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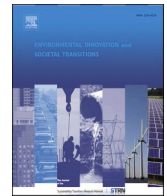
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Agency, directionality, location and the geographic situatedness of knowledge making: The politics of framing in innovation research on energy

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ABSTRACT

In this conceptual review, we use the concept of “framing” to explore how scholars work with innovation. Using a thematically and geographically diverse sample of 88 articles, we focus on sustainability transitions as research domain, energy as sector and literature review as method. Framings of innovation differ by themes such as agency, directionality and location, as well as onto-epistemological categories such as envisioned academic contribution and geographic situatedness of knowledge making. The implications of some framings are concerning, such as that econometric analysis of firm-level innovation in higher income countries can proxy for innovation globally, or that donors are the principal stimuli of innovation in lower income countries. This research shows how groups, places or outcomes are included or excluded in different domains of innovation research. We propose a heuristic tool which seeks to render explicit the boundaries for innovation drawn in any article, to aid reflexivity and epistemic humility.

1. Introduction

The concept of innovation has long been central to academic practice which seeks to understand processes of sociotechnical change. These discussions have produced highly cited, policy-influencing research across a broad range of empirical contexts and disciplines. For example, the roots of many contemporary and influential innovation understandings deployed in research (see for example Mazzucato, 2013; Acemoglu et al., 2012; Kivimaa and Kern, 2016) can be traced back to the seminal work of Joseph Schumpeter on “creative destruction” which distinguishes innovation from invention and diffusion and highlights how novelty continually displaces - or destroys - what came before (Schumpeter, 1942). Schumpeter’s emphasis on novelty laid the foundations for highly influential models which frame innovation as a linear and sequential process of change (Godin, 2006). Subsequent analyses have shifted away from linear models (albeit not entirely, as seen in Grubb et al., 2021) towards systems-orientated frames (Freeman, 1995; Bergék et al., 2008a; Martin, 2016; Ornetzeder and Rohracher, 2013; Hewitt et al., 2019). Concurrently, critical theorists have engaged with innovation from historical (Godin and Gaglio, 2019), feminist (Pettersson & Lindberg, 2013) or decolonial (Jammulamadaka, 2019) perspectives, conceiving and critiquing innovation more as construct than empirical phenomenon. There is a broad range of literature engaging somehow with innovation as a concept from differing ontological and epistemological standpoints.

The literature on sustainability transitions is one such example of a sociotechnical research domain in which innovation is

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commonly discussed. Reflecting the prevalence of systems-orientated understandings (Martin, 2016), frameworks such as the Multi-level Perspective (MLP), Technological Innovation Systems (TIS) and Strategic Niche Management (SNM) have been extensively theorized. The energy sector has been a key domain of focus for sustainability transitions research (Van der Bergh et al., 2011); the following analysis is positioned at this intersection between sustainability and energy system change.

In this conceptual study, our research aim is to turn the analytical lens on the *knowledge making* process of innovation to understand how the concept is framed in and by academic articles. This is motivated by two central concerns. The first is that the knowledge politics between innovation understandings are often obscured from view by scholars occupying an “eagle eye” epistemological perspective of assumed universalised knowledge production. This is despite calls for “worm eye” perspectives with the “epistemic humility” to acknowledge one’s situatedness and thus the necessity of plural approaches (Stirling, 2019 p.11). The second concern is that the politics of framing understood from a spatial perspective may lead to problematic portrayals of both actors and locations. For example on a transcontinental scale, the African continent has been depicted either as a passive *recipient* of innovation (Mavhunga, 2017) or even entirely absent from analysis (see for example Chen et al., 2018) This connects to observed geographic imbalances in energy knowledge production processes and politics between these knowledges (Ali et al., 2023). These concerns, rooted in the knowledge politics of exclusion, shed light on central questions in the sustainability transitions literature around who participates in transitions.

This research seeks to therefore fill a gap in the literature on sustainability transitions. There are growing calls for reflexivity in transitions research (Stirling, 2011; Feola, 2020; Wieczorek, 2018; Hopkins et al., 2020) but these perspectives remain marginal in the sustainability transitions literature, and have not yet been applied specifically to innovation, which continues to be primarily conceived as something “out there” to be studied. Furthermore, there remains a paucity of tools and examples to assist transitions scholars to practice reflexivity regarding how their own academic output may play into knowledge politics.

Our contribution towards addressing this gap is therefore threefold. First, we demonstrate characteristics of innovation which can be framed differently and thus operationalise innovation in a certain way in any given article. This renders the knowledge politics in innovation research explicit, since different scholars foreground very different things. Second, the categories of analysis by which we show innovation to be framed - agency, directionality, location and the geographic situatedness of knowledge making - provide insights in relation to our concern about how actors and places are portrayed as passive or absent in innovation. Given our concern regarding geographic imbalances, we work with a thematically and geographically diverse body of literature, with special attention paid to literature both on and emerging from countries in Sub-Saharan Africa. Third, we propose a heuristic tool to help scholars to be more reflexive in their use of “innovation” as a conceptual construct. While far from a holistic and comprehensive framework for reflexivity, this provides one possible means for academics to ask themselves about the frames that they work through when they use innovation as a concept.

This article begins by introducing the theoretical lens of knowledge politics, definitions and connotations of innovation and categories of analysis by which innovation may differ, as well as the concept of “framing” which we use to unpack the literature sample. After an overview of the method used to review the sample of 88 articles, the results section describes how the literature varies in relation to framing of academic contribution and geographic situatedness of knowledge making as well as how scholars envision agency, directionality and location in innovation. This is followed by a discussion of possible connections between these framings and their implications, including for sustainability transitions, followed by conclusion and limitations.

2. Theory

This article applies a lens of knowledge politics to innovation understandings in academic literature that explicitly deals with changes in energy sectors, framed in the language of sustainable development or sustainability transitions. To anchor this approach theoretically, we will first briefly describe the term “knowledge politics” followed by definitions and connotations of innovation and then a discussion of how we think of articles as individual “actants” which frame innovation. We conclude the section with a brief introduction to the categories of analysis by which innovation understandings differ.

2.1. Knowledge politics

As an umbrella term, knowledge politics has old roots in epistemological debates around the character of academic knowledge (see Longino, 2019), as opposed to other knowledge systems or ways of knowing. At its heart lies a recognition that all scientific knowledge and technological applications are both situated (Haraway, 1988; Rose, 1997) and “agents of political production” (Jasanoff, 2011 p.12) despite the common presentation of knowledge as universal, neutral and objective (Grosfuguel, 2011). The term is broadly used to signify the myriad ways in which science as institution and practice is shaped by and shapes political agendas, is used for political goals, engages in politics, and evolves with and through politics (Haraway, 1988; Stehr, 2005; Said, 2005; Fischer, 2019). But also, the politics of knowledge concerns the “meaning-producing technologies of the field, its methods and theories, its ways of telling stories” (Bellacasa, 2011 p. 86; Haraway 1988). Such politics - understood in a broad sense of political beliefs and principles - are embedded within mundane academic practice in the social activity of producing knowledge. Scientists’ categories and constructs are thus not naturally given but “contingent on social traditions, perceptions and experience” (Fischer 2019, p.137).

The theoretical and methodological orientations of scientists and research fields reflect more widely held norms and beliefs in society, which historically has meant that science has served many purposes. Such purposes have included to legitimize the subordination and exploitation of women, the poor, colonized and indigenous people (Fanon, 2002; Said, 1978; Jones, 2015; Martinen, 2015; Merchant, 1990). After the second World War, academic minorities such as women and scholars from former colonies launched

fundamental critiques of academic institutions and practices (Said, 1978; Haraway, 1978; Harding, 1986; Akbar, 1984), exposing methodological bias and research designs that reproduce stereotypes (Haraway, 1978; Rose, 1983). These coruscating critiques have combined with sociological critiques regarding the social shaping of scientific practice (Pinch, 1990; Collins, 1992; Cetina, 1999; Law, 2008). Although these critiques mushroomed in institutions all over the world, they are concentrated in the field of Science and Technology Studies (STS). More recently, scholars have shown how the institutionalization of research continues to privilege elites and continues to exclude marginalized groups (Maeso and Araújo, 2015; Seawright, 2014; Rose and Kalathil, 2019).

At the conflictual, yet productive, border of the positivist versus constructivist paradigms, new fields and perspectives have emerged that engage with plural ontologies, epistemologies and socio-material entanglements in interdisciplinary fields like human geography, STS and critical resource studies (Bellacasa, 2011; Nightingale, 2016; Banerjee, 2021; Sprenger and Großmann, 2018). Narrating progress beyond this impasse, Baert & Rubio (2011) reflect that focus in contemporary scholarly discussion is more concerned about the ontological dimensions of knowledge: that is, about its generative capacity to produce new entities and relations in the world (Baert and Rubio, 2011). As a broad lens, a knowledge politics framing is not a call to dismantle or discredit knowledges but rather encourages careful reflection around the logics which underpin research and the world-making effects of analytical observation (Scott, 2004; Bellacasa, 2011). In this study, we apply a knowledge politics frame to the concept of innovation.

2.2. Defining innovation

Several scholars and institutions have sought to define innovation. Dictionary definitions define innovation as “1. a new idea, method, or device; 2. the introduction of something new” (Merriam-Webster, 2023) or “a new thing or a new method of doing something” (Collins English Dictionary, 2023). Innovation has also been broken down into categories, whether between product and business process innovation (OECD/Eurostat, 2018); hardware, software and orgware changes, or combinations of these (Smits, 2002); or between “technological innovation” and “non-technological innovation” (Schmidt and Rammer, 2007; Mothe and Thi, 2010). The lines between these disaggregated categories attempting more granular categorisations depend upon the context within which innovation is being discussed, and how one understands terms such as “technology”. On a broad level, Andersson & Törnberg (2018 p.124) define innovation simply as a causal process of change which intrinsically is “without regard to whether the change is good or bad, or with respect to whom or what”.

2.3. Connotations and implications of innovation as a concept

Innovation, as the definitions above indicate, is thus an incredibly broad term, with a huge range of possible activities and outcomes which it could be used to describe. This creates space for a wide range of possible connotations and imbued meanings of innovation as soon as one departs from a fundamental definition of novelty or change by operationalizing it in a specific context. As Faunce (2012) demonstrates with a case study of Free Trade Agreements, references to innovation may be intentionally ambiguous, with its potential for amorphousness creating a productive space in terms of what can be claimed to count as innovation. Furthermore, the meanings associated with innovation have been alleged to reflect policy and corporate agendas. It has become valorized with strongly desirable connotations, greater even than policy principles such as equality and making those unsupportive appear retrograde (Faunce, 2012). Whether innovation is operationalised as linear and controlled or disordered and unpredictable plays a part in shaping what scholars imagine a transition to be and who leads it (Stirling, 2009).

A central critique of the term innovation is that using it in discussions of sociotechnical change tends to conjure certain kinds of activities and directionalities over others. Scholars describe how the term innovation is strongly associated with framings of techno-optimism, resulting in discussions of innovation being encoded with assumptions that technology will “save the day” and overlooking perceiving problems and thus solutions from alternative perspectives, such as that of “communities of diverse practitioners ranging from workers and peasants to craftspeople and forest peoples”¹ (Arora et al., 2020 p.253). Concerns such as these have led scholars to even look beyond the term innovation, for example in recent calls for “exnovation” (David, 2017). This is not in place of the term innovation, but rather to rebalance focus in transitions away from dominant techno-optimistic conceptualisations of innovation and towards dismantling what exists at present. From a geographic perspective, scholars have argued that there is a need to reconceptualise how innovation is understood so that innovations that are rooted in histories and practices from different parts of the world, and in particular the African continent, can be recognised (Mavhunga, 2017). Different operationalizations of the broad term innovation appear better or worse suited to enacting desirable visions of the future; all depending on one’s perspective.

2.4. Defining framing as a process

Wolsink (2020) describes how conceptual frames - used by scholars to make sense of the world around them - can be used to make “cognitive shortcuts” which enforce certain interpretations and discourage others, particularly when used shorthand in conclusions or policy recommendations. Relatedly, Nancy Frazer (interviewed in Nash and Bell, 2007) emphasizes that the act of including some things and excluding others render framing a political process. Framing of concepts or issues can thus subtly lock-in injustices by overlooking certain aspects of that concept or issue which, from Frazer’s perspective, ought to be part of the discussion. Thus the process of framing

¹ Although the article does not offer a precise definition of forest peoples, we understand the term to refer to people living in forests as opposed to – for example – urban or cultivated rural areas.

is not purely conceptual: it has material effects. Framings having different kinds of influences upon technological and societal change. Sovacool et al. (2020a) and Wolsink (2020) explain how terms like innovation frame problems and solutions differently, fulfilling an instrumental purpose by enabling proponents to yield influence and capture resources.

Given the broadly applied yet nebulous character of innovation as a concept, “framing” becomes a useful analytical tool for us to unpack what is included and excluded in understandings of innovation. In this article, we define framing as the dynamic process by which a specific combination of aspects which give a concept meaning - in this case, innovation - are brought into the foreground; locating other aspects which could lead to alternative meanings in the background. We think of academic framing in this article less as a fixed object - e.g. “a framing of innovation” - and more as a dynamic process which is constantly changing but can be reproduced by an act of scholarship framing an issue or domain in a certain way. We use our literature sample to build evidence of this framing process.

2.5. Academic articles as actants which frame innovation

In this article, we treat scientific articles as artefacts embodying a framing of innovation. The concept of boundary work, and boundary objects (Gieryn, 1983; Rijswoud, 2012), when combined with the concept of framing, implies that scholarship on innovation implicitly locates certain actors and places in the foreground as involved in innovation. Such boundary objects create spaces. These spaces become associated with meanings which may differ between groups - that people can act towards and with (Star, 2010). Specific articles, distinct from who authored them, can act as boundary objects in this regard by building consensus (deliberately or not) around what counts as innovation for different groups. This logic of separating scholar and article is rooted in STS perspectives which decentre human agency and control, meaning that seemingly apolitical artefacts can be thought of as actants that ‘do’ things and are enroled in politics (Law and Singleton, 2013; Akrich, 1992). Articles work like the ‘script’ (Akrich, 1992) that is performed and given new interpretation in the unique constellation of its contingent performance. We characterise articles as carrying a point-in-time frame related to innovation, perceptibly distinct from its author who likely thinks through multiple dynamic frames.

2.6. The geographic situatedness of knowledge making

Literature discussing politics between knowledges has pointed to the geographic situatedness of knowledge as a critical differentiator between scholarship. This can be understood in terms of where scholars speak *from* and *to*. Both feminist STS (Haraway, 1988) and decolonial scholars (Mignolo, 2009; Grosfoguel, 2007) place emphasis on locating the onto-epistemological perspective which scholars speak *from*, even if their situatedness is obscured by dominant scholarly practices (Grosfoguel, 2007 p.168). The power structures which constitute the full situatedness of knowledge are multidimensional (Collins, 2000) but in this article we foreground situatedness primarily in terms of geographic location. “Speaking from” can thus comprise both the location of research practice as well as the provenance of the academic logics, frameworks and methods used (Sugiharto, 2020).

By “speaking to”, we refer to the scale of the knowledge claims being made; where geographically is relevance assumed? One can question what knowledge making from a certain vantage point might *do*. For example, Dwyer & Jones (2000) allege that spatial epistemological framings of Whiteness enable authors to navigate and speak to spaces from an implied position of authority. Relatedly, black feminist scholars have demonstrated how powerful interests limit the extent of knowledge claims which can be made by those somehow “outsiders” to dominant knowledge production (Collins, 2000). One aspect of where knowledge speaks *to* is the relation - often mismatch - between empirical grounding and claims to relevance. Here, work on alternative knowledge systems indicates that scientific knowledge and indigenous knowledge cannot simply be considered “complementary”; there are more profound knowledge conflicts related to framing, observation and legitimacy (Lebel, 2006; Ahlborg and Nightingale, 2012).

The effects of geographic situatedness of knowledge making can be illustrated by examples. A number of studies have shown how knowledge making processes which speak to lower income countries - but from (i.e. theoretically situated in) higher income countries² - are likely to frame conclusions in a certain way. Van Welie et al. (2018) show how the commonly used sustainability transitions concept of “regime”, if taken at face value, misrepresents the characteristics of the sanitation sector in Nairobi, Kenya; particularly its high level of heterogeneity and instability. The suggested alternative concept of “splintered regime” constitutes several distinct regimes, with cleaning buckets and plastic bags constituting the infrastructure in some regimes. This raises questions about what counts as a regime in both higher and lower income countries. Similarly, Arora et al. (2014) show how the concept of “institutions” needs to be reworked in countries such as Tanzania, where they study the biofuel innovation system and find that colonial legacies play a strong role in shaping institutional meanings and arrangements. Similarities can be seen in Gandy (2008)’s emphasis on the particularities of the Indian context in an analysis of state formation in relation to water management in Mumbai.

Further examples include the “contradiction” of innovation in India; that is, how analysing the Indian medical system from a

² Various terminologies have been used to categorise countries in the world into groups reflecting political, economic and social differences, such as the “Global North” and “Global South”. We find these terms to be somewhat amorphous and to require encoded judgements regarding what constitutes “North” and “South”. While we do work with these concepts when this is the language specifically used by referenced scholars, on a general basis we prefer to work with a simple and concrete distinction between nation states as either lower or higher income. We define lower income countries to be “Low and Middle Income Countries” (LMICs) and higher income countries to be “High Income Countries” (HICs) as defined by the World Bank. While the notion of a binary geographic distinction between more and less “developed” places has been critiqued (Horner, 2020) we do find it necessary to somehow distinguish between places.

western, patent-orientated understanding of innovation makes the country appear non-innovative relative to Europe and the US. In contrast, adopting an Indian “frugal innovation” understanding demonstrates how factors usually perceived as barriers to patent-orientated innovation - a lack of funding and adequate infrastructure - in fact foster frugal innovations such as low-cost yet effective methods of eye surgery (Jammulamadaka, 2018). Other examples demonstrate how this also affects policy actors; that elites, including donors and development banks, often encode a commitment to follow the example of higher income countries when seeking to spur modernity in lower income countries (Nilsson, 2016). These examples emphasise how both material locations and concepts such as innovation often carry encoded values, meanings and strongly contextual specificity, and that the relationship between the two must be carefully considered. Extreme care - and often substantial theoretical revision - is indicated to be necessary.

2.7. Unpacking how innovation is framed from an agential, directional and locational perspective

Within the literature on transitions and transformations towards sustainability, there are concepts - such as agency, location and directionality - which scholars use to analyse the character of transition pathways and differentiate between them. Unpacking how scholarship approaches these three concepts in relation to innovation (i.e. who has agency in innovation, where does it happen and what does it lead to) can similarly illustrate the diverse ways in which innovation can be framed. Agency is a central category of analysis in discussions of transitions and transformations towards sustainability (Pesch, 2015; Fischer and Newig, 2016; Huttunen et al., 2021). Agency has traditionally been contrasted with structure; and is used to describe, compare and often dispute actors’

Table 1

List of searches in Scopus which were used to produce the sources included in the literature sample.

Search description and rationale	Search terms for scopus - must be in keywords, title or abstract ⁵	Scopus search results ⁶	# of Abstracts shortlisted ⁷	# of Articles included in sample ^{****}
Sustainability transitions understandings	Transitions OR Multi-level perspective OR Technological Innovation Systems OR Niche Management AND innovation AND energy OR electricity	458	8	8
Innovation Studies working with economics-orientated concepts	Productivity OR Economic Growth OR R&D OR Research and Development OR Patent AND Energy OR Electricity AND Innovation	729	11	5
Energy innovation literature on Africa	At least one African country named AND innovation AND energy OR electricity	249	23	9
Energy innovation literature from Africa	At least one author affiliated with an institution in an African country AND innovation AND energy OR electricity	235	15	8
Energy democracy and energy justice perspectives on innovation	Energy justice OR energy democracy AND innovation	17	8	5
Perspectives on democratising innovation	Deliberation OR citizen science OR coproduction OR cocreation OR co-production OR co-creation OR democratizing OR democratic AND innovation AND energy OR electricity	57	8	7
Responsible research and innovation	Responsible research and innovation AND Energy OR Electricity	14	10	4
Entrepreneurship	Entrepreneurship AND innovation AND Energy OR electricity	55	7	3
Service innovation	Service Innovation OR Servitization OR Servitisation AND Energy OR electricity	21	8	3
Open innovation	Open innovation AND Energy OR Electricity	30	7	3
Social innovation	Social innovation AND energy OR electricity	33	5	3
Business model innovation	Business model AND Energy OR electricity	103	8	2
Frugal innovation	Frugal OR Gandhi OR Reverse engineering OR Jugaad OR Energy sufficiency AND Energy OR Electricity AND Innovation	7	3	2
Grassroots innovation	Grassroots innovation AND energy OR electricity	24	4	2
Inclusive innovation	Inclusive innovation AND energy OR electricity	62	2	1
User innovation	User innovation AND energy OR electricity	15	5	1
Critical theory, postcolonial and decolonial perspectives on innovation	Innovation AND Postcolon- OR Decolon- OR Critique OR Problematic ⁸	38	13	9
Feminist or gender-orientated perspectives on innovation	Feminist OR Gender AND Energy OR Electricity AND Innovation	40	7	6
Efforts to characterise innovation as multiple	Innovation worldviews OR Innovation discourses OR innovation understandings OR innovation paradigms ⁹	45	14	7

⁵ All articles searched for were required to include “innovation” as an author keyword, as a way of ensuring the articles focused clearly on innovation as a theme.

⁶ Accurate on May 20th 2021.

⁷ From the initial list of search results for each search, results were organised in order of citations. We then screened the titles and abstracts of the top 50 results and produced a shortlist of abstracts of articles.

⁸ Further screening of abstracts took place, based on which articles offered contrasting perspectives regarding energy innovation, seeking to avoid replication with the other selected literature, and to balance the time available for literature review across these different areas.

⁹ Very few results are energy-specific, so the search did not include energy as a required keyword.

capacity to affect change. Location in this context is understood to relate to what the role is of different places in pathways towards sustainability (Coenen and Truffer, 2012; Coenen et al., 2012; Truffer et al., 2015). Directionality, understood here as the possible directions associated with change, has a long conceptual history in discussions of technological pathways (Lovins, 1976; Stirling, 2008) and is now a central category of analysis related to where precisely transitions and transformations might head towards (Trischler et al., 2022; Kanger and Schot 2019; Köhler et al., 2019).

How scholars approach these different aspects in research on innovation varies significantly and provides a means of rendering innovation more precise. Some scholars may explicitly foreground certain directionalities, locations or actors; others do so implicitly through the design of their empirical case studies for example. Either way, these are aspects of the framing process which foreground certain locations, actors or directions as more associated with innovation than others. When understandings of innovation are consequently enacted materially, certain actors or locations - associated with directions of innovation considered desirable by those offering resources - may benefit comparatively more from resources associated with such an understanding. It is therefore valuable to investigate how articles vary in the way they frame innovation from an agential, directional and locational perspective.

3. Materials and method

We chose to undertake an integrative review, including a selection of articles from different academic traditions on innovation, to characterise breadth at the expense of depth, without attempting to be exhaustive (Synder, 2019). Table 1 below summarises the searches we included to identify 88 articles for the literature review. The aim was to build a sample with a wide enough breadth of innovation perspectives to identify differences between literatures. We did not sample literature in proportion to the size of academic output or citations, recognising that this would trend strongly towards higher income country perspectives. Rather we used search terms to ensure the inclusion of innovation scholarship both on and from Africa, given geographic imbalances in knowledge production (Ali et al., 2023). The final sample includes articles with an empirical focus on every continent bar Antarctica. From a geographic perspective, 38 of the articles have an empirical focus on OECD countries, and 25 of the articles include focus on one or more countries outside the OECD. The remaining articles look across both OECD and non-OECD countries or take a conceptual perspective. Methodologically, 53 articles include qualitative empirical research and 14 articles undertake quantitative empirical research. The remaining articles are conceptual or reviews.

First, we shortlisted articles from each search which engaged with the concept of innovation and that related somehow to change in the energy sector. These searches were limited to articles fitting within the “social sciences”. According to Scopus, this includes the Arts and Humanities, Business, Management, and Accounting, Decision Sciences, Economics, Econometrics, and Finance, Psychology, and Social Sciences subject areas. We then scanned shortlisted articles to identify a final list for closer reading and coding by themes. For searches with a high number of hits, we selected a sample of these articles by ranking search results first by citations (high to low) and then by date of publication. This enabled us to orientate the sample towards a combination of highly cited articles (typically published 5 or more years ago) along with more recent articles which have already received citations. We selected a subset of the results of each search by scanning the abstracts of those articles to ensure they have a substantive connection to the theme of the search (e.g. “responsible research and innovation” or “sustainability transitions”) as opposed to only mentioning a link to innovation in passing. This gave us a combination of some “seminal” articles and other newer or niche perspectives, relating to a variety of different perspectives on innovation, as well as being a geographically broad sample.

We then closely read the articles, looking out specifically for how articles conceptualize innovation. The idea of foregrounding is central to the approach. We do not argue that literature suggests only a single actor or context is associated with innovation - indeed much innovation literature emphasises plurality and systems perspectives. Rather, we assert that in most innovation literature an implicit foregrounding effect takes place in which certain kinds of actor, driver, outcome or location receive comparatively greater attention than others. We argue that this foregrounding (and consequent backgrounding) effect is one aspect of knowledge production which has political dimensions, by implying boundaries around certain characteristics of innovation.

We believe that a core contribution of this research method is to illustrate the need for scholars who work with the concept of innovation to be reflexive; to think of framing as a *process* which is ongoing and dynamic, and which they engage in as part of academic practice. This creates space for the proposal and discussion of heuristic tools to assist researchers to study innovation as part of a research process which is more sensitive to what is backgrounded and foregrounded, and the possible effects of this. This responds to calls for greater reflexivity amongst scholars, discussed in more detail in the theory section (Stirling, 2008; Haraway, 1988). By way of example, we propose a possible heuristic tool in the conclusion of this article. Recognising the integrative nature of the literature sampled, the focus is thus on framing as *process*: the specific frames described in this article are merely illustrative and situated products of the literature sample we assessed.

4. Results

In this results section, we analyse how innovation is framed in different ways within the literature example. We seek to unpack what precisely is connoted by innovation in literature related to energy systems change, according to how it is framed. Drawing on the theory introduced above, we use five categories of analysis to highlight the differences and politics between knowledges of innovation within our literature sample. The first two relate to onto-epistemological query and the following three categories relate to how innovation is operationalised in an article. While there are connections between the second and fifth category of analysis, we understand geographic situatedness to refer to the context within which knowledge making is situated (as described above), whereas location refers more to how place is conceptualised by knowledge making on innovation (Khan et al., 2013). These categories structure

our results, and are as follows:

- 1 Framing of academic contribution in relation to innovation
- 2 Geographic situatedness of knowledge making on innovation
- 3 Agency in innovation
- 4 Directionality of innovation
- 5 Location of innovation

For each of these categories, there are several distinct trends which are presented as sub-sections below. We follow these sub-sections with Section 4.6 which describes possible connections between framing of academic contribution and other characteristics of innovation which are operationalised in the articles within the sample.

A synthesis of these results can be found in Fig. 1 which indicates the range of possible ways in which each aspect of innovation can be framed, and how any specific article draws on a particular constellation of different characteristics to present innovation in a certain way. This is illustrative of framing as a process rather than an exhaustive account of frames which exist. There are both more characteristics of how innovation is framed than those presented in the bubble, and there are also many more different ways of framing these specific characteristics than those found in our literature sample.

4.1. Framing of academic contribution in relation to innovation theory

The first trend we see in the literature regarding how the academic contribution is framed is articles which seek to contribute towards an existing innovation theory. This may be by questioning assumptions, filling identified gaps or developing theories within a recognised innovation research domain. These articles do so by broadly adhering to - and thus implicitly endorsing - the research domain in question. Domains within the sample include the MLP (Sovacool and Brisbois, 2019; Geels et al., 2016); service innovation (Lütjen et al., 2019; Daim et al., 2013); sustainable entrepreneurship (Gasbarro et al., 2017); technology acceptance (Müggenburg et al., 2012), adoption (Olaoye et al., 2020), the effects of innovation prizes (Barnett and Brown, 2021) and functioning of testbeds and living labs (Engels et al., 2019). Depending on the research domain, the identified gaps differ, related for example to system dynamics in TIS (Bergek et al., 2008a; Bergek, 2019), or aspects of the innovation process understood to be commercially significant (Lütjen et al., 2019; Daim et al., 2013). Other articles seek to establish connections between understandings such as business model innovation and sustainability transitions (Bolton and Hannon, 2016), RRI in relation to energy justice frameworks, social practice and value centred design (Jenkins et al., 2020; Sovacool et al., 2021) as well as looking across system, network and ecosystems perspectives (Russo-Spena et al., 2017).

A related but distinct trend emerging in the literature is articles which seek to contribute by reacting to observations that innovation theories have mostly been deployed in the geographies within which they were conceived - primarily higher income countries. The authors therefore apply these theories elsewhere, believing them to be of instrumental value. Thus, while they may reflect on the experience of translating these theories to new places, the main contribution is framed as an empirical insight *enabled* by theory, rather than a more theoretical contribution. Examples of innovation understandings which are extended geographically include grassroots energy innovation (Berka et al., 2020), TIS (Tigabu et al., 2015; Tigabu, 2018), innovation systems (Pansera, 2013a; Vidican, 2015), strategic niche management (Ongoma, 2018) and broader technological innovation (Dauda et al., 2021; Owwoye et al., 2020; Sanni, 2018).

Other articles seek to apply innovation theory to policy processes in order to better understand how to achieve desired policy outcomes. These articles take a specified innovation understanding without questioning it, forming part of the articles' framing. Analytically, this renders innovation as a "black box" concept which is not critically engaged with in the article in question. Rather, the causal *relationship* between a fixed understanding of innovation (understood as a desirable outcome) and other phenomena is foregrounded. This includes its relationship with wind power diffusion (Söderholm and Klaassen, 2007) competition and environmental policy (Nesta et al., 2014; Dechezleprêtre and Glachant, 2014) or patenting regimes and other intellectual property protections (Zobel et al., 2016; Li et al., 2020) or various factors (Grubb et al., 2021). Alternatively, scholarship focuses on how innovation drives desirable outcomes; such as energy productivity (Santra, 2017) and carbon emissions (Ganda, 2019). Questions regarding optimum policy mixes also come to the fore, particularly whether carbon pricing can achieve decarbonisation via innovation (Acemoglu et al., 2016; Fischer and Newell, 2008).

Another trend in the literature related to policymaking is articles which applying innovation theory to demonstrate that current policymaking somehow misrepresents innovation. These articles critique problematic assumptions regarding innovation at work within innovation policy, as opposed to leaving it as a "black box" as those articles described above. These include excessive focus upon technological innovation (Hewitt et al., 2019), a lack of attention paid to regime destabilisation (Kivimaa and Kern, 2016) or over-reliance on private finance (Mazzucato and Semieniuk, 2017). Policy scenario planning is also critiqued, perceived to assume unreasonable levels of rationality, excessive focus on end states and neglect of political and sociocultural factors (Foxon et al., 2010; Verbong and Geels, 2010). A third perceived area of problematic policy assumptions is in the lack of focus on energy innovation relative to other policy priorities in countries in lower income countries (Soumonni, 2013; Perrot and Sanni, 2018).

A final perceptibly distinct trend in the literature is articles whose contribution is to critique innovation theory on a foundational level, rather than seeking to adjust or expand it. Allegations include that innovation theory is problematically reductive of complexity, or even actively exclusionary in how it is formulated. Research domains critiqued as marginalising actor roles or simplifying processes include generalised understandings of innovation (Winkel, 2017; Wolsink, 2018; Surie, 2017; Davidson, 2019) and its diffusion

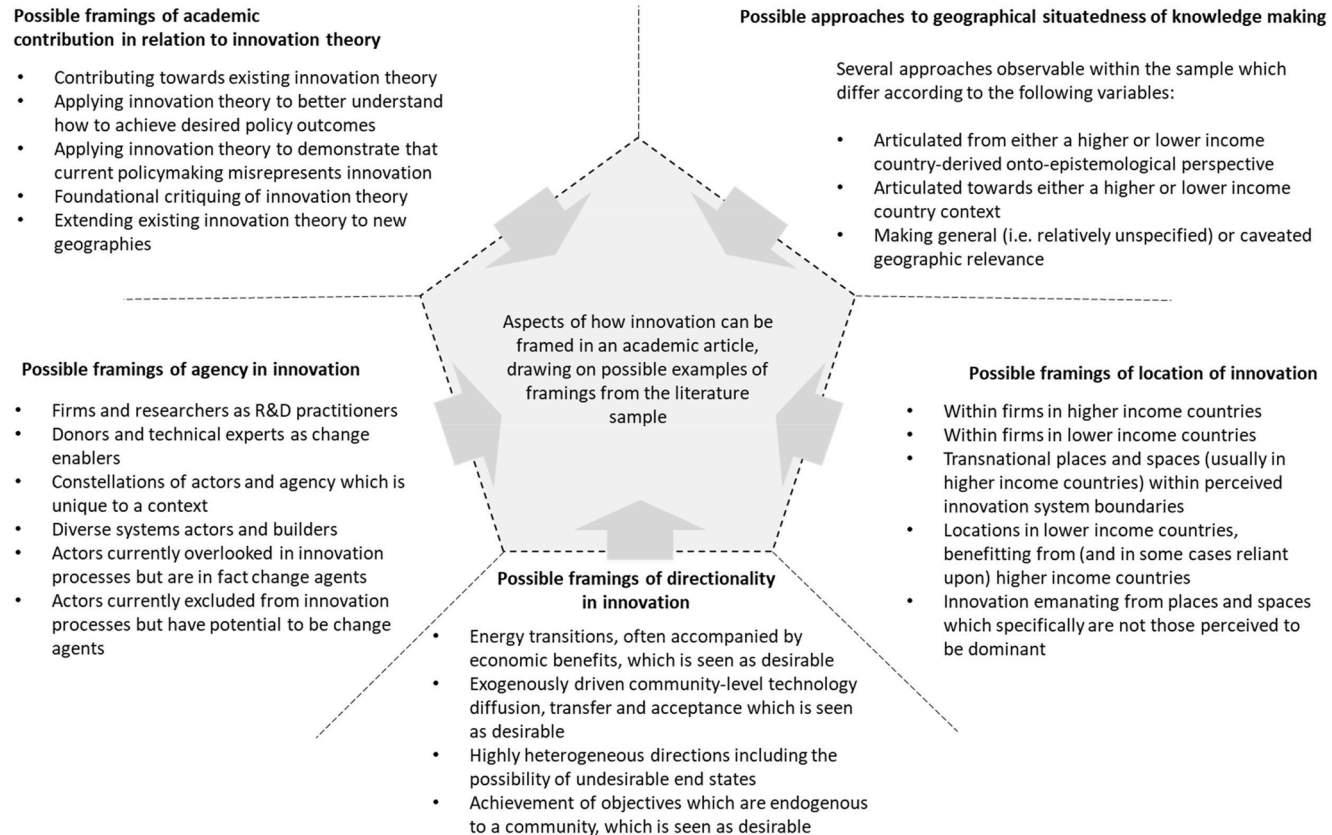


Fig. 1. Visual summary of results showing the multidimensional ways in which innovation is framed, based on the different characteristics of innovation identified in the literature sample.

(Sovacool et al., 2020b; Sampsa et al., 2016) and western innovation understandings which are perceived as dominant (Pansera, 2013b; Chen et al., 2018). Specific domains critiqued which are alleged to be overly simplistic include Sectoral Systems of Innovation (Arora et al., 2014), RRI (Groves et al., 2016), the MLP (Doci et al., 2015), frugal innovation (Levänen et al., 2016); user innovation (Martiskainen et al., 2021); and the linear model of innovation (Carayannis and Campbell, 2009; Hekkert and Negro, 2009). Allegations of exclusions are directed towards the MLP (Hopkins et al., 2020; Lieu et al., 2020; Seyfang and Heseltine, 2012), TIS (Hopkins et al., 2020), RRI (Koch, 2020; Sauermann et al., 2020); living labs experimentation (Delina, 2020; Batinge et al., 2021); perceived technological innovation orthodoxy (Arora et al., 2020; Kotilainen et al., 2019; Burke and Stephens, 2017; Jerneck and Olsson, 2013; Koirola et al., 2018), “masculinist” innovation discourse (Pettersson and Lindberg, 2013) and perceived eurocentric understandings of innovation (Calvo Martinez et al., 2019; Jammulamadaka, 2018; Ludwig and McNaughten, 2020). Such exclusions are related to but are distinct from allegations of oversimplification: here scholars allege that actors are excluded from innovation rather than simply playing an overlooked role.

4.2. Geographic situatedness of knowledge making

A key trend in the sample is articles which speak from a higher income country vantage point (i.e. by scholars from higher income countries, using analytical frameworks developed at research institutions in higher income countries) and do not reflect upon this positionality. Nonetheless, most of these articles either imply or in one case specify (Acemoglu et al., 2016) that their empirical analysis can be considered globally relevant. Acemoglu et al., p.73) utilise US firm-level data, but then extrapolate this for the global economy: they assume “that both emissions and technological change in our model can proxy for those in the global economy e.g. because new technologies can be utilized globally” and furthermore that “new technologies, often first developed in advanced economies, in particular, the United States, whose microdata we are using, will spread only slowly to other countries”. This article therefore introduces assumptions around the direction of technology transfer between lower and higher income countries which connects to the theme below of “location”. Taken together, these articles draw on analytical principles from economics which have an almost entirely European and American theoretical footprint (see Austin 2007; Ekelund and Hebert, 2014)³ but which claim relevance to elsewhere. Not all articles which fit this trend of geographic situatedness are from the economics literature; Bergek et al. (2008a) and Geels et al. (2016) present theoretical contributions, based on primarily European evidence, which specify general relevance; several other articles in the sample imply this (e.g. Daim et al., 2013).

A further distinct trend in the sample is articles which work with analytical frameworks originally developed in higher income countries but apply them to locations in lower income countries. These articles geographically caveat the geographic relevance of their results, with the situatedness of their knowledge making clear. For example Owoeye et al. (2020)’s conclusions on African technological innovation trends run counter to observed trends in Asia. Similarly, Santra (2017), while using general econometric understandings of innovation, directs policy recommendations towards BRICS countries as opposed to presenting geographically generalisable statements. Within the literature sample, the principal distinction between these articles and those above that claim general relevance are that these articles are by scholars based in, and use data from, lower income countries.

Other articles within the sample (for example Bolton and Hannon, 2016; Gasbarro et al., 2017) work with European theory and data but acknowledge that their analysis and theory building is specific to the geographic location they analysed. Relatedly, Bergek (2019) explicitly highlights how the TIS functional approach has been applied to developing economies and raises concerns about how this is not the empirical context within which TIS was originally conceived. Bergek points out how these TIS analyses are often focused on adaptation of technologies from other countries rather than original knowledge development, placing TIS study locations on a spectrum of “pioneers, followers or later entrants trying to catch up” (Bergek, 2019 p.204).

One article in the sample (Chen et al., 2018) is an outlier in that it strongly emphasises their situatedness as Eastern scholars of innovation and expresses concern that much innovation knowledge is rooted in ways of knowing stemming from Europe. However, they do not appear to do so in order to advocate for epistemic plurality, but rather to push for a new “innovation paradigm” rooted in Eastern epistemology with general relevance. By structuring a table about existing innovation knowledges by the continents they are understood to originate from, the authors inadvertently silence the entire continent of Africa as a producer of innovation knowledge.

A final trend in the sample is articles which express concern regarding the geographic footprint of dominant innovation epistemology; but they seek to do this from a situatedness outside higher income countries, e.g. drawing on ontologies and epistemologies from places in lower income countries. Within our sample, this includes India (Jammulamadaka, 2018) and Colombia (Calvo Martinez et al., 2019) for example. Here, scholars turn to marginalised knowledges such as indigenous or traditional ecological knowledge and express concern about how Eurocentric innovation theorizing is dominant.

4.3. Framing of agency in innovation

A key trend in the sample is articles which foreground firms and scientists as R&D practitioners possessing agency. Related to this, several scholars foreground the role of scientists and researchers as active innovation agents (Ganda, 2019; Li et al., al.,2020) in

³ The intention here is not to advocate that all that matters about theory is where it originally stems from. Economics, as with many research domains, now has a vibrant community of scholars working around the world on pushing the discipline forward. However, we ascertain that, as with many social science disciplines such as those we as Authors orient ourselves in, stem from a European tradition of theorizing, and that this has a framing effect. Furthermore, some of the specific economics principles used in these theories have an explicitly European, market-oriented history.

relation to firms. While these articles do not suggest these actors work in isolation, they do tend to focus the analysis on firms as specific actors perceived to be central to the innovation process. These articles, focused on R&D-practising firms, are often written from the implied vantage point of a policymaker; i.e. an actor making investment decisions who values certain kinds of macroeconomic outcomes above others.

Another distinct trend in the sample is articles which do not foreground agency in any single category of actor, but rather they place emphasis on the interactions between system actors and may focus on developing understandings of the role of a particular actor(s) within systemic frameworks such as TIS or the MLP. Articles explore the possible roles actors can play within systems, such as incumbents, intermediaries, niche actors or regulating bodies, implying that these actors possess agency to influence processes of innovation (Bergek et al., 2008b; Hyytinen et al., 2015; Geels et al., 2016).

Other articles which similarly take a systems perspective but, specifically, in lower income country contexts foreground donors and technical experts within the perceived system and imply it is they who possess agency to spur and direct innovation (Tigabu et al., 2015; Müggenburg et al., 2012; Tigabu, 2018). In effect they catalyse the system into action. This connotes that innovation is unlikely or unable to happen in lower income country contexts *without* the presence of development actors; intervention is required.

A further distinct trend in the literature is those which also extend systems theories geographically but do not work from overarching archetypes: they instead emphasise constellations of actors which are unique to contexts. For example, Olaoye et al. (2020) emphasise the role of local innovators - whoever they may be - and Berka et al. (2020) expand SNM and TIS to Aotearoa New Zealand but note that different roles may be played by different actors in different countries, emphasising the unique characteristics of the country's Maori population whom they focus upon.

Some of the articles focus on the agency of actors currently overlooked by theories but who, in fact, possess agency within innovation processes. These articles call for recognition of a wider range of actors who play a key role in innovation processes, such as ordinary people (Pansera, 2013b; Sampsa et al., 2016), users (Martiskainen et al., 2021), communities at the grassroots level, negatively affected communities (Sovacool et al., 2020b) or the media (Carayannis and Campbell, 2009; Arora et al., 2014).

In contrast with the above, other articles seek to foreground actors which the articles explicitly describe as currently *lacking* agency in relation to innovation. This may include social movements and communities (Seyfang and Haxeltine, 2012; Burke and Stephens, 2017; Koirola et al., 2018;), end users (Delina, 2020; Kotilainen et al., 2019) women (Jerneck and Olsson, 2013; Pearl-Martinez and Stephens, 2016; Lieu et al., 2020; Batinge et al., 2021) or indigenous firms and informal / indigenous workers in a higher income country-dominated global innovation landscape (Akinwale, 2018). This normative emphasis on foregrounding excluded actors is complemented by articles which critique the actors who dominate mainstream innovation discourse production - whether higher income country-based scholars (Koch et al. 2020), technocratic institutions (Arora et al., 2020) or men and their associated masculinities (Pettersson and Lindberg, 2013).

4.4. Framing of directionality in innovation

A key trend amongst the economics-orientated articles is to heavily foreground the interplay between policy, competition and prices as driving and directing innovation towards energy transitions through a prism of profit-orientated rational choice. Reflecting the energy sector focus, future costs of energy emissions-driven climate change are used by some of the scholarship as a driver for policy, which in turn induces innovation via price changes (Acemoglu et al., 2016). These articles foreground falling costs of technology and associated learning rates alongside positive effects on indicators such as GDP growth. A more immediate, firm-level effect is that firms add new products or test new production processes, utilising or generating "clean technology" innovations. While most of the articles fitting this trend clearly indicate that these transitions are desirable, several articles rather have a more subtle underlying normative thrust that innovation is beneficial without explicitly discussing possible outcomes (Russo-Spena et al., 2017; Daim et al., 2013; Adamczyk et al., 2011). These articles do acknowledge other forms of activity as innovation, but analytically foreground those activities seen to lead to desired outcomes.

Another trend in the sample is articles which emphasise many different possible drivers and directions as well as the complexity and contextual specificity of innovation processes. Factors influencing the shape and outcomes of innovation vary between complex institutional arrangements and colonial legacies (Arora et al., 2014); societal desires for convenience and hence technological smartness (Groves et al., 2016); or frugality (Levänen et al., 2016). Looking to the future direction which innovation may lead us to, several articles critique normatively-orientated innovation understandings which assume positive outcomes of innovation. These may be economic profit and personal gain or achieving sustainability. Instead, several articles question whether innovation can deliver these kinds of positive benefits across the world, and notes that innovation may in fact increase inequality (Pansera, 2013b), result in negative environmental and social implications (Martiskainen et al., 2021; Sovacool et al., 2020b) or lead to a prioritisation of convenience and comfort over privacy (Groves et al., 2016).

Some of the articles, associated with international development discourse in lower income country contexts, emphasise exogenously-driven technology diffusion, transfer and acceptance. This is seen to be accompanied by environmental and social benefits enjoyed by the willing participant. Müggenburg et al. (2012) suggest that technology acceptance (measured via a willingness of the community to pay for the technology) is the desired outcome of the innovation process. Relatedly, Tigabu (2018) suggests external contextual factors (such as development partners) outside the local TIS are greater drivers of TIS functional accumulation than internal interaction of functions within the innovation system. These examples thus imply that desirable directions and drivers of innovation are set outside of the geographic place intended to benefit from innovation.

In contrast with the above trends, other articles foreground drivers which are endogenous to the group or community. They are thus in contrast with the paragraph above, despite sharing the focus on meso- and micro-scale drivers and directions of change. These may

include shared values and locally specific conceptualisations of concerns such as peak oil and climate change amongst a group (Seyfang and Haxeltine, 2012).

4.5. Framing of locations in innovation

Once again, a key trend is perceptible amongst the economics-orientated articles which primarily focus on innovation happening within firms in OECD countries (the same as those highlighted in Section 4.3 on agency above). While some of the articles acknowledge that innovation can and does happen elsewhere, the combination of patent data, R&D spending data and firm-level operating data for an “innovation production function” strongly foregrounds firms in the OECD as the context where innovation happens. Dechezleprêtre & Glachant (2014); Grubb et al. (2021) and Zobel et al. (2016) also broadly fit this pattern, although they acknowledge that the implicit hierarchies of evidence in innovation studies privilege codified firm-level data such as patenting and overlook tacit data and informal modes of innovation. A small number of economics articles in the sample draw on similar analytical approaches to those described above but focus on firm-level data in BRICS countries (Santra, 2017) or developing economies more broadly (Li et al., 2020) rather than those in higher income countries.

Another key trend in the sample is articles which emphasise the transnational complexity of innovation systems and contexts which do not fit geographic boundaries. Bergek (2019) urges caution in defining TIS analyses geographically. Nonetheless, most of these articles locate observed innovative activities in Europe. There are notable exceptions (Arora et al., 2014), including those suggesting innovation could disrupt the socioeconomic dominance of the Global North by redistributing wealth between places (Pansera, 2013b; Surie, 2017).

Some of the articles foreground locations in lower income countries but indicate that they benefit from (and in some cases are reliant upon) innovation-related activities in higher income countries. These countries include Bolivia (Pansera, 2013a), Rwanda and Kenya (Tigabu et al., 2015; 2018), Ethiopia (Müggenburg et al., 2012), Nigeria (Olaoye et al., 2020) or multiple African countries (Dauda et al., 2021; Owwoye et al., 2020). Many of these papers adopt a systems approach to innovation by locating at least some aspects of innovation outside of these countries. Müggenburg et al., (2012) establish a dichotomy between the laboratory (whose location is unknown but is occupied by “western technicians”) and communities of end users, implying innovation is centred in the former and acceptance takes place in the latter.

Other articles within the sample foreground locations of innovation which are perceived by the authors to be marginal to dominant portrayals of where innovation happens. These include informal settlements (Hopkins et al., 2020), grassroots or community settings (Seyfang and Haxeltine, 2012; Kotilainen et al., 2019; Koivola et al., 2018), gendered spaces (Jerneck and Olsson, 2013) or lower income countries more broadly (Jammulamadaka, 2019; Akinwale, 2018). Conversely, technologically intensive settings such as R&D centres which are perceived to be dominant are critiqued (Arora et al., 2020; Pettersson and Lindberg, 2013).

4.6. Tracing connections between how articles frame their academic contribution and how they subsequently operationalise innovation

Looking across the results above, the literature sample contains a range of operationalisations of innovation. Fig. 1 demonstrates the range of possible constellations which combine different characteristics of innovation. In some instances in the sample, connections are perceptible between the apparent aim of the scholars (categorised above as “framing of intended academic contribution”) and the characteristics of innovation which they foreground (e.g. in agency or locations and directions of innovation). We do not allege that the characteristics of innovation which are foregrounded are a direct causal consequence of a certain academic framing, and the constellations are highly heterogeneous across most articles in the sample. Some correlations are nevertheless particularly notable. We would argue that the correlations described below are problematic and could be considered forms of theoretical lock-in: the characteristics which they use in operationalising innovation are not noticeably subject to processes of reflexivity by the Authors.

The first observable correlation relates to those articles in the sample which seek to make an academic contribution by applying innovation theory to policy challenges. This set of articles (with the notable exception of policy-orientated articles focused on lower income countries such as Santra, 2017) make universalized claims of epistemological relevance, foreground firms as agents of change, and connect innovation to desirable environmental outcomes and economic benefits. Several of these articles also assume that the activities of firms in higher income countries can proxy for such activities in lower income countries. This implies that an article seeking to better understand innovation’s relationship with policy, regardless of the intended location of benefit, may seek to build knowledge from observing the private sector in higher income countries or even seek to emulate its activities.

A second notable correlation is that several articles whose contribution is to extend innovation theory to new geographies foreground donors and western firms as change agents and establish a locational relationship between higher income countries as generative and lower income countries as receptive of innovation. It is evident nonetheless that this is not the only framing possible in theory extension; other scholars such as Berka et al., (2020) emphasise local and contextual specificity including the role of local indigenous actors. This implies that without sufficient care being taken when scholars seek to transport innovation theory to new contexts which are distinct from where they were originally conceived, these articles tend to emphasise the agency of external actors such as donors, implying (and potentially replicating) relationships of dependence.

5. Discussion and conclusion

These differences between how innovation is operationalised in our sample relate less to the inherent characteristics of innovation (given the breadth of what can be considered innovation) than to academic framings which shape what is foregrounded and

backgrounded in any article. We do not allege that this is ordinarily driven by a scholar's desire to frame innovation in a certain way. Agency, locations and directionalities of innovation or the type of academic contribution which come into view may, from the scholars' perspective, be a consequence of observations of empirical phenomena. The knowledge products which result from this academic practice are thus socio-material, constituted of a mix of the perceived empirical phenomena and the framing decisions made by a scholar to translate these phenomena into a concise and bounded knowledge product such as an academic article. This reading of innovation has similarities with scholarly analysis of how other broad and contested concepts are operationalised in relation to the phenomena studied, such as 'power' and 'resilience' (Ahlborg, 2017; McEvoy et al., 2013).

This scholarly approach to innovation as always situated should not be misunderstood as pushing for a kind of conceptual provincialism which demands that innovation is only theorized from, and to, the geographic location which is studied. Rather we align ourselves with scholars who seek a careful theoretical exchange and dialogue, where learning goes in two spatial directions (Austin, 2007; Van Welie et al., 2018). Similarly, we argue that the relevance of a pre-existing theoretical innovation frame to material phenomena should be an open question to be engaged with critically, rather than a starting point which is taking for granted. It is when the latter happens - which is seemingly evident in a minority of articles in our sample - that innovation research appears to lead to a higher income country-orientated theoretical lock-in.

In these cases of apparent lock-in, described in Section 4.6, there is a tendency to decentre the contextual specificities of these places and place alternative pathways in the background, such as innovation through actors other than firms or external development actors. These cases relate perhaps to the structural resemblance of donors to European institutions which have historically played a role in fostering forms of innovation considered desirable (in Europe). They may also relate to the strong association between innovation and finance, with expensive technologies associated for example with the "fourth industrial revolution"⁴ often perceived to be more innovative than frugal low-cost solutions (Jammulamadaka, 2018). Conversely, scholars based in lower income countries demonstrate comparatively lower willingness to make the kind of bold, far reaching knowledge claims which are common amongst scholars based in and studying locations in higher income countries. This could be interpreted as evidence supporting the claims of Collins (2000): that the dynamics of dominant knowledge production - located in higher income countries for energy research (Ali et al., 2023) - may limit the extent of knowledge claims which are made by "outsiders" to this mainstream.

The politics of framing innovation have material implications for how transitions and transformations towards sustainability are enacted. Nancy Frazer explains that "When political space is unjustly framed, the result is the denial of political voice to those who are cast outside the universe of those who 'count'" (interviewed in Nash and Bell, 2007 p.77). It follows that the kinds of actors who have a "seat at the table" in the design of transition and transformation pathways may be informed by how we frame concepts perceived to be critical to transitions, such as innovation. And conversely, we may not be able to see or think about actors, places or possible directions which our conceptual frames do not allow for.

One critical domain where the material effects of framing innovation may be observable is amongst actors who seek to finance and thus foster innovation in support of transitions. The actors who most closely resemble the framing of innovation adopted by those seeking to finance innovation will be best placed to secure resources and materially enact change. If a funding programme operationalises an innovation framing orientated around excluded groups innovating to deliver sustainability transitions, actors understood to fit this framing get a "seat at the table" in the design of transitions by being recognised as practitioners of innovation. However, what currently manifests to a greater extent in discussions of innovation in the policy and financing domain is a continued relatively narrow focus on technology and firms as innovators. For example, the OECD's Science, Technology and Innovation Outlook 2023 explains that "significant levels of investment are needed across the entire innovation chain to meet the scale and pace of the net-zero transition". In this context, the innovation chain is framed to include actors whose activities are traceable in R&D terms (OECD, 2023) and places where this kind of activity is concentrated. We argue that a focus on the role of R&D practising firms can be a central part of transformations towards sustainability, but that a sociotechnical systems approach to the challenge requires the enactment of a plurality of innovation framings. This means resources for a diverse range of innovation actors - and by extension, locations and onto-epistemologies. That said, a detailed study of these downstream effects of framing, as well as the broader relationship between innovation scholarship and its application in policy domains, is outside the scope of this study.

With regard to academic practice, we believe it is of critical importance that scholars practice reflexivity in doing innovation research. This can contribute towards greater epistemic humility and care in geographically situating one's knowledge making, evaluating the implications of one's framing and considering alternative ways of framing one's research. To this end, in Fig. 2 we propose a simple heuristic device which may help to navigate the messiness and multifacetedness of innovation understandings. Scholars could use this to reflect on the research frames which they could work through when conceptualising a research project. Noting our results, this could be particularly valuable when scholars seek to make an academic contribution by building knowledge on the relation of innovation to policy or extending innovations systems theory to new geographies. Asking questions such as those below may help them to avoid reproducing possible theoretical lock-ins such as those described in Section 4.6.

To conclude, this study has demonstrated the broad range of framings in how innovation is operationalised in discussions of energy systems change, the risks associated with these framings and their implications. Our sample shows that some framings of innovation unreflexively imply that models of innovation stemming from higher income countries are a good fit for places in lower income countries. This is related perhaps to operationalising innovation in ways which subtly valorise higher income country economic development pathways as "the path [African countries] were denied, but may possibly find" (Austin, 2007 p.5). However, our sample

⁴ These include but are not limited to artificial intelligence, virtual reality, 3D printing, robotics, big data, cloud computing and the internet of things (McKinsey, 2022).

Questions to prompt onto-epistemological reflexivity:

1. What kind of scholarly contribution am I making (or seeking to make), in relation to innovation theory?

2. How is my research geographically situated, in terms of where I speak from and intend to speak to? Can I be precise in how generalisable I consider my research to be?

Questions to prompt analytical reflexivity:

B. Who am I foregrounding as possessing agency in innovation? (observed, expected and/or desired)

D. Which locations am I foregrounding as associated with innovation?
(observed, expected and/or desired)

C. What directionalities am I framing as associated with innovation? (observed, expected and/or desired)

Fig. 2. A framework to prompt scholarly reflexivity in innovation research, based on categories of analysis.

also shows that alternative framings of innovation are possible: other kinds of actors, places and directions that can be thought of as central to innovation besides the commonly discussed cast of firms, locations in the OECD and economic growth. We do not seek to assert the significance or superiority of any specific framing existing within our sample: a different sample would produce different kinds of framings. We rather consider our analysis as evidence of framing as a process, which we believe to be of potentially broader theoretical significance. We align ourselves with scholarship which directly acknowledges the politics between innovation knowledges and the need to make space for alternative ways of theorizing innovation besides those stemming from higher income countries (Calvo Martinez et al., 2019; Pansera, 2013b; Mavhunga, 2017).

Our findings have implications for transitions and transformations towards sustainability. One of the main consequences of the frames we characterise is the engendering of certain kinds of actor and location with or without implied agency. This boundary work effectively limits the activities recognised as innovation and may in turn condition access to resources (e.g. finance) for activities recognised as innovative in transitions and transformations towards sustainability. This is despite the fact that innovation in the broad sense is happening all over the place, all the time as invisible work (Star, 2010; Martin, 2016). Andersson and Törnberg (2018) indicate that the range of possible innovations at any point in time are constrained by a range of factors such as dominant design, sociotechnical regimes or regulatory networks. We would emphasise that how innovation is framed conceptually may also be critical to the possible directions which are “open” (Stirling, 2008) in transitions and transformations.

Our work is limited by its onto-epistemological frame. Recent postcolonial perspectives in STS caution that critical scholarship can become problematic as it travels between geographies and may include implicit assumptions about hierarchies between Euro-American terms of analysis and other ways of thinking (Law and Lin, 2017). In our case, by searching for innovation understandings only in indexed journals and identifying codes in the data which stem from our scholarly training in higher income countries, we inevitably exclude other understandings and characteristics of innovation from our analysis that do not fit our framing. We welcome research from alternative positionalities which look beyond or dismantle these categorisations.

Declaration of Competing Interest

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.

Data availability

Data will be made available on request.

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