Innovation Policy for Grand Challenges. An Economic Geography Perspective

Coenen, Lars; Hansen, Teis; Rekers, Josephine

Published in: Geography Compass

DOI:
10.1111/gec3.12231

2015

Link to publication

Citation for published version (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
Innovation Policy for Grand Challenges. An Economic Geography Perspective

Lars Coenen\textsuperscript{1,2}, Teis Hansen\textsuperscript{1,2,3∗}, and Josephine V. Rekers\textsuperscript{1,3}

Forthcoming in Geography Compass

\textsuperscript{1} Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE), Lund University, P.O. Box 117, SE-22100 Lund, Sweden

\textsuperscript{2} Nordic Institute for Studies in Innovation, Research and Education (NIFU), Box 5183, Majorstuen, N-0302 Oslo, Norway

\textsuperscript{3} Department of Human Geography, Lund University, Sölvegatan 10, SE-22362 Lund, Sweden

∗ Corresponding author

Lars.Coenen@circle.lu.se; Teis.Hansen@keg.lu.se; Josephine.Rekers@keg.lu.se

This is a post-print (i.e. final draft post-refereeing) version of the paper, now published in Geography Compass
DOI: 10.1111/gec3.12231
Innovation Policy for Grand Challenges. An Economic Geography Perspective

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 in particular examined infrastructural, capability, network and institutional challenges 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.
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 associated with the need for development and diffusion of innovation. 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).

Some consider this orientation towards grand challenges as a new wave of mission-oriented innovation policy that substitutes, or at least complements a previous, more generic concern with innovation policy as an engine of economic growth (Gassler, Polt and Rammer 2008). What distinguishes challenge-driven innovation and innovation policy from historical examples of mission-oriented science, technology and innovation policies (such as the Manhattan Project or the Apollo project) is a greater appreciation of and attention for broad system transformation (Borrás and Edler 2014), demand side policies (Mowery, Nelson and Martin 2010) and transformative change, i.e. radical, long-term alterations in both production and consumption that significantly modify the functioning of society (Grin, Rotmans and Schot 2010, Schot 2015). While in mission-oriented policies, the challenge was largely framed in technical terms, challenge based policies claim to be less instrumental and refer to open-ended missions that require a mix of technological and social innovation, open up for contestation, both with respect to policy aims and means, and involve new
actor constellations that include a larger variety of actors, and consider new roles for traditional actors (Kuhlmann and Rip 2014).

Rather than pushing technological advancement and solutions or enhancing competitiveness, it seems that so-called persistent problems lie at the heart of challenge-driven innovation policy (Rittel and Webber 1973). These problems are persistent for a variety of reasons (Schuitmaker 2012). First, they are complex and multi-sided. Multiple causes and consequences co-exist often covering several societal domains. Second, they are uncertain and unstructured. Wicked problems defy easy solutions, and reduction of uncertainty by producing more knowledge is not always possible. One partial solution at one point of time may generate new, additional problems at a different point of time or elsewhere. Third, they are difficult to manage. Many different actors are involved that represent different interests, have different problem perceptions and advocate different solutions.

What these challenges have in common is that they are not only (or even primarily) searching for technological advancements, but that they necessitate transformative, system change. At a conceptual level, thinking about transformative, system change has been heavily influenced by the burgeoning literature on socio-technical transitions (Markard, Raven and Truffer 2012). The literature on socio-technological transitions analyses how transformative shifts in systems of production and consumption unfold as disruptive technological change co-evolves with changes in markets, user practices, policy, discourses and governing institutions (Kemp, Schot and Hoogma 1998, Geels 2002, Smith, Voß and Grin 2010, Markard, Raven and Truffer 2012). This literature calls attention for the co-evolution of a broad range of innovations which highlights technological, social, organisational, and business model novelty. It shares many theoretical roots with innovation studies, most notably a system perspective on innovation and a neo-Schumpeterian evolutionary understanding of change and industrial dynamics (Coenen and López 2010). However, compared to innovation system approaches, it claims to comprise a wider set of institutions and networks of heterogeneous actors including firms, user groups, scientific communities, policy makers, social movements and special
interest groups. As a result, it stresses the importance of directionality, resistance and contestation in (radical) innovation processes. The most well-known examples of such socio-technological transitions concern low-carbon transition in fields of energy and transport.

Thus, while research from a socio-technical perspective is very relevant to policymaking on the topic of grand challenges, we would argue that this is also the case for economic geography research. Innovation and innovation policy has been a topic of central concern for economic geographers (Feldman 2000) who have considered and examined the responsibility for policy action at different spatial scales (Laranja, Uyarra and Flanagan 2008). 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 Etxebarria 1997, Asheim and Gertler 2005), Learning Regions (Morgan 1997) as well as other kinds of territorial innovation models (Moulaert and Sekia 2003). Still, the community has only recently started to engage more intensively with policymakers beyond the regional level through work on the rapidly proliferating EU policy notion of smart specialisation (Boschma 2014, McCann and Ortega-Argilés 2015).

Further, so far, economic geography has paid scarce attention to innovation for transformative change (see below) and primarily only in relation to sustainability transitions (see Hansen and Coenen 2015 for a review). Unfortunately, lack of engagement with an emerging topic of central importance to current policy discussions appears to be a general tendency among economic geographers. As argued by Dicken (2004), economic geography has a propensity to ‘miss the boat’; for instance, it has only been of marginal importance in policy debates in relation to processes of globalisation and simply lacks visibility and voice among policymakers, despite being centrally placed to inform policy on the topic. As argued by Glasmeier and Conroy (2003, p. 182), “[i]n spite of this natural link, few geographers are present in the high-profile global debates about key issues in the current wave of globalization” which is instead dominated by scholars from economics and law.
Similarly, while the World Development Report 2009 (The World Bank 2009) was termed “Reshaping Economic Geography”, it was written by economists. This has been attributed to the inability of economic geographers to engage in constructive dialogue around policy relevant research with high-level practitioners (Rodríguez-Pose 2010).

In light of this lineage, this paper, firstly, 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 and, secondly, identifies research areas that push economic geographers to consider transformative change and thereby go beyond their existing understanding of innovation and innovation policy. This is important in preventing grand challenge policies from being spatially blind or failing to consider the place-based multiplicity in possible development paths. Before turning to these issues, 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 (IS) approach. The 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. In contrast to the generally limited policy relevance of economic geography research, case-based empirical studies using the IS conceptual framework have in fact 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 ‘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 specialised, old industrial regions; and, finally, problems connected with internal system fragmentation typically found in diverse metropolitan regions. According to Tödtling and Tripl (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) argues 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 Rohracher (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
Conceptualising transformative change as a question of system failures could be considered somewhat mechanistic from a socio-technical transitions literature perspective, which has elaborated extensively on the requirements for institutional transformation. However, we argue that this framework is very valuable in describing some key aspects of transformative change in a manner which is accessible to policymakers in the field of innovation. Furthermore, as noted in the introduction, economic geographers appear to be rather slow to address emerging topics of central importance to current policy discussions; thus, it may be particularly useful for researchers from this field to take a point of departure in the systems failure framework. Therefore, 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 Rodríguez-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 positively 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...
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 pipelines’ 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 linchpins 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 relates to 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, which is concerned with understanding the importance of spatial context and relations across different scales for transition processes (Coenen, Benneworth and Truffer 2012, see Hansen and Coenen 2015 for a review); i.e. this research is 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 Rohracher 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 build 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 in the geography of sustainability transitions literature, 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 (Monstad 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. This highlights that tension that may follow from an increasingly complex innovation policy mix (Flanagan, Uyarra and Laranja 2011). 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 diffusion, modification and co-production of innovations by 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 the problems associated with grand challenges and suggest ways for policy to cope with these challenges. 

Infrastructural failures, referring to physical as well as knowledge infrastructures, can manifest in grand challenges in terms of the absence or weakness of connectivity between relevant actors. In
particular when these actors are not found in the region, improved physical connectivity between
regions is important and the above-mentioned investments in transport infrastructures are justified
for plugging into global networks of production and innovation. In addition, universities, research
laboratories, testing facilities, and other organizations that are part of a region’s knowledge
infrastructure (although they are only a subset of stakeholders involved in addressing grand
challenges) provide vital resources and connections to other stakeholders inside 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
element 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 where interactive
learning is inhibited. 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 stimulate, initiate and 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 – geographical 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 grassroot 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 Rohracher (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 related to climate change and environmental degradation, ageing societies, public health, security, as well as water and food scarcity pushes economic geographers to go beyond the hitherto dominant focus on innovation as an enabler for economic growth. As pointed out in a critical review of the territorial innovation models (Moulaert and Sekia 2003), the emphasis in these theories is on territorial competitiveness while considerably less attention is paid to the effects of innovations on non-market aspects such as quality of life and sustainability. Addressing grand challenges, and the persistent problems that often underpin these challenges, requires a broader perspective that is not only concerned with structural failures in innovation systems and related policies (in connection to capabilities, networks and a limited set of institutional factors). In addition, more attention should be directed to analyses and policies targeting system transformation and the ‘failures’ associated with such transformative shifts in production and consumption.
The identified 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 call for more demand-oriented innovation policy instruments (Edler and Georghiou 2007), there is still an overwhelming emphasis on the supply-side of territorial innovation systems (Marques 2011). Grand challenges force us 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, in particular at the regional level. These failure types 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.

In closing, it is worth emphasising that the dimensions of grand challenges we discussed in this paper, their being a mix of technological and social innovation, open to contestation and involving new actor constellations, highlight the importance of moving beyond a focus on narrow technological advancement. In other words, the need to go beyond so-called technological fixes when addressing grand challenges foregrounds the value of geographical perspectives in policy making, where the role
played by place-based social and political contexts in transformational change are explicitly acknowledged.

Acknowledgements
This paper benefitted from comments by two anonymous reviewers and the editor James Faulconbridge. The authors acknowledge financial support from the Swedish Research Council (Linnaeus Grant No. 349200680) and the Swedish Governmental Agency for Innovation Systems (Grant agreement 2010-07370).
Alkemade F, Hekkert MP, and Negro SO 2011 Transition policy and innovation policy: Friends or foes? Environmental Innovation and Societal Transitions 1 125-129

Almeida P, and Kogut B 1999 Localization of Knowledge and the Mobility of Engineers in Regional Networks. Management Science 45 905-917


Andersson R, Quigley JM, and Wilhelmsson M 2005 Agglomeration and the Spatial Distribution of Creativity. Papers in Regional Science 84 445-464

Asheim BT, Boschma RA, and Cooke P 2011 Constructing Regional Advantage: Platform Policies Based on Related Variety and Differentiated Knowledge Bases. Regional Studies 45 893-904


Bathelt H, Malmberg A, and Maskell P 2004 Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. Progress in Human Geography 28 31-56


Boschma RA 2005 Proximity and innovation: A critical assessment. Regional Studies 39 61-74

Boschma RA 2014 Constructing regional advantage and smart specialisation: Comparison of two European policy concepts. Scienze Regionali 13 51-68


Bulkeley H, and Broto VC 2012 Urban experiments and climate change: securing zero carbon development in Bangalore. Contemporary Social Science 1-22

Cagnin C, Amanatidou E, and Keenan M 2012 Orienting European innovation systems towards grand challenges and the roles that FTA can play. Science and Public Policy 39 140-152


Coenen L, and Asheim BT 2006 Constructing regional advantage at the northern edge. In: Cooke P and Piccaluga A eds Regional development in the knowledge economy Routledge, Abingdon 84-110

Coenen L, Benneworth P, and Truffer B 2012 Toward a spatial perspective on sustainability transitions. Research Policy 41 968-979

Coenen L, and López FJD 2010 Comparing systems approaches to innovation and technological change for sustainable and competitive economies: an explorative study into conceptual commonalities, differences and complementarities. Journal of Cleaner Production 18 1149-1160
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Year</th>
<th>Title</th>
<th>Journal</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooke P, Uranga MG, and Etxebarria G</td>
<td>1997</td>
<td>Regional innovation systems: Institutional and organisational dimensions.</td>
<td>Research Policy</td>
<td>26 475-491</td>
</tr>
<tr>
<td>Coutard O, and Rutherford J</td>
<td>2010</td>
<td>Energy transition and city–region planning: understanding the spatial politics of systemic change.</td>
<td>Technology Analysis &amp; Strategic Management</td>
<td>22 711-727</td>
</tr>
<tr>
<td>Cunningham P, and Karakasidou A</td>
<td>2010</td>
<td>Innovation and societal challenges.</td>
<td>Manchester Institute of Innovation Research, University of Manchester, Manchester</td>
<td></td>
</tr>
<tr>
<td>Dahl MS, and Pedersen CØR</td>
<td>2004</td>
<td>Knowledge flows through informal contacts in industrial clusters: myth or reality?</td>
<td>Research Policy</td>
<td>33 1673-1686</td>
</tr>
<tr>
<td>Dewald U, and Truffer B</td>
<td>2012</td>
<td>The Local Sources of Market Formation: Explaining Regional Growth Differentials in German Photovoltaic Markets.</td>
<td>European Planning Studies</td>
<td>20 397-420</td>
</tr>
<tr>
<td>Dicken P</td>
<td>2004</td>
<td>Geographers and ‘globalization’: (yet) another missed boat?</td>
<td>Transactions of the Institute of British Geographers</td>
<td>29 5-26</td>
</tr>
<tr>
<td>Edler J, and Georghiou L</td>
<td>2007</td>
<td>Public procurement and innovation—Resurrecting the demand side.</td>
<td>Research Policy</td>
<td>36 949-963</td>
</tr>
<tr>
<td>European Commission</td>
<td>2013</td>
<td>Europe 2020: Europe's growth strategy.</td>
<td>European Commission, Brussels</td>
<td></td>
</tr>
<tr>
<td>Feldman MP</td>
<td>2000</td>
<td>Location and innovation: the new economic geography of innovation, spillovers, and agglomeration.</td>
<td>Institute of British Geographers</td>
<td>29 5-26</td>
</tr>
<tr>
<td>Feldman MP, and Francis JL</td>
<td>2003</td>
<td>Fortune Favours the Prepared Region: The Case of Entrepreneurship and the Capitol Region Biotechnology Cluster.</td>
<td>European Planning Studies</td>
<td>26 475-727</td>
</tr>
<tr>
<td>Freeman C</td>
<td>1987</td>
<td>Technology Policy and Economic Performance: Lessons from Japan</td>
<td>London, Frances Pinter</td>
<td></td>
</tr>
<tr>
<td>Gassler H, Polit W, and Rammer C</td>
<td>2008</td>
<td>Priority setting in technology policy: Historical development and recent trends.</td>
<td>Innovation Policy in Europe</td>
<td>7 139-168</td>
</tr>
<tr>
<td>Georghiou L, and Metcalfe S</td>
<td>1998</td>
<td>Equilibrium and evolutionary foundations of technology policy.</td>
<td>STI Review – Special Issue on New Rationale and Approaches in Technology and Innovation Policy</td>
<td>22</td>
</tr>
<tr>
<td>Giuliani E</td>
<td>2007</td>
<td>The selective nature of knowledge networks in clusters: evidence from the wine industry.</td>
<td>Journal of Economic Geography</td>
<td>7 139-168</td>
</tr>
</tbody>
</table>


Hansen T 2014 Juggling with Proximity and Distance: Collaborative Innovation Projects in the Danish Cleantech Industry. *Economic Geography* 90 375-402

Hansen T 2015 Substitution or overlap? The relations between geographical and non-spatial proximity dimensions in collaborative innovation projects. *Regional Studies* Forthcoming

Hansen T, and Coenen L 2015 The geography of sustainability transitions: Review, synthesis and reflections on an emergent research field. *Environmental Innovation and Societal Transitions*


Kuhlmann S, and Rip A 2014 The challenge of addressing Grand Challenges. A think piece on how innovation can be driven towards the “Grand Challenges” as defined under the European Union Framework Programme Horizon 2020. The European Research and Innovation Area Board, Brussels


Lund Declaration 2009 Europe must focus on the grand challenges of our time. Swedish EU Presidency,


McCann P, and Ortega-Argilés R 2015 Smart Specialization, Regional Growth and Applications to European Union Cohesion Policy. Regional Studies 49 1291-1302

McCauley SM, and Stephens JC 2012 Green energy clusters and socio-technical transitions: analysis of a sustainable energy cluster for regional economic development in Central Massachusetts, USA. Sustainability Science 7 213-225


Moretti E 2012 The New Geography of Jobs Boston, Houghton Mifflin Harcourt

Morgan K 1997 The learning region: Institutions, innovation and regional renewal. Regional Studies 31 491-503

Morgan K 2004 The exaggerated death of geography: learning, proximity and territorial innovation systems. Journal of Economic Geography 4 3-21


Mowery DC, Nelson RR, and Martin BR 2010 Technology policy and global warming: Why new policy models are needed (or why putting new wine in old bottles won’t work). Research Policy 39 1011-1023

Nygaard Tanner A 2014 Regional Branching Reconsidered: Emergence of the Fuel Cell Industry in European Regions. Economic Geography 90 403-427

Pinch S, and Henry N 1999 Paul Krugman’s geographical economics, industrial clustering and the British motor sport industry. Regional Studies 33 815-827

Rekers JV, and Hansen T 2015 Interdisciplinary research and geography: Overcoming barriers through proximity. Science and Public Policy 42 242-254


Rodríguez-Pose A 2013 Do institutions matter for regional development? Regional Studies 47 1034-1047

Rodríguez-Pose A, and Fratesi U 2004 Between Development and Social Policies: The Impact of European Structural Funds in Objective 1 Regions. Regional Studies 38 97-113

Saxenian A 1994 Regional Advantage: Culture and Competition in Silicon Valley and Route 128 Cambridge, MA, Harvard University Press

Saxenian A 2007 The new argonauts: Regional advantage in a global economy Cambridge, Massachusetts, Harvard University Press

Schot J 2015 Moving Innovation Policy from a Competition to a Transformative Change Agenda. EU-SPRI annual conference, Helsinki

Schuitmaker TJ 2012 Identifying and unravelling persistent problems. Technological Forecasting and Social Change 79 1021-1031


Seyfang G, and Smith A 2007 Grassroots innovations for sustainable development: Towards a new research and policy agenda. Environmental politics 16 584-603


Steward F 2012 Transformative innovation policy to meet the challenge of climate change: sociotechnical networks aligned with consumption and end-use as new transition arenas for a low-carbon society or green economy. Technology Analysis & Strategic Management 24 331-343


Tödtling F, and Trippl M 2005 One size fits all?: Towards a differentiated regional innovation policy approach. Research Policy 34 1203-1219

von Hippel E 1976 The dominant role of users in the scientific instrument innovation process. Research Policy 5 212-239

von Hippel E 1988 The sources of innovation New York, Oxford University Press

Weber KM, and Rohracher H 2012 Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive ‘failures’ framework. Research Policy 41 1037-1047

Co-author declaration

Lund, August 17th, 2015

To whom it may concern

This co-authorship declaration applies to the following paper:


The three authors participated equally in all phases of the process of writing the paper.

Lars Coenen

Teis Hansen

Josephine Rekers