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Responsible innovation and societal challenges: The multi-scalarity dilemma

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ABSTRACT

Societal challenges tend to be characterized by their multi-scalarity as problems emerge and co-evolve on multiple scales. Resolving these challenges requires innovators to navigate often conflicting considerations between multiple scales when dealing with complexity, uncertainty, and contestation. Innovators need to ground resolutions in local values and worldviews while simultaneously fitting these into global efforts to help drive systemic responses. Nevertheless, studies on Responsible Innovation commonly focus exclusively on a local or global scale. In this perspective paper, we explore rationales for these two prevalent but opposing approaches, and provide tentative insights into how multi-scalarity could be navigated by uniting scales through a hybrid approach. The paper proceeds by opening up research on multi-scalarity, and the geographical and relational aspects of Responsible Innovation in a broader sense.

Responsible innovation and the multi-scalarity of societal challenges

The academic discourse on Responsible (Research and) Innovation - hereafter 'Responsible Innovation' - focuses on anticipatory, inclusive, reflexive, and responsive approaches to "stewardship of science and innovation in the present" (Stilgoe et al., 2013, p. 1570). The European Commission and various researchers believe that these approaches have the potential to help resolve societal challenges (e.g., Genus & Stirling, 2018; Owen et al., 2012, 2020; Schomberg & Hankins, 2020; Von Schomberg, 2013). As such, Responsible Innovation resonates with a broader discourse, also known as the third frame (Schot & Steinmueller, 2018), that considers science and innovation important drivers for overcoming challenges like pandemics, climate change, and social injustice.

Societal challenges frequently fall in the category of wicked problems (Rittel & Webber, 1973) and are characterised by their multi-scalarity (Wanzenböck et al., 2020). We understand multi-scalarity as an attribute that is both fixed (i.e., place-based and geographical) and fluid (i.e., relational and constructed; c.f., Born & Purcell, 2006; Brown & Purcell, 2005; Gibson-Graham, 2002; Massey, 2004). It refers to the idea that wicked problems exist, unfold, and interact at multiple scales, and that 'grand' challenges are not contained

but nearly always surpass geographical borders. An (in)action in one region may influence the conditions and capabilities of other regions (Jasanoff, 2013). Although uniform resolutions to these grand challenges may seem appealing, regions are affected by challenges in unique and unequal ways whilst the success of resolutions is context-dependant (Wanzenböck & Frenken, 2020). In addition, what is deemed responsible in one region, may not be considered so in another.

What is more, innovators design resolutions in unique local contexts while commonly assuming to create scalable resolutions that fit into global frames (Pfotenhauer et al., 2022). However, such local resolutions often neglect global implications whereas scalable resolutions frequently obscure local diversities. Therefore, resolving societal challenges requires innovators to think both locally and globally when dealing with the complexity, uncertainty, and contestation associated with wicked problems (Farrell & Hooker, 2013; Wanzenböck et al., 2020).

In light of these challenges, this paper aims to draw attention to an important but largely overlooked question: How should Responsible Innovation deal with the multi-scalarity of societal challenges?

Some scholars argue that the scale at which Responsible Innovation operates principally depends on the scale of its anticipated impacts (Fig. 1; Fitjar et al., 2019). Local (or global) impacts call for local (or global) anticipatory and reflexive deliberations. Although an
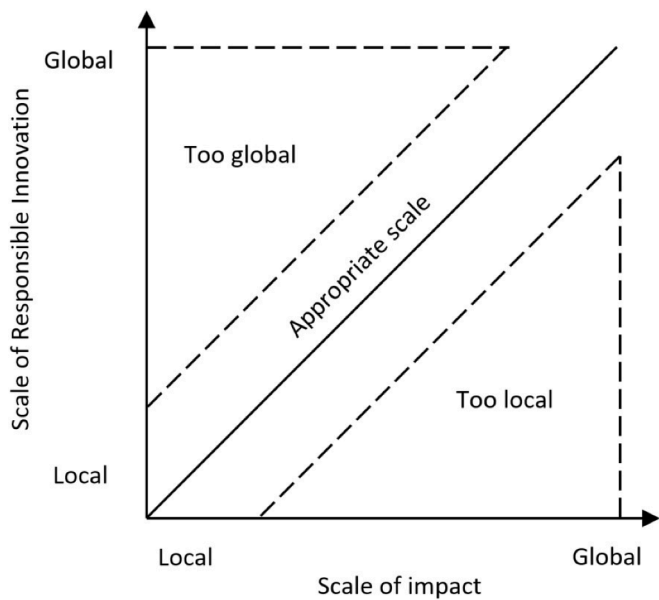

Fig. 1. A multi-scalar approach to Responsible Innovation. Illustration adapted from Fitjar et al. (2019).

innovation's impact is uncertain (Hoffmann-Riem & Wynne 2002), innovators make *ex ante* assumptions and decisions that influence the scale at which they expect to make an impact. The reasoning behind these scales plays a crucial role in dealing with multi-scalarity but has been largely overlooked in the discourse of Responsible Innovation – especially in the context of grand challenges.

Two prevalent lines of reasoning involved in the 'politics of scaling' include the local reasoning and the global reasoning,[1] each offering epistemic and normative advantages and disadvantages (Pfotenhauer et al., 2022). As we will discuss, local approaches are generally believed to be more grounded in local values and worldviews, while global approaches are associated with more collective and systemic responses. Let us first discuss arguments in favour of each approach, before exploring how multi-scalarity can be dealt with.

Arguments favouring a local approach

Various scholars plead for Responsible Innovation to be grounded in local contexts by drawing on local values and worldviews (e.g., Hooli et al., 2019; Koirala et al., 2018). This is likewise encouraged by the European Commission by reason of the subsidiarity principle that prescribes to take decisions as close as possible to citizens (Wanzenböck & Frenken, 2020). Many European-funded projects on Responsible Innovation have taken a local, regional, or territorial turn, e.g., TeRRIFICA, TRANSFORM, TetRRIS, and CHERRIES. Studies similarly adopted concepts from regional innovation studies (Martikainen et al., 2021; Rehfeld, 2019; Thapa et al., 2019; Uyarra et al., 2019) such as regional innovation systems (Benneworth et al., 2019; Floysand et al., 2020), regional development (Barton et al., 2019), and Research and Innovation Strategies for Smart Specialization (RIS3; Fitjar et al., 2019).

Perhaps the most prevalent argument that support such an approach rests on the notion that societal challenges are contextual as they "affect places in different ways and to different extents" (Wanzenböck & Frenken, 2020, p. 56). Engaging with local stakeholders may help

understand how they experience challenges in their unique way (Kerr et al., 2007) and thus benefits the 'problematization' phase of research and innovation (Franssen, 2022). Regions differ in how they make sense of problems and how they reason to resolve them (Jasanoff, 2013). For example, there are considerable differences in how regions conduct assessments of emerging technologies (Delvenne & Rosskamp, 2021).

In terms of resolutions, the distinctiveness of regions may obstruct their compatibility with standardized approaches. The implementation of resolutions takes place in unique contexts that are hard to grasp by conventional, often spatially distant, experts and policymakers (Macfarlane, 2003). *In situ* interactions stimulate learning as tacit knowledge is hard to obtain through 'global pipelines' that predominantly offer codified knowledge (Bathelt et al., 2004). Recognizing the heterogeneity of local publics helps understand the normative pluralism that would otherwise be homogenized (Pesch et al., 2020) and which is essential for constructive approaches to conflict resolutions (Cuppen, 2012; Ligtvoet et al., 2016). Engagement with locals furthermore contextualizes potential ramifications by making them more concrete (Pesch et al., 2020). Local stakeholders do not merely enrich innovation processes, they may even propose resolutions themselves (von Hippel, 1986). Bottom-up resolutions tend to enjoy considerable support (Smith et al., 2014).

In addition, reducing the scope of Responsible Innovation to a local scale tends to be more feasible than extending its scope to a global one (Fitjar et al., 2019; Lubberink et al., 2017). Local considerations are more homogenous than global considerations, and identifying and navigating these global considerations requires immense resources that many innovators do not possess. While global approaches usually require lengthy negotiations that generally reinforce dominant views or lead to inadequate compromises (Ludwig et al., 2021), local approaches may respond more quickly to urgent challenges that require radical resolutions.

Ultimately, the uptake of local considerations enables innovators to resolve challenges according to context-specific values, worldviews, and conditions, which suggests that these local resolutions may be more aligned, effective, and socially desirable for local stakeholders.

Arguments favouring a global approach

Let us now turn to some prevalent arguments in favour of a global approach. A central argument supporting a global scale is that most societal challenges are not spatially contained. First, one region's (in) action affects the condition of other regions (Jasanoff, 2013; Wanzenböck & Frenken, 2020). For example, how two adjacent regions individually respond to riverine (fluvial) flood risks can contribute directly to the flood safety of the neighbouring region. Second problems may emerge in one region as symptoms of supra-regional phenomena. For instance, local (coastal) flood risks can result from global climate change-induced sea-level rise.

Responsible Innovation pleads for actors to become mutually responsive, and to bear a shared responsibility that is distributed amongst stakeholders (Owen et al., 2020; Van Oudheusden, 2014; Wiarda et al., 2021). It is precisely this geographically distributed nature of stakeholders that endorses global responses – stakeholders are not solely situated within one's region. While the 'Global North' is generally deemed a driver of innovation (Florida, 2005, 2010), it is the 'Global South' that tend to be most vulnerable to societal challenges (Ludwig et al., 2021). Some scholars therefore argue that the Global North has the moral obligation to include the Global South in its innovation processes (Schroeder & Kaplan, 2019). Taking responsibility for global challenges could avert a potential tragedy of the commons (Hardin, 1968), and may even prevent maladaptive forms of problem shifting from one region to another (Magnan et al., 2016).

Despite the place-dependant nature of know-how (Florida, 2005, 2010; Heimeriks & Balland, 2016; Hidalgo et al., 2007), local knowledge may not adequately match the challenge at hand. Regions benefit from global innovation systems because the knowledge, actors, and capital

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[1] We would like to stress that the notions 'local' and 'global' suffer from interpretative flexibility and that the ways these scalar layers are understood may very accordingly (Gibson-Graham, 2002). We nevertheless use these terms for matters of simplicity to enhance the understandability of the multi-scalarity dilemma.

needed to realize resolutions are globally distributed and thus surpass regional boundaries (Binz & Truffer, 2017).

Furthermore, local approaches are frequently deemed to lack the capacity and scale needed to resolve grand challenges (Uyarra et al., 2019). They are inclined to address low-level symptoms that fail to adequately address high-level problems, causing a societal challenge to "no longer shows its teeth before it bites" (Churchman, 1967, p. 141). What is more, 'small wins' only become effective once they accumulate as nodes in a larger network (Bours et al., 2021; Termeer & Dewulf, 2019). Many scholars plead to meet 'big problems' with 'big science' (Ergas, 1987; Mazzucato, 2018a) because individual regions frequently lack the resources to resolve societal challenges comprehensively (Uyarra et al., 2019). The effectiveness of inter-regional responses partly stems from their economies of scale, spillover effects, and institutional complementarities that allow a response's sum to be greater than its parts.

On a more conceptual note, a globally coordinated approach allows for more cumulative patterns of innovation that increase the pace at which society can respond to societal challenges (Dosi, 1982; Mazzucato, 2017). The transformative change required to address societal challenges benefits from synergies and mutual learning amongst regions (Coenen et al., 2012; Coenen & Truffer, 2012). This is important for matters of directionality, but also for mitigating reflexivity failures (i.e., inadequate forms of reflection, anticipation, and inclusion in processes of self-governance), policy coordination failures (i.e., incoherency in policies across scales), and demand articulation failures (i.e., the insufficient understanding of future demands; Weber & Rohracher, 2012).

Navigating the multi-scalarity dilemma: A hybrid approach

We observe that most studies exclusively focus on one of these two approaches while overlooking the importance of other scales (e.g., (trans-)national). If challenge-led forms of Responsible Innovation are to live up to their promise, they cannot ignore the multi-scalarity of the wicked problems they intend to resolve. Operating on all scales is necessary in our view, and we do therefore not unconditionally support an exclusive focus on a single scale. Indeed, multi-scalarity urges innovators to ground resolutions in local values and worldviews, but it also requires them to fit these into global efforts that drive systemic responses. As such, multi-scalarity imposes a dilemma on innovators who need to navigate the contradicting considerations between different scales (Fig. 2). To deal with this dilemma, we advocate a hybrid approach that reaps benefits from multiple scales. In what follows, this section discusses three tentative scale-related considerations that could contribute to such an approach.

Combine complementary approaches. Managing the multi-scalarity of wicked problems requires innovators to understand that problem-resolutions framings may differ between scales of analysis (Wanzenböck et al., 2020). For instance, while climate change-induced sea-level rise generally represents a high-level problem framing on a global scale, individuals may frame this phenomenon differently at a lower-level scale by focusing on local flood hazards. Understanding the values and worldviews of stakeholders at different scales requires Responsible Innovation to apply different, but complementary, approaches that are suitable for each scale. Focus groups, co-design methods, and science cafes are exemplary approaches that operate at small scales, whereas standards, technology assessments, and innovation policies tend to be associated with larger scales (Doorn et al., 2013). By combining such complementary approaches, Responsible Innovation could establish multi-level capacities that embed responsibility on multiple scales (Fisher & Rip, 2013).

Leverage boundary objects. To safeguard local diversities when driving cooperation, Responsible Innovation could benefit from boundary objects. These are constructs "that are plastic enough to adapt to local needs …, yet robust enough to maintain a common identity across sites." (Star & Griesemer, 1989, p. 393). They facilitate communication and collaboration across boundaries as they can be interpreted and used in different ways (Bechky, 2003). Exemplary boundary objects in the context of societal challenges include Sustainable Development Goals and societal missions (Mazzucato, 2018b; UN, 2022). These boundary objects help mobilize regions into a shared direction, while arguably providing space for their own integrity and ingenuity (Brett et al., 2023). To effectively address societal challenges, boundary objects need to be clear, targeted, measurable, and time-bound (Mazzucato, 2018a). In light of the contested nature of wicked problems and resolutions, boundary objects should be co-created in inclusive settings that help bridge contradicting values and worldviews (Janssen et al., 2023). This may for instance be done through so-called hybrid forums (Callon et al., 2009) or arenas (Loorbach, 2010; Wesseling & Meijerhof, 2021).

Embrace conflict. Wicked problems are inevitably associated with disagreement because of the heterogeneous values and worldviews across regions and scales. Decisions tend to result in 'winners' and 'losers'. Responsible Innovation should not assume consensus, but should learn from disagreement and diversity (Schot & Steinmueller, 2018). Constructive approaches yield insights that stimulate mutual learning needed to identify common ground, potential compromises, and fundamental disagreements (Cuppen, 2012; Ligtvoet et al., 2016). In case of fundamentally opposing views, innovations may be viewed as responsible by some stakeholders but deemed irresponsible by others. Various scholars suggest that Responsible Innovation could consequently build on agonistic approaches by acknowledging opponents as rational when making hard decisions (Popa et al., 2021; Scott, 2021). This prompts the question of who will make, and benefit from, these decisions (Stilgoe et al., 2013). As Responsible Innovation aims to be actionable, decisions will need to be made. In line with agonism, this calls for transparency – and by extension accountability – to communicate the bases of these difficult decisions (Fraaije & Flipse, 2020).
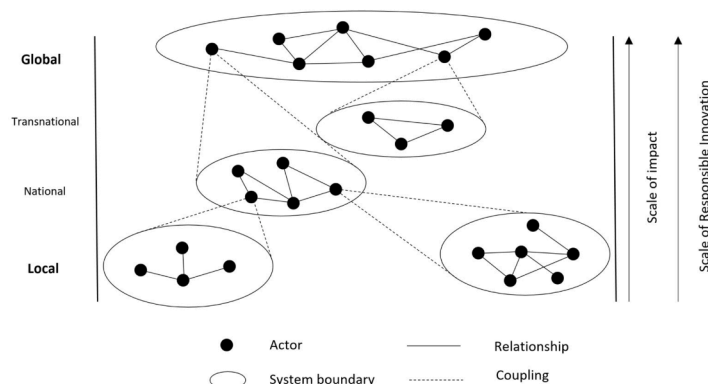

Fig. 2. A multi-scalarity framework for Responsible Innovation. Inspired by Binz and Truffer (2017).

A geographical and relational perspective on responsible innovation

In this paper, we explored the multi-scalarity dilemma that Responsible Innovation faces in the context of societal challenges. We discussed three tentative considerations that could contribute to a hybrid approach that safeguards local diversities in light of global efforts. We subsequently advocate research on how this dilemma should be navigated. For instance, large scale approaches (e.g., standardisation) tend to be performed by a select group of powerful stakeholders who seldom represent all interests (Wiarda et al., 2022). Future research could explore how local interests could better feed into such approaches. In addition, while large scale boundary objects (e.g., missions) have discursive and political power, there is limited evidence that they *de facto* impact the activities of local economies (Biermann et al., 2022). Empirical insights could validate/reject whether such boundary objects encourage local responsible innovation. Even if stakeholders from vulnerable regions are able to partake in large scale approaches and the design of boundary objects, they commonly lack the resources, time, and political power to meaningfully provide input (Biermann & Möller, 2019). This inability greatly reduces the potential value that conflict offers for challenge-led forms of Responsible Innovation, and raises the question of what decision-making approaches (e.g., agonism) enable responsible outcomes in these contexts. All these questions draw attention to the notions of power, justice and fairness.

It is important to stress that the multi-scalarity dilemma is part of a larger knowledge gap. The Responsible Innovation literature promotes *mutual* responsiveness to make innovations ethically acceptable (Von Schomberg, 2011). Taking this mutuality seriously requires regions to look beyond their borders and consider each other's considerations. Although there are scholarly debates on the geography of innovations (e. g., Asheim & Gertler, 2009; Balland et al., 2015; Boschma, 2005), transitions (e.g., Coenen et al., 2012; Coenen & Truffer, 2012), and societal challenges (e.g., Flanagan et al., 2021), we still lack a geography of Responsible Innovation. A geography of Responsible Innovation would yield broader insights into the distributive nature of responsibilities, i.e., the spatial nature of inclusive, anticipatory, reflexive and responsive practices. Our understanding of the multi-scalarity dilemma would also benefit from a relational perspective on Responsible Innovation (Albertson et al., 2021; Chilvers & Pallett, 2018). For example, we need insights on how inter-scale relations are constructed and how they give rise to hierarchical structures (e.g., interdependencies; Albertson et al., 2021). While regions may share responsibilities, they do not necessarily have an equal responsibility and agency (Muttitt & Kartha, 2020; O'Neill, 1996; Young, 2006).

A geographical and relational perspective on Responsible Innovation could even challenge the current predominantly Western conceptualization of Responsible Innovation if other regions (e.g., the Global South) have different understandings of responsibility (Macnaghten et al., 2014; Wong, 2016). Because the notion of responsibility is culturally bound, we may never arrive at a shared understanding of responsibility (Lukes, 2011).

Studying the scale of Responsible Innovation could furthermore provide an awareness of which regions are included and excluded in innovation. It informs us about how innovators navigate considerations of different locations, and thus reveals which regions tend to benefit from innovation. Such research would draw explicit attention to power distributions and geopolitics as challenge-led innovations have substantial political and socio-economic implications. Consequently, we should revisit van Oudheusden's (2014) question in the spatial sense: "*Where* are the politics in Responsible Innovation?" (p. 67, emphasis added).

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Albertson, K., de Saille, S., Pandey, P., Amanatidou, E., Arthur, K. N. A., Van Oudheusden, M., et al. (2021). An RRI for the present moment: Relational and 'well-up' innovation. *Journal of Responsible Innovation, 8*(2), 292–299. https://doi.org/10.1080/23299460.2021.1961066

Asheim, B. T., & Gertler, M. S. (2009). The Geography of Innovation: Regional Innovation Systems. *The oxford handbook of innovation* (pp. 291–317). Oxford Academic. https://doi.org/10.1093/oxfordhb/9780199286805.003.0011%0A

Balland, P., Boschma, R. O. N., & Frenken, K. (2015). Proximity and innovation: From statics to dynamics. *Regional Studies, 0*(0), 1–14. https://doi.org/10.1080/00343404.2014.883598

Barton, J.R., Román, Á., Rehner, J., Barton, J.R., Román, Á., Responsible, J.R. et al. (2019). *Responsible research and innovation* (RRI) in Chile : From a neostructural productivist imperative to sustainable regional development ? *Development ?* 4313. 10.1080/09654313.2019.1658719.

Bathelt, H., Malmberg, A., & Maskell, P. (2004). Clusters and knowledge: Local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography, 1*, 31–56.

Bechky, B. A. (2003). Object lessons: Workplace artifacts as representations of occupational jurisdiction. *American Journal of Sociology, 109*(3), 720–752. https://doi.org/10.1007/978-94-6091-915-2

Benneworth, P., Schulze-Greiving, V., & Konrad, K. (2019). Knowledge bases and responsibility within regional innovation systems: Reflections from the Twente region. *European Planning Studies, 27*(12), 2491–2509.

Biermann, F., Hickmann, T., Sénit, C. A., Beisheim, M., Bernstein, S., Chasek, P., et al. (2022). Scientific evidence on the political impact of the sustainable development goals. *Nature Sustainability, 5*(9), 795–800. https://doi.org/10.1038/s41893-022-00909-5

Biermann, F., & Möller, I. (2019). Rich man's solution? Climate engineering discourses and the marginalization of the Global South. *International Environmental Agreements: Politics, Law and Economics, 19*(2), 151–167. 10.1007/s10784-019-09431-0.

Binz, C., & Truffer, B. (2017). Global innovation systems — A conceptual framework for innovation dynamics in transnational contexts. *Research Policy, 46*, 1284–1298. https://doi.org/10.1016/j.respol.2017.05.012. May.

Born, B., & Purcell, M. (2006). Avoiding the local trap: Scale and food systems in planning research. *Journal of Planning Education and Research, 26*(2), 195–207. https://doi.org/10.1177/0739456X06291389

Boschma, R. A. (2005). Proximity and innovation: A critical assessment. *Regional Studies, 39*(1), 61–74. https://doi.org/10.1080/0034340052000320887

Bours, S. A. M. J. V., Wanzenböck, I., & Frenken, K (2021). Small wins for grand challenges . A bottom-up governance approach to regional innovation policy. *European Planning Studies, 0*(0), 1–28. https://doi.org/10.1080/09654313.2021.1980502

Brett, N., Magnusson, T., & Andersson, H. (2023). From global climate goals to local practice—Mission-oriented policy enactment in three Swedish regions. *Science and Public Policy*. https://doi.org/10.1093/scipol/scad010

Brown, J. C., & Purcell, M. (2005). There's nothing inherent about scale: Political ecology, the local trap, and the politics of development in the Brazilian Amazon. *Geoforum: Journal of Physical, Human, and Regional Geosciences, 36*(5), 607–624. https://doi.org/10.1016/j.geoforum.2004.09.001

Callon, M., Lascoumes, P., & Barthe, Y. (2009). *Acting in an uncertain world an essay on technical democracy*. MIT Press.

Chilvers, J., & Pallett, H. (2018). Energy democracies and publics in the making: A relational agenda for research and practice. *Frontiers in Communication, 3*, 1–16. https://doi.org/10.3389/fcomm.2018.00014. April.

Churchman, C. W. (1967). Wicked problems. *Management Science, 14*(4), 141–146.

Coenen, L., Benneworth, P., & Truffer, B. (2012). Toward a spatial perspective on sustainability transitions. *Research Policy, 41*(6), 968–979. https://doi.org/10.1016/j.respol.2012.02.014

Coenen, L., & Truffer, B. (2012). Places and spaces of sustainability transitions: Geographical contributions to an emerging research and policy field. *European Planning Studies, 20*(3), 367–374. https://doi.org/10.1080/09654313.2012.651802

Cuppen, E. (2012). Diversity and constructive conflict in stakeholder dialogue: Considerations for design and methods. *Policy Sciences, 45*(1), 23–46. https://doi.org/10.1007/s11077-011-9141-7

Delvenne, P., & Rosskamp, B. (2021). Lessons learned from attempts to address the deficit of technology assessment in Europe. *Journal of Responsible Innovation, 8*(3), 445–470. https://doi.org/10.1080/23299460.2021.1988433

Doorn, N., Schuurbiers, D., van de Poel, I., & Gorman, M. E. (2013). Early Engagement and new technologies: Towards comprehensive technology engagement? In N. Doorn, D. Schuurbiers, I. van de Poel, & M. E. Gorman (Eds.), *Early engagement and new technologies: Opening up the laboratory* (pp. 233–251). Springer. https://doi.org/10.1007/978-94-007-7844-3_12.

Dosi, G. (1982). *Technological paradigms and technological trajectories*. 1982, 147–162.

Ergas, H. (1987). Does technology policy matter? In B. Guile, & H. Brooks (Eds.), *Technology and global industry: Companies and nations in the world economy* (pp. 191–245). National Academies Press.

Farrell, R., & Hooker, C. (2013). Design, science and wicked problems. *Design Studies, 34*(6), 681–705. https://doi.org/10.1016/j.destud.2013.05.001

Fisher, E., & Rip, A. (2013). Responsible innovation: Multi-level dynamics and soft intervention practices. *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*, 165–183. https://doi.org/10.1002/9781118551424.ch9

Fitjar, R. D., Benneworth, P., & Asheim, B. T. (2019). Towards regional responsible research and innovation ? Integrating RRI and RIS3 in European innovation policy. *Science and Public Policy, 46*, 772–783. https://doi.org/10.1093/scipol/scz029. May.

Flanagan, K., Uyarra, E., & Wanzenböck, I. (2021). Towards a problem-oriented regional industrial policy: Possibilities for public intervention in framing, valuation and market creation. *Regional Studies*.

Florida, R. (2005). THE WORLD IS SPIKY Globalization has changed the economic playing field, but hasn't leveled it. *Atlantic Monthly, 296*(3).

Florida, R. (2010). *Who's your city?: How the creative economy is making where to live the most important decision of your life*. Vintage Canada.

Floysand, A., Lindfors, E. T., Jakobsen, S. E., & Coenen, L. (2020). Place-based directionality of innovation: Tasmanian salmon farming and responsible innovation. *Sustainability*.

Fraaije, A., & Flipse, S. M. (2020). Synthesizing an implementation framework for responsible research and innovation. *Journal of Responsible Innovation, 7*(1). https://doi.org/10.1080/23299460.2019.1676685

Franssen, T. (2022). Enriching research quality: A proposition for stakeholder heterogeneity. *Research Evaluation*, 1–10. https://doi.org/10.1093/reseval/rvac012

Genus, A., & Stirling, A. (2018). Collingridge and the dilemma of control: Towards responsible and accountable innovation. *Research Policy, 47*(1), 61–69. https://doi.org/10.1016/j.respol.2017.09.012

Gibson-Graham, J. K, Herod, A., & Wright, M. W. (2002). Beyond global vs. local: Economic politics outside the binary frame. *Geographies of power: Placing scale* (pp. 25–60). Blackwell Publishers.

Hardin, G. (1968). The tragedy of the commons. *Science (New York, N.Y.), 162*, 1243–1248.

Heimeriks, G., & Balland, P. (2016). How smart is specialisation ? An analysis of specialisation patterns in knowledge production. *Science and Public Policy, 43*, 562–574. https://doi.org/10.1093/scipol/scv061. October 2015.

Hidalgo, C. A., Klinger, B., Barabasi, A.-L., & Hausmann, R. (2007). The product space conditions the development of nations. *Science (New York, N.Y.), 317*, 403–415. https://doi.org/10.4324/9781315657455-44

Hoffmann-Riem, H., & Wynne, B. (2002). In risk assessment, one has to admit ignorance. *Nature, 416*(6877), 123. https://doi.org/10.1038/416123a

Hooli, L. J., Jauhiainen, J., & Nkonoki, E. (2019). Contextualising innovation in Africa: Knowledge modes and actors in local innovation development. *2019 IST-Africa Week Conference*. https://doi.org/10.23919/ISTAFRICA.2019.8764864. *March*.

Janssen, M. J., Wesseling, J. H., Torrens, J., Weber, K. M., Penna, C., & Klerkx, L. (2023). Mission as a boundary objects for transformative change: Understanding coordination across policy, research, and stakeholder communities. *Science and Public Policy*, scac080.

Jasanoff, S. (2013). Epistemic subsidiarity - Coexistence, cosmopolitanism, constitutionalis. *European Journal of Risk Regulation, 4*(2), 133–141. https://doi.org/10.1017/S1867299X00003305S1867299X00003305

Kerr, A., Cunningham-burley, S., & Tutton, R. (2007). Experts and lay people in public dialogue. *Social Studies of Science, 3*, 385–411. https://doi.org/10.1177/0306312706068492. June.

Koirala, B.P., van Oost, E., & van der Windt, H. (2018). Community energy storage: A responsible innovation towards a sustainable energy system? *Applied Energy*, 231 (June), 570–585. 10.1016/j.apenergy.2018.09.163.

Ligtvoet, A., Cuppen, E., Di Ruggero, O., Hemmes, K., Pesch, U., Quist, J. et al. (2016). New future perspectives through constructive conflict: Exploring the future of gas in the Netherlands. *Futures*, 78–79, 19–33. 10.1016/j.futures.2016.03.008.

Loorbach, D. (2010). Transition management for sustainable development: A prescriptive, complexity-based governance framework. *Governance: An International Journal of Policy, Administration, and Institutions, 23*(1), 161–183.

Lubberink, R., Blok, V., van Ophem, J., & Omta, O. (2017). A framework for responsible innovation in the business context: Lessons from responsible-, social- and sustainable innovation. *Responsible Innovation 3: A European Agenda?*, 181–207. https://doi.org/10.1007/978-3-319-64834-7

Ludwig, D., Blok, V., Garnier, M., Macnaghten, P., Pols, A., Ludwig, D., et al. (2021). What ' s wrong with global challenges ? *Journal of Responsible Innovation, 0*(0), 1–22. https://doi.org/10.1080/23299460.2021.2000130

Lukes, S. (2011). *Moral relativism*. Profile books.

Macfarlane, A. (2003). Underlying yucca mountain: The interplay of geology and policy in nuclear waste disposal. *Social Studies of Science, 33*(5), 783–807.

Macnaghten, P., Owen, R., Stilgoe, J., Wynne, B., Azevedo, A., de Campos, A., et al. (2014). Responsible innovation across borders: Tensions, paradoxes and possibilities. *Journal of Responsible Innovation, 1*(2), 191–199. https://doi.org/10.1080/23299460.2014.922249

Magnan, A.K., Schipper, E.L.F., Burkett, M., Bharwani, S., Burton, I., Eriksen, S. et al. (2016). Addressing the risk of maladaptation to climate change. *Wiley Interdisciplinary Reviews: Climate Change*, 7(5), 646–665. 10.1002/wcc.409.

Martikainen, A., Kautonen, M., & Raunio, M. (2021). *Towards sustainable and responsible regional innovation policy—The case of tampere region*. In W. L. Filho, E. V Krasnov, & D. V Gaeva (Eds.) (pp. 279–294). Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-030-78825-4.

Massey, D. (2004). Geographies of responsibility. *Geografiska Annaler: Series B, Human Geography, 86*(1), 5–18.

Mazzucato, M. (2017). Mission-oriented innovation policy. *UCL Institute for Innovation and Public Purpose Working Paper, 1*.

Mazzucato, M. (2018a). Mission-oriented innovation policies: Challenges and opportunities. *Industrial and Corporate Change, 27*(5), 803–815. https://doi.org/10.1093/icc/dty034

Mazzucato, M. (2018b). *Mission-oriented research & innovation in the european union. A problem-solving approach to fuel innovation-led growth* (Vol. 58, Issue 1). 10.2777/36546.

Muttitt, G., & Kartha, S. (2020). Equity, climate justice and fossil fuel extraction: Principles for a managed phase out. *Climate Policy* (pp. 1024–1042). https://doi.org/10.1080/14693062.2020.1763900

O'Neill, O. (1996). *Towards justice and virtue. A constructive account of practical reasoning*. Cambridge University Press. 10.1017/CBO9780511621239.

Owen, R., Macnaghten, P., & Stilgoe, J. (2012). Responsible research and innovation: From science in society to science for society, with society. *Science and Public Policy, 39*(6), 751–760. https://doi.org/10.1093/scipol/scs093

Owen, R., Von Schomberg, R., & Macnaghten, P. (2020). Reflections on a decade of responsible research and innovation. *Journal of Responsible Innovation, 0*(0), 1–17. https://doi.org/10.1080/23299460.2021.1948789

Pesch, U., Huijts, N. M. A., Bombaerts, G., Doorn, N., & Hunka, A. (2020). Creating 'Local Publics': Responsibility and involvement in decision-making on technologies with local impacts. *Science and Engineering Ethics, 26*(4), 2215–2234. https://doi.org/10.1007/s11948-020-00199-0

Pfotenhauer, S., Laurent, B., Papageorgiou, K., & Stilgoe, J. (2022). The politics of scaling. *Social Studies of Science, 52*(1), 3–34.

Popa, E. O., Blok, V., & Wesselink, R. (2021). An AGONISTIC APPROACH TO TECHNOLOGICAL CONflict. *Philosophy and Technology, 34*(4), 717–737. https://doi.org/10.1007/s13347-020-00430-7

Rehfeld, D. (2019). Responsible research and innovation (RRI) and regional innovation studies (RIS)–reflecting on the normative aspects. *European Planning Studies, 27*(12), 2344–2358. https://doi.org/10.1080/09654313.2019.1667308

Rittel, H., & Webber, M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4*, 155–196. https://doi.org/10.1080/01636609209550084

Schomberg, R. Von, & Hankins, J. (2020). Introduction to the international handbook on responsible innovation. In R. Von Schomberg & J. Hankins (Eds.), *International Handbook on Responsible Innovation: A global resource* (pp. 1–11). Edward Elgar Publishing Ltd.

Schot, J., & Steinmueller, W.E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research Policy*, 47(July), 1554–1567. 10.1016/j.respol.2018.08.011.

Schroeder, D., & Kaplan, D. (2019). Responsible inclusive innovation: Tackling grand challenges globally. In R. Von Schomberg & J. Hankins (Eds.), *International Handbook on Responsible Innovation* (pp. 308–324). Edward Elgar Publishing.

Scott, D. (2021). Diversifying the deliberative turn: Toward an agonistic RRI. *Science, Technology, & Human Values*, 016224392110672. https://doi.org/10.1177/01622439211067268.

Smith, A., Fressoli, M., & Thomas, H. (2014). Grassroots innovation movements: Challenges and contributions. *Journal of Cleaner Production, 63*, 114–124. https://doi.org/10.1016/j.jclepro.2012.12.025

Star, S. L., & Griesemer, J. R. (1989). Institutional ecology, "translation" and boundary objects: Amateurs and professionals in Berkely's museum of vertebrate zoology, 1907-39 *Social Science Information, 19*, 387–420.

Stilgoe, J., Owen, R., & Macnaghten, P. (2013). Developing a framework for responsible innovation. *Research Policy, 42*(9), 1568–1580. https://doi.org/10.1016/j.respol.2013.05.008

Termeer, C. J. A. M., & Dewulf, A. (2019). A small wins framework to overcome the evaluation paradox of governing wicked problems. *Policy and Society, 38*(2), 298–314. https://doi.org/10.1080/14494035.2018.1497933

Thapa, R. K., Iakovleva, T., & Foss, L. (2019). Responsible research and innovation: A systematic review of the literature and its applications to regional studies. *European Planning Studies, 27*(12), 2470–2490. https://doi.org/10.1080/09654313.2019.1625871

UN. (2022). *Take action for the sustainable development goals*. https://www.un.org/sustainabledevelopment/sustainable-development-goals/.

Uyarra, E., Ribeiro, B., & Dale-Clough, L. (2019). Exploring the normative turn in regional innovation policy: Responsibility and the quest for public value. *European Planning Studies, 27*(12), 2359–2375. https://doi.org/10.1080/09654313.2019.1609425

Van Oudheusden, M. (2014). Where are the politics in responsible innovation? European governance, technology assessments, and beyond. *Journal of Responsible Innovation, 1*(1), 67–86. https://doi.org/10.1080/23299460.2014.882097

von Hippel, E. (1986). Lead users: A source of novel product concepts. *Management Science, 32*(7), 791–805. https://doi.org/10.1287/mnsc.32.7.791

Von Schomberg, R. (2011). Towards research and innovation in the information and communication technologies and security technologies fields. *Science in society*.

Von Schomberg, R. (2013). A vision of responsible research and innovation. In *Responsible innovation: Managing the responsible emergence of science and innovation in society* (Issue June 2013). 10.1002/9781118551424.ch3.

Wanzenböck, I., & Frenken, K. (2020). The subsidiarity principle in innovation policy for societal challenges. *Global Transitions*, 2, 51–59. 10.1016/j.glt.2020.02.002.

Wanzenböck, I., Wesseling, J. H., Frenken, K., Hekkert, M. P., & Weber, K. M. (2020). A framework for mission-oriented innovation policy: Alternative pathways through the problem–solution space. *Science and Public Policy, 47*, 474–489. https://doi.org/10.1093/scipol/scaa027. July.

Weber, K. M., & 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* (6), 1037–1047. https://doi.org/10.1016/j.respol.2011.10.015

Wesseling, J.H., & Meijerhof, N. (2021). *Developing and applying the Mission-oriented Innovation System (MIS) approach.*

Wiarda, M., van de Kaa, G., Doorn, N., & Yaghmaei, E. (2022). Responsible innovation and de jure standardisation: An in-depth exploration of moral motives, barriers, and facilitators. *Science and Engineering Ethics, 28*(65), 1–26. https://doi.org/10.1007/s11948-022-00415-z

Wiarda, M., van de Kaa, G., Yaghmaei, E., & Doorn, N. (2021). A comprehensive appraisal of responsible research and innovation: From roots to leaves. *Technological Forecasting and Social Change, 172*, Article 121053. https://doi.org/10.1016/J.TECHFORE.2021.121053

Wong, P. H. (2016). Responsible innovation for decent nonliberal peoples: A dilemma? *Journal of Responsible Innovation, 3*(2), 154–168. https://doi.org/10.1080/23299460.2016.1216709

Young, I. M. (2006). Responsibility and global justice: A social connection model. *Justice and Global Politics, 4*(4), 102–130. https://doi.org/10.1017/CBO9780511550744.005