henderson 2000, p. 349). This notion has however found little resonance in the wider literature on regional innovation policy. Still, a possible re-appreciation may be expected given EUs current interest in the related notion of living laboratories (Cooke 2015).

Implications for studying grand challenges

So why would this body of work help us to understand ways of addressing grand challenges? We argue that the features that make these challenges challenging have a lot in common with the difficulties experienced in innovation processes when combining knowledge in new and useful ways. Grand challenges, whether it concerns climate change or healthy aging, are by nature multi-dimensional and multi-disciplinary and therefore require collaboration between many stakeholders. This implies that solutions to address such challenges are not just about technological advancements, but also about the need to find acceptance and buy-in from different actors and organisations. This is where the geography of innovation is able to contribute. Here we argue that the innovation system failures identified above help to identify the roots of grand challenges and suggest ways to cope with the challenges.

Infrastructural failures can manifest themselves in grand challenges in terms of the absence or weakness of relevant actors in the region. Although they are only a subset of stakeholders involved in addressing grand challenges, universities, research laboratories, testing facilities, and other organizations part of a region's knowledge infrastructure provide vital resources and connections to other stakeholders in and outside the region. This relates closely to *capability failures*. While the grand challenges do not confine themselves geographically, we find that the potential for solutions depends heavily on local availability of skills and firm competencies, absorptive capacities and regional culture. These characteristics may have developed in response to need or adapted from previous specialisations. An example of the former is the environmental technology industry in the Ruhr district, which developed out of a need for limiting the negative environmental effects of the heavy industry in the area (Hospers 2010). An example of the latter is the fuel cell industry, which has been found to emerge in regions where competences exist in related technological fields (Nygaard Tanner 2014).

Third, we find that grand challenges are especially prone to *network failures*. Even when relevant stakeholders are present in the region and have the capabilities necessary to work together in response to localized conditions, they still require certain network conditions to have fruitful interactions. In order to coordinate interaction between an increasing, and increasingly diverse, number of stakeholders, geographical proximity offers certain advantages (Rekers and Hansen 2015). Contrary to subjects of previous rounds of “mission-oriented investment” such as the Apollo program or the Manhattan project, our contemporary grand challenges have less clearly defined technological goals and require more disciplinary diversity in search of solutions. As Leijten, Butter, Kohl, Leis and Gehrt (2012, p. 5) argue: “Grand challenges are not to be defined, assessed or solved by any single scientific or technological discipline or within one specific sectoral policy framework.” This implies a need for collaboration between the public and private sectors, multiple industries, and producers as well as users and intermediary organisations (Kuhlmann and Rip 2014). In order to overcome the differences between such diverse stakeholders – and the lack of organisational and institutional proximity that is likely to be associated with such diversity – geographic proximity is an asset. This is particularly important in combination with the high degree of complexity (in the context of innovation projects) that characterises our grand challenges.

Of greatest significance when dealing with grand challenges, however, are *institutional failures*. Responses to grand challenges require the development and diffusion of innovations, which, as suggested above, is tightly coupled to characteristics of the local environment. From work on the geography of innovation, we recognise that the systemic nature of grand challenges demands policy responses that take the local institutions and context into consideration: “the global nature of technological solutions means that the institutional, economic, and/or industrial settings within which these solutions are deployed will be enormously diverse, requiring a great deal of “localized” adaptation of these solutions” (Foray, Mowery and Nelson 2012, p. 1701). However, too strong dependence on specific contextual factors in the development of innovations may also limit their diffusion potential, if the innovations end up being very place-specific. This is exactly the conundrum

that continues to hamper the wider diffusion of so-called grass-root innovations (Seyfang and Smith 2007). To exemplify, Bridge, Bouzarovski, Bradshaw and Eyre (2013) propose that the diffusion potential of renewable energy technologies is culturally contingent as it depends on localised cultural routines. This suggestion is confirmed empirically by Wirth, Markard, Truffer and Rohrer (2013) in an analysis of biogas technologies in Austria, where it is found that informal institutions condition the diffusion potential of different forms of biogas technologies. Taking institutional factors seriously helps to understand why innovative solutions to grand challenges are likely to be rooted in (but perhaps also tied to) the particularities of places.

Recalling our earlier point on capability failures, this implies that innovative responses are highly localised both in terms of their development as well as implementation. It therefore does not come as a surprise that we observe enormous variation between places in terms of policy responses (Leijten, Butter, Kohl, Leis and Gehrt (2012)). On the one hand it is a promising sign that local and regional governments have authority and freedom to develop innovation oriented initiatives targeting grand challenges, even when general strategies may be more centrally defined (Cunningham and Karakasidou 2010, Bulkeley and Broto 2012, Leijten, Butter, Kohl, Leis and Gehrt 2012). However, this also points to a critical obstacle when tackling grand challenges: the significance of local context poses barriers to potential policy harmonisation and the transfer of best practices, the diffusion of innovative responses, and the upscaling of successful strategies beyond its place of origin. Here we can see there is considerable scope and need for economic geographers to go beyond previous work on the geography of innovation. Addressing transformational systems failures (directionality, demand articulation, policy coordination and reflexivity) is a useful next step.

Conclusion – lessons for economic geographers studying grand challenges

The increasing emphasis on grand challenges pushes economic geographers to go beyond the hitherto very dominant focus on innovation as an enabler for economic growth and structural innovation system failures. As pointed out in a critical review of the territorial innovation models

(Moulaert and Sekia 2003), the emphasis in these theories is on competitiveness and they fail to consider the direct effects of innovations on non-market aspects. Building on these insights, it can be argued that there is a need for considering the broader effects of localised innovation processes on e.g. quality of life and sustainability. This will naturally involve research that assists policymakers in overcoming transformational system failures – also related to grand challenges beyond climate change and environmental degradation, e.g. ageing societies, public health, security, and water and food scarcity.

The lack of attention to *demand articulation failures* points to a general negligence in economic geography to the importance of innovation diffusion. No matter how technologically advanced and superior solutions are being developed, they are of little value if they are not successfully implemented, used and diffused. This diffusion challenge is especially prominent in the case of grand challenges, and where users, decision-makers and buyers are likely to comprise a diverse group. While some bodies of work highlight the importance of users as sources and drivers of innovation (von Hippel 1976, 1988, Beise 2004, Grabher, Ibert and Flohr 2008), and others that call for more demand-oriented innovation policy instruments (Edler and Georghiou 2007), there is an overwhelming emphasis on the supply-side of territorial innovation systems (Marques 2011). Grand challenges force use to consider factors that help to explain why solutions can be more successful in one place compared to another, and why some solutions spread beyond their place of origin and scale up, while others remain trapped by local context.

Finally, the limited interest in the field of economic geography towards *directionality failures*, *policy coordination failures* and *reflexivity failures* is actually quite paradoxical, since it has been a key objective of many economic geographers to carry out policy relevant research that could inform innovation policymakers. These failures have in common that they to a large extent relate to the process and politics of policy-making. However, the policymaking process itself has been left largely untouched by economic geographers, who appear to assume that (or, at least, have not questioned

if) this takes place in rational and seemingly technocratic ways. Similar to Peck's (2011, p. 780) critique of the political science literature on policy transfer, this *"calls for a different point of departure from the idealized universe of rational-actor models, in which atomized agents operate in the bright sunlight of information-rich policy markets."* Thus, a thorough engagement with the place-specificity of the politics in policymaking processes within the field of innovation is still missing. Here we argue that the emerging work on policy mobilities in critical geography may provide a suitable point of departure. Analysing urban development policies, this literature takes as a starting point that policy formation and transformation are socially constructed processes (Peck and Theodore 2010). It explicitly focuses on the role of practices in the form of e.g. study trips and best practice analyses, and actors such as travelling consultants in the policymaking process (McCann 2011), in order to understand how global flows of policy models become inserted into different local contexts (Cochrane and Ward 2012, Temenos and McCann 2013). A similar examination of the processes around formulation of policies on the topic of innovation would allow economic geographers to reach a better understanding of the causes of transformational system failures, which until now have received limited attention.

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