Deutsches Biomasseforschungszentrum
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DBFZ REPORT NR. 54

Transition towards a bioeconomy: discourses, vantage points, and actors' contextualized institutional work

Doctoral thesis
Kerstin Maria Wilde

SPONSORED BY THE
Federal Ministry of Education and Research

IMPRINT

Publisher:
DBFZ Deutsches Biomasseforschungszentrum
gemeinnützige GmbH
Torgauer Straße 116
04347 Leipzig
Phone: +49 (0)341 2434-112
info@dbfz.de

Funding:
DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH, Leipzig, an enterprise of the German Government with funding from the Federal Ministry of Food and Agriculture pursuant to a resolution by the German Bundestag.

With support from

Federal Ministry
of Food
and Agriculture

by decision of the
German Bundestag

General Management:
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DBFZ Report Nr. 54
Transition towards a bioeconomy:
discourses, vantage points,
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institutional work – Doctoral thesis
Kerstin Maria Wilde
Leipzig: DBFZ, 2025
ISSN: 2197-4632 (Online)
ISBN: 978-3-949807-27-5
DOI: 10.48480/mkpk-8k71

Author:
Kerstin Maria Wilde

Pictures:
If not indicated on the image: DBFZ, Stefanie Bader (Map)
Frontpage: freepik, Adobe Stock

Date of Publication:
25/04/2025

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The German National Library lists these publications in the German National Bibliography; detailed bibliographic data are available on the Internet at the address www.dnb.de.

Transition towards a bioeconomy: discourses, vantage points, and actors' contextualized institutional work

Dissertation
zur Erlangung des
Doktorgrades der Agrarwissenschaften (Dr. agr.)

der
Naturwissenschaftlichen Fakultät III
Agrar- und Ernährungswissenschaften,
Geowissenschaften und Informatik
der Martin-Luther-Universität Halle-Wittenberg

vorgelegt von
Frau Wilde, Kerstin Maria

Datum der Verteidigung: 24.03.2025

Mitglieder der Prüfungskommission
Prof. Dr. Alfons Balmann
Prof. Teis Hansen
Dr. Frans Hermans
Prof. Dr. Thomas Herzfeld
Prof. Dr. Norbert Hirschauer

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List of Abbreviations

BBD	Biobased Delta
BG	‘Born Green’ actors
CEO	Chief Executive Officer
CTO	Chief Technology Officer
EU	European Union
GAP	General Agricultural Policy of the European Union
GHG	Greenhouse Gas
GMO	Genetically Modified Organism
I	Industry
IP	Intellectual Property
IS	Innovation System
IW	Institutional Work
LCA	Life Cycle Assessment
LMC	Large or Multinational Company
MLP	Multi-level Perspective
MNC	Multinational Company
MNTQ	Metrology, Norming, Testing, and Quality Management
N	Industry-specific Intermediaries
NGO	Non-government Organisation
NIS	National Innovation System
OEM	Original Equipment Manufacturer
PI	Progressive Incumbent
R	Research
R&D	Research and Development
RIS	Regional Innovation System
SCB	Spitzencluster Bioökonomie
SCM	Spitzencluster Mitteldeutschland
SIS	Sectoral Innovation System
SME	Small or Medium-sized Enterprise
SSG	Sustainable Development Goals
STI	Science, Technology and Innovation
STS	Socio-technical System
TIS	Technological Innovation System
UK	United Kingdom
X	Cross-industry Intermediaries

1. Introduction

1.1 Rationale and objective

The Sustainable Development Goals (SDGs) are essential for the future of the planet as they provide a comprehensive framework to address pressing global challenges. One European approach to advance goal achievement is bioeconomy promotion. This is a top-level political call to radically change current approaches to production, consumption and disposal of biological resources. At its core stands a vision of the economic system harmonized with ecological sustainability (OECD, 2009; EC, 2012). Establishing a bioeconomy has also been portrayed as new opportunity for regional and rural development in Europe: "it can maintain and create economic growth and jobs in rural, coastal and industrial areas, reduce fossil fuel dependence and improve the economic and environmental sustainability of primary production and processing industries" (EC 2012, p. 8).

In this conceptualisation, the bioeconomy "includes agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological and energy industries" (EC, 2012, p. 5). It comprises all sectors and industries that "develop, produce, process or use plants, animals or microorganisms" (Albrecht and Ettling, 2014, p. 11). Although there are traditional bioeconomy segments that have long operated on inputs from agriculture or forestry (like leather processing or paper production, e.g. Hermans, 2021), most bioeconomy policies envisage a bio-based transformation: a substitution of fossil with renewable raw materials throughout the economy (Dietz et al., 2018; Kardung et al., 2021; Stark et al., 2022). Seemingly contradicting aims of a cheap and abundant provision of biomass, protected family farming, high quality production and development of rural areas are to be safeguarded by specific bioeconomy principles (food first, sustainable yields, cascading use and circularity, see EC, 2015, p. 30ff).

Agriculture and forestry in Europe already face many conflicting demands from society. It is still uncertain how different pattern of renewable resource production, cascaded usage and circularity can provide the basis for new segments of industry (Casau et al., 2022; Grouiez et al., 2023; Muscat et al., 2021a). Bioeconomy promoters have high hopes for advancements in areas like plant breeding, cultivation techniques, biorefineries, changed food distribution and nutritional practices (Bauer, 2018; Dahiya et al., 2018; El-Chichakli et al., 2016). Some actors highlight the benefits of plant molecular farming while others aim to advance the exploitation the entire plant with all its functionalities (e.g. Aguilar et al., 2019). Some production methods of new bio-based products raise important ethical questions.

The promotional strategy of purposive clustering relevant actors from research and industry aims to advance the aspired transition towards a bioeconomy (BMBF, 2014, Bioeconomy Council, 2015; De Besi and McCormick, 2015; EC, 2016). However, it is barely understood how different stakeholders interpret the bioeconomy mission and evaluate their context conditions. The systematic analysis of national bioeconomy strategies often highlights conflicting goals (Dietz et al., 2018; Park and Grundmann, 2023; Zeug et al., 2020). Competition among biomass end-use sectors is almost omnipresent (e.g. Dubois and Gomez San Juan, 2016). Equally important: the deep structural entrenchment of societal and economic practices based on fossil resource extraction points to tremendous challenges (e.g. Labanca et al., 2020). Societal, inter-sectoral and inter-industry conflicts are to be expected (e.g. Eversberg and Fritz, 2022).

In view of SDG attainment, a socio-economic transformation is widely deemed necessary. Low-carbon or sustainability transitions denote large-scale disruptive changes in societal systems that historically emerge over a period of (at least) several decades. Economic, science and technology-induced structural change processes are studied from many epistemological and disciplinary backgrounds (for an overview see e.g. Markard et al., 2012 or Loorbach et al., 2017). The relevant heuristic approaches and process theories originate mainly from sociology, evolutionary economics and human geography (for a comprehensive overview see Sovacool et al., 2023). Research on innovation systems (IS) and sustainability transition has broadly analysed historical development pathways, structures and system functions in view of pattern of emergence, diffusion, and reconfiguration. Tracing transition dynamics can focus on a technological system, an industry, the whole societal system or a number of "societal functions such as transport, communication, housing, feeding, energy supply and use, and recreation" (Geels et al., 2004, p. 3).

Using insights from related streams of research to analyse an emerging bioeconomy is challenging because the delineation of a bioeconomy clearly is difficult. Additionally, the attention of these conceptual approaches to actors and their interaction with other system components has been rather weak (Farla et al., 2012; Hermans, 2018; Purkus et al., 2018). There is considerable support for the proposition that research needs to incorporate how actors experience and contribute to the enactment of complex processes such as innovation, system transformation and the creation of new development trajectories (e.g. Sotarauta, 2017; Upham et al., 2018; Weber and Truffer, 2017). Against this background, this thesis deals with the perspectives and contextualised activities of bioeconomy actors. It takes a critical realist stance and uses analytical concepts relevant to understanding 'transitions-in-the-making'. The next section will introduce key research streams and related theoretical concepts. Then, it will connect these concepts to the study of the emerging bioeconomy. Before presenting three distinct articles, the thesis will explain how various stakeholders are empirically covered. The discussion section will review main findings from the different conceptual approaches employed for the exploration of stakeholders' perspectives and their agency. It will highlight the differing and complementary insights on the transition to a sustainable bioeconomy.

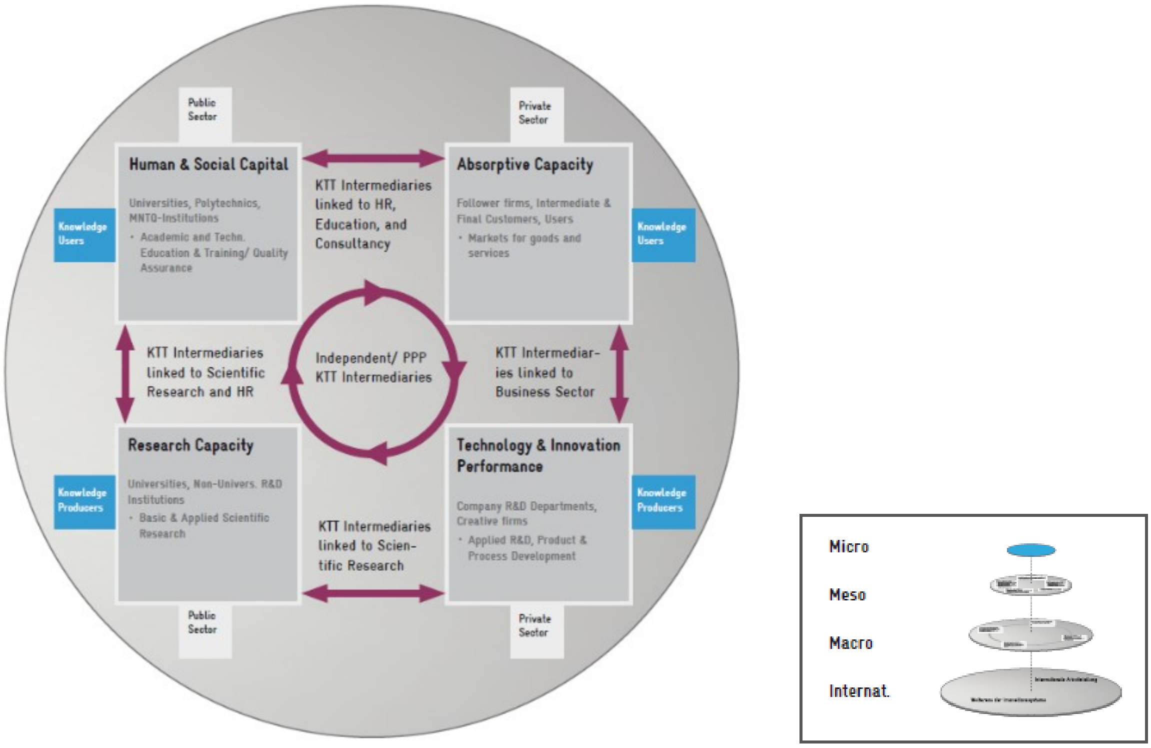
1.2 Introduction to relevant theoretical concepts and analytic approaches

1.2.1 Innovation Systems

In economics, profound change is associated entrepreneurship and innovation as mechanisms to generate new economic and social value. Apart from entrepreneurs in the private sector, researchers, policy makers, consumers, traders, media, and a multitude of other actors are usually involved in the process through which an invention is turned into a new product or process that satisfies user needs and succeeds in markets. Hence, research on innovation systems (IS) builds on evolutionary economics and system thinking, has a broad societal orientation and provides an analytical framework for widespread or profound innovation processes. Freeman first defined it as the "network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (1987, p.1). A material focus is maintained in some parts of the scholarly community while others have increasingly framed innovation as a social learning process that is based on interaction between various actors and institutions. Accordingly, Lundvall and his colleagues (2009, p. 6) specified: "The national innovation system is an open, evolving and complex system that encompasses relationships within and between organisations, institutions and socioeconomic structures which determine the rate and direction of innovation and competence building emanating from processes of science based and experience-based learning". All strands of research are united in the perspective that IS develop their unique properties slowly over a number of decades.

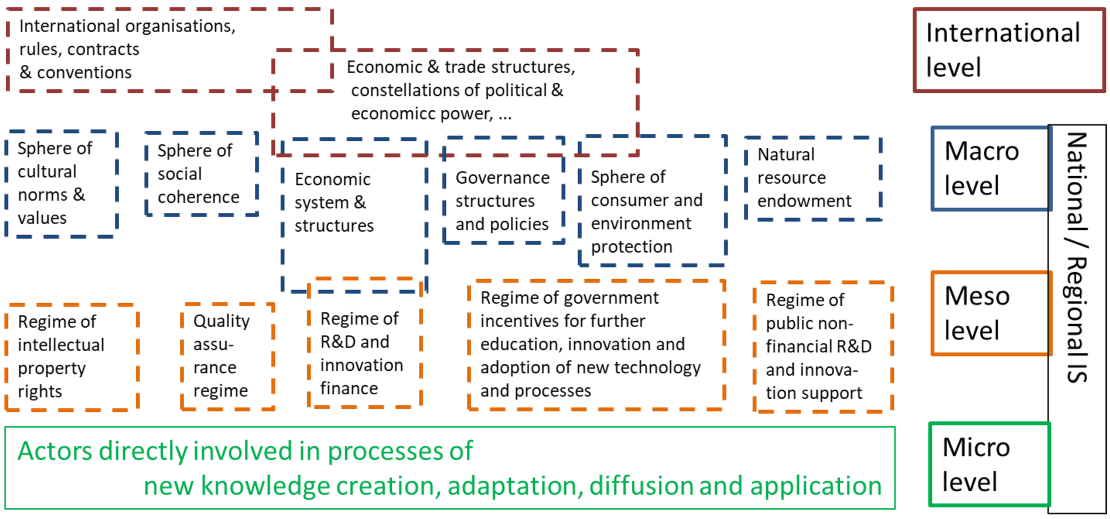
The concept of national IS (NIS) (Freeman, 1988; Lundvall, 1992; Nelson and Rosenberg, 1993) was quickly complemented by corresponding conceptualisation of regional IS (RIS) (Braczyk et al., 1998; Edquist, 1997; Howells, 1999). Specific characteristics of a RIS and NIS were found to be bound to governance at regional and national levels while interacting and overlapping multi-level governance systems were diagnosed to apply to others (e.g. Kaiser and Prange, 2004).

Figure 1 Micro-level IS sub-systems and actor types



Source: Kadura et al., 2011, p. 76

Figure 2 Scheme for structural NIS/RIS analysis and innovation policy design



Source: On the basis of Kuhlmann et al., 2010, and Kadura et al., 2011

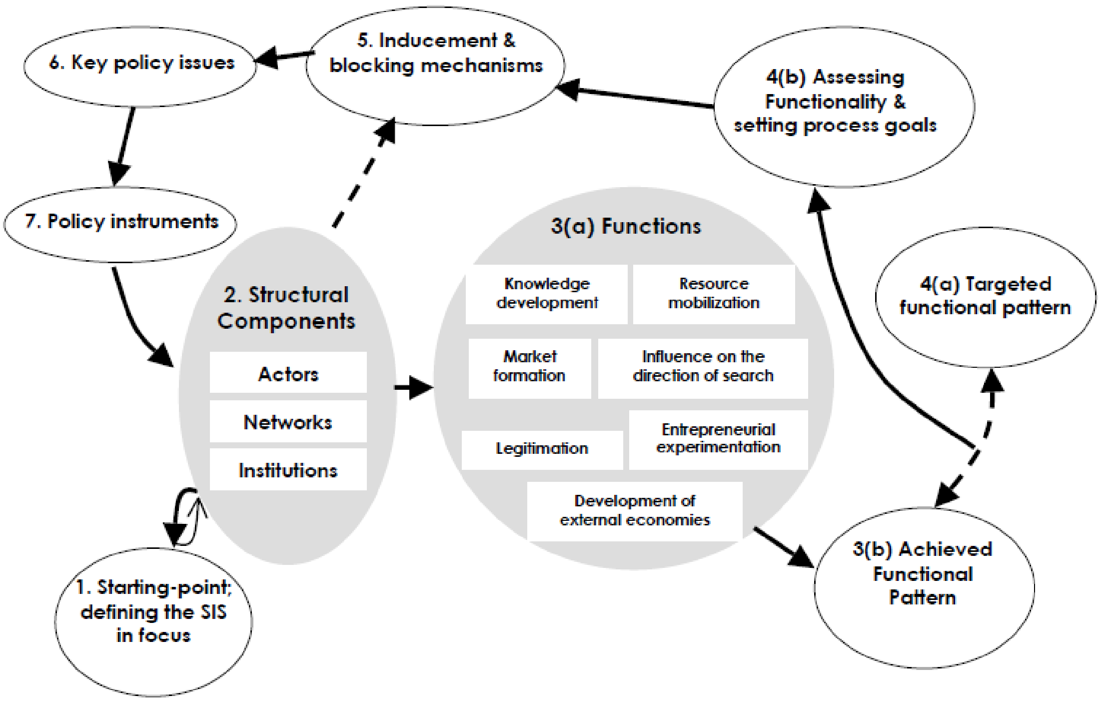
Breaking away from the geographical orientation, Breschi and Malerba (1997) kicked of research on industries as sectoral innovation systems (SIS). Here, the cumulativeness of knowledge and processes involved in building up a specific technological regime are highlighted (Dosi, 1982). In a similar vein, other researchers started system exploration based on a technology or a technological field. A technological IS (TIS) has been defined as "a network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure or set of infrastructures and involved in the generation, diffusion, and utilization of technology. … In the presence of an entrepreneur and sufficient critical mass, such networks can be transformed into *development blocks,* i.e. synergistic clusters of firms and technologies within an industry or a group of industries" (Carlsson and Stankiewicz, 1991, p. 111). A set of TIS may jointly constitute a SIS and its set of core technologies while being anchored in a number of RIS or NIS (e.g. Hermans, 2018).

There are two important strands of research that highlight different IS conceptualisations, both driven by policy perspectives.

1. **The structural IS approach:** This approach (Lundvall, 1992; Nelson and Rosenberg, 1993) focused upon organisations, institutions and socioeconomic structures as components of the systems. Organisations are characterised as the players or actors, while institutions were conceived as the rules of the game (Edquist, 2011). Knowledge producers and users in the public and in the private sector are different as distinct subsystems at the micro-level. Different sets of institutions and related organisations are identified at the meso, macro and international levels (see e.g. Figures 1 and 2). The concept aims to offer an empirical-analytical framework and action frame for public policy intervention (e.g. Kuhlmann and Edler, 2002).
2. **The functional IS approach:** In this approach (McKelvey, 1997; Bergek and Jacobsson, 2003; Edquist, 2004), an IS is defined in terms of what it does – namely: its functions (McKelvey, 1997; Bergek and Jacobsson, 2003; Edquist, 2004). This process-focussed approach was found more suitable to explain technological change (e.g. Hekkert et al. 2007). It was proposed that policy should be guided by reference to a specific set of IS functions (Weber et al., 2006).

Aiming at a synthesis, Bergek et al. (2005) differentiated 'structural components' (actors, networks, institutions) of the IS on the one hand and 'functions' on the other hand to jointly determine the performance and orientation of an IS (Figure 3).

Figure 3 Scheme for structural-functional SIS analysis and policy design



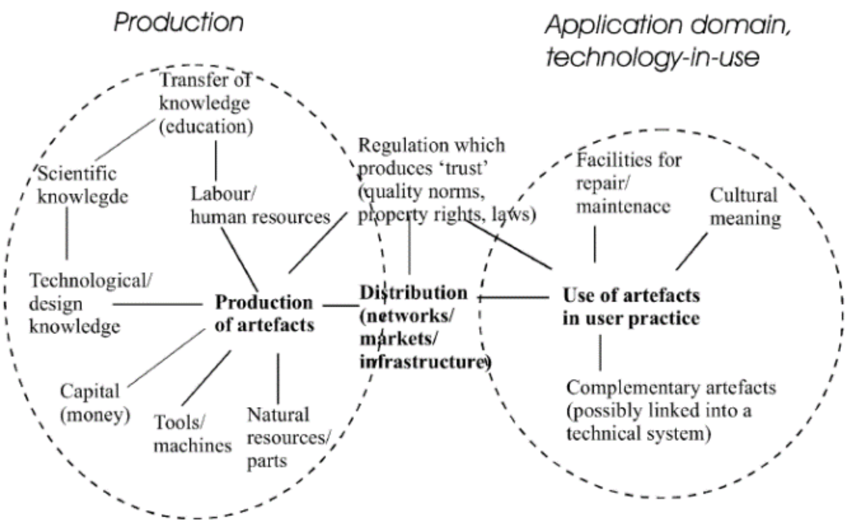
Source: Bergek et al., 2005, p.3

Overall, the systemic perspective often identifies "system failures", "blocking mechanism" or bottlenecks, such as insufficient awareness about knowledge stocks in the community of core actors, a mismatch of existing and required capabilities or incompatibilities of existing institutions with prerequisites of innovation success (e.g. Heiberg and Truffer, 2022; Metcalfe, 2005). With due account of the merits of IS analysis, all approaches were criticised for their inability to describe or explain IS internal dynamics. Structural components and functions are not easily linked to human agency. Moreover, the analysis of the distributed component development of more complex and digital technologies demonstrates that similar sectors (and SIS) can be linked in a technology's value chain and affect several TIS functions. Analysis becomes extremely complex while intense intra-sectoral and cross-sectoral policy coordination at regional and national levels might be required to advance a specific TIS (e.g. Stephan et al., 2017; Mäkitie et al., 2022). Finally, IS analysis might fail to offer compelling policy advice where several technologies with different degrees of maturity compete for policy attention (e.g. Magnusson and Berggren, 2018).

1.2.2 Socio-technical transition and the multi-level perspective

Socio-technical transitions or sustainability transitions are understood as "long-term, multi-dimensional, and fundamental transformation processes" (Markard et al., 2012, p. 956). The respective research is motivated by the consequences and seriousness of the multi-facetted threats that are caused by climate change (e.g. Geels and Turnheim, 2022). The normative orientation of sociotechnical transition research calls for a clear policy directionality (Köhler et al., 2019). In an effort to account for the material basis (technological artefacts, infrastructures, etc.) of SIS in a better way, Geels (2004) drew on sociology and institutional theory. He conceptualised systems in view of the fulfilment of specific societal functions (e.g. transport, communication, energy supply) and proposed to distinguish "systems (resources, material aspects), actors involved in maintaining and changing the system, and the rules and institutions which guide actor's perceptions and activities" (Geels, 2004, p. 898). The focus of analysis is directed towards technologies and change dynamics of socio-technical systems (STS) defined as "heterogeneous configurations of elements including technical artefacts, scientific knowledge, industry structures, markets, consumption patterns, infrastructure, policy, and cultural meanings" (Geels and Turnheim, 2022, p. 5; see Figure 4). The tangible or observable STS elements are maintained, dismissed, improved or changed by actors and social groups engaged for example in research, technology development activities, use of artefacts, debates or policymaking. The intangible STS components are (formal and informal) institutions which shape the preferences, strategies, and behaviour of actors. Structural elements are referred to as the 'socio-technical regime'.

Figure 4 The basic elements and resources of socio-technical systems

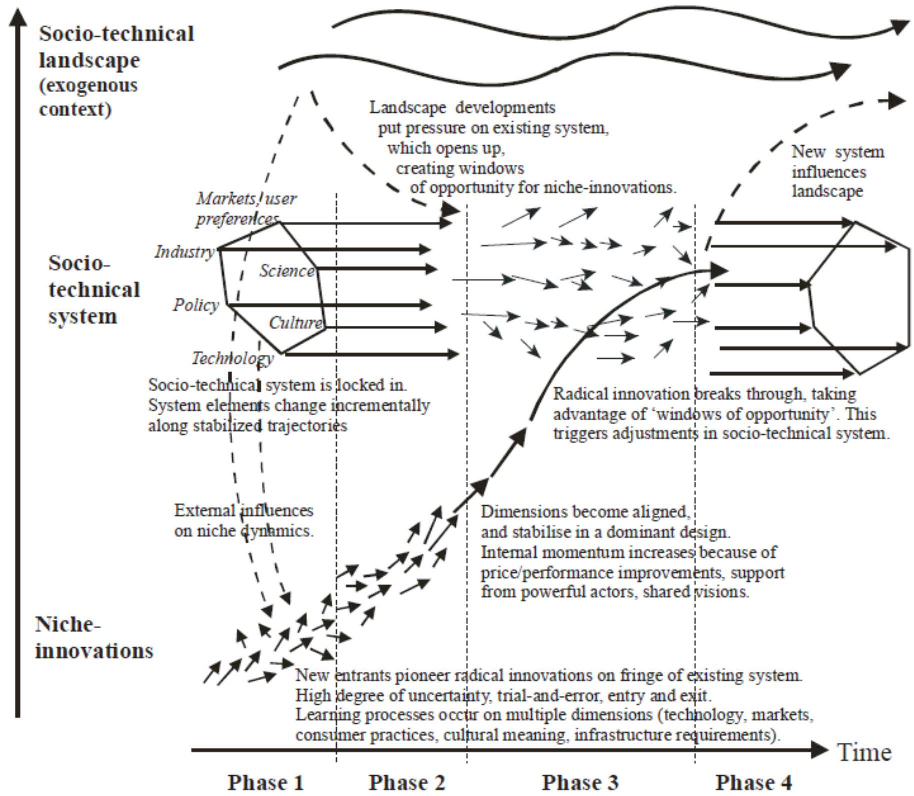


Source: Geels, 2004, p. 900

STS research highlights that transitions not only require a broad-based adoption of new technologies but also the establishment of new infrastructural components, new laws and regulations or new user practices (Planko et al., 2016). Transition studies have been conducted on functionally defined STS (e.g. Heiberg et al., 2022), on specific industries and technologies (e.g. Andersen and Gulbrandsen, 2020), or with different geographic delineations (Boschma et al., 2017, Frantzeskaki et al., 2012; Repolho, 2017). Specific STS components stabilise a status quo, may represent lock-in mechanism and cause STS to evolve in path-dependent trajectories. Accordingly, a transition towards low-carbon pattern of production and consumption requires not only individual system elements but also their mutual alignment and pattern of co-evolution to change in the right direction.

The "Multi-level Perspective" (MLP) conceptualise socio-technical transitions as resulting from the (non-linear) interactions at and in between three analytical levels: a) STS, b) protected spaces ("niches") where disruptive or systemic innovation can be nurtured, and c) socio-technical "landscapes" which symbolise macro-level factors such as slow-changing trends (e.g. demographics, ideologies) or shocks (e.g. elections, economic crises, wars). The latter are exogenous to the STS but do have a bearing on the other two levels. Developments at the landscape level may strengthen the STS or facilitate regime destabilisation and systemic innovation originating from the niche level (see Figure 5). The German energy transition is often described as a model case: attractive feed-in-tariffs set for twenty years allowed industrial actors to experiment with wind, photovoltaic and biogas technologies and eventually reach a convincing performance level. Meanwhile a powerful anti-nuclear civil society movement and the global impact of reactor core melting incidents where promoting alternative energy-supply visions and goals throughout society. In line with these observations, the phase 3 in Figure 5 visualises landscape pressure creating a window of opportunity for change promoters to fundamentally transform the STS.

Figure 5 The Multi-level perspective on sociotechnical transitions



Source: Geels et al., 2017, p. 1245

Regime properties within the STS induce conformity of incumbents' operations. Thus, radical or systemic innovation with a high-intensity effect in the STS structure has to originate at the niche level (Geels and Schot, 2007; Kivimaa et al., 2021; Weber et al., 2004). Disruption of the existing STS would threaten the positions and capabilities of incumbent actors (Lauber and Jacobsson, 2016; Johnstone et al., 2017; Smith and Raven, 2012), giving them strong motivation to prevent or slow down transitions (Lindberg et al., 2019; Markard et al., 2016; Smink et al., 2015). However, empirical studies have revealed a broader range of strategies and highlighted the need for further research into the behavior of incumbents (Magnusson and Werner, 2023; Steen and Weaver, 2017; Turnheim and Sovacool, 2020).

The MLP faced criticism from various angles. Critics argue that the MLP's conceptual approach neglects important aspects of governance and politics, such as power, norms, and accountability, and fails to adequately address the mechanisms and trajectories of change (Patterson et al., 2017). One of the key shortcomings is its limited focus on actors (e.g. Fuenfschilling and Truffer, 2016). Additionally, the common practice of deducing explanatory narratives of the MLP from a search for regularities in a sequence of events was found to result in a neglect of “the relational interplay between necessary and contingent explanatory factors” (Svensson and Nikoleris, 2018, p. 468). The epistemic position, micro foundations of STS and methodological approaches are still being refined (e.g. Balanzó-Guzmán and Ramos-Mejía, 2023; Geels, 2020; Sovacool et al., 2020). Particularly in the context of bioeconomy research, the diverse, layered, and evolving dynamics across different STS remain to be understood in greater depth (Andersen et al., 2020; Kanger et al., 2021; Rosenbloom and Rinscheid, 2020).

1.2.3 Institutional Theory

The concept of an institutional field, originating from Kurt Lewin (1951), is a cornerstone of institutional theory (Wooten and Hoffman, 2008). Institutional fields operate at the meso level, situated between broad societal fields at the macro level and intra-organizational relationships at the micro level. These fields focus on inter-organizational interactions, examining the effects of actors' institutional embeddedness. A field is mostly defined as a community of organizations that interact together “frequently and fatefully” (Scott, 1995, p. 207) in a “recognized area of institutional life” (DiMaggio and Powell, 1983, p. 148). Field-level processes include field formation and the pressure for institutional conformity (isomorphism). The institutional formation or 'structuration' of a field begins when interactions among a number of organizations intensify, leading to the development of informal or formal networks. As these networks form, insiders identify outsiders and establish distinctive relational channels (Faulconbridge and Muzio, 2019).

Zietsma et al. (2017) differentiate between two types of fields based on their purpose: exchange fields and issue fields. Issue fields encompass various discourse arenas where alternative ideas are debated, often focusing on questions like 'What is the problem? What needs to change and why?' (Kuzemko et al., 2016). Exchange fields, on the other hand, typically form around an industry, defined as a group of firms connected through vertical (i.e., value chain) or horizontal (i.e., complementary or substitute products) links (Lepoutre and Valente, 2012). The sub-populations of this field type consist of a focal population of actors and their interaction or exchange partners. Dynamics may lead to coalitions and/or status hierarchies, shared practices and field-specific institutional logics to evolve (Friedland and Alford, 1991; Scott, 2014; Thornton et al., 2012). The latter “are defined as the socially constructed patterns of symbols and material practices, assumptions, values, beliefs, and rules by which individuals and organizations produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality” (Thornton and Ocasio, 1999, p. 804).

In an evolutionary perspective, institutions are understood to simultaneously arise from and constrain social action (Giddens, 1979, 1981). They have been characterised as the “*rules of the game in a society, or, more formally, are the humanly devised constraints that shape human interaction. In consequence they structure incentives in human exchange, whether political, social, or economic. Institutional change shapes the way societies evolve through time*” (North, 1990, p. 3). Bruton et al. (2010) identify two major streams within institutional theory: the economic/political perspective and the sociology/organizational perspective. In the economic/political perspective, the focus is primarily on governance structures—rule systems created by agencies—and the associated incentives that drive decision-making behavior. Actors' efforts geared towards the establishment and maintenance of governance systems typically aim to facillitate interactions. Institutionalised rules allow to manage conflicts and cooperation (North, 1991). In contrast, the sociology/organizational perspective emphasizes the need for actors to use heuristics in decision-making because of cognitive limitations. The related stream of research highlights how social norms, shared cultures, and cognitive scrips guide human behaviour in an almost preconscious manner. Social norms stabilize uncertain situations and define the legitimacy of behaviour (DiMaggio and Powell, 1991; Suchman, 1995; Geels et al., 2017).

Edquist highlighted the difference between institutions that are consciously created by human agency (economic actors, policy shapers, etc.) and institutions that are 'self-grown'. He notes, "*The rules may, of course, gradually evolve behind the backs of the players as the play goes on, but they may also be deliberately changed by the players themselves or as a consequence of the interaction between players*" (Edquist, 2005, p. 57). Institutions evolving in human interaction but not by any specific party's deliberate are often overlooked, and their persistence can be underestimated. Purposive coordination or actors' strategic intent is not necessarily required for these institutions to form and become effective (Lounsbury and Crumley, 2007). Partly, they evolve due to the diversity among actors in terms of their experiences, competencies and organization: "*Different agents know how to do different things in different ways*" (Malerba, 2004, p. 14). Moreover, institutions are rarely fully defined, and it is common to find multiple institutional orders existing simultaneously (Sewell, 1992; Clemens and Cook, 1999; Zietsma et al., 2017). This multiplicity can further complicate the understanding and management of institutional dynamics.

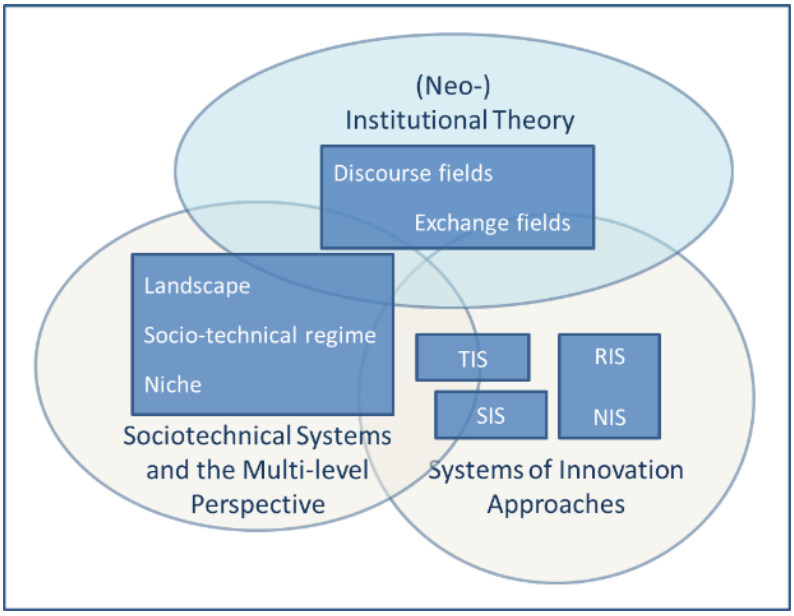
In summary, institutions are understood to consist of formal constraints, such as rules, laws, and constitutions, which can be deliberately altered, and informal constraints, like norms, conventions, behavioral 'scripts,' and self-imposed codes of conduct, which tend to evolve organically. Related enforcement mechanism may be codified in legal documents or unwritten laws enacted in a specific community. Informal constraints have also been characterised as basic ideals or logics that shape distinctive ways of framing, interpreting and interacting with reality reality (e.g. Micelotta et al., 2017; Thornton et al., 2012). They include techniques for structuring practices (e.g. Barley and Tolbert, 1997; Hasselbladh and Kallinikos, 2000). The rigidities of institutions and associated socio-technological structures have often been identified as root causes of path dependencies, which limit the flexibility of responses to changing conditions (e.g. Goldstein et al., 2023; Johnstone et al., 2017; Steen and Weaver, 2017).

Neo-institutional theory underlines that social structures are constantly renewed by actors. It follows that (disruptive) change promoters operate in parallel to other actors being engaged in the reproduction of established institutions (Lawrence and Suddaby, 2006). Struggle among different actors and intense network formation efforts have often been observed in the early stages of technology development or new field emergence. When relevant institutions do not yet exist, disparate actors wrangle about meanings, roles and field position (Zietsma et al., 2017). The process of ongoing reinterpretations of relevant (possibly contradicting) institutions in uncertain and changing environments has been shown to lead to new frames being enacted (Giddens, 1984; Seo and Creed, 2002; Gray et al., 2015).

1.3.4 Transition theory concepts for the study of an emerging bioeconomy

The potential of transition theory for the exploration of an emerging bioeconomy has been outlined on various occasions (e.g. Hermans, 2018). The theoretical concepts introduced in the previous sections have overlaps and similarities as shown in Figure 6. Institutional theory forms part and parcel of theorizing on IS and STS. As outlined by Geels and Schot with respect to the MLP, both "niches and regimes have the character of organisational fields (community of interacting groups)" (2007, p. 402). The MLP places slow changing factors on the sociotechnical landscape level (Figure 5) while one stream of NIS research differentiates institutions on meso, macro and international levels (Figure 2). NIS analysis often neglects informal institutions which gain more attention in STS research (e.g. Fuenfschilling and Binz, 2018). From an institutional perspective, however, the study of systemic change most of all needs a constitutive approach to actors and their behaviour as highlighted by Lounsbury and Wang (2020).

Figure 6 Heuristic concepts used in transition sciences



The composition, resources and capabilities of actors are assumed to be influenced by the geographical context and historical development paths of the region and country in which an actor is embedded. The unfolding micro-level dynamism in (systemic) innovation processes is difficult to capture (Grillitsch and Sotarauta, 2018). The actors´ current behaviour is clearly constrained and enabled by past experiences and pre-existing structures on the one hand (Dosi, 1982). On the other hand, global linkages broaden development visions and the actors' present actions reach out to future opportunities (Emirbayer and Mische, 1998; Garud et al., 2010; Trippl et al., 2017). The central concepts of transition theory - emergence and decline - have often been studied by employing the TIS concept (Gong and Andersen, 2024; Markard, 2020; Walrave and Raven, 2016). Longer value chains of a specific technology may, however, link actors from different industrial segments. Therefore, the SIS-perspective and quest for inter-sectoral links can hardly be avoided (Bergek et al., 2015; Markard and Truffer, 2008; Stephan et al., 2017). Conceptualising empirical analysis in the SIS perspective, on the other hand, will render the deduction of policy advice on specific socio-technical regimes difficult.

From an IS perspective, interactive learning is the central motor of change. Promotional efforts should therefore facilitate actors' experimentation with wide scope for interactive organising. European promotional schemes are aligned with this perspective as they tend to support the colocation of bioeconomy actors in clusters, so-called "bioclusters". These efforts may generate more or less convincing results depending on RIS and NIS conditions, the cluster focus, and a larger range of other factors. However, the comparatively simple promotional measure of industrial companies' colocation might prove insufficient to tackle the challenges of a bioeconomy. The deep-rooted societal and economic practices based on fossil resource extraction are part and parcel of firmly established sociotechnical regimes. Can these entrenched systems unravel in consequence of the formation of a few bioclusters?

As a general criticism of the analytic approaches in transition theory, it is increasingly underlined that a theory has to incorporate how actors themselves experience and contribute to the enactment of complex processes like innovation and the creation of new trajectories (Stacey, 2007; Sotarauta, 2017; Upham et al., 2018). With respect to an emerging bioeconomy, Hermans (2018) highlighted the necessity to study the processes of innovation orchestration between multiple actors at the micro level, not least to understand processes of niche formation. Because bioeconomy innovation tends to require divers types of knowledge, skills, and substantial financial resources, multiple actors might need to align their visions and pool resources. The type of innovation required for an advancement of the bioeconomy is systemic. It typically requires:

1) the involvement of previously unconnected actors and knowledge domains,
2) a (re-)construction of value chains,
3) a reform or adaptation of institutional arrangements at several levels (EC 2012; Lovrić et al., 2020; Van Lancker et al., 2016), and
4) new relations to the biophysical environment (e.g. Liobikiene et al., 2019; Ramcilovic-Suominen and Pülzl, 2018; Vivien et al., 2019).

Against this background, the exploration of an emerging bioeconomy cannot directly or unreserved build on the theoretical concepts introduced in this chapter. A bottom-up perspective will focus on relevant actor groups and refer to available insights from transition sciences as far as possible.

1.3 Research questions, conceptual approaches and empirical basis

This thesis explores the vantage points and contextualised activities of bioeconomy actors. More specific, the following research question is being addressed:

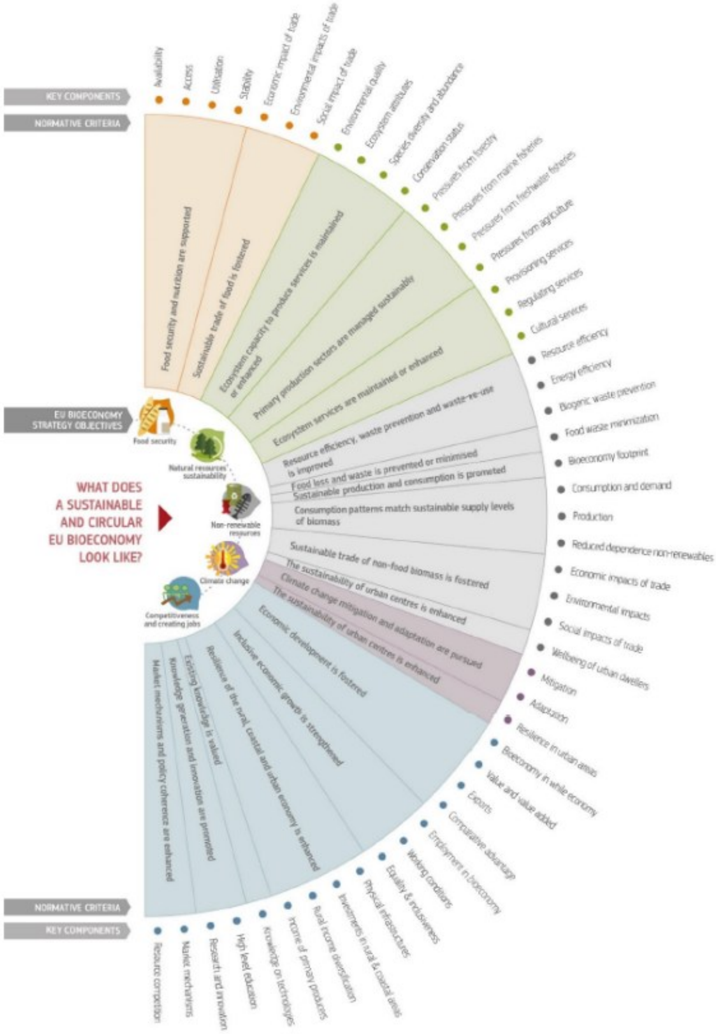
> ***How do bioeconomy stakeholders' sociotechnical imaginaries, their perception of innovation prospects and their institutional work contribute to an emerging bioeconomy?***

The following articles address the following three aspects in detail:

a) The relevant varieties of sociotechnical imaginaries that shape stakeholder attitudes towards bioclusters and the bioeconomy;
b) Industrial actors' perceptions of those context conditions, that determine their assessment of the desirability and feasibility of bioeconomy opportunity structuration and exploitation;
c) The patterns of the main bioeconomy actors' institutional work that emerge in response to institutional conditions in different industries.

The research effort shall contribute to an explanation of the observable outcomes of bioeconomy promotion and innovation activities as well as an improved understanding of innovation systems or field configurations. A striking lack of transformative knowledge for bioeconomy policy-making has often been diagnosed (Bogner and Dahlke, 2022; Lühmann and Vogelpohl, 2023; Urmetzer et al., 2018). Against this background, findings are meant to provide intelligence for an adaptation or further refinement of science, technology and innovation (STI) policy instruments at regional or national levels. In line with the concept of policy mixes (Rogge and Reichardt, 2016; Kern et al., 2019), specific attention is paid to the aspects of policy "comprehensiveness", "credibility", and "consistency of elements". Bioeconomy cluster managers and members may deduce insight for the orchestration of joint efforts.

Figure 7 Conceptual framework of the EU Bioeconomy Monitoring System

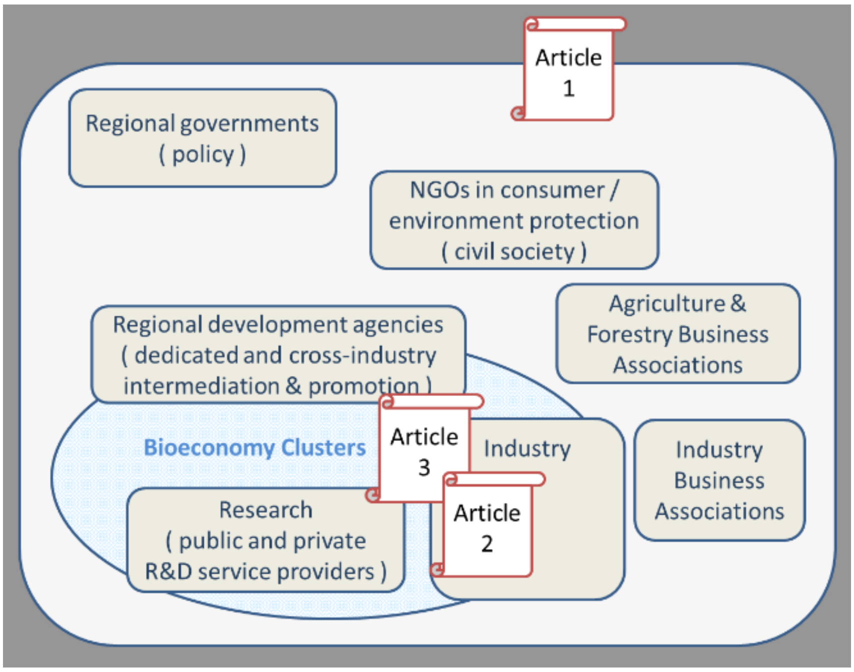


Source: Patani et al., 2023, p. 4

Any analysis of bioeconomy evolution, economic, social and environmental impact is still severely hampered by the fact that the delineation of traditional industries and an emerging bioeconomy is far from clear-cut (Rebolledo-Leiva et al., 2023; Sanz-Hernández et al., 2019; Wydra, 2020). An ongoing discussion reflects the search for a proper definition of a bioeconomy or several types of bioeconomies (e.g. Befort, 2020; Pyka et al., 2021; Vivien et al., 2022). Meanwhile, many bioeconomy innovation efforts are stuck in pilot phases (no upscaling) and others are not very likely to achieve competitiveness within the next 20 years (e.g. Carus et al., 2016; Vandermeulen, 2012). New products often have considerable public good qualities and the respective business models are unlikely to function without broad societal consensus on their superiority. In consequence, product related market data do not represent emerging segments of a bioeconomy. Experts of the EU Joint Research Center entrusted with the monitoring of advancement towards a bioeconomy recently proposed “Consumption patterns of bioeconomy goods match sustainable supply levels of biomass” as one of the indicators of progress towards the objective to reduce dependence on non-renewable unsustainable resources (Patani et al., 2023, see Figure 7).

The identification of partial, prospective or full members of a bioeconomy in industry or among European regions is rather impossible on the basis of existing economic statistics. Literature analysis and patent statistics do nevertheless allow to determine members in the scientific community. Important intermediaries involved in the implementation of national or regional bioeconomy promotion are not recorded in official statistics while bioeconomy support in the public discourse arena comes from very different corners of the political spectrum. Against this background, a clear-cut delineation of the bioeconomy or specific segments was not attempted. Instead, relevant actors were identified in and around two European bioeconomy cluster regions who are engaged in R&D and collaborative experimentation in the chemical, polymer processing, and construction materials industries.

Figure 8 Stakeholder groups included in the analysis



As visualised in Figure 8, article one explores the perspectives of a wide range of bioeconomy stakeholders. Article two is focussed on industrial actors while article 3 also includes intermediaries and researchers. A number of intermediaries were promotional agencies, closely linked and fully aware of interests and bioeconomy-related assessments in the private financial sector while some industrial actors also functioned as venture capitalists for start-ups. Similarly, stakeholders from professional or academic education were not explicitly targeted while dual roles of researchers in higher education led to the inclusion of related perspectives. Trade organisations and final consumers definitely are decisive stakeholders with respect to any socioeconomic transition (e.g. Geels, 2004). So far, however, these groups hardly got in contact with the notion of a bioeconomy. Professional service providers, such as legal or commercial consultancy companies, design and marketing firms or machine builders were not included in data collection because their involvement typically depends on the main industrial actors.

Each of the three individual articles will specify the methodological approaches (including data collection) in the following sections. It hereby noted that the interviews conducted with respondents from industry served as empirical basis on this actor group in the articles two and three.

2 Publications

2.1 Deconstructing the attractiveness of biocluster imaginaries

Wilde, K., & Hermans, F. (2021). Deconstructing the attractiveness of biocluster imaginaries. *Journal of Environmental Policy & Planning*, *23*(2), 227-242.

https://doi.org/10.1080/1523908X.2021.1891872

Published by Taylor & Francis, the Journal of Environmental Policy & Planning is an international, ranked, peer-reviewed journal. Title of Volume 23 - Issue 2: „Big transformation or old wine in new bottles? The bioeconomy as an emerging policy field.“

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	Source title	CiteScore	Highest percentile	Citations 2019-22	Documents 2019-22	% Cited	SNIP	SJR	Publisher
1	Journal of Environmental Policy and Planning	7.1	83% 65/384 Management, Monitoring, Policy and Law	1,554	220	89	1.372	1.064	Taylor & Francis

Source: Scopus

Impact Factor: 3.2 (JCR 2022 - Impact Factor)

JOURNAL OF ENVIRONMENTAL POLICY & PLANNING
2021, VOL. 23, NO. 2, 227–242
https://doi.org/10.1080/1523908X.2021.1891872

Deconstructing the attractiveness of biocluster imaginaries

Kerstin Wilde and Frans Hermans

Department for Structural Change, Leibniz Institute for Agricultural Development in Transition Economies (IAMO), Halle, Germany

ABSTRACT
In this paper, we investigate the promises that are employed within and around clusters that were formed in the evolving bioeconomy: bioclusters for short. Our paper aims to provide a conceptual clarification of the biocluster concept. To that effect, we employ the prism of sociotechnical imaginaries. We argue that both industrial clusters and the bioeconomy constitute separate, but partly overlapping sociotechnical imaginaries that shape stakeholder attitudes towards bioclusters. We applied a Q-methodology study in two bioeconomy clusters, one in Germany and one in The Netherlands, to investigate the resonance of different imaginaries in the cluster regions. Five distinct narratives, combining specific elements of cluster and bioeconomy imaginaries, are shared by different stakeholder groups. We revealed bioeconomy imaginaries at large to be far more contested than different cluster imaginaries. The latter mobilise overwhelmingly positive associations across diverse stakeholder groups. From this perspective, the popularity of biocluster promotional policies can be explained as they support some of the contested elements of bioeconomy imaginaries in gaining traction.

ARTICLE HISTORY
Received 30 June 2020
Accepted 25 October 2020

KEYWORDS
Bioeconomy; cluster policy; innovation policy; sustainability; Q-methodology; regional development

1. Introduction

The bioeconomy has come up as a way to promote the production of renewable biological resources (biomass like wood, plants, and algae) and the conversion of these resources and their waste streams into value-added products, such as food, feed, bioplastics, pharmaceuticals, and bioenergy (Brunori, 2013; Diakosavvas & Frezal, 2019). However, the bioeconomy is still in its infancy. The combined value added of the European bioeconomy in 2015 was estimated to be 460.6 Billion Euros, or 11% of Gross Domestic Product in a recent report (Kuosmanen et al., 2020). This means that the expected benefits of a transition to the bioeconomy are largely based on expectations and promises. The promise of the bioeconomy rests on two pillars. Firstly, the bioeconomy is expected to aid in combatting climate change by helping with the substitution of fossil fuels by biomass (Daioglou et al., 2019; Stegmann et al., 2020). Secondly, the bioeconomy will spur innovative entrepreneurship and contribute to the so-called knowledge economy through the promotion of economic activities related to biotechnology, plant breeding, and innovative processing technologies (Bugge et al., 2016; McCormick & Kautto, 2013).

In this paper, we investigate these promises as they are employed within and around clusters that were formed in the evolving bioeconomy: bioclusters for short. Industrial clusters have their own promises: they are generally associated with high competitiveness, opportunities for employment and can serve as incubators for innovative start-ups (Birch, 2017; Sölvell, 2008). Based on the work of Porter (1998), the creation of clusters has become popular with regional policy-makers all over the world (Ketels et al., 2006, 2012; Perez-Aleman,

CONTACT Kerstin Wilde Wilde@iamo.de Department for Structural Change, Leibniz Institute for Agricultural Development in Transition Economies (IAMO), Theodor-Lieser-Strasse 2, 06120 Halle, Germany
Supplemental data for this article can be accessed https://doi.org/10.1080/1523908X.2021.1891872

2005). Within policy circles, there are high expectations of the contribution of bioclusters to the transition away from the use of fossil fuels while fostering innovation and rural development (Dietz et al., 2018).

Despite their popularity, neither of the two underlying concepts, cluster and bioeconomy, is very well defined. The terms 'bioeconomy', 'biobased economy', 'knowledge-based bioeconomy' and 'circular bioeconomy' are often used interchangeably but can have different meanings and implications (Lewandowski, 2018). Similarly, the cluster concept is 'fuzzy' and critics argue that cluster definitions and boundaries are often arbitrarily and subjectively chosen (Martin & Sunley, 2003). A shared understanding is, nevertheless, important to stimulate change and engage different groups in development efforts. When different actors attach different meanings to these concepts, a profound conceptual confusion ensues that will eventually impede realisation of innovation potentials (Beers et al., 2010). Since relevant stakeholders' future expectations also steer investments and the selection of activities, they deserve strengthened research attention (e.g. Njøs et al., 2020).

Against this background, our paper aims to provide a clarification of the biocluster concept by investigating how different stakeholders interpret and value the different elements, meanings and promises. To that effect, we will analyse both components of the concept through the prism provided by sociotechnical imaginaries. Sociotechnical imaginaries describe attainable, desirable futures – 'what constitutes the public good' (Jasanoff & Kim, 2009). We will argue that both industrial clusters and the bioeconomy, have separate, but partly overlapping, sociotechnical imaginaries that are important in shaping stakeholders' attitudes. Accordingly, the research question of this paper is: *How are sociotechnical imaginaries of a bioeconomy and industrial clusters combined and translated by regional stakeholders?*

With this question, we connect distinct fields. Although there are a number of studies of bioeconomy discourses (Bugge et al., 2016; Vivien et al., 2019) and regional cluster theory interpretations (Ebbekink & Lagendijk, 2013; Moulaert & Sekia, 2003; Njøs et al., 2017), these different perspectives remained separate. Our effort aims to contribute to a due consideration of the material, social and ideational aspects of bioclusters.

In the next section, we will first clarify the different concepts used in this paper: sociotechnical imaginaries, discourses and narratives. Furthermore, we present a categorisation of bioeconomy discourses that links them to existing environmental and sustainability discourses. Cluster conceptualisations are reviewed as well. This overview forms the basis on which different elements are included in the study and investigated for resonance in different groups' visions of a good future.

We use Q-methodology to trace the uptake of imaginaries. Respondents from two different clusters, one in the Netherlands and one in Germany, have been asked to sort statements representing elements of deconstructed imaginaries. Statistical analysis of these sorts serves to identify different shared narratives of different groups of actors. These narratives will be presented in the result section. The paper ends with a discussion on the implications of findings for (bio)cluster theory and practice.

2. Sociotechnical imaginaries of bioeconomy clusters

As the starting point, we use the definition of Jasanoff and Kim (2009) who portrayed sociotechnical imaginaries as 'collectively imagined forms of social life and social order reflected in the design and fulfilment of nation-specific scientific and/or technological projects'. This definition locates imaginaries at the level of the nation state and emphasises the role of government organisations in enacting sociotechnical imaginaries. In her later work, Jasanoff broadened the definition to also include the roles of other types of organised groups, such as social movements, corporations and professional societies in the co-production of imaginaries (Carrozza, 2015; Jasanoff, 2015). In this later definition, sociotechnical imaginaries describe desirable futures of what constitutes the public good and that are attainable through or supportive of advances in science and technology. Sociotechnical imaginaries result from discourses that deal with the future, especially related to (new forms and achievements) of science and technology. However, the concept of a 'discourse' has a number of different theoretical routes in the social sciences. For a comprehensive overview of that topic, we refer to the work of Arts and Buizer (2009) who identified four conceptualisations of discourse and approaches of discourse analysis: (1) discourse as communication, (2) discourse as text, (3) discourse as expression of mental frames and (4) discourse as social practice. These four categories are not mutually exclusive and partly overlapping and most authors use a combination of different conceptualisations to analyse sociotechnical imaginaries.

In this paper, we refer to sociotechnical imaginaries in terms of 'discourse as an expression of mental frames' and 'discourse as social practice'. The first approach emphasises how certain groups of actors share a certain 'frame of reference or meaning' that mediates their use of certain language. These frames live in the minds of people, known or unknown, and shape their mental models of the world. Based on shared conceptual frames, different groups identify certain problems and solutions (and not others) that can be revealed using the texts they use to communicate (Van Assche et al., 2014). Narratives result when individuals or groups combine some elements of discourses (concepts, subjects, objects and events) into coherent storylines that describe a problem, lay out its consequences and suggest (simple) solutions (Bauer, 2018; Roe, 1994). Using a frame-analytic approach, Eaton et al. (2014), for example, analyse sociotechnical imaginaries around bioenergy. Accounting for multiple understandings of the material world, popular narratives of past and future in specific places, allows them to identify competing sets of frames.

The use of discourse as practice is related to the work of Foucault (1994) and Hajer (1995) who highlighted the relation between discourses and social practices, including the shaping of institutional arrangements and power processes: different actors are empowered by particular social relations and can draw on discourses as an institutional resource to advance their agendas. In order to gain traction in society, imaginaries have to be enacted. This enactment leads to publicly visible experiments and prototypes, demonstration plants or projects that are accompanied by discursive practices that try to make sense of the enactment, supporting or rejecting what eventually represents social progress. Studies that highlight the 'politics of sociotechnical imaginaries' like Burnham et al. (2017) or focus on the on-going political struggles between actors promoting different visions in order to gain policy commitments and R&D funds (Levidow & Papaioannou, 2013) follow this conceptualisation of discourse.

We interpret sociotechnical imaginaries as results of a specific future-oriented form of discourse with an emphasis on the role of science and technology. Sociotechnical imaginaries can serve as a cultural resource that different actors can draw from, knowingly or unknowingly, to argue for certain solutions based on their identification of important regional problems or development potentials. This way, elements of diverse sociotechnical imaginaries are adopted and translated in specific regional contexts by specific regional actor groups. In the next two sections, we will present a review of the literature on discourses and imaginaries that refers to the bioeconomy and industrial clusters.

2.1. Discourses and imaginaries of the bioeconomy

Discourse analysis has been applied extensively to analyse the concept of the bioeconomy, for instance on the basis of scientific papers (Bugge et al., 2016; Pfau et al., 2014; Vivien et al., 2019) and policy documents (De Besi & McCormick, 2015; McCormick & Kautto, 2013; Ramcilovic-Suominen & Pülzl, 2018). Depending on their research interest, these authors identify two, three, four or five different discourses. To structure these different contributions, we use Dryzek's classification of environmental discourses (Dryzek, 1997/2005). His categorisation allows us to bring different contribution into a single framework and at the same time links them to existing sustainability discourses.

Dryzek's classification of environmental discourses centres around two axes (Table 1). The first axis is the general attitude (positive or negative) towards technology and industrialisation. Industrialisation and

Table 1. Classification of environmental sustainability discourses.

		Attitude towards industrialisation	
		Radical	Reformist
Place of the environment	Imaginative (integrated)	'Green radicalism'	'Ecological modernisation'
	Prosaic (separated)	'Survivalism'	'Problem solving'

Note: adapted from Dryzek (1997, p. 14).

Table 2. Overview of bioeconomy imaginaries.

	Biotech economy	Bioresource economy	Biosphere economy	Bio-ecology economy
Dryzek's sustainability discourse	Problem solving	Ecological modernisation	Survivalism	Green radicalism
Typical references	Organisation for Economic Co-operation and Development (OECD, 2009)	European Commission (2012)	Georgescu-Roegen (1978)	Levidow et al. (2013), Schmid et al. (2012)
Definition	A science-based economy driven by industrial biotechnology	A biomass-based economy	An ecological economy that is compatible with the biosphere	An ecological economy within local conditions
Aims and objectives	Economic growth and employment	Economic growth and sustainability	Human survival	Biodiversity of ecosystems, soil conservation
Research and technology	Industrial biotech as a goal: the main driver of progress	Biotech as a means to boost primary production and feedstock	Technology necessary to fit human activity within global biochemical cycles	Promotes co-production of knowledge and alternatives based on agro-ecological principles
Value creation	Application of biotech, commercialisation of R&D	Conversion and upgrading of bioresources	Focus on 'degrowth'	Localisation of production systems with territorial identity
Role of the primary sector	Mostly irrelevant	Narrow: Provision of raw materials	Part of global circular value chains	Focus on agro-ecological farming practices including landscape values

Based on Bugge et al. (2016), Dryzek (1997), Schmid et al. (2012), and Vivien et al. (2019).

technology are either a potential solution, or the main culprits of some of the most important environmental problems society experiences. The second axis is concerned with perceptions of the political-economic situation and its relationship with environmental problems. Prosaic discourses see environmental problems as things that require action; however, they do not require a new kind of society. In contrast, imaginative discourses seek to completely redefine the current situation. Environmental problems are rooted in the way economic and social systems are structured and solving these problems requires a complete re-organisation of society. Environmental questions are thus brought into the heart of political deliberations and this discourse envisages to identify 'win–win–win' solutions across the three pillars of sustainable development.

Building on Bugge et al. (2016), Levidow et al. (2013) and Vivien et al. (2019) it is possible to identify four bioeconomy imaginaries that are rooted in these typical environmental discourses: (1) a biotech imaginary, (2) a bioresources imaginary, (3) a biosphere imaginary and (4) a bio-ecology imaginary. These imaginaries provide a vision of the future that identifies different problems and proposes different solutions. Some of the decisive elements of the imaginaries are summarised in Table 2.

The biotech imaginary represents a typical 'problem solving' discourse in Dryzek's typology. It is closely associated with the Organisation for Economic Co-operation and Development's version of a bioeconomy (OECD, 2009). Central is the focus on the implementation and further development of biotechnology. The conviction is that it offers great potential to transform the way many products are being made. Economic growth based on a 'knowledge economy' that employs biotechnology is the goal. The primary sector doesn't really play a role in this sociotechnical imaginary – except as beneficiary of new breeding technologies that will increase production output.

The bioresource economy imaginary rests on an ecological modernisation discourse: it's fairly positive about the possibilities of technology and innovation and at the same time environmental concerns are assessed within the triple Ps of sustainability: People, Planet, Profit. The bioresource economy imaginary is closely linked to the bioeconomy vision of the European Union. Farmers and foresters play an important role as providers of biomass.

The bio-ecology imaginary is described by Schmid et al. (2012) as a public goods-oriented bioeconomy that emphasises agro-ecological methods, organic and low (external) input farming systems, ecosystem services, social innovation in multi-stakeholder collective practices and joint production of knowledge. The bio-ecology imaginary looks at the local and regional scale and favours the localisation of production. By contrast, the biosphere imaginary, as originally elaborated by Goergescu-Roegen, has a global outlook on a bioeconomy and defines sustainability squarely on the global scale: a quest for human survival. This imaginary is far more pessimistic on the possibility of technological development and innovation to provide solutions for environmental problems: this might not happen, or only too late. Circularity is important here and defined on the scale of global biochemical flows (Georgescu-Roegen, 1978). The biosphere and bio-ecology imaginaries have a critical view on the role of technology. This does not mean that they are completely opposed to the use of technology. However, they often prefer different kinds of knowledge and technology rooted in specific knowledge frameworks around the issue of agro-ecology.

2.2. Discourses and imaginaries around industrial clusters

Sociotechnical imaginaries around the cluster concept have their roots in the promotion of industrial clusters as a policy instrument for regional development in the work of Michael Porter. In the 'The Competitive Advantage of Nations', Porter (1990) made the observation that a country's most competitive companies are often geographically concentrated in just a number of places: clusters. From that observation, it was a small step to actively promote the creation of new clusters in order to encourage regional competitiveness, innovation and growth. Policy-makers around the world have tried to create the 'next Sillicon Valley' (Ebbekink & Lagendijk, 2013). However, Porter's definition left ample room for interpretation and Martin and Sunley (2003) have criticised the subjective and arbitrary nature of the cluster concept in many scientific studies. The same is true for the uptake by other stakeholders:

> actors will have different conceptions of what clusters are and in cluster projects, different cluster stakeholders, such as cluster facilitators, regional policy-makers, research and development (R&D) institutions, industry associations and firms, add new, and often divergent, interpretations of the traditional academic understanding. (Njøs et al., 2017, p. 2)

Although there is increasing awareness of the relevance of specific social and cultural practices, discourses and expectations that form cluster identities and development paths (Amdam et al., 2020; Hassink & Gong, 2019; Steen, 2016), social constructivist perspectives on clusters and cluster formation processes are still rare. The paper by Fløysand et al. (2012), where clusters are studied as a mix of discursive and material elements, is one of the rare exemptions. As examples of the material characteristics of a cluster they name the geographical co-location of firms, the flows of good and services between these firms and the local infrastructure with roads, buildings and laboratories. The discursive elements of a cluster are the result of communicative processes among policy-makers, academics, firm representatives and other stakeholders. Especially for 'policy-driven clusters' (Ebbekink & Lagendijk, 2013; Richardson et al., 2012), which are the result of strong commitment of governmental actors, discursive processes can precede the actual material agglomeration processes 'on the ground'. Bioclusters are prominent examples of such policy-driven clusters. Reflections on the role of clusters in promoting green and sustainable innovations and for the re-orientation of existing clusters towards sustainable regional development have also been increasing in recent literature (Hermans, 2018; McCauley & Stephens, 2012; Sjøtun & Njøs, 2019).

Growing attention for the sustainability of industrial clusters has also broadened the associated sociotechnical imaginaries. The once dominant imaginary associated with the work of Porter had a focus on competitiveness, local factor conditions and innovation. This has broadened towards other expectation in terms of contributions to regional development and the transition towards sustainability. Thus, the focus of attention also shifts towards those processes that are of crucial importance in transition theories: vision development, networking and learning (Susur et al., 2019), the importance of leadership (Grillitsch & Sotarauta, 2019), environmental impacts of clusters at different scales and levels (Ayrapetyan & Hermans, 2020; Siebert et al., 2018), the emergence of radical innovations that are 'new to the region and new to the world' (Boschma et al., 2017) and other organisational forms, like Living Labs as sites to design, test and learn from innovations in real time (von Wirth et al., 2019). There is no overarching typology, yet, for a categorisation of evolving discourses and resulting imaginaries of green-tech and bioclusters. This paper could be seen as a first step towards creating such a typology: we investigate the actual narratives of stakeholders in a discursive realm instead of the theoretical classifications that predominantly refer to the material properties of (bio)clusters.

2.3. Deduction of the research question

With respect to a bioeconomy, we identified four imaginaries and linked them to existing environmental discourses. For industrial clusters, the dominant sociotechnical imaginary is related to the work of Porter. From our overview, we conclude that some combinations of bioeconomy imaginaries and expectations related to Porter-type clusters are a natural fit. For example, the biotech imaginary shares a positive attitude towards industrialisation and technology with the classical cluster concept and both promise increased competitiveness of industry. However, with an increasing attention for the role of clusters in sustainability and regional transition processes, the cluster imaginary is being broadened, challenged and stretched (Njøs et al., 2017). We are interested in the question how imaginaries of clusters and of a bioeconomy resonate in practice: how their enactment and adoption at the regional level brings certain elements to the forefront and diminishes the importance of others. Thus, we investigate real-world discursive interaction on bioclusters.

3. Case selection and Q-methodology implementation

3.1. Case selection and characterisation

To answer our research question, we have administered a Q-methodology study in and around two bioclusters. We selected clusters that emerged with early bioeconomy promotional strategies launched in the European Union, one in Germany ('Spitzencluster Biooekonomie', or SCB) and one in The Netherlands (Biobased Delta – BBD). From a material and discursive perspective, both clusters are similar in many aspects: both originated in the vicinity of old petro-chemical clusters, both clusters cross multiple governance scales (three provinces in the Netherlands and three Federal States in Germany) and both try to make use of local inputs from forestry or agriculture. From interviews conducted in both regions, we learned that some actors in both regions identify them as peripheral places that either lack intellectual luminance or innovation dynamic.

An important difference can be found in the innovation policy rationales driving bioeconomy promotion in the two countries. The Dutch innovation policy can be characterised as company-driven innovation for near-term growth with demand-driven promotional impulses and attention to eventual necessities of regulatory changes (RVO, 2015). German innovation policy has a stronger focus on science-driven opportunity exploration in a medium to long-term perspective (BMEL, 2016).

3.2. Construction of the concourse and statement sampling

Q-methodology is a form of discourse analysis that combines quantitative and qualitative techniques to access personal experiences, preferences and beliefs (Brown, 1980; McKeown & Thomas, 1988). It is designed for small numbers of participants and does not require a random sample.

The first step in Q-methodology is the construction of a concourse that should capture the complete range of perspectives that different groups of stakeholders might have. We used different sources towards that end. Our most important source were the transcripts of 56 in-depth interviews that were done in the two cluster regions in 2018. These interviews were directed at the perceived hurdles and drivers of bioeconomy development. Interviewees were chief executive officers and chief technology officers of companies (19 German, 11 Dutch), researchers from universities, private and public R&D service providers (12 German; 4 Dutch) and representatives of the cluster and a few promotional units (4 German, 6 Dutch). Some respondents were residing in the cluster area but did not join cluster activities and therefore contribute the perspectives of 'outsiders'. Relevant interview statements were categorised and labelled by theme. This collection of statements was enriched with other sources such as press releases, strategy papers, speeches and other materials published by stakeholder types which were not covered by the interviews. Out of all sources, we gathered about 250 relevant statements from the German and Dutch context each.

The second step was to compose a sample from these statements. We used a structured sampling matrix, based on the different elements of the bioeconomy cluster imaginaries, identified earlier. This way, we included a total of nine categories, more precisely: categories related to elements of bioeconomy imaginaries, categories that are related to old and new imaginaries of clusters and elements that are shared by both.

(1) Regional economic characteristics and bioeconomy rationale.
(2) Concept of nature, agriculture and forestry.
(3) Role and characteristics of markets.
(4) Role of consumers.
(5) Role of knowledge and research.
(6) Role of the government.
(7) (Transition) Management strategy and process steering.
(8) Relevance of (bio)cluster policy.
(9) Role of and impact on the rest of the world.

It is important to note here that we found no statements, neither in the interviews nor in the additional material gathered that matched elements of the biosphere discourse of Goergescu-Roegen. It seems to be an academic or radical non-governmental organisations' (NGO) imaginary without relevance for current policy discussions. Likewise, Vivien et al. (2019) concluded that this original bioeconomy discourse was 'hijacked' by a green growth imaginary. Therefore, we decided to drop this category out of the sampling matrix.

Statements in these nine categories were prioritised in view of their clarity and thought-provoking formulation. Through several discussion and selection rounds, a total of 36 statements were finally chosen to best represent divergent bioeconomy and cluster imaginaries. Original statements were translated with attention to issues of cross-cultural understanding. An effort was made to keep the tone and substance of the original statements reflected (see Annex, Table 4). Six pre-tests were implemented and led to the final Q-sort.

3.3. Mobilisation of respondents and Q-sorting

Potential respondents were selected from known contacts in and around the two clusters and complemented by internet research on missing or underrepresented stakeholder types. The process resulted in invitations to 75 Dutch and 83 German organisations. The respondents, who participated in the study, are specified by actor type in Table 3. In both clusters, seven respondents also participated in the 2018 interviews.

Data collection took place via the platform QSortWare, developed by Pruneddu (2017). Respondents were guided through the software-supported rank-ordering of the statements in Dutch and German in March and April 2020. The 36 statements were sorted on the grid displayed in Figure 1. Researchers contacted the respondents for clarifications in cases of perceived inconsistencies.

Table 3. Number of respondents, by actor type and nationality.

	DE*	NL**
Regional Government/Policy	4	3
Regional Development Promotional Agency	1	1
NGO (Environment & Consumer Protection)	4	0
University (of Applied Sciences)	2	4
Research Institute/R&D Service Provider/Cluster management units	3	2
Company (Industrial Economy)	3	5
Agriculture & Forestry Business Association	1	0
Industrial Business Association	3	0
Total	21	15

*Stakeholders from Saxony-Anhalt, Saxony and Thuringia.
**Stakeholders from Brabant, Zeeland and Zuid Holland.

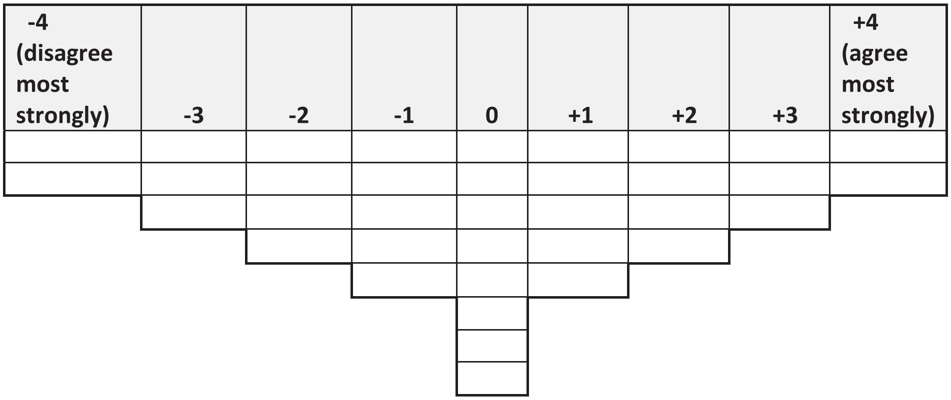

Figure 1. Q-methodology grid.

3.4. Statistical analysis

The statistical analysis reveals how subjective positions are shared by respondents. This is done by the calculation of correlations and factor analysis of the 36 Q-sorts completed by the respondents. Q-sorts from the two clusters were analysed together.

For quantitative data processing and analysis a combination of PQMethod (Schmolck, 2014) and the QMethod package in R was used (Zabala, 2014). The amount of components to retain in the analysis was determined using Horn's parallel analysis (paran package in R, v 1.4.0). With Principle Component Analysis followed by a Varimax rotation 5 factors were extracted that captured 57% of the total variance. The highest correlation between these five-factor scores was 0.42 (between factors 1 and 4) and all other correlations were considered low (less than 0.21, see Annex, Table 5). Correlation at this level is generally taken as a hint that viewpoints are similar (Watts & Stenner, 2012). With further analysis significant loadings on the factors were identified. The two standard criteria in QMethod software were employed for that purpose:

- Q-sorts with factor loading is higher than the threshold for p-value < 0.05, and
- Q-sorts with square loading is higher than the sum of square loadings of the same Q-sort in all other factors.

The Q-sorts of the respondents, who significantly loaded on a specific factor, were used to calculate a weighted average for the statements. The higher the load of an individual's Q-sort, the heavier we counted it in the weighted average. Negative loadings were also included in the analysis. Since not all factors contain the same number of respondents, the statement factors are normalised by the calculation of a standard z-score for comparing them.

4. Results

The five factors were first interpreted by the two authors independently from each other, compared and discussed thereafter. We provide a narrative account below and provide detailed statistical results in the appendix of this paper (see Annex, Table 6).

Factor 1: a good life with sustainability through bioclusters

This narrative is shared by the majority of respondents, representing a broad range of actors: government officials, political actors, environmental NGOs, innovative SMEs, R&D service providers and university professors. Supporters envisage a good life for everybody with a transition to a more sustainable mode of production without making any difficult choices or radical life style changes: green growth will preserve employment, while industry absorbs less (fossil) resources, recycles them and produces less waste. Agricultural land use and environment protection go hand-in-hand with a diversified farm structure and the import of raw materials from abroad is not problematic. There is a large trust in the market: when prices include external effects, government can stay in the background. Biobased solutions will flourish and the rest of the world will benefit in terms of reduced inequality. This narrative take the existing industrial sectors as the starting point for further development with a biocluster. Biotechnology is not a major concern in this narrative because it's not perceived as a strong point of the regions. The task of clusters in this narrative is to build new actor networks and cross-industry value chains.

Factor 2: industry policy for a bioeconomy with biorefineries

This narrative believes strongly in the future of regional biorefineries. They shall build on the existing competencies in industrial processing of agricultural and wood resources, and in chemistry. Biorefineries allow the substitution of fossil fuels, but leave the rest of the value chain intact. Life style changes are, therefore, unnecessary. The role of agriculture is to supply these biorefineries with large feedstock volumes. Biotechnology has no role to play in agriculture but is relevant for industrial processes in organic chemistry. Here, sustainability is not prioritised as much as in the Factor 1 and 3 narratives: the Factor 2 perspective does not aspire full inclusion of social and environmental costs. Conditions in the rest of the world are not perceived as a regional responsibility.

University spin-offs and entrepreneurial graduates are important in this perspective, while clusters are evaluated positive but are not expected to play a prominent role. Stronger than all other narratives, the Factor 2 storyline argues for government support with global competitive pressure and jobs in the region. It appears to belong to industrial incumbent. However, primarily (non-biotech) researchers in our sample supported the call for subsidised first-of-their-kind biorefineries.

Factor 3: green transition with industry-led bioclusters

Change towards increased sustainability is rated as urgent in this narrative. The vision for the region is to turn it into a European hotspot of high-tech companies. Biorefineries are part of such a high-tech strategy, but regional agriculture and forestry are not. This is the narrative of ambitious technology-based entrepreneurs who see themselves leading the transition. These actors may rely on global sourcing of feedstocks and will come up with scalable technical solutions and provide good quality goods at reasonable prices with reduced environmental impact and waste. Clusters serve the (industry's) purpose to create new contacts or industrial alliances, but that is about it. This perspective has no role for inspirational leaders or a management team with politicians and researchers. Strong disagreement to this narrative was raised by an environmentally concerned SME as well as by a business association from agriculture and forestry. More pronounced than in the Factor 2 (and unlike in the Factor 1) narrative, the future is not 'for all' to benefit.

Factor 4: bioeconomy with science leadership

The fourth narrative is positive about the prospect to harmonise economic growth and sustainability. Support for bioeconomy development is not particularly grounded in regional characteristics. Instead, the general contributions of biotechnology to sustainable and efficient agriculture and biobased industrial production are highlighted. Accordingly, actors express worries about a brain drain from the region and Europe at large due to strict regulations on Genetically Modified Organism (GMO). The future will be technology driven, like in the Factor 2 and 3 narratives, and the rest of the world is associated with competitive threats. The government should support the bioeconomy and cluster promotion is regarded as a suitable and effective strategy as clusters are seen as a good way to disseminate the results of fundamental research. Universities and researchers play a leading role.

This narrative is supported by German respondents only, namely researchers who work close to natural resource production and processing at institutes of applied research and universities . In this perspective government-assisted and managed change is welcomed – in contrary to the Factor 3 and Factor 5 narratives.

Factor 5: growth and free markets

This is the narrative where the rest of the world is neither a threat nor something to care about. It is not concerned with (environmental) sustainability or any change in the regions' agricultural sector. Instead, there is alignment with the Factor 3 framing of the region as seedbed and hotspot of high-tech companies. As growth is considered important for continued prosperity, the diverse qualities of the region can and should be leveraged in competition on global markets. This narrative detests government subsidies, rejects government steering efforts in regional development and clusters. The latter are perceived as ruled by 'the establishment' and built for subsidy acquisition.

This narrative is supported only by Dutch respondents in our sample. These are a regional representative of a right-wing populist party, a senior official in regional development promotion and an innovative company fighting with market access hurdles in spite of superior environmental performance of the product. Perspectives expressed are positioned closest to the Factor 2 and 3 narratives and underline that it is best to leave economic dealings to businesses which will also employ and feed ordinary people in the region.

5. Discussion and conclusions

We started with the question how local stakeholders combine and translate (inter)national imaginaries of a bioeconomy and clusters. Which elements of the two imaginaries found resonance and gained traction in regional actors' narratives about a good future? We will first review the uptake of the bio-ecology imaginaries and then discuss the uptake of the different cluster imaginaries to come to our conclusion.

5.1. Resonance of the bioeconomy imaginaries in distinct shared narratives

We analysed the average *z*-scores for each of the five narratives on the statements associated with the three guiding bioeconomy imaginaries we used in our sampling matrix ('bio-ecology', bioresources' and 'biotech', see Figure 2). High appreciation of the bio-ecology and bioresource imaginaries is present in the Factor 1 narrative supported by a broad range of respondents. Even higher resonance can be found between the bioresource imaginary and the Factor 2 biorefinery-focussed narrative supported by researchers. Bio-ecology is rejected, because it is associated with small scale agriculture that doesn't fit with the assigned role of the primary sector as feedstock producer. The Factor 3 narrative also leans towards the bioresources imaginary. Biorefineries have a role to play while high-tech entrepreneurs are the driving force. The biotech imaginary got substantial traction only in the Factor 4 narrative. By contrast, the Dutch Factor 5 narrative simply does not subscribe to any of the bioeconomy imaginaries: these are perceived as yet another lever of established elites to justify their lobbying for government support.

An important conclusion is that certain bioeconomy imaginaries are rejected by each narrative leading to controversial relations of the distinct storylines and supporting actor groups. The bio-ecology and the biotech imaginaries actively exclude each other in our results. The bioresource imaginary takes up a middle ground. It can be positively associated with bio-ecology (as in Factor 1), or it can be positively associated with biotech as it is in Factor 3 and Factor 4. Based on these conflicting narratives we diagnose a lack of a societal consensus over the significance and definition of problems or attainable objectives in both cluster regions. A majority of stakeholders subscribing to Factor 1 rather ignores that a combination of the bioresource and bioecology imaginaries (Fritsche & Rösch, 2020) is problematic with growing demands around the globe (Fritsche & Rösch, 2020; Piotrowski et al., 2016).

Widespread criticism of the biotechnology imaginary, for instance about an insufficiently precautious treatment of biotechnology applications in agriculture (Brunori, 2013; Schmid et al., 2012), might explain why the

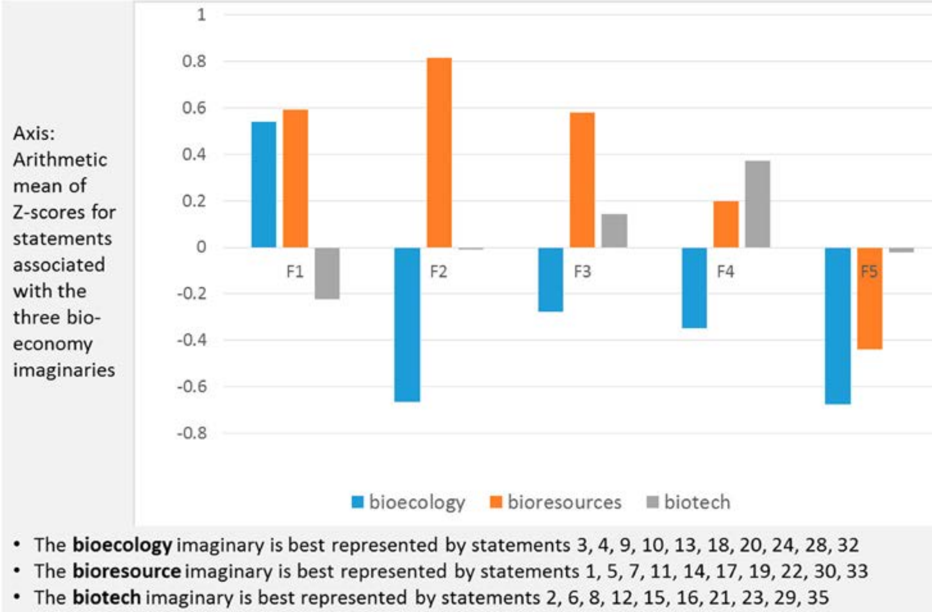

Figure 2. Representation of bioeconomy imaginaries in stakeholder narratives.

biotech imaginary doesn't play an important role (neither negatively nor positively) in most narratives. Most respondents don't see the problem of biotechnology research leaving Europe that was highlighted by Factor 4 supporters.

5.2. Resonance of cluster imaginaries in the narratives

We have argued that with the inclusion of the issue of sustainability leads to a recognition of other shapes and functions of clusters beyond Porter's focus on competitiveness and innovation. New cross-sectoral interaction with an inclusion of actor groups like, e.g. NGOs and consumers is increasingly advocated. As a consequence, 'new' clusters require orchestration of more actors, inspirational leadership and active steering of collaboration arrangements. In Figure 3, we have visualised how each of the five narrative scores on statements that refer to Porter type of cluster imaginaries and 'new' cluster imaginaries.

In contrast to the high level of controversy on bioeconomy imaginaries, imaginaries connected to both 'old' and 'new' types of clusters are viewed positively in almost all the narratives. The Factor 3 (industry-led bioclusters) represents the only exemption. Successful high-tech entrepreneurs view their peers not in the region, but on the global playing field. This narrative doesn't really care about any type of cluster, (old or new), and rejects any major involvement of politicians or researchers in their dealings. The Factors 1 and 2 storylines have a preferences for old clusters, although both also have some positive recognition of aspects associated with new clusters. Different rationales are likely: The Factor 1 relies less on the government but places stronger hopes on the broader civil society to drive the transition. Factor 2 supporters prefer collaboration with the group of established (large-scale) companies and research centres but also recognise the need for some government support, regional development finance and the involvement of university spin-offs.

Supporters of the Factor 5 narrative show up with quite some appreciation of more inclusive Living Labs that might at least be expected to not (only) serve the established elites. The high score for the new cluster associated with the Factor 4 (the science-led biocluster narrative) demands some explanation. We hypothesised that the biotech imaginary would be positively associated with the traditional view of

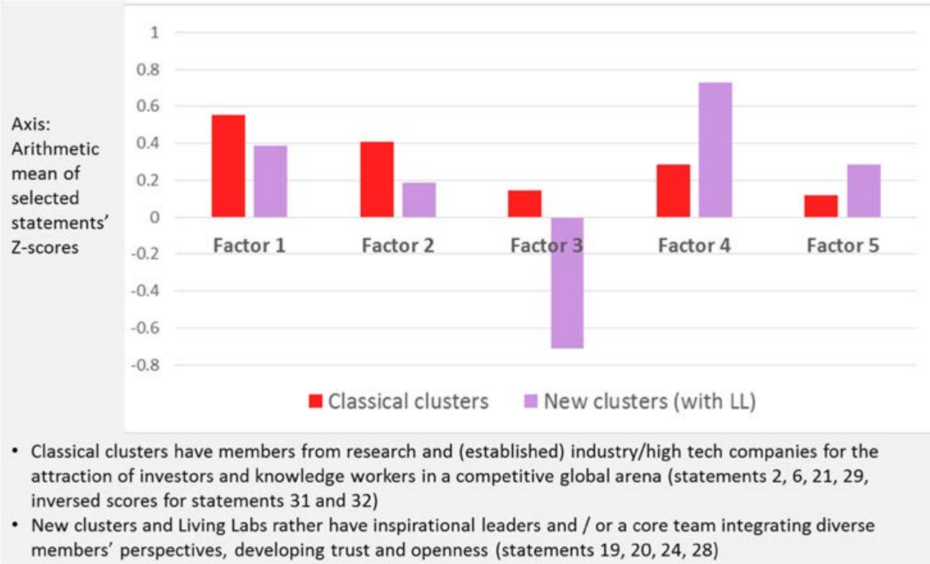

Figure 3. Shared narratives in relation to different sociotechnical imaginaries of a (bio)cluster.

clusters. The Factor 4 narrative scores high on 'old' cluster imaginaries, but still likes the alternative new cluster imaginary best. Thus, we assume the need to achieve more societal acceptance of biotech applications and products to drive supporters towards deepened contacts to consumers and NGOs.

5.3. New imaginaries around bioclusters

From our overview of the resonance of cluster and bioeconomy imaginaries in the different narratives, we can conclude that the bioeconomy imaginaries received more contestation than the cluster imaginaries. After years of government-supported cluster promotion almost every narrative can benefit from a 'next Sillicon Valley'-imaginary to draw upon (Ebbekink & Lagendijk, 2013). It can be flexibly stretched from no-government-involvement in the Marshallian dynamics of industrial districts to high-government-involvement in clusters formed in the framework of mission-driven innovation policy.

In our two cases the cluster requirement of geographical co-location of companies is weakened. In the later stages of the German SCM cluster development, membership was expanded to firms located far away. Similarly, Flemish-Dutch transboundary contacts were mobilised early on in order to frame the BBD cluster as a bioeconomy 'mega-cluster' at the European level (RDI2CluB, 2018). The fact that this 'cluster' has no registered membership makes it even clearer that BBD is rather developed by inspirational leadership in the discursive realm than by the infrastructure and regional characteristics in the material realm.

In order to substantiate this reading of results, we ranked Q-sort statements in the order of their standard deviation across the five *z*-scores. A high standard deviation indicates a controversial evaluation, while a low standard deviation indicates a degree of consensus. We then segmented the statements into three equaly strong (12 statements each) categories with high consensus, a mid-range between consensus and contestation, and contested statements.

As shown in Figure 4, only 16% of bioeconomy statements (three out of 19) were among the consensual statements, while the same applied to three out of six cluster statements. The statements that combined a reference to bioeconomy and cluster imaginaries recorded a high degree of consensus for most of the statements. This confirms again that the bioeconomy imaginaries are rather contested, while the cluster imaginaries

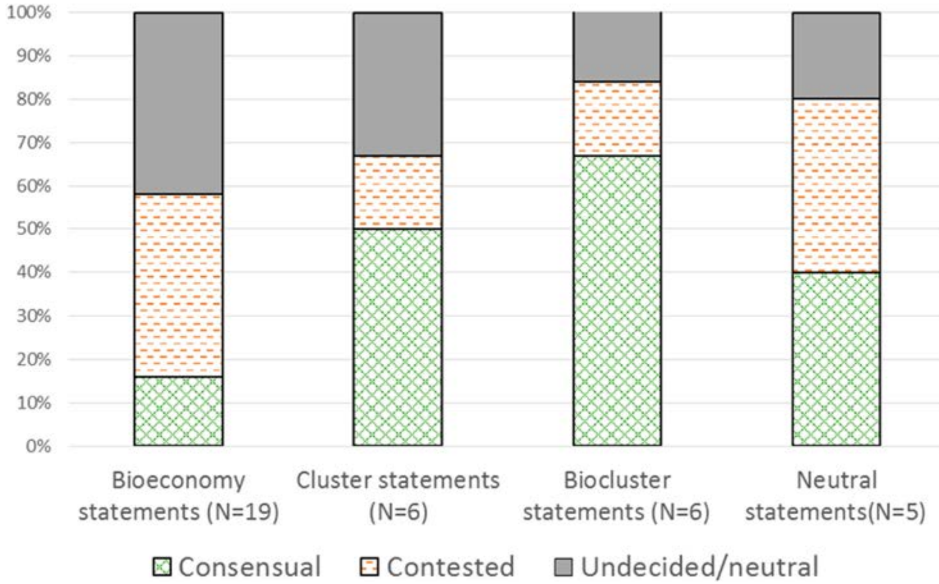

Figure 4. Consensual and contested imaginaries in Q-methodology results.

mobilise overwhelmingly positive associations with resonance across diverse stakeholder groups. From this perspective, the popularity of the cluster concept in policy and across other relevant actor groups helps the bioeconomy concept to gain traction. With the main cluster argument of augmented competitiveness and the main bioeconomy argument of strengthened sustainability, a biocluster imaginary becomes a winning proposition in the discursive realm.

5.4. Limitations and further research

Q-methodology is not built on random sampling and this means that we cannot extrapolate our results beyond the chosen cluster regions. Moreover, our two clusters are examples of (potential) green chemistry clusters while the biocluster concept includes also other types: clusters entirely focused on the life sciences, fashion districts or food clusters (Hermans, in press). As such, findings resulting from the two cases only represent a small subsection of possible biocluster narratives. An even wider variety connecting specific bioeconomy and cluster imaginaries may surface in other contexts. Future studies could also aim to differentiate the analysis further and thereby account for different types of regional innovation systems, specific industries and the perception of incumbents vis-à-vis 'born green' start-up companies and their scientific counterparts.

Acknowledgements

This study was financed through the TRAFOBIT project 'The Role and Functions of Bioclusters in the Transition to a Bioeconomy' (031B0020) under the call 'Bioökonomie als gesellschaftlicher Wandel' of the German Federal Ministry of Education and Research (BMBF). The authors are also indebted to comments from the special issue editors on an early version of this paper. Most importantly we want to express deep appreciation to all respondents who took the time to meet and discuss questions in depth and those who took the effort to sort statements.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by Bundesministerium für Bildung und Forschung: [grant number 031B0020].

Notes on contributors

Kerstin Wilde is a PhD student at IAMO focusing on innovation systems and transition to a bioeconomy. After her graduation in political economics at Hamburg University, Germany, she did research on sustainable regional development and then turned to consultancy. Insights and competences from SME and entrepreneurship promotion were used later to support inter- and trans-disciplinary entrepreneurship education at Rostock University, Jacobs University, and Leipzig University, Germany. After the development of a guideline-type ASEAN policy document for strengthened university-business cooperation, she joined IAMO in October 2016.

Frans Hermans is a research group leader on the TRAFOBIT project: The Role and Functions of Bioclusters in the Transition to a Bioeconomy, at the Leibniz Institute of Agricultural Development in Transition Economies in Halle (Saale), Germany. His research interests are the dynamics of innovation networks and innovation systems, social learning and collaboration and (innovation) policy for regional sustainable development.

ORCID

Kerstin Wilde http://orcid.org/0000-0002-4574-3057
Frans Hermans http://orcid.org/0000-0003-3394-9012

References

Amdam, R. P., Lunnan, R., Bjarnar, O., & Halse, L. L. (2020). Keeping up with the neighbors: The role of cluster identity in internationalization. *Journal of World Business*, *55*(5), 101125. https://doi.org/10.1016/j.jwb.2020.101125

Arts, B., & Buizer, M. (2009). Forests, discourses, institutions: A discursive-institutional analysis of global forest governance. *Forest Policy and Economics*, *11*(5–6), 340–347. http://www.sciencedirect.com/science/article/B6VT4-4V2J6PS-1/2/fc0e0e2f5a97951a3715627dd93ddb04 https://doi.org/10.1016/j.forpol.2008.10.004

Ayrapetyan, D., & Hermans, F. (2020). Introducing a multiscalar framework for biocluster research: A meta-analysis. *Sustainability*, *12*(9), 3890. https://doi.org/10.3390/su12093890

Bauer, F. (2018). Narratives of biorefinery innovation for the bioeconomy: Conflict, consensus or confusion? *Environmental Innovation and Societal Transitions*, *28*, 96–107. https://doi.org/10.1016/j.eist.2018.01.005

Beers, P. J., Veldkamp, A., Hermans, F., van Apeldoorn, D., Vervoort, J. M., & Kok, K. (2010). Future sustainability and images [special issue: Landscape visions]. *Futures*, *42*(7), 723–732. http://www.sciencedirect.com/science/article/pii/S0016328710000649 https://doi.org/10.1016/j.futures.2010.04.017

Birch, K. (2017). *Innovation, regional development and the life sciences; beyond clusters*. Routledge.

BMEL. (2016). *Fortschrittsbericht zur Nationalen Politikstrategie Bioökonomie*. Bundesministerium für Ernährung und Landwirtschaft.

Boschma, R., Coenen, L., Frenken, K., & Truffer, B. (2017). Towards a theory of regional diversification: Combining insights from evolutionary economic geography and transition studies. *Regional Studies*, *51*(1), 31–45. https://doi.org/10.1080/00343404.2016.1258460

Brown, S. R. (1980). *Political subjectivity, applications of Q methodology in political science*. Yale University Press.

Brunori, G. (2013). Biomass, biovalue and sustainability: Some thoughts on the definition of the bioeconomy. *EuroChoices*, *12*(1), 48–52. https://doi.org/10.1111/1746-692X.12020

Bugge, M. M., Hansen, T., & Klitkou, A. (2016). What is the bioeconomy? A review of the literature. *Sustainability*, *8*(7), 691. https://doi.org/10.3390/su8070691

Burnham, M., Eaton, W., Selfa, T., Hinrichs, C., & Feldpausch-Parker, A. (2017). The politics of imaginaries and bioenergy sub-niches in the emerging northeast U.S. Bioenergy economy. *Geoforum; Journal of Physical, Human, and Regional Geosciences*, *82*, 66–76. https://doi.org/10.1016/j.geoforum.2017.03.022

Carrozza, C. (2015). Democratizing expertise and environmental governance: Different approaches to the politics of science and their relevance for policy analysis. *Journal of Environmental Policy & Planning*, *17*(1), 108–126. https://doi.org/10.1080/1523908X.2014.914894

Daioglou, V., Doelman, J. C., Wicke, B., Faaij, A., & van Vuuren, D. P. (2019). Integrated assessment of biomass supply and demand in climate change mitigation scenarios. *Global Environmental Change*, *54*, 88–101. https://doi.org/10.1016/j.gloenvcha.2018.11.012

De Besi, M., & McCormick, K. (2015). Towards a bioeconomy in Europe: National, regional and industrial strategies. *Sustainability*, *7*(8), 10461–10478. https://doi.org/10.3390/su70810461

Diakosavvas, D., & Frezal, C. (2019). *Bio-economy and the sustainability of the agriculture and food system*. https://www.oecd-ilibrary.org/content/paper/d0ad045d-en

Dietz, T., Börner, J., Förster, J. J., & Von Braun, J. (2018). Governance of the bioeconomy: A global comparative study of national bioeconomy strategies. *Sustainability*, *10*(9), 3190. https://doi.org/10.3390/su10093190

Dryzek, J. S. (2005). *The politics of the earth: Environmental discourses* (2nd ed.). Oxford University Press. (Original work published 1997)

Eaton, W. M., Gasteyer, S. P., & Busch, L. (2014). Bioenergy futures: Framing sociotechnical imaginaries in local places. *Rural Sociology*, *79*(2), 227–256. https://doi.org/10.1111/ruso.12027

Ebbekink, M., & Lagendijk, A. (2013). What's next in researching cluster policy: Place-based governance for effective cluster policy. *European Planning Studies*, *21*(5), 735–753. https://doi.org/10.1080/09654313.2013.734460

European Commission (EC). (2012). Innovating for Sustainable Growth: A Bioeconomy for Europe. (COM (2012) 60). Brussels.

Fløysand, A., Jakobsen, S.-E., & Bjarnar, O. (2012). The dynamism of clustering: Interweaving material and discursive processes. *Geoforum; Journal of Physical, Human, and Regional Geosciences*, *43*(5), 948–958. https://doi.org/10.1016/j.geoforum.2012.05.002

Foucault, M. (1994). *Power*. The New Press.

Fritsche, U, & Rösch, C. (2020) The Conditions of a Sustainable Bioeconomy). In J. Pietzsch (Ed.), *Bioeconomy for Beginners* (pp. 177–202). Berlin, Heidelberg: Springer.

Georgescu-Roegen, N. (1978). De la science économique `a la bioeconomie. *Revue D'économie Politique*, *88*(3), 337–382. https://doi.org/10.2307/1056148

Grillitsch, M., & Sotarauta, M. (2019). Trinity of change agency, regional development paths and opportunity spaces. *Progress in Human Geography*, *0*(0), https://doi.org/10.1177/0309132519853870

Hajer, M. A. (1995). *The politics of environmental discourse. Ecological modernization and the policy process*. Oxford University Press.

Hassink, R., & Gong, H. (2019). Six critical questions about smart specialization. *European Planning Studies*, *27*(10), 2049–2065. https://doi.org/10.1080/09654313.2019.1650898

Hermans, F. (2018). The potential contribution of transition theory to the analysis of bioclusters and their role in the transition to a bioeconomy. *Biofuels, Bioproducts and Biorefining*, *12*(2), 265–276. https://doi.org/10.1002/bbb.1861

Hermans, F. (in press). Bioclusters and sustainable development. In S. R. & S. Blasi (Eds.), *Rethinking Clusters: Place-based Value Creation in Sustainability Transitions*. Springer.

Jasanoff, S. (2015). Future imperfect: Science, technology, and the imaginations of modernity. In S. Jasanoff & S.-H. Kim (Eds.), *Dreamscapes of modernity: Sociotechnical imaginaries and the fabrication of power* (pp. 1–33). Chicago: University of Chicago Press.

Jasanoff, S., & Kim, S.-H. (2009). Containing the atom: Sociotechnical imaginaries and nuclear power in the United States and South Korea. *Minerva*, *47*(2), 119–146. https://doi.org/10.1007/s11024-009-9124-4

Ketels, C., Lindqvist, G., & Sölvell, Ö. (2006). *Cluster initiatives in developing and transition economies*. Centre for Strategy and Competitiveness.

Ketels, C., Lindqvist, G., & Sölvell, Ö. (2012). *Strengthening clusters and competitiveness in Europe: The role of cluster organisations*. Retrieved from Stockholm, Sweden.

Kuosmanen, T., Kuosmanen, N., El-Meligi, A., Ronzon, T., Gurria, P., Iost, S., & M'Barek, R. (2020). *How big is the bioeconomy? Reflections from an economic perspective* (EUR 30167 EN). Retrieved from Luxembourg.

Levidow, L., Birch, K., & Papaioannou, T. (2013). Divergent paradigms of European agro-food innovation. *Science, Technology, & Human Values*, *38*(1), 94–125. https://doi.org/10.1177/0162243912438143

Levidow, L., & Papaioannou, T. (2013). State imaginaries of the public good: Shaping UK innovation priorities for bioenergy. *Environmental Science & Policy*, *30*, 36–49. https://doi.org/10.1016/j.envsci.2012.10.008

Lewandowski, I. (2018). *Bioeconomy: Shaping the transition to a sustainable, Biobased economy*. University of Hohenheim & Springer.

Martin, R., & Sunley, P. (2003). Deconstructing clusters: Chaotic concept or policy panacea? *Journal of Economic Geography*, *3*(1), 5–35. https://doi.org/10.1093/jeg/3.1.5

McCauley, S. M., & Stephens, J. C. (2012). Green energy clusters and socio-technical transitions: Analysis of a sustainable energy cluster for regional economic development in central Massachusetts, USA. *Sustainability Science*, *2012*(7), 213–225. https://doi.org/10.1007/s11625-012-0164-6

McCormick, K., & Kautto, N. (2013). The bioeconomy in Europe: An overview. *Sustainability*, *5*(6), 2589–2608. https://doi.org/10.3390/su5062589

McKeown, B., & Thomas, D. (1988). *Q-Methodology* (Vol. 07-066). Sage University Paper.

Moulaert, F., & Sekia, F. (2003). Territorial innovation models: A critical survey. *Regional Studies*, *37*(3), 289–302. https://doi.org/10.1080/0034340032000065442

Njøs, R., Jakobsen, S.-E., Wiig Aslesen, H., & Fløysand, A. (2017). Encounters between cluster theory, policy and practice in Norway: Hubbing, blending and conceptual stretching. *European Urban and Regional Studies*, *24*(3), 274–289. https://doi.org/10.1177/0969776416655860

Njøs, R, Sjøtun, S G, Jakobsen, S E, & Fløysand, A. (2020). Expanding Analyses of Path Creation: Interconnections between Territory and Technology. *Economic Geography*, *96*(3), 266–288. https://doi.org/10.1080/00130095.2020.1756768

Organisation for Economic Co-operation and Development. (2009). *The bioeconomy in 2030: Designing a policy agenda*. OECD Publishing.

Perez-Aleman, P. (2005). CLUSTER formation, institutions and learning: The emergence of clusters and development in Chile. *Industrial and Corporate Change*, *14*(4), 651–677. https://doi.org/10.1093/icc/dth063

Pfau, S. F., Hagens, J. E., Dankbaar, B., & Smits, A. J. M. (2014). Visions of sustainability in bioeconomy research. *Sustainability*, *6*(3), 1222–1249. https://doi.org/10.3390/su6031222

Piotrowski, S, Carus, M, & Essel, R. (2016). Sustainable biomass supply and demand: a scenario analysis. *Open Agriculture*, *1*. https://doi.org/10.1515/opag-2016-0003

Porter, M E. (1990). The competitive advantage of nations. *Harvard business review*, *68*(2), 73–93.

Porter, M E. (1998). *On Competition*. Harvard Business School Press.

Pruneddu, A. (2017)). *QSortWare [Computer software]*. www. qsortware. net.

Ramcilovic-Suominen, S., & Pülzl, H. (2018). Sustainable development – A 'selling point' of the emerging EU bioeconomy policy framework? *Journal of Cleaner Production*, *172*, 4170–4180. https://doi.org/10.1016/j.jclepro.2016.12.157

RDI2CluB. (2018). *Benchmarking report: Triple-helix co-operation in biobased delta: RDI2CluB consortium benchmarking visit to biobased delta bioeconomy cluster in the Netherlands, April 18.–20.*2018.

Richardson, C., Yamin, M., & Sinkovics, R. R. (2012). Policy-driven clusters, interfirm interactions and firm internationalisation: Some insights from Malaysia's multimedia super corridor. *International Business Review*, *21*(5), 794–805. https://doi.org/10.1016/j.ibusrev.2011.09.002

Rijksdienst voor Ondernemend Nederland (RVO). (2015). *Onderzoeksagenda Biobased Economy 2015 - 2027. 'B4B: biobased voor bedrijven, burgers en beleid'*. Retrieved from The Netherlands. https://chemistrynl.com/wp-content/uploads/2019/01/Onderzoeksagenda-BBE.pdf

Roe, E. (1994). *Narrative policy analysis: Theory and practice*. Duke University Press.

Schmid, O., Padel, S., & Levidow, L. (2012). The bio-economy concept and knowledge base in a public goods and farmer perspective. *Bio-Based and Applied Economics*, *1*(1), 47–63. https://doi.org/10.22004/ag.econ.125698

Schmolck, P. (2014). *PQMethod (Version 2.35)*. http://www.rz.unibw-muenchen.de/~p41bsmk/qmethod/

Siebert, A., Bezama, A., O'Keeffe, S., & Thrän, D. (2018). Social life cycle assessment: In pursuit of a framework for assessing wood-based products from bioeconomy regions in Germany. *The International Journal of Life Cycle Assessment*, *23*(3), 651–662. https://doi.org/10.1007/s11367-016-1066-0

Sjøtun, S. G., & Njøs, R. (2019). Green reorientation of clusters and the role of policy: 'The normative' and 'the neutral' route. *European Planning Studies*, 1–20. https://doi.org/10.1080/09654313.2019.1630370

Sölvell, Ö. (2008). *Clusters: Balancing evolutionary and constructive forces*. Ivory Tower Publishing.

Steen, M. (2016). Reconsidering path creation in economic geography: Aspects of agency, temporality and methods. *European Planning Studies*, *24*(9), 1605–1622. https://doi.org/10.1080/09654313.2016.1204427

Stegmann, P., Londo, M., & Junginger, M. (2020). The circular bioeconomy: Its elements and role in European bioeconomy clusters. *Resources, Conservation & Recycling: X*, *6*, 100029. https://doi.org/10.1016/j.rcrx.2019.100029

Susur, E., Hidalgo, A., & Chiaroni, D. (2019). A strategic niche management perspective on transitions to eco-industrial park development: A systematic review of case studies. *Resources, Conservation and Recycling*, *140*, 338–359. https://doi.org/10.1016/j.resconrec.2018.06.002

Van Assche, K., Beunen, R., & Duineveld, M. (2014). The power of stories. In R. Beunen, K. Van Assche, & M. Duineveld (Eds.), *Evolutionary governance theory* (pp. 45–54). Springer.

Vivien, F. D., Nieddu, M., Befort, N., Debref, R., & Giampietro, M. (2019). The hijacking of the bioeconomy. *Ecological Economics*, *159*, 189–197. https://doi.org/10.1016/j.ecolecon.2019.01.027

von Wirth, T., Fuenfschilling, L., Frantzeskaki, N., & Coenen, L. (2019). Impacts of urban living labs on sustainability transitions: Mechanisms and strategies for systemic change through experimentation. *European Planning Studies*, *27*(2), 229–257. https://doi.org/10.1080/09654313.2018.1504895

Watts, S., & Stenner, P. (2012). *Doing Q methodological research: Theory, method & interpretation*. Sage Publications.

Zabala, A. (2014). Qmethod: A package to analyse human perspectives using Q methodology. *The R Journal*, *6*(2), 163–173. https://journal.r-project.org/archive/2014-2/zabala.pdf https://doi.org/10.32614/RJ-2014-032

2.2 Innovation in the bioeconomy: Perspectives of entrepreneurs on relevant framework conditions

Wilde, K., & Hermans, F. (2021). Innovation in the bioeconomy: Perspectives of entrepreneurs on relevant framework conditions. *Journal of cleaner production*, *314*, 127979.

https://doi.org/10.1016/j.jclepro.2021.127979

Published by Elsevier, the Journal of Cleaner Production is an international, ranked, peer-reviewed and transdisciplinary journal focusing on Cleaner Production, Environmental, and Sustainability research and practice.

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Source: Scopus

Impact Factor: 11.1 (JCR 2022 - Impact Factor, Updated June 2023)

Journal of Cleaner Production 314 (2021) 127979

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Innovation in the bioeconomy: Perspectives of entrepreneurs on relevant framework conditions

Kerstin Wilde *, Frans Hermans

Leibniz Institute for Agricultural Development in Transition Economies (IAMO), Department for Structural Change, Theodor-Lieser-Strasse 2, 06120, Halle (Saale), Germany

ARTICLE INFO

Handling editor: Mingzhou Jin

Keywords:
Bioeconomy
Barriers to innovation
Innovation capabilities
Innovation opportunities
STI policy
Sectoral innovation systems

ABSTRACT

Although entrepreneurial activities are of key importance in a properly functioning innovation system, the micro level of actors is often neglected in the innovation systems' literature. The goal of this paper is to show how the configuration of innovation systems shapes entrepreneurs' perceptions and behaviors. The originality of the present article rests upon a novel framework that distinguishes between the willingness, capability, and perceived opportunities of entrepreneurs embedded in specific innovation systems. We explore the perceptions of 30 entrepreneurs from two European bioeconomy cluster regions who are engaged in R&D and collaborative experimentation in the chemical, plastics, and construction materials industries. Our findings show that with documented innovation willingness, entrepreneurs' innovation capacity is not the decisive bottleneck. Rather, bioeconomy actors perceive that innovation opportunities are blocked by institutions at the national and international levels. The configuration of relevant sectoral innovation systems and value-chains is crucial. We conclude that bioeconomy promotion should emphasis the demand side and systemic multi-level policies that address innovation barriers with due consideration for industry-specific innovation systems and value-chain configurations.

1. Introduction

Major environmental, social, and economic challenges have led to the claim that Europe must radically change its approach to production, consumption, processing, storage, recycling and disposal of biological resources (EC, 2012). The bioeconomy has emerged as a novel economic paradigm in science, technology, and innovation (STI) policy with a mission to minimize adverse environmental impacts of economic activities, thereby aiming to achieve important sustainable development goals (SDGs) (Robert et al., 2020; Fritsche et al., 2020). The transition to a bioeconomy involves the replacement of fossil inputs in a broad range of industries by renewable carbon sources, as well as increased resource efficiency and the preservation of the resource values in material circles (Giampietro, 2019). Alongside the environmental benefits associated with such innovation, the bioeconomy also holds promises regarding the creation of new economic opportunities. New business formation in rural areas, reduced import dependence, and strengthened knowledge-based sectors are widely expected by promoters (Aguilar et al., 2018; Befort, 2020; Brunori, 2013).

Examples of bioeconomy related innovations comprise not only a range of new products such as biopolymers, fuels, and novel food additives (Frisvold et al., 2021; Wydra et al., 2021), but also new processes associated with biorefining (Dahiya et al., 2018; Hellsmark et al., 2016) and industrial biotechnology (Wohlgemuth et al., 2021; Wydra, 2019). In 2015, non-traditional bioeconomy activities only accounted for 4.7% of the European GDP (Kuosmanen et al., 2020). This implies that the bioeconomy still has a long way to go to deliver on its promises. Therefore, it is of interest to investigate the drivers and barriers that might spur or hinder dynamic bioeconomy development.

A wide range of recent research has addressed innovation barriers for segments of the bioeconomy, mostly using an innovation systems (IS) perspective at the national level (e.g., Bosman and Rotmans, 2016; Chung, 2018; Giurca and Späth, 2017; Hellsmark et al., 2016; Nevzorova and Karakaya, 2020; Purkus et al., 2018). However, related assessments lack the perspective of the actors who actually effect these innovations: the entrepreneurs. For this article, we investigated the barriers and drivers that entrepreneurs identified concerning opportunities in the bioeconomy field. By addressing this research gap, we aim to make a theoretical, empirical and practical contribution to the literature. Our theoretical contribution derives from the introduction of a novel framework that links the characteristics of the innovation system

* Corresponding author.
E-mail addresses: Wilde@iamo.de (K. Wilde), Hermans@iamo.de (F. Hermans).

https://doi.org/10.1016/j.jclepro.2021.127979
Received 16 October 2020; Received in revised form 4 May 2021; Accepted 15 June 2021
Available online 20 June 2021

List of abbreviations

BBD	Biobased Delta in the Netherlands
GAP	European General Agricultural Policy
IS	Innovation System
LMC	Large and Multinational Company
MNTQ	Metrology, Norming, Testing, and Quality Management
NIS	National Innovation System
OEM	Original Equipment Manufacturer
R&D	Research and Development
RG	Respondent from Germany
RIS	Regional Innovation System
RN	Respondent from the Netherlands
SCM	Spitzencluster Mitteldeutschland in Germany
SDG	Sustainable Development Goal
SIS	Sectoral Innovation System
STI	Science, Technology and Innovation

to entrepreneurial innovation behavior at the micro-level. As such, our paper combines two research fields that, so far, have not been combined: entrepreneurial behavior and IS. Combining these two knowledge streams addresses the frequently raised criticism of the IS approach that it ignores the agency of micro-level actors (Kern, 2015; Markard and Truffer, 2008). The empirical contribution comes from a comparative analysis of two regional case studies in the Netherlands and Germany. We highlight the differences of entrepreneurs' perceptions in distinct segments of an evolving bioeconomy (i.e. the chemical, polymer processing, and construction materials industries). Based on these data, we identify differences in regional and sectoral ISs. Our results allow for a number of STI policy recommendations that serve to improve the effectiveness of regional bioeconomy promotion. Thus, we strive to inform the operationalization of STI policies with sustainability missions, thereby potentially contributing to the associated SDGs.

This paper starts with an elaboration our theoretical framework in Section 2. Here we discuss the different actor-internal elements that codetermine entrepreneurial behavior and link these to the relevant context conditions at various levels. In Section 3, we elucidate our methodological approach to answer the research question as also visualized by a flow chart. The subsections describe the study regions, industry and respondent selection, data collection, and analysis. In Section 4, we report our results in view of decisive components of geographic and sectoral IS. Implications for theory and policy follow in Section 5, which ends with some conclusions.

2. Theoretical framing

From the STI policy perspective, the required changes in lifestyle, production processes, and resource use associated with bioeconomy concepts call for system innovations or transitions, including changes in the architecture, components, and interfaces of entire sociotechnical or socioeconomic systems (Geels, 2005). Although entrepreneurs are often seen as key drivers of sustainability transitions, the field lacks a systematic investigation of innovation decisions, specific innovation hurdles, and drivers from their perspective (Devaney and Henchion, 2018). So far, firm behavior is hardly covered by research on national ISs (NISs) and regional ISs (RISs). Conceptualized as one of the seven main functions of ISs (Hekkert et al., 2007), the dynamics of entrepreneurial activities and their embeddedness in ISs still lack a theoretical foundation (Coenen and Díaz López, 2010). Tracing ongoing transitions requires attention to the dynamic interaction of actors and other system components (Ács et al., 2014; Farla et al., 2012; Hermans, 2018). To enable policy makers to assess the impact of promotional approaches, a systematic assessment of barriers and drivers of bioeconomy innovation is needed (Wydra, 2020). So far, little is known about companies' attention to risks, synergies, rebound effects, and trade-offs. Comprehensive assessment tools are still in development (Zeug et al., 2020). Certainly research needs to incorporate how entrepreneurs experience and contribute to the enactment of complex processes such as innovation and system transformation (Upham et al., 2018).

Against this background, we build our framework using studies on innovation at the firm level. Obviously, innovation requires entrepreneurs – specifically, their "perception of opportunities to productively change existing routines or resource configurations, their willingness to undertake such change, and their ability to implement these changes" (Zahra et al., 2006: p. 918). We assume that actors are aware of their capabilities, interests, and values and continuously scan their environment for risks, opportunities, and change with uncertain outcomes (Wilden and Gudergan, 2015). In our framework, *innovation behavior* therefore depends on an entrepreneurial actors' evaluation of their perceived innovation opportunities in view of their innovation capabilities and willingness (see Fig. 1). In other words, a positive evaluation of the desirability and feasibility of addressing an opportunity successfully is the crucial prerequisite for relevant activities. We describe these different elements in more detail below.

Innovation willingness alludes to human attitudes as well as organizations' learning and performance orientation. Researchers have studied innovation willingness using psychological, organizational, institutional, and economic lenses (e.g., Crossan and Apaydin, 2010). The phenomenon may boil down to the "willingness to learn, willingness to work hard and persistently, willingness to exercise self-discipline, willingness to adapt and to apply the right policies and practices" (Drucker, 2014, p. 173). An organizations' innovation willingness is shaped by the culturally and socially embedded values, experiences, and preferences of its entrepreneurs and managers. Earlier research has revealed that, in particular, environmental innovations can be driven by values and deep environmental concerns (Hojnik and Ruzzier, 2016; Ploum et al., 2018). The structural properties of relevant ISs and STI policy can influence the prevalence of innovation willingness among firms (e.g., Díaz-García et al., 2015; Mueller et al., 2013; Yitshaki and Kropp, 2016).

In this article, innovation *capabilities* refer to companies' characteristics. They indicate the ability to leverage, combine, and recombine knowledge and resources so that new products, technologies, and markets result (Iddris, 2016; Lawson and Samson, 2001). A specific actor's set of capabilities results from a multitude of resources and competencies, which are often acquired through learning by repeated trials (Crossan and Apaydin, 2010). Public resources in the vicinity, the capabilities of close allies (within the supply chain or separate, see, e.g., Chowdhury and Quaddus, 2021; Duygan et al., 2021; Lau and Lo, 2015), and the company's externally attributed legitimacy and status might expand or restrict its maneuvering room (Balland et al., 2016; Bitektine and Haack, 2015). Moreover, companies in different industries can be characterized by typical sets of different innovation capabilities (Giuliani and Bell, 2005; Malerba, 2005; Nooteboom et al., 2007). Thus, entrepreneurs' embeddedness leads them to account for proprietary capabilities as well as those of other actors and the own social position during assessments. What constitutes the relevant set of capabilities, however, not only differs across industries, but also depends on the type of innovation favored (Kabongo and Boiral, 2017; Mahmud et al., 2020). Different types of sustainability strategies require different capabilities to create value in different ways (Bocken and Geradts, 2020; Khan et al., 2020; Salim et al., 2019).

Actors evaluate their innovation willingness, as well as proprietary and accessible capabilities, against the incidence and shape of perceived *innovation opportunities*. From the ontological position of social constructivism, opportunities are discovered, created, or co-created by individuals who perceive, imagine, and interpret their external environments, which are uncertain and subject to change (Sarasvathy et al., 2010). The perception and evaluation of uncertainties, risks, and benefits differs among individuals and with external conditions (Alvarez

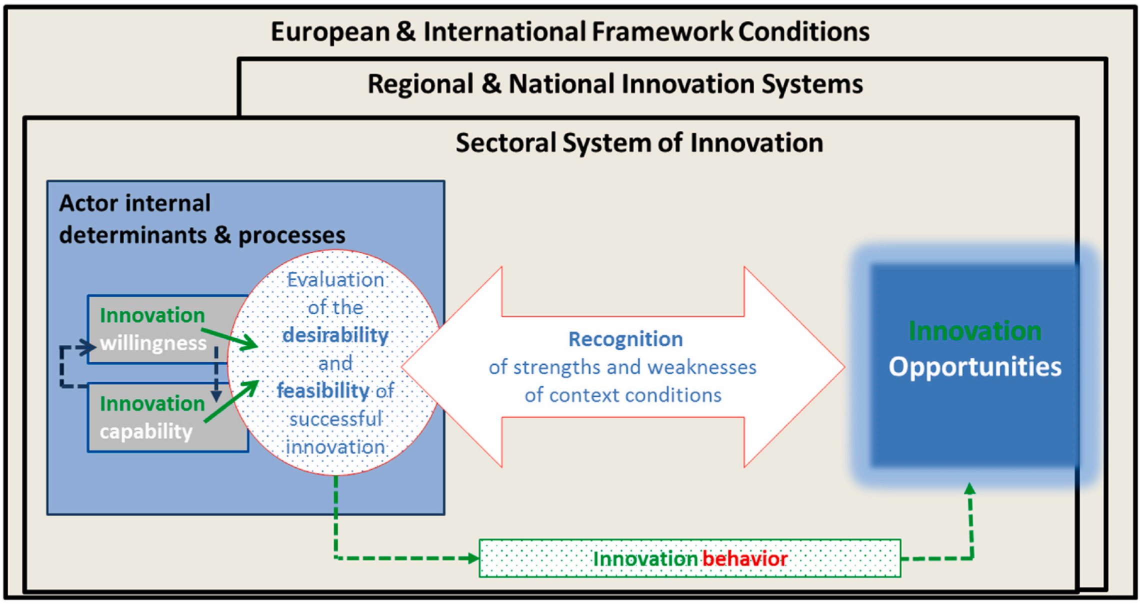

Fig. 1. Assessment of the desirability and feasibility of successful innovation at the company level.

and Barney, 2013; Martin and Wilson, 2016). Thus, our conceptualization goes beyond the construct of "opportunity confidence" as defined by Davidsson (2015). It accounts not only for a subjective evaluation of the opportunities' attractiveness—or lack thereof—but also for the concomitant evaluation of the likelihood of innovation success in view of available capabilities. By success, we mean the establishment of a viable economic activity with significantly novel input composition, value proposition, or value architecture.

Opportunity desirability and opportunity feasibility are distinct but related constructs that refer to the *why* and *how* aspects of entrepreneurial action (Ivanova et al., 2018). While "desirability" refers to an actor's goals, beliefs and values, "feasibility" has been characterized as a function of perceived knowledge, skills, abilities, and resources controlled by an entrepreneur relative to the knowledge, skills, abilities, and resources required by the opportunity. According to Haynie et al. (2009), established entrepreneurs assess opportunities as more attractive when those opportunities relate to their existing capabilities. For new ventures, this evaluation of endogenously and exogenously shaped circumstances has been characterized as an essential part of the incubation cycle (Vogel, 2017).

New opportunity spaces may evolve based on new knowledge, infrastructures, materials, equipment, relations, trends, regulations, or crises. With respect to the bioeconomy and related sustainability goals, the evaluation is complex (e.g., Leipold and Petit-Boix, 2018). The different time horizons and life cycle stages of relevant industries and technologies might influence opportunity evaluation. In addition, the inherently collective nature of innovation requires a certain degree of shared imagination (Pham et al., 2019) and collective responsibility for opportunity development (Stilgoe et al., 2013). If perceived opportunities are unappealing or successful innovation is deemed unfeasible under the current conditions, related activities might be confined to further observation.

This highlights the core of the conceptual model: The company-specific nature of context and opportunity perceptions lead to subjective evaluations and decision-making regarding innovation behavior. The same resources, actor networks, institutions, or incidents might be interpreted differently by different actors. This also applies to uncertainties related to raw material and access to other resources, the competitive environment, consumers' acceptance, and regulatory or political conditions (Shepherd et al., 2015).

To better structure these disparate elements, we propose applying an IS perspective. Central to the IS concept is the idea that some system configurations are much more effective than others in terms of inducing and facilitating learning and innovation success (Lundvall, 2007). The insufficiency or rigidity of critical IS components might block or slow the performance of an entire dynamic system (Boekholt, 2010; Grillitsch and Trippl, 2016; Wieczorek and Hekkert, 2012). Depending on the aims of an analysis and the consequential drawing of system boundaries, different IS types have been distinguished in the literature. NISs and RISs are conceptualized on a spatial basis, whereas sectoral ISs (SISs) are determined by the economic sector, knowledge base, technologies, and product groups that unify actors (Coenen and Díaz López, 2010). With respect to the impact of bioeconomy promotion, changing components such as institutions or actor constellations might affect one or several RISs and NISs, whereas new technologies might take effect across several sectors (Hermans, 2018).

In summary, our conceptual model posits that the structural components (i.e. actor populations, networks, institutions, and infrastructures) of relevant innovation systems are in continuous interaction with the firm-level determinants of innovative behavior: innovation willingness and capability evaluated with respect to perceived opportunities. On the one hand, the resources, competencies, and relational ties, as well as the opportunity spaces themselves, are shaped in specific ways by different international, national, regional, and sectoral determinants (see, e.g., Kiefer et al., 2019; Pieroni et al., 2020). On the other hand, by acting on the perceived opportunities, entrepreneurs actively shape relevant components of interrelated ISs. As recently underlined anew by Sotarauta, "institutions not only confine and mould aspirations of actors but also are dependent on them" (2016, p.14). The conceptual framework highlights the embeddedness of actors' innovation behaviors and the related outcomes.

The aim of this paper is to acquire a better understanding of the national, regional, and sectoral determinants of observable innovation behavior in specific segments of the evolving bioeconomy. By referring to both analytic IS conceptualizations (i.e. the geographic and the sectoral), we also explore whether progress is easier in specific industries or regions than in others. We address the following research question:

Which IS components do entrepreneurs from different industries regard as prominent barriers to or potential drivers of their innovation capability and opportunities?

3. Methodological approach

The following subsections describe the methodological approach. An overview is provided in Fig. 2.

3.1. Purposive sampling: introduction to the study areas

We focused our investigations on Germany and the Netherlands. These two countries belong to the group of European countries with early and comprehensive national STI programs that promote the bioeconomy (Langeveld, 2015). Both national bioeconomy conceptualizations are aligned with the EU strategy (EC, 2012). They emphasize commitments to the Paris agreement, the relevance of the efficient use of natural resources, and the need to reach higher levels of environmental sustainability in economic undertakings (BMEL, 2014; MEZ, 2013). Economic competitiveness and attention to entrepreneurship also play an important role in both countries. Neither strategy includes broad-based awareness-raising or dedicated educational interventions. In essence, the Dutch bioeconomy promotion policy targets mainly company-driven innovations for near-term growth, whereas the German policy has a stronger focus on science-driven opportunity exploration in a medium-to long-term perspective.

When looking for agglomerations of bioeconomy actors, it was a logical step to turn to clusters that emerged with dedicated bioeconomy promotion. Actors' involvement in clusters provides evidence of collaborative R&D and learning efforts and confirms their innovation willingness. It guarantees entrepreneurs' experience with a specific regional context and facilitates the establishment of trusted contacts via backing of the study by cluster management units.

We focused our investigations on the Spitzencluster Mitteldeutschland (SCM) in Germany and Biobased Delta (BBD) in the Netherlands. The SCM is centered near Halle/Leipzig, and a large majority of its members reside in the federal states of Saxony-Anhalt, Saxony, and Thuringia. The BBD cluster covers the provinces of North Brabant, Zeeland, and South Holland, with a focal point at Bergen op Zoom. The regional context of the two clusters differs in some important aspects, as evidenced by indicators of the European Regional Innovation Scoreboard (EC, 2019, see Fig. 3).

First, the framework conditions are more favorable in terms of the populations' educational levels and the general attractiveness of the research systems in the BBD context. Second, innovation investments rather originate in the public sector in the SCM regions, with SMEs more involved in non-R&D investments such as equipment purchases or the acquisition of patents compared to their BBD counterparts. Third, innovation activities result in considerably higher levels of public-private co-publications and patent, trademark, and design applications in the BBD context, whereas there is more SME collaboration and in-house, marketing, and process innovation in the SCM context. Nevertheless, the two impact indicators reported for the regions show high homogeneity with very similar employment levels in knowledge-intensive activities and SME achievements measured in terms of sales of new-to-market/firm innovations.

3.2. Purposive sampling: selection of industries and companies

Ehrenfeld and Kropfhäuser (2017) identified 0.2% of all companies in the SCM cluster region as belonging to the plant-based bioeconomy. Out of these researchers' total sub-sample of 139 actors with workforce data, 83% were micro and small enterprises and only 4% had more than 250 employees (Ehrenfeld and Kropfhäuser, 2017, p. 9). The researchers found that about half of the companies were less than 10 years old, and 53 companies were active in manufacturing. Analysis of the project and membership lists made available by the SCM management unit revealed that innovations in chemical products, polymer processing, and construction materials production were at the core of activities. Joint efforts were aimed at substitutions for fossil inputs or the development of new bio-based products.

Purposive sample construction (heterogeneous sampling) was performed in line with the specifications of Etikan et al. (2016). We preferred companies involved in ongoing or recently completed R&D projects. The projects' lead partners were addressed unless attention to the coverage of all company sizes and of all three German regions suggested doing otherwise. In this way, ten companies located in Saxony-Anhalt, two in Thuringia, and three in Saxony, were approached. For an outsider's perspective on conditions in the SCM region, we also included four enterprises from two other regions.

The BBD cluster has no official membership administration. During several in-person and phone discussions, the cluster leadership assisted with identifying suitable interview partners based on their engagement in cluster activities. A matching sample was constructed in the selected

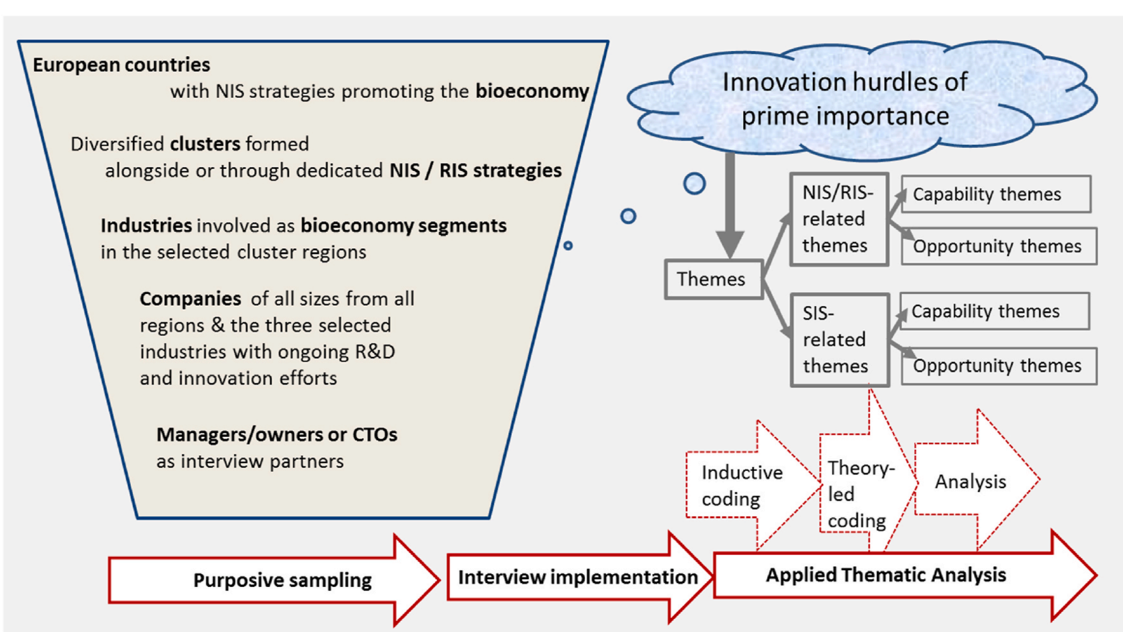

Fig. 2. Research process and methodology.

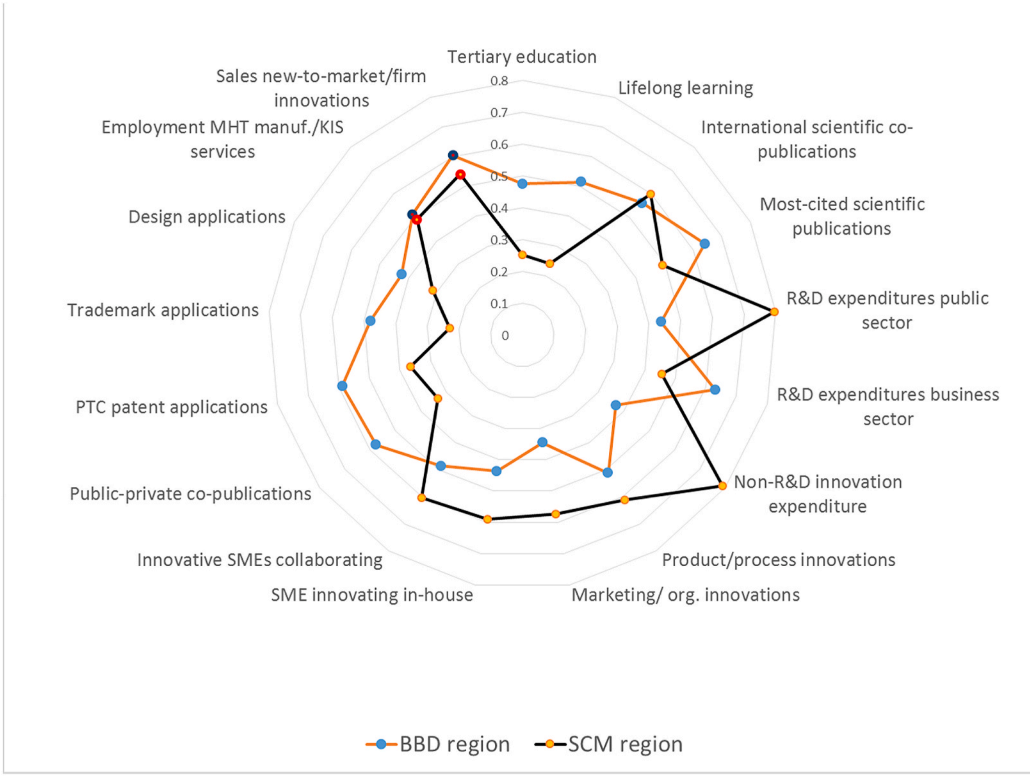

Fig. 3. Average normalized scores of the European Regional Innovation Scoreboard, 2019.
Notes: For the BBD region, the graph displays the arithmetic mean of normalized scores for Noord-Brabant, Zeeland, and Zuid-Holland Provinces. For the MSC region, the mean of normalized scores for Saxony-Anhalt, Thuringia, and the Saxonian sub-regions of Leipzig, Chemnitz and Dresden is indicated.
Source: Based on data from EC, 2019.

industries and with companies engaged in ongoing R&D and innovation efforts. Here, six representatives of companies located in North-Brabant were selected alongside two in Zeeland and three in Zuid-Holland. Overall, 30 companies were covered, including 19 in Germany and 11 in the Netherlands. See Fig. 4 for their size and industry distribution.

The industry sample from fine chemicals in both cluster regions includes companies established based on fossil feedstocks, as well as actors using only renewable inputs. All respondents grouped under the “plastic

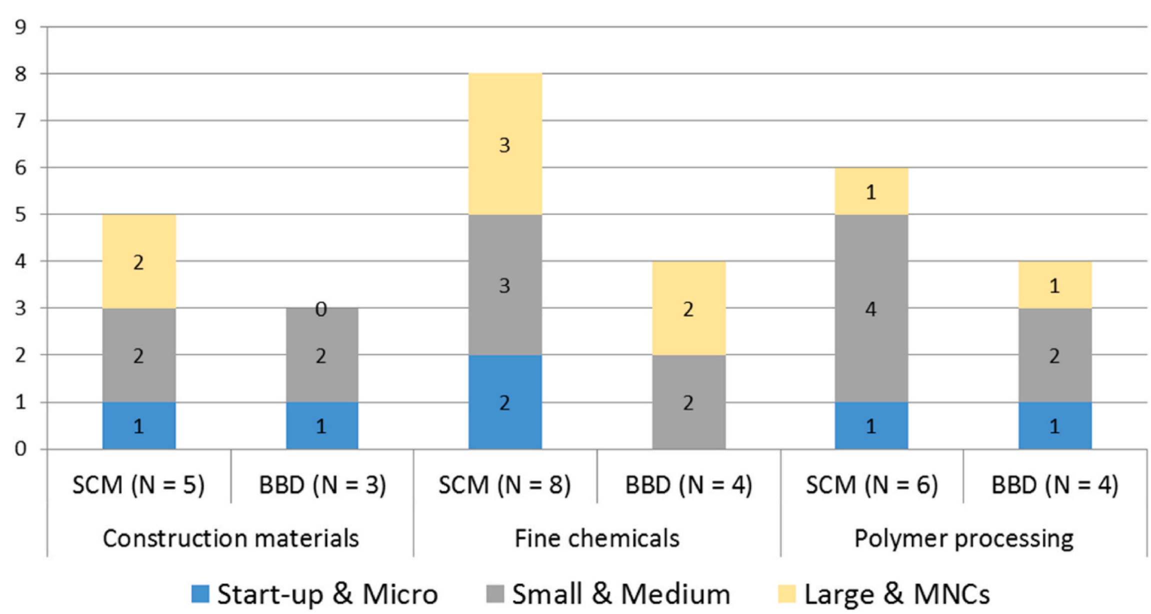

Fig. 4. Respondents from business by industry, cluster affiliation, and size (N = 30).
Note: Company size categories correspond to the EU standards in terms of employees: <10 micro enterprises, 11 to 249 SMEs, >250 large enterprises. To better specify companies’ characteristics, their age (<10 years) was also considered: all start-ups had <10 employees. Subsidiaries of multinational companies were grouped with large enterprises even in cases where units had fewer than 250 employees.

industry" category belonged to plastic converters, with some covering compounding activities as well. In the construction materials industry, wood was the basis of operations for three respondents. Others dealt with fossil and renewable resources or the manufacturing of joining elements.

3.3. Interview implementation

Semi-structured in-depth interviews combine features from formal and informal interviews. They allow for more "natural" cognitions, emotions, and behaviors while focusing on personal experiences that can lead to unexpected results (Hair et al., 2019; Lee et al., 1999). A typical interview took about an hour and was conducted with owners or managers and chief technical officers at the respondent's place of work. In a few cases, they asked additional members of the company management team to join. After the clarification of issues related to anonymity, confidentiality, and the purpose of the study, as well as the core activities and innovation endeavors of the company, the key questions were addressed based on a pre-tested interview guide elaborated in line with Helfferich (2011) and Glaser and Laudel (2010). This approach safeguards coverage of all themes identified from a theoretical point of view, as well as flexibility in a variety of contexts. The formulation and sequencing of key questions was performed as follows: Questioning began with the company context at the local level: "In view of a dynamic, innovation-driven bioeconomy development: what are the most important strengths and weaknesses in your local context from your perspective?" This question allowed respondents to reflect on, for example, their company history, infrastructure endowment, or supplier relations - issues that had mostly positive associations and minimal political implications. It also provided us with insight into the respondent's conceptualization of a bioeconomy while gently directing their attention to IS components and the respondent's innovation activities. Rephrasing the same question for the regional and national levels facilitated the exploration the respondent's perceptions of RIS and NIS components, as well as STI policies. Finally, the same question was reformulated for the European/international level to capture the relevance and evaluation of institutions and network relations beyond national authority. Inductive probing questions were used throughout the interview to clarify meanings and the attribution of relevance to specific themes.

Throughout this process, keywords from respondents' statements were written on Post-it notes and stuck to the table so that the interview partners had a visual overview of the factors mentioned. This visualization effort was meant to minimize "priming", the mechanism by which a response is influenced by a preceding question (Moss and Lawrence, 1997). This was important in view of the crucial point where the central constructs of "capability" and "opportunity" were addressed. Following the rationale of Vitale et al. (2008), we thereby sought to avoid a bias in the results toward internationally co-determined factors of influence when asking respondents the following: "Considering all of the factors you highlighted at the different levels, which factors have the strongest impact on your innovation capabilities?" A simple explanation (i.e. "resources and competencies") was given in each interview, thereby preventing completely divergent interpretations. The final question, "Which factors have the strongest relevance for bioeconomy innovation opportunities from your perspective?", was raised to explore the relevance of different IS characteristics to opportunity spaces perceived by the respondents.

The interviewees were allowed to pursue an idea or response in more detail, thereby diverging from the preconceived sequence of addressing the different governance levels. As emphasized by Gill et al. (2008), the flexibility of this approach, especially compared to that of structured interviews, supports the discovery of aspects the researchers had not previously considered pertinent.

3.4. Data analysis and coding

Field note recording utilized the Post-its notes and included themes raised before or after the actual interview. The voice-recorded interviews were transcribed verbatim. Applied thematic analysis was used for further data analysis. Thematic analysis entails a search for themes that emerge as important to the description of a phenomenon (Daly et al., 1997). This approach is a "rigorous, yet inductive, set of procedures designed to identify and examine themes from textual data in a way that is transparent and credible" (Guest et al., 2011, p. 14). As a first step, the researcher who conducted all the interviews used inductive coding to identify relevant themes using MAXQDA software (Standard version, Release 18.2.5). Accordingly, relevant parts of the transcripts were assigned labels that best represented the text. In line with a descriptive and exploratory orientation, the code book was allowed to develop iteratively with coding. A second round of reviewing all interviews' coding led to adjustments and a congruent application of codes across the whole sample, as also recommended by Saldaña (2015). Field notes were used to check for consistency and missing items. The themes found inductively are listed in Tables A1 and A2 in the appendix.

Using theory-led coding, themes were then sorted by their reference to RIS/NIS or SIS characteristics. Further analysis led to the differentiation of themes with relevance for the respondents' own innovation capability or perceived opportunities. Several parts of the transcripts were revisited to clarify the respondents' causal reasoning. Positive and negative connotations and neutral and mixed evaluations of specific factors were differentiated. Code categories and related quotes were then transferred to Excel. The table of summarized results was evaluated by searching for divergent statements across the Dutch and German samples, as well as by industry. Finally, the quantitative mentioning records were visualized.

4. Results

The exploration of two European cluster regions, where substantial public and private resources were invested during several years of R&D and innovation efforts geared towards advancing a bioeconomy, revealed *no* case of a company actually replacing fossil with bio-based feedstocks: the companies that used fossil inputs since their establishment continued to do so routinely. Knowledge-intensive start-ups were found among the group of companies that were "born green", meaning they never had a fossil raw material base (Demirel et al., 2019). However, these had evolved five to ten years earlier, *unrelated* to the clusters and dedicated bioeconomy promotion at the national and regional levels. Likewise, *no* spin-off from a university or research institute was found in the context of bioeconomy cluster activities. Consequently, the following results are exclusively focused on innovation barriers—that is, hurdles perceived by entrepreneurs as preventing them from building upon new knowledge, technologies, or partners and effect the use, application, and market-based exploitation of their learning.

4.1. Perceived hurdles to innovation originating from properties of NISs/RISs

When participants were asked about the most important factors affecting their *innovation capacity*, some form of finances emerged as a prioritized theme in most of the interviews. Access to risk and growth capital was reported most often as prime hurdle in the German context, where many public R&D grants are available and appreciated as helpful. When Dutch actors referred to public R&D grants and subsidies for experimentation, they repeatedly talked about a "jungle" where consultancy services were needed. By contrast, problems in mobilizing risk or growth capital did not lead to strong emotional arousal.

In both study regions, some entrepreneurs complained about the "non-neutrality" of public co-investment or funding decisions (RG15, RN5): "big companies, big names" get it and "networks" from which proposal evaluators are drawn into public administration decision-making lead to situations where "own partners are supported and others are consciously not supported".

Access to knowledge received slightly less attention. Respondents specified knowledge in terms of scientific knowledge and qualified R&D partners, business partners with complementary knowledge, strategic business consultancy, market intelligence for bio-based materials, or strengthened efforts in knowledge consolidation. Two Dutch respondents outlined how the government's funding of university research on bioeconomy topics generally was insufficient and specified that institutes also do not have the equipment to contribute meaningfully to R&D. The theme led to mixed and often ambivalent reactions in the context of German regions. Some entrepreneurs perceived the universities' or research institutes' expertise as an asset, while others evaluated their mode of operation as a threat or of limited use. The following statements exemplify aspects of reported dissatisfaction from both sub-samples:

> RG29: "An economic evaluation of the research results … is not at all wanted in the institutes … They go for technical questions, do a few years of research … and when it is over, they move to the next project."

> RN4: "[P]rofessors, they want to have a perfect product and they want to sit … in their chamber … two years – I mean: I have clients [waiting]."

In both study regions, entrepreneurs nevertheless invested time into contributing to higher education, not only with an objective to motivate students but primarily to raise researchers' awareness on relevant topics.

Access to a skilled workforce was a relevant theme in sparely populated and structurally weak German regions. The respondents called for dedicated study programs and generally strengthened efforts in education. Here, also business partners with complementary knowledge were mentioned as a bottleneck. Smaller units requested consolidated technical or market knowledge and consultancy, predominantly in the German context. Although rarely prioritized by Dutch respondents, access to R&D and testing infrastructures also received some attention.

There were 11 interviews with explicit statements about innovation capacity not being a bottleneck holding back bioeconomy innovation (see Fig. 5). In these cases, opportunities for launching innovation projects successfully were not evaluated as convincing enough to use or upgrade capabilities. This was because the potential economic and ecological benefits of exploiting perceived opportunities were questioned, the respondent's business was not under major competitive threat, or resistance along the downstream value-chain was rather high.

> RG12: "[I]nnovation willingness is comparatively high and the innovation capacities will be established – if that is a good idea."

> RG6: "Or, there's not enough distress to develop that [innovation capacity] now."

> RG22: "[T]he innovation willingness for transition, I think, is not really given with many … When we approach a company … they say: 'Bioeconomy – what a crock', 'Doesn't work!', 'Never change a running system' or similar."

Respondents perceived a large variety of conditions, mostly at the national or international level, as affecting market conditions and blocking *innovation opportunities*. All of the Dutch and a majority of the German entrepreneurs raised the theme of unfavorable factor price relations (see Fig. 6). Due to the low prices of fossil fuels as well as the absence of effective CO_2 emissions pricing, products based on renewable resources could not flourish in the market. A CO_2 tax was relatively more often requested in the Dutch as compared to the German context. Actors from both sub-samples believed that environmental footprints should be considered in international trade regulation. In addition, German entrepreneurs repeatedly mentioned the European General Agricultural Policy (GAP) as a problem and its reform as a priority. Increased biomass production as well as farmers who are more responsive and entrepreneurial would be needed. The government was called upon to draft a resource strategy and acknowledge true scarcities.

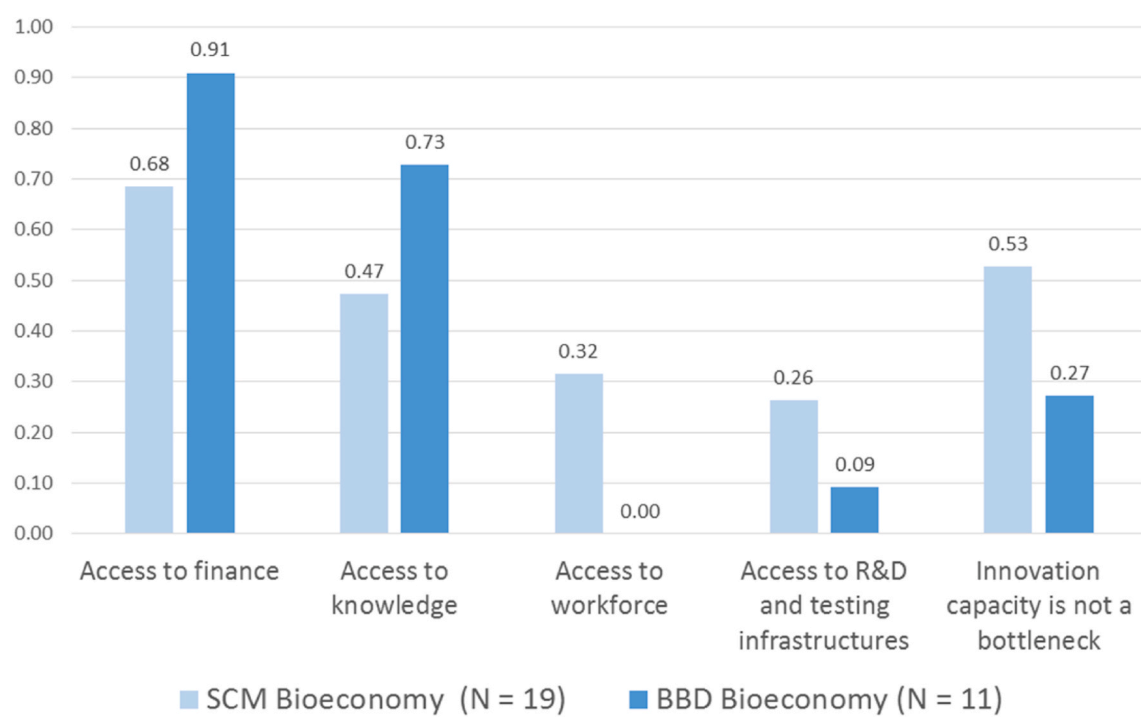

Fig. 5. Perceived hurdles to strengthened innovation capacities by cluster area (N = 30, number of mentions relative to the number of actors in each group). Note: Some actors mentioned two topics that were clustered in one category. Thus, 100% does not necessarily mean that all of the group members mentioned the topic.

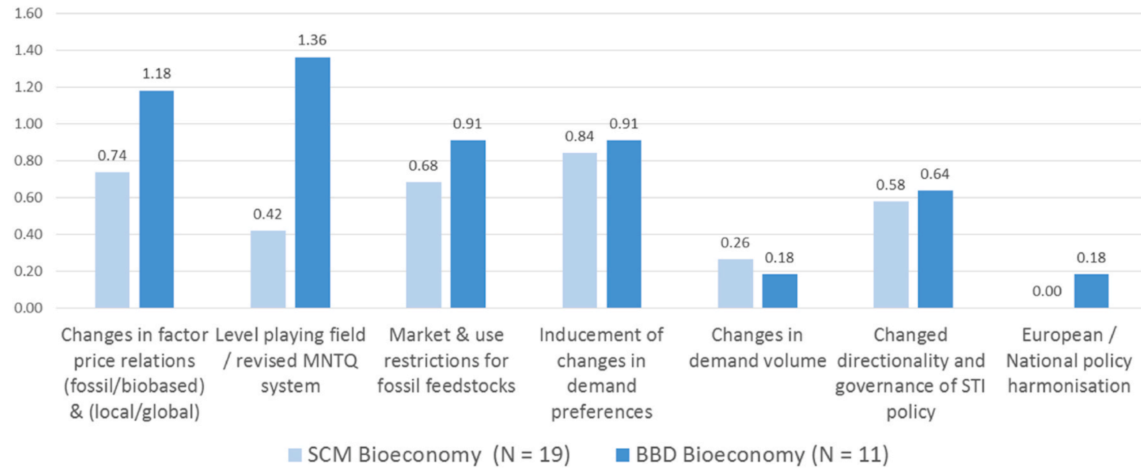

Fig. 6. Drivers of innovation opportunities, by NIS (N = 30, number of mentions relative to the number of actors in each group).
Note: Some actors mentioned two topics that were clustered in one category. Thus, 100% does not necessarily mean that all group members mentioned the topic.

RG9: "High plants with a lot of biomass as a side stream should be the breeding priority."

Dutch actors highlighted "fair play" as the most important potential driver of new opportunities. Both countries' energy regulations provide subsidies for the use of biomass for energy but not for its material uses. In addition, predominantly Dutch respondents requested adjustment of norms, standards, testing procedures, and certification. Furthermore, market and use restrictions for fossil feedstocks were envisioned as potentially boosting opportunities for bio-based products. These could take the form of stricter environmental or health regulations, up to outright bans of certain materials. However, against the background of Dutch pension provisions which are invested widely in the country's oil and gas industry, two respondents also warned against fast policy changes.

Respondents in both countries advocated for government interventions to foster awareness and change in values: from the education sector up to "normal" consumers. These interventions concern overall resource use and pollution (as exemplified by statement RN12) as well as biotechnology applications that face acceptance problems among consumers (statement RN11).

RN12: "I would really like more people to understand what we are doing to our planet today."

RN11: "What we have not done properly is … educate people."

Cross-country agreement was also evident, with respondents underlining that changes in the waste system could have positive effects on consumer preferences. Limiting possibilities to just dump or burn waste and increasing recycling obligations could open up new bioeconomy opportunity spaces ("Inducement of changes in demand preferences" in Fig. 6).

The German respondents placed the highest emphasis on government intervention to change demand preferences. Cultural change was perceived as requiring stimuli.

RG12: "The German market is stone on stone … and perceives wood construction as inferior …"

4.2. *Innovation hurdles perceived as originating from SISs properties*

The characteristics of the national and regional ISs apply to all of the firms located in the same geographical area. We found that the industry characteristics relevant for a specific firm — and therefore the aligned SIS configurations — additionally played a crucial role in entrepreneurs' perceptions of their opportunities and capabilities. For instance, predominantly actors from the chemical industry believed that more risk or venture capital was needed to strengthen *innovation capabilities*. Interviewees explained that new bio-based processes currently cannot meet "normal" profitability expectations because continuous experimentation over an extended time period would be needed to reach acceptable efficiency levels.

RN11: "I think we could already build new factories today: first of their kind, new bio-based factories. Will they be very efficient? Probably not. If you look at the oil industry … it took also more than 50 years to become really efficient and use everything that is in oil … up to asphalt."

Respondents in this industry also raised problems like the substantial STI policy budget cuts in the recent past (Netherlands) and high hurdles to sizeable R&D funding or public co-investments (Germany). German respondents in the fine chemicals industry more often reported difficulties with attracting the right workforce and (partners') expertise.

The prime concern of the respondents in the polymer-processing group was access to knowledge: neither university curricula nor professional education include topics related to bio-based polymers well enough, and public R&D investment is insufficient. Change would enable these (predominantly small) actors operating with tight profit margins to make room for more in-house efforts. Access to R&D and testing infrastructures is a related concern: in-house facilities normally are blocked by ongoing production and in-house quality-assurance processes.

The construction materials industry rated capital and the overall national university capacities as crucial bottlenecks. In the German context, the public image of the construction and construction materials industry was not sufficiently "knowledge-driven" to qualify for STI policy attention. Dutch respondents pointed to the huge investments necessary to adjust to the end of cheap national gas for residential heating – a debate that hardly leaves space for augmented funding of other innovations. Expertise appears to be dying out gradually, with renowned professors reaching the retirement age in Germany. The quantity of basic research currently implemented on bio-based construction was deemed inadequate in both countries (see also Fig. 7).

Regarding expanded *innovation opportunities*, the chemical industry actors were not fond of market or use restrictions for fossil feedstocks as well as efforts to create a level playing field. Instead, they emphasized inducing change to demand preferences alongside (step-wise) adjustments of the factor price relations. STI policy reform ranked high on their agendas, beyond the view of co-investment or risk minimization for biorefineries. Respondents complained about national and/or regional

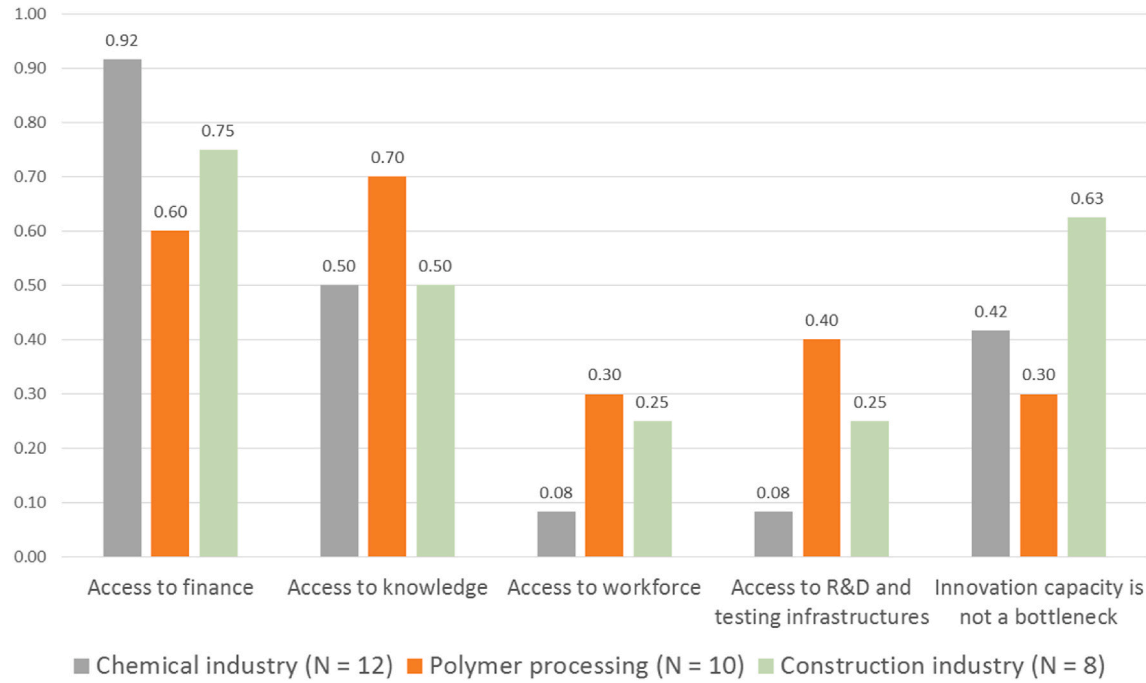

Fig. 7. Perceived hurdles to strengthened innovation capacities by industry (N = 30, number of mentions relative to the number of actors in each group).
Note: Some actors mentioned two topics that were clustered in one category. Thus, 100% does not necessarily mean that all group members mentioned the topic.

policy-makers being insufficiently dedicated to the bioeconomy vision and transition to sustainability. Bottlenecks in sectoral and international policy harmonization were diagnosed as causing policy inconsistencies, which hampered many actors. Policy decisiveness and consistency with a long-term perspective were rated as being insufficient.

RG29: “I can understand that promotional projects do not run for 10–20 years. I can see that our democratic system does not allow for that. Nevertheless, that’s annoying.”

Two respondents recommended a radical mind shift and consequential revision of bioeconomy-promoting policies.

RN11: “That is a choice: do we stick to our original thinking that scale factors really are dominant … ? If you are bio-based, then you could also go for smaller plants - localized - close to the feedstock.”

RN16: "There is no vision for 20 - 40 years. But you need big decisions. …When governments … are making these big decisions and visions, then it’s easier to get the business cases right".

For both, the chemical and plastic industries, profit-driven waste-incineration plants and landfills were perceived as a problem. Residue and waste streams could represent alternative resources from entrepreneurial perspectives. Polymer compounders and processors were convinced that (forced) recycling cost inclusion would open up new bioeconomy markets. However, the advantages of bio-based (and eventually compostable) bioplastics can only take effect with a separate collection system or if these materials are accepted in waste containers for compost. Accordingly, the government and the EU were called upon to reform the entire waste sector.

Themes related to a level playing field received the highest attention within the plastic industry. Respondents often perceived normal consumers as being overcharged with multiple non-transparent labels and disposal instructions. In addition, the high costs and efforts required to prove the origins or characteristics of and certify bio-based products were regarded as unfair burdens, as compared to the situation for traditional suppliers.

RN10: “The … overall migration tests: they have been laid out for the traditional plastics … so they are not very suitable to test bio-based plastics. The … testing [is] about the inertness of the material. So it doesn’t say anything about the toxicity …”

RN15: “[We need] one extra clause that raises the possibility of bioplastic [companies] to demonstrate that a product is safe by self-assessment.”

Alongside their strong agreement with chemical industry respondents on raising customer awareness, polymer processors would also welcome some demand stimulation. Regarding STI policy implementation, a German respondent criticized how having no government sanctions follows the research institutes’ pattern of overambitious goal setting in funding proposals and subsequent failures to deliver promised results. Some respondents from the industry could not find sufficient STI policy support for improved (hybrid) solutions, as exemplified by the following statement:

RN19: “[W]e want to move from the current situation to the ideal situation … which is unfeasible. You need to move … in different phases and stages … and this is not seen as a transition yet …”

From the points of view of the construction materials industry, the low fossil fuels, emissions, and transportation prices constrict opportunities based on renewable (local) feedstocks:

RN5: “If … you really sanction the conventional building industry, the problem [of an unfavorable competitive situation of bio-based materials] is solved. So, get the fees, the penalties, where they belong … the one who is polluting ought to pay.”

RG32: “[Y]ou have to regulate it again. You cannot globalize on the one hand, and then, on the other hand, just let slide all the negative effects that arise.”

Respondents underlined problems in the realm of metrology, norming, testing, and quality management (MNTQ), similarly to their peers in the plastic industry (see Fig. 8). The actors explained how measurement standards and norms were outdated, biased toward fossil fuel based

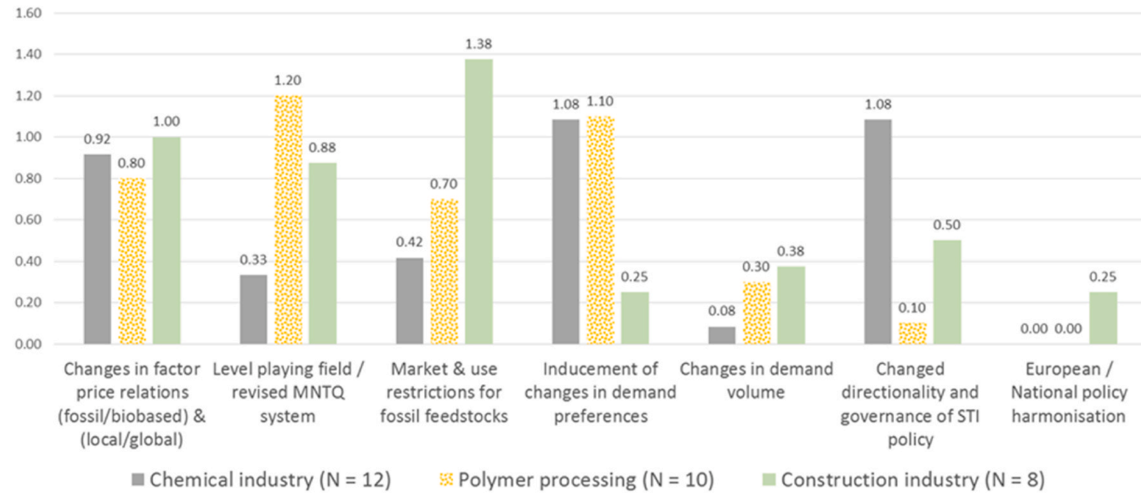

Fig. 8. Drivers of innovation opportunities, by industry (N = 30, number of mentions relative to the number of actors in each group).
Note: Some actors mentioned two topics that were clustered in one category. Thus, 100% does not necessarily mean that all group members mentioned the topic.

products, or inappropriately translated from other industries. A reform would remove or lower innovation hurdles and shorten time to market. They also provided specific ideas concerning building standards (including for fire safety) and regulations as well as a call to abolish non-bio-based insulation materials. Stricter regulation was understood as a short-term remedy in view of the current (unsustainable) consumption patterns and demand preferences blocking bioeconomy innovation spaces. The immediate evolution of bioeconomy-innovation opportunities is expected from effective demand on markets, such as government-ordered kindergartens, schools, and low cost housing.

Policy harmonization across German federal states or Dutch provinces as well as concerted efforts were deemed indispensable in the construction industry, in which fragmented structures and regulatory barriers prevail. A value-chain approach should involve planning offices, construction firms, traders, producers of materials, and companies with the required craftsmanship.

5. Discussion

We proposed a theoretical framework that combines firm-level determinants of innovation behavior and characteristics of the ISs in which entrepreneurs are embedded. In this way, we analyzed the effects of interrelated ISs on entrepreneurs' evaluation of the desirability and feasibility of successful innovation within an emerging bioeconomy. The application of our framework in two cluster regions offers new theoretic and empirical insights. We will first discuss this study's theoretical and empirical contributions. We will end this section with some policy recommendations.

5.1. Integration of entrepreneurial perspectives and innovation systems

At the theoretical level, our framework addresses the existing criticism that the IS literature ignores the micro-level. By integrating the micro-level determinants of entrepreneurial behavior, we offer a new bottom-up perspective on innovation systems. Most of the IS research is directed to system "failures" (Grillitsch and Trippl, 2016; Klein Woolthuis et al., 2005; Metcalfe, 2005). Especially with regard to the bioeconomy, a strong policy discourse exists at the European level that emphasizes the hurdles (e.g., Purkus et al., 2018) and threats in view of other countries' competitive strength (e.g., Birch et al., 2014). Although our results also highlight substantial barriers to innovation, the entrepreneurial perspective explicitly takes into account various pathways toward expanded innovation opportunities. In that sense, our framework not only covers the negative aspects, but also allows for the positive perspective of opportunity creation within the dynamics of interrelated ISs. This approach offers a promising starting point for connecting innovation research on the bioeconomy with a "smart specialization" strategy of regional development that takes a differentiated view on a region's existing industrial base (Hassink and Gong, 2019).

The second theoretical implication of results derived on the basis of our conceptual framework is attention for the necessity of performing an integrated IS analysis that covers the barriers and opportunities at multiple geographic levels and that accounts for embeddedness in a specific industry/SIS, as relevant from an entrepreneur's perspective. Most of the academic studies on ISs limit themselves to analyzing either a geographically bounded IS (at a regional or national level, e.g., Bosman and Rotmans, 2016; Grundel and Dahlström, 2016), focus on a specific natural resource (e.g., Mertens et al., 2019; Purkus et al., 2018), or analyzing the IS in view of a specific technology (Dahiya et al., 2018; Nevzorova and Karakaya, 2020; Wohlgemuth et al., 2021). However, as our results show, these academic distinctions mean little to entrepreneurs, who experience hurdles to innovation and perceive opportunities in specific industries and places with effects that unfold across geographies and bioeconomy segments.

Empirical results demonstrate the importance of including both the sectoral and the geographical IS conceptualizations in respective analyses. Currently, standard RIS and NIS indicators are unspecific and blind to SIS components. European RIS indicators (see Fig. 3) hid the paucity of relevant and dedicated research facilities for all industrial segments of the bioeconomy in two Dutch provinces as well as the fact that the construction industry representatives in the German study regions were actually in relatively sparse RIS. In addition, the relevance of regulation — and respective hurdles or opportunities for innovation — on interrelated governance levels differs by industry/SIS. So far, these particularities are not considered in recommendations for 'smart specialization' (e.g., Asheim et al., 2020; Haarich et al., 2017). Not only are the interests, opportunities, and power relations at other geographic levels generally relevant as underlined by Zukauskaite et al. (2017). In fact, innovation opportunities that require a modernization of material or product testing processes, standards and certification in Europe cannot be unblocked by conducive STI policy at the regional level.

Furthermore, our results emphasize the importance of the characteristics of the value-chain within the SIS for actors' innovation capabilities. The significance of positions in value networks can be illustrated by the example of polymer processors. Most companies in this industry build their competitive strength on specific recipes or cost-saving process innovations, in close cooperation with polymer producers, customers, and OEMs. The integrated nature of relevant value networks makes it very difficult for a single firm to innovate on its own. This result is line with other research on this industry (de Vargas Mores et al., 2018; Paletta et al., 2019; Van den Oever et al., 2017), and other bioeconomy segments (e.g., Carraresi et al., 2018; Gregg et al., 2020; Wohlfahrt et al., 2019).

Value-chain positions also come with differing distances to end consumers. Most products of the construction materials and chemical industries are invisible to customers when built into, or used in a final product. Based on ten country case studies, the OECD concluded that only a small proportion of all bioeconomy products concern the business-to-consumer market (Philp and Winickoff, 2019). However, earlier research proposed in particular that radical innovation is more likely to appear in consumer goods industries that operate (with visible products) in close contact with consumers (Galliano and Nadel, 2015). It follows that radical changes in rather "invisible" industries rather requires triggers by, e.g., performance-based regulation, international establishment or harmonization of production standards (Berg et al., 2018; Iles and Martin, 2013; Kedir and Hall, 2020).

5.2. Implications for STI policy promoting the bioeconomy

A somewhat surprising result of our study is that the entrepreneurs found the lack of innovation opportunities as a far more limiting factor for innovation than they did lacking innovation capabilities. Supply-side promotion in the framework of STI policy (science push measures) is meant to strengthen the innovation capabilities of bioeconomy actors and was mostly welcomed in both study regions. Likewise, demand-side projects, stimulating the use of new materials or products in the Netherlands, were overwhelmingly evaluated as somewhat helpful, but insufficient. None of the interviewed firms in this study had phased out the use of fossil feedstocks on a significant scale. Those firms that did favor renewable resources anyway (the "born green" firms) mostly were established before the bioeconomy concept became popular. As demand-side measures are meant to widen or deepen innovation opportunities (e.g., Edler and Georghiou, 2007; Fevolden et al., 2017), we have to conclude that STI policy should design more effective instruments for market-making in view of clean products and services. Evidence from this study, thus, supports the diagnosis that bioeconomy market-making by government procurement is difficult (Philp and Winickoff, 2019) and sustainability transitions require changes in fields beyond STI policy (e.g., Schot and Steinmueller, 2018).

Lastly, our interviewees' statements regarding missing opportunities can be attributed to a missing societal consensus on the significance and shape of relevant problems or attainable objectives of bioeconomy promotion. It might be true that RIS policy can become better with improved understanding of the sector-specific needs of knowledge-intensive entrepreneurship as proposed by Gifford and McKelvey (2019). The Grand Challenges, however, call for 'concerted action' according to Kuhlmann and Rip (2018). The different bioeconomy actors still had vastly different expectations and visions (see also Wilde and Hermans, 2021). Our findings show that "systemic policies" (e.g., cluster- or value-chain-based interventions) must link entrepreneurs to policy-makers with influence on regulatory hurdles and other bottlenecks perceived to originate from the national and international levels. In this regard, our study further strengthens calls for more coordination in view of a "transformative shift toward sustainability" through increased competence and effort in policy design (e.g., Mazzucato, 2018; Diercks et al., 2019) and more attention for policy orchestration across scales and governance levels of ISs in the bioeconomy (Ayrapetyan and Hermans, 2020; Chaminade, 2020; Nong et al., 2020).

5.3. Limitations and further research

This study is confined to only three segments of the emerging bioeconomy. Only a small fraction of the technologies and activities in the selected industries has been covered. However, based on earlier evidence and rationales provided through and for SIS analysis, we would assume that the main findings are generalizable for companies within these industries located elsewhere in Europe. While we covered entrepreneurs' perceptions in rather similar and comparatively strong RIS/NIS contexts. The findings in other parts of Europe may differ.

The study did not reveal how more start-ups could be supported to evolve. Yet, this is a crucial aspect for accelerating sustainability transitions, regional development, and SDG attainment. Additional comparative case studies might be helpful in this regard. Finally, our framework did neither explore entrepreneurial motives nor differentiate among degrees of innovation willingness. A more nuanced analysis could allow for further insights on the differences in innovation behavior between incumbents and "born green" bioeconomy entrepreneurs.

5.4. Conclusion

Our study explored the context conditions perceived as relevant for entrepreneurs' innovation capabilities and opportunities in an emerging bioeconomy. We have introduced a conceptual framework that links companies' innovation behavior to structural properties of interrelated innovation systems in which they are embedded. The connection of the micro level of actors to the system level is a new conceptualization for IS analysis. In addition, this study lifts IS analysis beyond its focus on failures by explicitly taking into account the opportunity spaces. Furthermore, our results show the importance of integrating RISs, SISs and TISs. Finally, our empirical results show that bioeconomy entrepreneurs rather negated the lack of innovation capabilities as decisive limiting factor for innovation, accelerated sustainability transition and SDG attainment. Respondents in the two study regions pointed out how innovation opportunities are blocked by unsuitable institutions mostly at the national, European, and international levels. We therefore concluded that effective bioeconomy promotion requires greater emphasis on the demand side and on systemic multi-level policies addressing innovation barriers, along with due consideration of industry-specific IS and value-chain configurations.

CRediT authorship contribution statement

Kerstin Wilde: Conceptualization, Methodology, Investigation, Visualization, Writing – original draft. **Frans Hermans:** Supervision, Writing – review & editing, Project administration, Funding acquisition.

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.

Acknowledgements

This study was financed through the TRAFOBIT project 'The Role and Functions of Bioclusters in the Transition to a Bioeconomy' (031B0020) under the call "Bioökonomie als gesellschaftlicher Wandel" of the German Federal Ministry of Education and Research (BMBF). Results could not have been achieved without the management and team of the Leading-edge Cluster Bioeconomy (Spitzencluster Mitteldeutschland) in Germany and of Biobased Delta in the Netherlands who provided us with valuable information and support. Most importantly, we want to express deep appreciation for all respondents who took the time to meet and discuss questions in depth.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2021.127979.

Appendix

Table A.1
Inductive coding themes and categorisation for strengthened innovation capacity

Access to finance	(Public/private) start-up or growth capital
	Public R&D grants & subsidies
	Neutrality in R&D funding/public investment decisions
Access to knowledge	Qualified R&D partners
	Scientific knowledge
	Business partners with complementary knowledge
	Strategic business consultancy
	Knowledge consolidation and effort coordination
	Market intelligence for bio-based materials
Access to workforce	Skilled workers and competent employees
	(Good and more) Education, education facilities
	Students with awareness, competence and motivation
	Attractive living conditions for highly skilled experts
Access to R& D and testing infrastructures	Accessible R&D facilities
	Testing facilities

Table A.2
Inductive coding themes and categorisation for strengthened innovation opportunities

Changes in factor price relations (fossil/bio-based) & (local/global)	Increase in the price of fossil feedstocks (oil price and price of CO2 emissions)
	Governmental resource strategy
	GAP reform & increased biomass production
	Trade regime reform
Level playing field/revised MNTQ system	Adjustment of norms, standards and testing
	Transparent & reliable certification
	Energy sector reform
Market & use restrictions for fossil feedstocks	Stricter environmental regulation
	More health & consumer protection
	Updated thermal insulation regulation
	Reform of building standards & regulation
Inducement of changes in demand preferences	Development of customer, consumer awareness and value change
	Strengthened efforts in education
	Reform of the waste system
	Use of recyclats, circular economy promotion
Changes in demand volume	Public demand stimulation and innovative procurement
	Private demand stimulation
Changed directionality and governance of STI policy	Political support for the bioeconomy/transition
	Consistent policy formulation and implementation
	Reform research funding system
	Coordination of efforts & knowledge
	Biotechnology promotion
	Start-up promotion
	Tax reform
	Attraction of large and MNCs
	Fostering a “felt urgency” (in policy & industry)
European/National policy harmonization	National policy harmonization of research, economic promotion, agriculture and natural resources
	European policy harmonization

References

Ács, Z.J., Autio, E., Szerb, L., 2014. National systems of entrepreneurship: measurement issues and policy implications. Res. Pol. 43 (3), 476–494. https://doi.org/10.1016/j.respol.2013.08.016.

Aguilar, A., Wohlgemuth, R., Twardowski, T., 2018. Preface to the special issue bioeconomy. N. Biotech. 40, 1–4. https://doi.org/10.1016/j.nbt.2017.06.008.

Alvarez, S.A., Barney, J.B., 2013. Epistemology, opportunities, and entrepreneurship: comments on Venkataraman et al.(2012) and Shane (2012). Acad. Manag. Rev. 38 (1), 154–157. https://doi.org/10.5465/amr.2012.0069.

Asheim, B.T., Isaksen, A., Trippl, M., 2020. The role of the Regional Innovation System approach in contemporary regional policy: is it still relevant in a globalised world?. In: Regions and Innovation Policies in Europe. Edward Elgar Publishing. https://doi.org/10.4337/9781789904161.

Ayrapetyan, D., Hermans, F., 2020. Introducing a multiscalar framework for biocluster research: a meta-analysis. Sustainability 12 (9), 3890. https://doi.org/10.3390/su12093890.

Balland, P.A., Belso-Martínez, J.A., Morrison, A., 2016. The dynamics of technical and business knowledge networks in industrial clusters: embeddedness, status, or proximity? Econ. Geogr. 92 (1), 35–60. https://doi.org/10.1080/00130095.2015.1094370.

Befort, N., 2020. Going beyond definitions to understand tensions within the bioeconomy: the contribution of sociotechnical regimes to contested fields. Technol. Forecast. Soc. Change 153. https://doi.org/10.1016/j.techfore.2020.119923, 119923.

Berg, S., Cloutier, L.M., Bröring, S., 2018. Collective stakeholder representations and perceptions of drivers of novel biomass-based value chains. J. Clean. Prod. 200, 231–241. https://doi.org/10.1016/j.jclepro.2018.07.304.

Birch, K., Levidow, L., Papaioannou, T., 2014. Self-fulfilling prophecies of the European knowledge-based bio-economy: the discursive shaping of institutional and policy frameworks in the bio-pharmaceuticals sector. J. Knowl. Econ. 5 (1), 1–18. https://doi.org/10.1007/s13132-012-0117-4.
Bitektine, A., Haack, P., 2015. The "macro" and the "micro" of legitimacy: toward a multilevel theory of the legitimacy process. Acad. Manag. Rev. 40 (1), 49–75. https://doi.org/10.5465/amr.2013.0318.
Bocken, N.M., Geradts, T.H., 2020. Barriers and drivers to sustainable business model innovation: organization design and dynamic capabilities. Long. Range Plan. 53 (4), 101950. https://doi.org/10.1016/j.lrp.2019.101950.
Boekholt, P., 2010. The evolution of innovation paradigms and their influence on research, technological development and innovation policy instruments. In: Smits, R. E., Kuhlmann, S., Shapira, P. (Eds.), The Theory and Practise of Innovation Policy. Edward Elgar Publishing, Cheltenham, pp. 333–361. https://doi.org/10.4337/9781849804424.00022.
Bosman, R., Rotmans, J., 2016. Transition governance towards a bioeconomy: a comparison of Finland and The Netherlands. Sustainability 8 (10), 1017. https://doi.org/10.3390/su8101017.
Brunori, Gianluca, 2013. Biomass, biovalue and sustainability: some thoughts on the definition of the bioeconomy. EuroChoices 12 (1), 48–52. https://doi.org/10.1111/1746-692X.12020.
Bundesministerium für Ernährung und Landwirtschaft (BMEL), 2014. Nationale Politikstrategie Bioökonomie. BMEL, Berlin. Last accessed 16-11-2020, available at: https://www.bmel.de/SharedDocs/Downloads/DE/Broschueren/Biooekonomiestrategie.pdf?__blob=publicationFile&v=3/https://www.bmel.de/DE/themen/landwirtschaft/bioeokonomie-nachwachsende-rohstoffe/politstrategie-biooekonomie2013.html.
Carraresi, L., Berg, S., Bröring, S., 2018. Emerging value chains within the bioeconomy: structural changes in the case of phosphate recovery. J. Clean. Prod. 183, 87–101. https://doi.org/10.1016/j.jclepro.2018.02.135.
Chaminade, C., 2020. Innovation for what? Unpacking the role of innovation for weak and strong sustainability. J. Sustain. Res. 2 (1) https://doi.org/10.20900/jsr20200007.
Chowdhury, M.M.H., Quaddus, M.A., 2021. Supply chain sustainability practices and governance for mitigating sustainability risk and improving market performance: a dynamic capability perspective. J. Clean. Prod. 278 https://doi.org/10.1016/j.jclepro.2020.123521, 123521.
Chung, C.C., 2018. Technological innovation systems in multi-level governance frameworks: the case of Taiwan's biodiesel innovation system (1997–2016). J. Clean. Prod. 184, 130–142. https://doi.org/10.1016/j.jclepro.2018.02.185.
Coenen, L., Díaz López, F.J., 2010. Comparing systems approaches to innovation and technological change for sustainable and competitive economies: an explorative study into conceptual commonalities, differences and complementarities. J. Clean. Prod. 18 (12), 1149–1160. https://doi.org/10.1016/j.jclepro.2010.04.003.
Crossan, M.M., Apaydin, M., 2010. A multi-dimensional framework of organizational innovation: a systematic review of the literature. J. Manag. Stud. 47 (6), 1154–1191. https://doi.org/10.1111/j.1467-6486.2009.00880.x.
Dahiya, S., Kumar, A.N., Sravan, J.S., Chatterjee, S., Sarkar, O., Mohan, S.V., 2018. Food waste biorefinery: sustainable strategy for circular bioeconomy. Bioresour. Technol. 248, 2–12. https://doi.org/10.1016/j.biortech.2017.07.176.
Daly, J., Kellehear, A., Gliksman, M., 1997. The Public Health Researcher: A Methodological Guide. Oxford University Press.
Davidsson, P., 2015. Entrepreneurial opportunities and the entrepreneurship nexus: a re-conceptualization. J. Bus. Ventur. 30 (5), 674–695. https://doi.org/10.1016/j.jbusvent.2015.01.002.
de Vargas Mores, G., Finocchio, C.P.S., Barichello, R., Pedrozo, E.A., 2018. Sustainability and innovation in the Brazilian supply chain of green plastic. J. Clean. Prod. 177, 12–18. https://doi.org/10.1016/j.jclepro.2017.12.138.
Demirel, P., Li, Q.C., Rentocchini, F., Tamvada, J.P., 2019. Born to be green: new insights into the economics and management of green entrepreneurship. Small Bus. Econ. 52 (4), 759–771. https://doi.org/10.1007/s11187-017-9933-z.
Devaney, L., Henchion, M., 2018. Consensus, caveats and conditions: international learnings for bioeconomy development. J. Clean. Prod. 174, 1400–1411. https://doi.org/10.1016/j.jclepro.2017.11.047.
Díaz-García, C., González-Moreno, Á., Sáez-Martínez, F.J., 2015. Eco-innovation: insights from a literature review. Innovation 17 (1), 6–23. https://doi.org/10.1080/14479338.2015.1011060.
Diercks, G., Larsen, H., Steward, F., 2019. Transformative innovation policy: addressing variety in an emerging policy paradigm. Res. Pol. 48 (4), 880–894. https://doi.org/10.1016/j.respol.2018.10.028.
Drucker, P., 2014. Innovation and Entrepreneurship. Routledge.
Duygan, M., Stauffacher, M., Meylan, G., 2021. What constitutes agency? Determinants of actors' influence on formal institutions in Swiss waste management. Technol. Forecast. Soc. Change 162. https://doi.org/10.1016/j.techfore.2020.120413, 120413.
Edler, J., Georghiou, L., 2007. Public procurement and innovation. Resurrecting the demand side. Res. Pol. 36 (7), 949–963. https://doi.org/10.1016/j.respol.2007.03.003.
Ehrenfeld, W., Kropfhäußer, F., 2017. Plant-based bioeconomy in Central Germany–a mapping of actors, industries and places. Technol. Anal. Strat. Manag. 29 (5), 514–527. https://doi.org/10.1080/09537325.2016.1140135.
Etikan, I., Musa, S.A., Alkassim, R.S., 2016. Comparison of convenience sampling and purposive sampling. Am. J. Theor. Appl. Stat. 5 (1), 1–4. https://doi.org/10.11648/j.ajtas.20160501.11.
European Commission (EC), 2012. Innovating for Sustainable Growth: a Bioeconomy for Europe (COM (2012) 60). Brussels. Last accessed 15.10.2020, available at: https://op.europa.eu/en/publication-detail/-/publication/1f0d8515-8dc0-4435-ba53-9570e47dbd51.
European Commission (EC), 2019. Regional Innovation Scoreboard 2019. Publications Office of the European Union, Luxembourg. Last accessed 15.10.2020, available at: https://ec.europa.eu/growth/industry/innovation/facts-figures/regional_en.
Farla, J., Markard, J., Raven, R., Coenen, L., 2012. Sustainability transitions in the making: a closer look at actors, strategies and resources. Technol. Forecast. Soc. Change 79 (6), 991–998. https://doi.org/10.1016/j.techfore.2012.02.001.
Fevolden, A.M., Coenen, L., Hansen, T., Klitkou, A., 2017. The role of trials and demonstration projects in the development of a sustainable bioeconomy. Sustainability 9 (3), 419. https://doi.org/10.3390/su9030419.
Frisvold, G.B., Moss, S.M., Hodgson, A., Maxon, M.E., 2021. Understanding the US bioeconomy: a new definition and landscape. Sustainability 13 (4), 1627. https://doi.org/10.3390/su13041627.
Fritsche, U., Brunori, G., Chiaramonti, D., Galanakis, C., Hellweg, S., Matthews, R., Panoutsou, C., 2020. Future Transitions for the Bioeconomy towards Sustainable Development and a Climate-Neutral Economy - Knowledge Synthesis Final Report. Publications Office of the European Union, Luxembourg, ISBN 978-92-76-21518-9. https://doi.org/10.2760/667966 (online), JRC121212.
Galliano, D., Nadel, S., 2015. Firms' eco-innovation intensity and sectoral system of innovation: the case of French industry. Ind. Innovat. 22 (6), 467–495. https://doi.org/10.1080/13662716.2015.1066596.
Geels, F.W., 2005. Technological Transitions and System Innovations: A Co-evolutionary and Socio-Technical Analysis. Edward Elgar, Cheltenham.
Giampietro, M., 2019. On the circular bioeconomy and decoupling: implications for sustainable growth. Ecol. Econ. 162, 143–156. https://doi.org/10.1016/j.ecolecon.2019.05.001.
Gifford, E., McKelvey, M., 2019. Knowledge-intensive entrepreneurship and S3: conceptualizing strategies for sustainability. Sustainability 11 (18), 4824. https://doi.org/10.3390/su11184824.
Gill, P., Stewart, K., Treasure, E., Chadwick, B., 2008. Methods of data collection in qualitative research: interviews and focus groups. Br. Dent. J. 204 (6), 291–295. https://doi.org/10.1038/bdj.2008.192.
Giurca, A., Späth, P., 2017. A forest-based bioeconomy for Germany? Strengths, weaknesses and policy options for lignocellulosic biorefineries. J. Clean. Prod. 153, 51–62. https://doi.org/10.1016/j.jclepro.2017.03.156.
Giuliani, E., Bell, M., 2005. The micro-determinants of meso-level learning and innovation: evidence from a Chilean wine cluster. Res. Pol. 34 (1), 47–68. https://doi.org/10.1016/j.respol.2004.10.008.
Glaser, J., Laudel, G., 2010. Experteninterviews und qualitative Inhaltsanalyse als Instrumente rekonstruierender Untersuchungen. VS, Wiesbaden.
Gregg, J.S., Jürgens, J., Happel, M.K., Strøm-Andersen, N., Tanner, A.N., Bolwig, S., Klitkou, A., 2020. Valorization of bio-residuals in the food and forestry sectors in support of a circular bioeconomy: a review. J. Clean. Prod. 267 https://doi.org/10.1016/j.jclepro.2020.122093, 122093.
Grillitsch, M., Trippl, M., 2016. Innovation policies and new regional growth paths: a place-based system failure framework. Pap. Innovat. Stud. 26, 1–23. https://EconPapers.repec.org/RePEc:hhs:lucirc:2016_026.
Grundel, I., Dahlström, M., 2016. A quadruple and quintuple helix approach to regional innovation systems in the transformation to a forestry-based bioeconomy. J. Knowl. Econ. 7 (4), 963–983. https://doi.org/10.1007/s13132-016-0411-7.
Guest, G., MacQueen, K.M., Namey, E.E., 2011. Applied Thematic Analysis. Sage Publications, London.
Haarich, S., Kirchmayr-Novak, S., Fontenl, A., Toptsidou, M., Hans, S., 2017. *Bioeconomy Development in EU Regions. Mapping of EU Member States' Regions' Research and Innovation Plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy for 2014-2020*; Study Commissioned by DG Research & Innovation; European Commission: Brussels, Belgium. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/15189f4a-2216-11e8-ac73-01aa75ed71a1.
Hassink, R., Gong, H., 2019. Six critical questions about smart specialization. Eur. Plann. Stud. 27 (10), 2049–2065. https://doi.org/10.1080/09654313.2019.1650898.
Hair Jr., J.F., Page, M., Brunsveld, N., 2019. Essentials of Business Research Methods. Routledge.
Haynie, J.M., Shepherd, D.A., McMullen, J.S., 2009. An opportunity for me? The role of resources in opportunity evaluation decisions. J. Manag. Stud. 46 (3), 337–361. https://doi.org/10.1111/j.1467-6486.2009.00824.x.
Hekkert, M.P., Suurs, R.A.A., Negro, S.O., Kuhlmann, S., Smit, R.E.H.M., 2007. Functions of innovation systems: a new approach for analysing technological change. Technol. Forecast. Soc. Change 74, 413–432. https://doi.org/10.1016/j.techfore.2006.03.002.
Helfferich, C., 2011. Die Qualität Qualitativer Daten, vol. 4. VS Verlag für Sozialwissenschaften, Wiesbaden.
Hellsmark, H., Mossberg, J., Söderholm, P., Frishammar, J., 2016. Innovation system strengths and weaknesses in progressing sustainable technology: the case of Swedish biorefinery development. J. Clean. Prod. 131, 702–715. https://doi.org/10.1016/j.jclepro.2016.04.109.
Hermans, F., 2018. The potential contribution of transition theory to the analysis of bioclusters and their role in the transition to a bioeconomy. Biofuels Bioprod. Biorefining 12 (2), 265–276. https://doi.org/10.1002/bbb.1861.
Hojnik, J., Ruzzier, M., 2016. The driving forces of process eco-innovation and its impact on performance: insights from Slovenia. J. Clean. Prod. 133, 812–825. https://doi.org/10.1016/j.jclepro.2016.06.002.
Iddris, F., 2016. Innovation capability: a systematic review and research agenda. Interdiscipl. J. Inf. Knowl. Manag. 11, 235–260. URN: urn:nbn:se:hh:diva-32097.

Iles, A., Martin, A.N., 2013. Expanding bioplastics production: sustainable business innovation in the chemical industry. J. Clean. Prod. 45, 38–49. https://doi.org/10.1016/j.jclepro.2012.05.008.
Ivanova, S., Treffers, T., Langerak, F., 2018. Emotional paths leading to opportunity desirability and feasibility beliefs through controllability. Int. Small Bus. J. 36 (5), 546–573. https://doi.org/10.1177/0266242617751596.
Kabongo, J.D., Boiral, O., 2017. Doing more with less: building dynamic capabilities for eco-efficiency. Bus. Strat. Environ. 26 (7), 956–971. https://doi.org/10.1002/bse.1958.
Khan, O., Daddi, T., Iraldo, F., 2020. Microfoundations of dynamic capabilities: insights from circular economy business cases. Bus. Strat. Environ. 29 (3), 1479–1493. https://doi.org/10.1002/bse.2447.
Kedir, F., Hall, D.M., 2020. Resource efficiency in industrialized housing construction–A systematic review of current performance and future opportunities. J. Clean. Prod. 286 https://doi.org/10.1016/j.jclepro.2020.125443, 125443.
Kern, F., 2015. Engaging with the politics, agency and structures in the technological innovation systems approach. Environ. Innovat. Soc. Transitions (16), 67–69. https://doi.org/10.1016/j.eist.2015.07.001.
Kiefer, C.P., Del Rio Gonzalez, P., Carrillo-Hermosilla, J., 2019. Drivers and barriers of eco-innovation types for sustainable transitions: a quantitative perspective. Bus. Strat. Environ. 28 (1), 155–172. https://doi.org/10.1002/bse.2246.
Klein Woolthuis, R., Lankhuizen, M., Gilsing, V., 2005. A system failure framework for innovation policy design. Technovation 25 (6), 609–619. https://doi.org/10.1016/j.technovation.2003.11.002.
Kuhlmann, S., Rip, A., 2018. Next-generation innovation policy and grand challenges. Sci. Publ. Pol. 45 (4), 448–454. https://doi.org/10.1093/scipol/scy011.
Kuosmanen, T., Kuosmanen, N., El-Meligi, A., Ronzon, T., Gurria, P., Iost, S., M'Barek, R., 2020. How Big Is the Bioeconomy? Reflections from an Economic Perspective. (EUR 30167 EN). Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/144526.
Langeveld, J.W.A., 2015. Results of the JRC-SCAR Bioeconomy Survey. *Biomass Research Report* 1501. Biomass Research, Wageningen. Last accessed 15.10.2020, available at: https://biobs.jrc.ec.europa.eu/.
Lau, A.K., Lo, W., 2015. Regional innovation system, absorptive capacity and innovation performance: an empirical study. Technol. Forecast. Soc. Change 92, 99–114. https://doi.org/10.1016/j.techfore.2014.11.005.
Lawson, B., Samson, D., 2001. Developing innovation capability in organisations: a dynamic capabilities approach. Int. J. Innovat. Manag. 5, 377–400. https://doi.org/10.1142/S1363919601000427, 03.
Lee, T.W., Mitchell, T.R., Sablynski, C.J., 1999. Qualitative research in organizational and vocational psychology, 1979–1999. J. Vocat. Behav. 55 (2), 161–187. https://doi.org/10.1006/jvbe.1999.1707.
Leipold, S., Petit-Boix, A., 2018. The circular economy and the bio-based sector-Perspectives of European and German stakeholders. J. Clean. Prod. 201, 1125–1137. https://doi.org/10.1016/j.jclepro.2018.08.019.
Lundvall, B.-Å., 2007. Innovation system research and policy. Where it came from and where it might go. In: Paper presented at CAS Seminar, Oslo, December 4. Last accessed 15.10.2020, available online at: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.502.1643&rep=rep1&type=pdf.
Mahmud, M., Soetanto, D., Jack, S., 2020. Environmental management and product innovation: the moderating role of the dynamic capability of small manufacturing firms. J. Clean. Prod. 264 https://doi.org/10.1016/j.jclepro.2020.121633, 121633.
Malerba, F., 2005. Sectoral Systems: how and why innovation differs across sectors. In: Fagerberg, J., Mowrey, D., Nelson, R. (Eds.), The Oxford Handbook of Innovation. Oxford University Press, Oxford, pp. 380–406.
Markard, J., Truffer, B., 2008. Actor-oriented analysis of innovation systems: exploring micro–meso level linkages in the case of stationary fuel cells. Technol. Anal. Strat. Manag. 20 (4), 443–464. https://doi.org/10.1080/09537320802141429.
Martin, L., Wilson, N., 2016. Opportunity, discovery and creativity: a critical realist perspective. Int. Small Bus. J. 34 (3), 261–275. https://doi.org/10.1177/0266242614551185.
MAXQDA MAXQDA Software for Qualitative Data Analysis. VERBI Software—Consult-Sozialforschung GmbH; Berlin, Germany. https://www.maxqda.com/.
Mazzucato, M., 2018. Mission-oriented innovation policies: challenges and opportunities. Ind. Corp. Change 27 (5), 803–815. https://doi.org/10.1093/icc/dty034.
Mertens, A., Van Lancker, J., Buysse, J., Lauwers, L., Van Meensel, J., 2019. Overcoming non-technical challenges in bioeconomy value-chain development: learning from practice. J. Clean. Prod. 231, 10–20. https://doi.org/10.1016/j.jclepro.2019.05.147.
Metcalfe, J.S., 2005. Systems failure and the case for innovation policy. In Inn*ovation policy in a knowledge-based economy*. In: Llerena, P., Matt, M. (Eds.), Innovation Policy in a Knowledge-Based Economy. Springer, Berlin/Heidelberg, pp. 47–74.
Minister van Economische Zaken (MEZ), 2013. Groene Groei: voor een sterke, duurzame economie. Brief van de minister van Economische Zaken, mede namens de staatssecretaris van Infrastructuur en Milieu, aan de Tweede Kamer van 28 maart 2013. Vergaderjaar 2012-2013, 33043, nr. 14. Available at: https://www.rijksoverheid.nl/documenten/kamerstukken/2013/03/28/kamerbrief-groene-groei-voor-een-sterke-duurzame-economie.
Moss, S.E., Lawrence, K.G., 1997. The effects of priming on the self-reporting of perceived stressors and strains. J. Organ. Behav.: Int. J. Ind. Occup. Organ. Psychol. Behav. 18 (4), 393–403. https://doi.org/10.1002/(SICI)1099-1379(199707)18:4%3C393::AID-JOB809%3E3.0.CO;2-5.
Mueller, V., Rosenbusch, N., Bausch, A., 2013. Success patterns of exploratory and exploitative innovation: a meta-analysis of the influence of institutional factors. J. Manag. 39 (6), 1606–1636. https://doi.org/10.1177/0149206313484516.
Nevzorova, T., Karakaya, E., 2020. Explaining the drivers of technological innovation systems: the case of biogas technologies in mature markets. J. Clean. Prod. 259 https://doi.org/10.1016/j.jclepro.2020.120819, 120819.
Nong, D., Escobar, N., Britz, W., Börner, J., 2020. Long-term impacts of bio-based innovation in the chemical sector: a dynamic global perspective. J. Clean. Prod. 272 https://doi.org/10.1016/j.jclepro.2020.122738, 122738.
Nooteboom, B., Van Haverbeke, W., Duysters, G., Gilsing, V., Van den Oord, A., 2007. Optimal cognitive distance and absorptive capacity. Res. Pol. 36 (7), 1016–1034. https://doi.org/10.1016/j.respol.2007.04.003.
Paletta, A., Leal Filho, W., Balogun, A.L., Foschi, E., Bonoli, A., 2019. Barriers and challenges to plastics valorisation in the context of a circular economy: case studies from Italy. J. Clean. Prod. 241 https://doi.org/10.1016/j.jclepro.2019.118149, 118149.
Pham, D.D.T., Paillé, P., Halilem, N., 2019. Systematic review on environmental innovativeness: a knowledge-based resource view. J. Clean. Prod. 211, 1088–1099. https://doi.org/10.1016/j.jclepro.2018.11.221.
Philp, J., Winickoff, D., 2019. Innovation Ecosystems in the Bioeconomy. OECD Publishing. https://doi.org/10.1787/23074957.
Pieroni, M.P., McAloone, T.C., Pigosso, D.C., 2020. Circular Economy business model innovation: sectorial patterns within manufacturing companies. J. Clean. Prod. 286 https://doi.org/10.1016/j.jclepro.2020.124921, 124921.
Ploum, L., Blok, V., Lans, T., Omta, O., 2018. Exploring the relation between individual moral antecedents and entrepreneurial opportunity recognition for sustainable development. J. Clean. Prod. 172, 1582–1591. https://doi.org/10.1016/j.jclepro.2017.10.296.
Purkus, A., Hagemann, N., Bedtke, N., Gawel, E., 2018. Towards a sustainable innovation system for the German wood-based bioeconomy: implications for policy design. J. Clean. Prod. 172, 3955–3968. https://doi.org/10.1016/j.jclepro.2017.04.146.
Robert, N., Giuntoli, J., Araujo, R., Avraamides, M., Balzi, E., Barredo, J.I., et al., 2020. Development of a bioeconomy monitoring framework for the European Union: an integrative and collaborative approach. N. Biotech. 59, 10–19. https://doi.org/10.1016/j.nbt.2020.06.001.
Saldaña, J., 2015. The Coding Manual for Qualitative Researchers, second ed. Sage, London.
Salim, N., Ab Rahman, M.N., Abd Wahab, D., 2019. A systematic literature review of internal capabilities for enhancing eco-innovation performance of manufacturing firms. J. Clean. Prod. 209, 1445–1460. https://doi.org/10.1016/j.jclepro.2018.11.105.
Sarasvathy, S.D., Dew, N., Velamuri, S.R., Venkataraman, S., 2010. Three views of entrepreneurial opportunity. In: Ács, Z.J., Audretsch, D.B. (Eds.), *Handbook of Entrepreneurship*, 77–96. Springer, New York.
Schot, J., Steinmueller, W.E., 2018. Three frames for innovation policy: R&D, systems of innovation and transformative change. Res. Pol. 47 (9), 1554–1567. https://doi.org/10.1016/j.respol.2018.08.011.
Shepherd, D.A., Williams, T.A., Patzelt, H., 2015. Thinking about entrepreneurial decision making: review and research agenda. J. Manag. 41 (1), 11–46. https://doi.org/10.1177/0149206314541153.
Sotarauta, M., 2016. An Actor-Centric Bottom-Up View of Institutions: Combinatorial Knowledge Dynamics through the Eyes of Institutional Entrepreneurs and Institutional Navigators. *Environment and Planning* C: Government and Policy. https://doi.org/10.1177/0263774X16664906.
Stilgoe, J., Owen, R., Macnaghten, P., 2013. Developing a framework for responsible innovation. Res. Pol. 42 (9), 1568–1580. https://doi.org/10.1016/j.respol.2013.05.008.
Upham, P., Dütschke, E., Schneider, U., Oltra, C., Sala, R., Lores, M., Klapper, R., Bögel, P., 2018. Agency and structure in a sociotechnical transition: hydrogen fuel cells, conjunctural knowledge and structuration in Europe. Energy Res. Soc. Sci. 37, 163–174. https://doi.org/10.1016/j.erss.2017.09.040.
Van den Oever, M., Molenveld, K., van der Zee, M., Bos, H., 2017. *Bio-based and Biodegradable Plastics: Facts and Figures: Focus on Food Packaging in the Netherlands* 1722. Wageningen Food & Biobased Research. https://doi.org/10.18174/408350.
Vitale, D.C., Armenakis, A.A., Feild, H.S., 2008. Integrating qualitative and quantitative methods for organizational diagnosis: possible priming effects? J. Mix. Methods Res. 2 (1), 87–105. https://doi.org/10.1177/1558689807309968.
Vogel, P., 2017. From venture idea to venture opportunity. Enterpren. Theor. Pract. 41 (6), 943–971. https://doi.org/10.1111/etap.12234.
Wieczorek, A.J., Hekkert, M.P., 2012. Systemic instruments for systemic innovation problems: a framework for policy makers and innovation scholars. Sci. Publ. Pol. 39 (1), 74–87. https://doi.org/10.1093/scipol/scr008.
Wilde, K., Hermans, F., 2021. Deconstructing the attractiveness of biocluster imaginaries. J. Environ. Pol. Plann. 1–16. https://doi.org/10.1080/1523908X.2021.1891872.
Wilden, R., Gudergan, S.P., 2015. The impact of dynamic capabilities on operational marketing and technological capabilities: investigating the role of environmental turbulence. J. Acad. Market. Sci. 43 (2), 181–199. https://doi.org/10.1007/s11747-014-0380-y.
Wohlfahrt, J., Frechaud, F., Gabrielle, B., Godard, C., Kurek, B., Loyce, C., Therond, O., 2019. Characteristics of bioeconomy systems and sustainability issues at the territorial scale. A review. J. Clean. Prod. 232, 898–909. https://doi.org/10.1016/j.jclepro.2019.05.385, 0.
Wohlgemuth, R., Twardowski, T., Aguilar, A., 2021. Bioeconomy moving forward step by step–A global journey. N. Biotech. 61, 22–28. https://doi.org/10.1016/j.nbt.2020.11.006.
Wydra, S., 2019. Value chains for industrial biotechnology in the bioeconomy-innovation system Analysis. Sustainability 11 (8), 2435. https://doi.org/10.3390/su11082435.

Wydra, S., 2020. Measuring innovation in the bioeconomy – conceptual discussion and empirical experiences. Technol. Soc. 61 https://doi.org/10.1016/j.techsoc.2020.101242, 101242.

Wydra, S., Hüsing, B., Köhler, J., Schwarz, A., Schirrmeister, E., Voglhuber-Slavinsky, A., 2021. Transition to the bioeconomy–Analysis and scenarios for selected niches. J. Clean. Prod. 294 https://doi.org/10.1016/j.jclepro.2021.126092, 126092.

Yitshaki, R., Kropp, F., 2016. Motivations and opportunity recognition of social entrepreneurs. J. Small Bus. Manag. 54 (2), 546–565. https://doi.org/10.1111/jsbm.12157.

Zahra, S.A., Sapienza, H.J., Davidsson, P., 2006. Entrepreneurship and dynamic capabilities: a review, model and research agenda. J. Manag. Stud. 43 (4), 917–955. https://doi.org/10.1111/j.1467-6486.2006.00616.x.

Zeug, W., Bezama, A., Thrän, D., 2020. Towards a Holistic and Integrated Life Cycle Sustainability Assessment of the Bioeconomy: background on Concepts, Visions and Measurements (No. 7/2020). UFZ Discussion Paper. http://hdl.handle.net/10419/224078.

Zukauskaite, E., Trippl, M., Plechero, M., 2017. Institutional thickness revisited. Econ. Geogr. 93 (4), 325–345. https://doi.org/10.1080/00130095.2017.1331703.

2.3 Transition towards a bioeconomy: Comparison of conditions and institutional work in selected industries

Wilde, K., & Hermans, F. (2024). Transition towards a bioeconomy: Comparison of conditions and institutional work in selected industries. *Environmental Innovation and Societal Transitions*, *50*, 100814.

https://doi.org/10.1016/j.eist.2024.100814

Published by Elsevier, the journal Environmental Innovation and Societal Transitions is an international, ranked, peer-reviewed journal that offers a platform for reporting studies of innovations and socio-economic transitions to enhance an environmentally sustainable economy.

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Environmental Innovation and Societal Transitions 50 (2024) 100814

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Transition towards a bioeconomy: Comparison of conditions and institutional work in selected industries

Kerstin Wilde[a,b,*], Frans Hermans[b]

[a] Deutsches Biomasseforschungszentrum Gemeinnützige GmbH, Torgauer Str. 116, Leipzig 04347, Germany
[b] Department for Structural Change, Leibniz Institute for Agricultural Development in Transition Economies (IAMO), Theodor-Lieser-Strasse 2, Halle (Saale) 06120, Germany

ARTICLE INFO

Keywords:
Bioeconomy
Sustainability transition
Neoinstitutional theory
Institutional work
Institutional fields
Value chains

ABSTRACT

Radical innovations aiming for sustainability usually need to transform existing institutions in order to become successful. From a transition perspective, institutional work is one of the actors' core activities in order to influence the dominant regime. This paper explores how institutional work materialises in an emerging bioeconomy. Our conceptual model shows how an industry's field conditions, combined with the actors' characteristics, shape the pattern of institutional work. We propose a set of categories for the classification of institutional fields and differentiate three forms of institutional work. Empirical evidence on actor characteristics and institutional work originates from the bioeconomy segments of the chemical, plastic and construction materials industries. Our findings lead to a new field typology: the impact on actors' institutional work can be conducive, barricading or exhausting. We recommend to question traditional actor classifications and formulate field specific policy measures for an emerging bioeconomy.

1. Introduction

The Sustainable Development Goals (SDGs) are crucial for the future of the planet as they provide a comprehensive framework to address pressing global challenges, promote economic prosperity, social inclusivity, and environmental sustainability for a more equitable and resilient world. The emerging bioeconomy is promoted through a top-level political call to radically change current approaches to production, consumption and disposal of biological resources and thereby advance SDG attainment. Although there are traditional bioeconomy segments that have long operated on inputs from agriculture or forestry (like leather processing or paper production, see e.g. Hermans, 2021), most bioeconomy policies envisage a bio-based transformation: a substitution of fossil with renewable raw materials enabled by more efficient and cascading uses of biomass (Dietz et al., 2018; Kardung et al., 2021; Stark et al., 2022). However, the deep structural entrenchment of societal and economic practices based on fossil resource extraction point to tremendous challenges and the unavoidable implication of societal conflicts accompanying transitions towards a bioeconomy (e.g. Eversberg and Fritz, 2022).

The literature on transition theory has been studying how new innovative practices at the micro-level of sociotechnical niches, under the right circumstances, can break through to the mainstream and ultimately replace the existing socio-technical regime (Fuenfschilling and Truffer, 2014; Geels and Schot, 2007; Grin et al., 2010). Nevertheless, individual actors and their exercise of agency have been largely overshadowed by the examination of niches, regimes, and socio-technical landscapes from a multi-level

* Corresponding author at: Deutsches Biomasseforschungszentrum Gemeinnützige GmbH (DBFZ), Torgauer Str. 116, Leipzig 04347, Germany.
E-mail addresses: Kerstin.Wilde@dbfz.de (K. Wilde), Hermans@iamo.de (F. Hermans).

https://doi.org/10.1016/j.eist.2024.100814
Received 23 February 2023; Received in revised form 29 December 2023; Accepted 10 January 2024
Available online 29 January 2024

perspective (Fischer and Newig, 2016; Duygan et al., 2021; Hermans, 2018). While institutions have long since received some degree of attention in transition studies (Andrews-Speed, 2016; Geels, 2020; Fuenfschilling, 2019), there has recently been a mounting call for a more systematic exploration of the interplay between innovations, institutions and actor agency (Hoogstraaten et al., 2020; van Mossel et al., 2018). Consequently, concepts derived from institutional theory, such as 'fields' (e.g. Kump, 2023), 'institutional work' (Fuenfschilling and Truffer, 2016; Kivimaa et al., 2021), and 'institutional entrepreneurship' (e.g. Sunio et al., 2019) are increasingly employed to explore actor-driven processes within transition studies. We respond to the call by investigating the research question: *What are the patterns of the bioeconomy actors' institutional work that emerge in response to institutional conditions in different industries*?

Firstly, this research question contributes to a growing body of work on the bioeconomy. While recent studies highlight general innovation and transition barriers like the absence of established quality standards and fragmented policy schemes (Van Lancker et al., 2016; Bröring et al., 2020; Grouiez et al., 2023), an analysis of specific conditions enabling or impeding actors' efforts in specific bioeconomy segments is missing so far. This study builds on industry-specific exchange fields as conceptualised in institutional theory. Its second contribution is an operationalisation of the analytical concept that allows for empirical investigation. Thirdly, the research question also represents a response to the agenda of transition studies: there is growing attention for actor agency in the course of sustainability transitions (Avelino, 2021; De Haan and Rotmans, 2018; Huttunen et al., 2021; Köhler et al., 2019; Sotarauta et al., 2021). Recent attention is directed at the variety of behavioural patterns exhibited by incumbents (Galvan et al., 2020; Magnusson and Werner, 2023; Turnheim and Sovacool, 2020). Thus, exploring institutional work pattern of specific actor groups in the transition process towards a bioeconomy is also meant to be a relevant contribution to this stream of research.

In the following sections, we will first start with the development of a theoretical framework and the clarification of concepts employed. In the subsequent section we will explain the details of our mixed-methods approach that combines a literature-based analysis of field conditions with stakeholder interviews on institutional work in and around three related industries: (1) the chemical industry, (2) the polymer processing industry and (3) the construction materials industry in Germany and the Netherlands. In the results section we will present our analysis of the different field conditions in these three industries and report on the institutional work that different types of actors are exhibiting. In the discussion section we reflect on the implications with respect to the aims of the study and deduce some policy recommendations. The paper ends with a conclusion.

2. Theoretical framework

2.1. Institutions and institutional work

Institutions have been extensively discussed in organisation sociology as established, prevalent and resilient social structures that shape or condition human behaviour and social interactions (Elzen et al., 2012; Hodgson, 2006; Scott, 2008). They are "composed of regulative, normative and cultural-cognitive structures that guide the behaviour of actors, such as laws, policies, standards, norms, values or cultural expectations" (Scott, 2008, p. 48). Some of these rule systems are explicit, codified, formalised and operate with disincentives or legal penalties (e.g. laws, regulations, standards, policies). Other institutions tend to be rather vague, implicit, fluid and informal, like norms of behaviour and social conventions. As emphasised by Hodgson, the power of all rules (formal and informal) ultimately depends on the fact that "they are embedded in shared habits of thought and behaviour" (2006, p.13).

The neoinstitutional perspective in organizational sociology came up as a response to the seminal work of Granovetter (1985) on the social embeddedness of economic action. It investigates the reciprocal relationship between agency and the institutional environment, recognizing how agency is both shaped by and contributes to field-level change (DiMaggio and Powell, 1991). This perspective has paved the way for closely related strands of research on institutional work (Lawrence et al., 2011) and institutional entrepreneurship (Dorado, 2013). Although these theoretical concepts are often treated as synonymous (Micelotta et al., 2017), we use the broader concept of "institutional work" which explores actors' strategies to create, disrupt, transform or maintain institutions (Hardy and Maguire, 2017; Zietsma and Lawrence, 2010). It makes room for the distributed agency of a multitude of rather unrelated actors as well as for the possibility of unintended consequences of actions (Hoogstraaten et al., 2020). Lawrence and his colleagues emphasised that only those substantive activities qualify as 'institutional work' which "involve physical or mental effort aimed at affecting an institution or set of institutions" (2011, p. 53). It is not decisive whether efforts are immediately successful or not (Lawrence and Suddaby, 2006). The aspired outcomes of actors' endeavours may include the maintenance, containment, amplification or suppression of the coverage or impact of a (formal or informal) rule system at different levels (Hampel et al., 2017).

Over time a multitude of categories have been used to structure and sort activities identified as institutional work. Mostly efforts towards the creation of new institutions are distinguished from activities aiming at the disruption or (incremental) transformation of existing institutions (e.g. Fuenfschilling and Truffer, 2016). However, Alvesson and Spicer (2019) pointed out that sorting observed activities according to (assumed) actor intentions is difficult and at times arbitrary. For instance, inter-organizational 'negotiating' aiming at joint problem solving or conflict resolution (Helfen and Sydow, 2013) or 'network anchoring' evidenced by intensified contact and exchange among actors (Leeuwis and Aarts, 2011) appear as justified categories of institutional work that fit with a variety of aims. Therefore, we follow recent studies which avoid sorting of actors' efforts in a narrow range of intended outcomes (Hampel et al., 2017; Hardy and Maguire, 2017; Löhr et al., 2022). Instead, we explore actual activities and their relation to specific aspects of the institutional context, thus distinguishing discursive, relational and material forms of institutional work. It is important to note however that actors can simultaneously embrace multiple agentic orientations and different forms of institutional work are often combined (Garud et al., 2011). Below we will shortly elaborate these different forms of institutional work:

First, **discursive work** refers to the use of symbols as expressions of meaning - including categories, identities and narratives. These efforts towards meaning-making may involve material objects (like texts) but language-bound symbols (such as memes, stories, narratives, discourses) are the centrepiece. Actors have been found to create new metaphors and storylines and to use field-specific meta-narratives or draw on ones that resonate with audiences across multiple fields (e.g. Riedy, 2022). Lizardo (2019) observed that sayings and vocabularies can routinely refer to specific practices and material objects and thereby subject them to an institutionalization process.

Second, **material work** "draws on the physical elements of the institutional environment" (Hampel et al., 2017, p. 27). Material artefacts are more than a type of institutional carriers that transport ideas over time and space as proposed by e.g. Scott (2003). The role of material, physical and other non-human elements in shaping social phenomena has meanwhile been studied from different theoretical perspectives (for an overview see Van Assche et al., 2022). Actors can use material objects (including technological devices and other results of intellectual or physical work, money, visual symbols and natural non-human entities) in a variety of ways to extend their agency or to create "facts on the ground" (Monteiro and Nicolini, 2015). Likewise, physical infrastructures are often non-neutral, embody specific institutional logics and carry decisive symbolic, normative or cultural-religious content as exemplified by the Medina airport (Biygautane et al., 2020) or the Northstream II pipeline that provided Germany with Russian gas. Prototypes, pilot plants and new architectural designs facilitate the physical experience of innovative concepts and their potential and thereby influence human behaviour. It is quite evident that not every artefact production or R&D effort represents institutional work. But creating the prototype that shall convince a European norming committee to change its testing prescriptions, for example, falls into this category.

Third, **relational work** is concerned with the continual shaping of interaction patterns and ties among actors. This form of institutional work can serve to gain followers for a cause (Dorado, 2013), mobilise actors to cross borders from other fields (Zietsma et al., 2017), or engender and sustain cooperation in collective-action domains (Wijen and Ansari, 2007). It also entails conflict resolution through negotiations (Helfen and Sydow, 2013) and the restructuring of value chains towards a company's optimal, institutionally endorsed differentiation (Zhao et al., 2017). In their analysis of supply chain development for bioenergy, Genus and Mafakheri (2014) illustrate efforts in purposive relationship building involving a multitude of distinct and previously unrelated actors the various efforts necessary to establish routinized practices. Because discursive and material work often presuppose relations, relational work appears to be of crucial importance.

2.2. Industries as organisational fields

In this section we identify the context conditions relevant for different forms of institutional work. In order to characterise different conditions, we employ the concept of the organisational field (Lewin, 1951), broadly defined as a "recognized area of institutional life" (DiMaggio and Powell, 1983: 148). Actors' institutional embeddedness and the origin of change are studied in meso-level fields (e.g. Boxenbaum and Jonsson, 2017; Wooten and Hoffman, 2017). In their review, Zietsma et al. (2017) conceptualised an industry as an exchange field that contains a focal population of actors and the partners with whom they interact (suppliers, customers, etc.). Members of a field population then deal with a particular set of technologies, production processes and product properties, regulations, practices, discursive frames and meanings. From the perspective of transition studies, sustainability challenges originating within an industry's field conditions may be instrumental for the motivation of some actors to start institutional work ("niche creation" in the words of Smith, 2007, p. 436). Early transition stages may start with interrelated developments "such as the entry of new players and changes in businesses models, value chains, policies, or user practices" (Markard et al., 2020, p. 1).

In neoinstitutional theory, some fields are proposed to offer better conditions for strategic agency than others (Battilana et al., 2009). We differentiate between (1) institutional logics, (2) regulatory institutionalisation, (3) field-level coordination mechanism, and (4) the endowment with an actor population and resources.

Institutional logics is the term used to characterise the organising principles in a field. Logics are defined as "supra-organizational patterns of activity by which humans conduct their material life in time and space, and symbolic systems through which they categorize that activity and infuse it with meaning" (Friedland and Alford, 1991, p. 243). They include "assumptions, values, beliefs, and rules" (Thornton and Ocasio, 1999, p. 804). Andrew-Speed highlighted that these pattern are normally composites and organizational field are "governed by a set of institutional logics" (2016, p. 219). The institutional-logic approach argues that society consists of various sectors that subscribe to different rationalities and the associated goals and rules for appropriate behaviour. For exchange fields, this conception includes "the rules and arrangements (e.g. contracts, trust, value chains and business networks) that govern markets and economic activities" (Elzen et al., 2012, p. 6). Incompatibilities, frictions and contradictions resulting from multiple logics can be a fruitful ground for institutional work (Dalpiaz et al., 2016; Gümüsay et al., 2020). Fuenfschilling and Truffer (2014) show that field logics and technologies can be strongly interwoven. Strong and **settled** field logics mostly result in a strong coherent regulatory institutionalisation and coordination mechanism which leave little room for institutional change initiatives. However, a field that has its logics **contested,** for instance through instability or a competition for legitimacy, would offer more latitude for actors to experiment with new practices.

Regulatory institutions comprise laws and rules, prescriptions from government authorities, standard setting, certification and testing bodies as well as the categories used for partitioning of technologies, economic activities, markets, environmental and social impacts or actor types. Battilana et al. (2009) highlighted the relevance of (in-)coherence of regulatory institutionalisation on several levels (from local to global). For an industry that operates within regional boundaries, regulatory institutions are comparatively clear and consistent whereas a branch of industry that is embedded in one or several global value chains faces jurisdictional overlaps, possibly fragmented and contradictory set of institutional rule systems (e.g. Zietsma et al., 2017). Technology-specific rules might also lead to structural couplings across industries, leading to rigidities that block change (e.g. Bergek et al., 2015). Fields that are characterised by higher degrees of such multiplicity of regulatory institutions will also see more contradictions, conflicts and ambiguities which can offer opportunities for institutional change (Dorado, 2005).

The third relevant element for a characterisation of an industrial exchange field are the prevalent **field-level coordination mechanisms**. They refer to the basic organizational structures which are decisive for interaction in the field (Hinings et al., 2017). Institutionalised coordination mechanism serve to ease interaction in a field. They enable and constrain specific forms of agency (Garud et al., 2007; Geels et al., 2004). Value chains structure industrial actor relations with suppliers and customers in field-specific ways. Therefore, we also include markets as important arenas or structures that allow for the organization and coordination of the exchange of products or services (Beckert, 2010; Fligstein and Dauter, 2007). Low barriers to market entry with fragmented markets and many niches, short local value chains and direct contact with consumers can make it easier for actors to enact institutional work (Ekman et al., 2021; Hipp and Binz, 2020). Field actors' shared dependences on physical infrastructures may necessitate a different type of coordination mechanism. Moreover, actors structure formal and informal networks (e.g. via regular conferences, trade shows, information platforms, award ceremonies) to enact field-specific meanings and thereby also deal with issues of identity, conformity and differentiation (Jones et al., 2017).

Lastly, each field has a different **endowment with actors and resources**. A field might be densely or sparsely populated, the actor population may be rather homogeneous or highly divers, rich or poor, old or new. As mentioned already, Zietsma and her colleagues proposed that core field actors, the field population, should largely "manifest the same organizational form or identity" (2017, p. 14). These actors are confronted with the same legitimacy demands resulting from shared logics and regulatory conditions, and have access to specific coordination mechanisms. A field's endowment with tangible and intangible resources and material structures can afford the field population with certain possibilities for sense-making and for choosing a course of action. Scientific knowledge, competencies, technologies, products, design standards, brands and visual symbols, infrastructural facilities or places may represent relevant assets and resources for the population (e.g. Garud et al., 2011). With convincing properties material objects may become intrinsically tied to a field population's institutionalised practices (Boenink and Kudina, 2020; Friedland and Arjaliès, 2021; Jones et al., 2019). Bioeconomy laboratories, pilot plants and education facilities can emerge as crystallisation points for relations and shared practices.

2.3. Actor positions and characteristics in relation to institutional work

The ability to perform certain forms of institutional work not only depend on the field conditions, but also on the individual characteristics of an actor or the position an actor inhibits within this field. According to their position and characteristics, different perception and interests evolve. Opportunities for change perceived by actors occupying peripheral positions in a field might have been unobserved by well-established peers (Dorado, 2005). Margaret Archer proposed that actors' "interests are built into positions *by* the relationship of that position to others' (1995, p. 130, original italics). Moreover, access to resources differs for various actor types (Kern and Rogge, 2018; Wittmayer et al., 2017). For instance, the roles of incumbents, new entrants and start-ups in industry differ in decisive ways from those of aligned actors in research or intermediation. These different types of organisations also have specific organisational objectives, values and incentive structures (e.g. Hermans et al., 2019). There is a wide consensus on resulting differences in actors' formal or informal authority, status, legitimacy, social influence and relative power (Andrews-Speed, 2016; Battilana

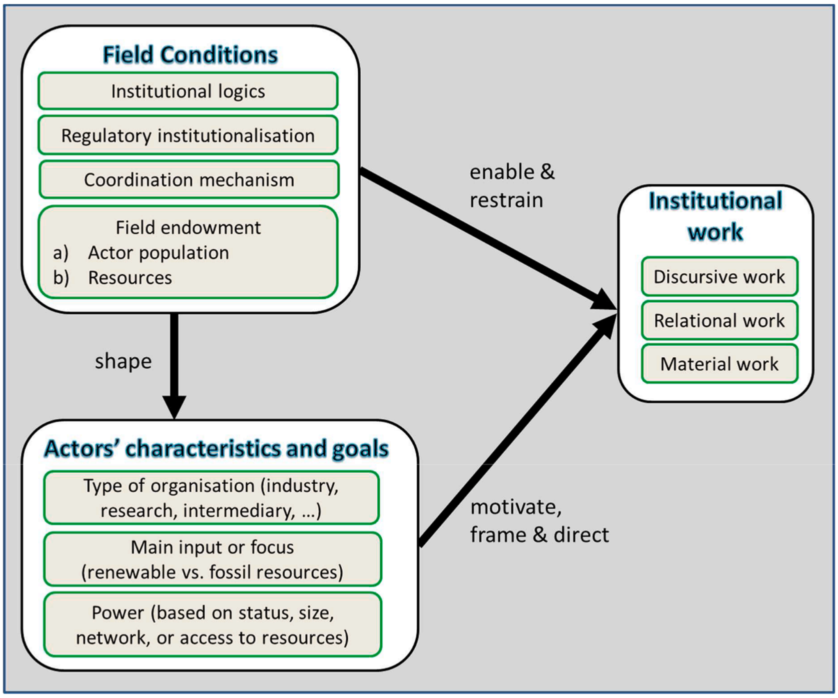


Fig. 1. Factors influencing the emergence, pattern and strength of institutional work.

and Casciaro, 2012; Hilgers and Mangez, 2014; Levy and Scully, 2007; Maguire et al., 2004; Powell et al., 2017; Zietsma et al., 2017).

Irrespective of social positions and roles, individual actors have different context knowledge, social and technical competences, perspectives and objectives (Delbridge and Edwards, 2013; Dosi et al., 1997). Reflective individuals with different degrees of knowledge and competencies are "inhabiting" pre-existing positions and assume the associated roles (Hallett and Hawbaker, 2021; Hallett and Ventresca, 2006). As evidenced by the comprehensive description of Raaijmakers and her team (2015), there is a multitude of ways how managers in equivalent positions can perceive and deal with demands for compliance in the same field. In consequence, an actors' individual behaviour cannot and should not be solely explained by a set of roles or "the particular intersection of social categories that they happen to occupy" (Granovetter, 1985, p. 469). A critical realist ontology, thus, acknowledges the existence of specific institutional framework conditions in a specific place and time and still makes room for individual handling of the (often unconscious) effects of "embeddedness".

Based on the preceding analysis, Fig. 1 presents a summary of our theoretical concept. The degree of regulatory institutionalisation, the sophistication of coordination mechanism and the coherence of prevalent institutional logics can enable or restrain institutional work. In addition, these conditions shape the set and range of positions available in the field with higher or lower degrees of legitimacy, status, connection and access to resources (summarised here as 'power'). Individual actors' perspectives and goal orientation are influenced but not determined by their positions and roles. Their individual characteristics are assumed to at least co-determine the strength, direction and forms of institutional work chosen with awareness of other parties' activities.

3. Research methodology

The research concept combines a qualitative analysis of the relevant field conditions based on the available literature with Applied Thematic Analysis of institutional work based on semi-structured interviews. We found sizeable numbers of bioeconomy-oriented companies and research institutes cooperating in two older cross-industry bioeconomy clusters: the Spitzencluster Mitteldeutschland (SCM) in Germany and Biobased Delta (BBD) in the Netherlands. Both of these clusters try to use local inputs from forestry or agriculture to advance bio-based innovation. Most industrial members in both clusters operate in either the chemical, plastics or construction materials industries (see also Wilde and Hermans, 2021b). We consider these industries as separate yet interrelated fields: the chemical industry produces the building blocks for compounders and polymer processing companies. The chemical and plastic industries supply inputs for the construction materials industry (see appendix, Fig. A.1). In the three selected industries, the share of bio-based products was assessed as still fairly small but steadily increasing (EC, 2020a, 2022; Göswein et al., 2021; Spekreijse et al., 2019). Though some national governance mechanism and regulations differ, European industries are subject to a large body of uniform European and global regulations and policies. With similar per-capita income levels and extensive cross-border integration in the Northwest of the EU, we assume that also societal demands, competitive threats and unfolding technological progress constitute industry-specific challenges which are very much alike in both cluster regions. In consequence, we suggest that the actors of a specific industrial exchange field experience largely the same institutional conditions.

3.1. *Qualitative analysis of the relevant field conditions*

We screened and analysed the scientific literature as well as reports of think tanks, ministries, the European Union, industry associations and foundations, focussing on the institutional conditions and endowment in the three selected exchange fields. The search for scientific analysis of relevant conditions in the selected industries started with examining studies mentioned in the theory section. We then used the so-called snowballing procedure (Wohlin, 2014) and Google Scholar to explore further and complement information. We integrated current data from European studies and grey literature. For the construction materials industry, which is heavily influenced by cultural factors at the regional and national levels, we made a special effort to compare evidence from various European countries.

3.2. *Sample construction for the empirical analysis of institutional work*

Purposive sample construction (heterogeneous sampling) of interview respondents in and around the two selected bioeconomy clusters was effected in line with the specifications of Etikan et al. (2016). With a nascent status of a bioeconomy, the decisive selection criteria was that interviewees were highly likely to know their governments' bioeconomy strategy, relevant industrial practices and bioeconomy challenges. Sample construction aimed to include old/large and young/small actors from industry as well as a broad variety of (public and for-profit) researchers and (small and large) intermediaries with different functions. We coordinated part of the selection of interviewees with the management of the bioeconomy clusters. In addition, the authors searched cluster files and information from third parties to identify actors who left the clusters or kept a critical distance. While many respondents were located in a 50 km radius from cluster management units, an effort was made to also include geographically distant actors. In total, we conducted 56 interviews (see Fig. 2) until no more new substantive information came up during interviews.

We contacted managers, CEOs and CTOs of companies; their contact partners in research (individual researchers and/or research group leaders) and the heads or regular staff members of intermediaries during the eight-month data collection period. The bioeconomy cluster management bodies were categorised as "cross-field bioeconomy intermediaries" alongside public local/regional development agencies. Other types of intermediaries like investment brokers, industrial parks or technology centres can be dedicated to an industry. The sample contains all actor types in each of the three exchange fields alongside the cross-field intermediaries (Fig. 3).

Some interviewees from industry were operating on the basis of renewable feedstocks only. We labelled organisations that

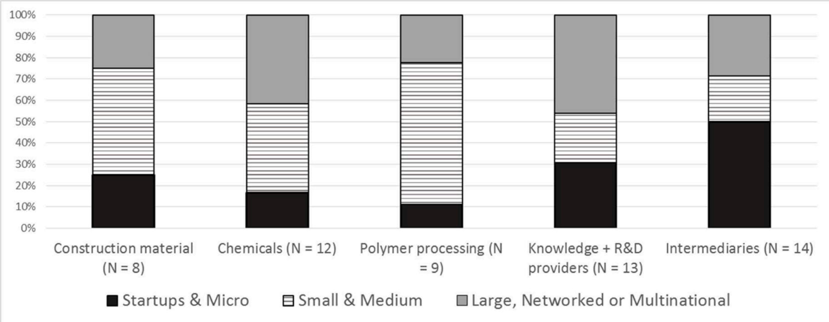


Fig. 2. Size distribution of interviewed actors by type (N = 56, percentages by subgroups)
Note: N = Total number of interviews conducted.

specialised in renewable feedstocks (firms, research institutes and intermediaries) as "born green" (see Fig. 4). Actors with fossil or mixed-input operations in industry, related research topics or intermediation activities could be classified as "progressive incumbents". Their involvement with bioeconomy topics provides evidence of them being (somewhat) supportive of fossil fuel replacement.

It is important to note that the sample includes a mix of actors' characteristics in terms of input or resource specialisation and

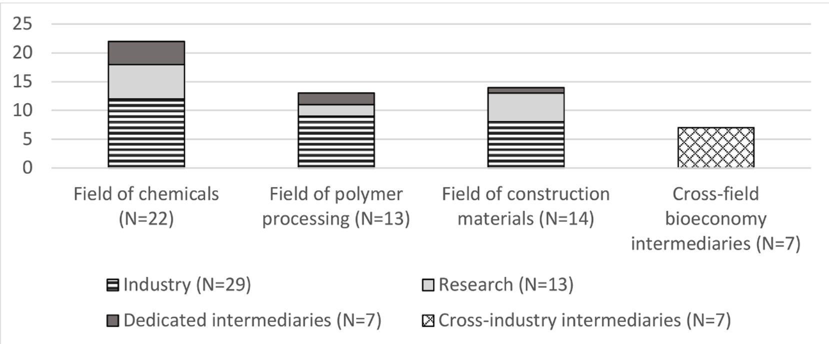


Fig. 3. Sample composition by exchange field and actor type (N = 56)
Note: N = Total number of interviews conducted.

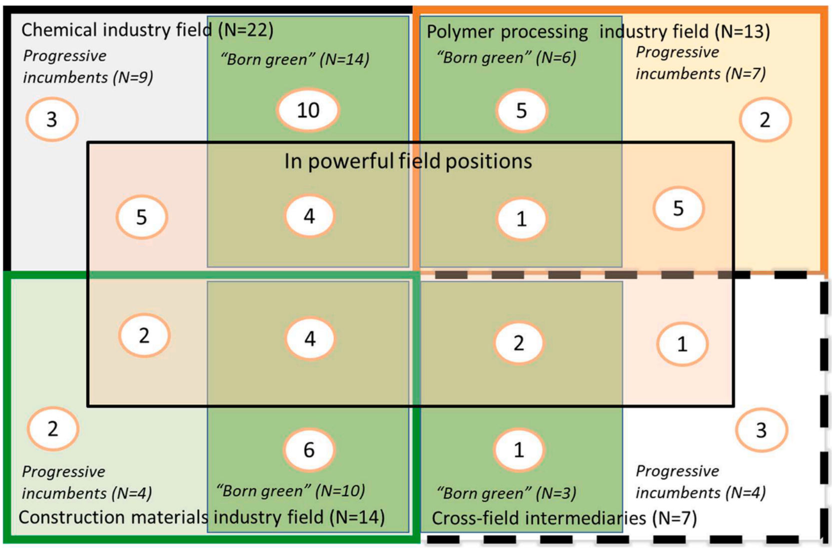


Fig. 4. Sample composition (number of interviewees) by industrial exchange field, use of / focus on renewable feedstocks and power positions (N = 56)
Note: N = Total number of interviews conducted.

power. Fig. 4 shows that sampling paid attention to cover all possible combinations. Obviously, "born green" respondents are not necessarily powerless start-ups and "progressive incumbents" of an emerging bioeconomy exist in normal or peripheral field positions as well. A couple of "born green" actors have a large influence for instance over their upstream input providers, on policy, in the financial sector or within the relevant scientific community. Prior research on the (German) bioeconomy confirms that also some research institutes occupy a very central position within policy networks and thereby access a large volume of financial resources (Bogner and Dahlke, 2022).

We conducted in-depth semi-structured interviews with an average duration of about one hour at the respondents' places of work. The same researcher conducted all interviews, in three exceptional cases by phone. We used open and tangential questions to explore actors' bioeconomy alignment and engagement in institutional work.

3.3. Applied thematic analysis of institutional work

Thematic analysis entails a search for themes that emerge as important to the description of a phenomenon. This approach is a "rigorous, yet inductive, set of procedures designed to identify and examine themes from textual data in a way that is transparent and credible" (Guest et al., 2011). We voice-recorded interviews and transcribed them verbatim. Inductive coding served to identify relevant themes using MAXQDA software (standard version, Release 18.2.5). Using theory-led coding, we repeated the same process to discern discursive, relational and material forms of institutional work.

4. Results

4.1. Field conditions and institutional work in the chemical industry

The institutional logics of the chemical industry are settled while the climate crisis and geopolitical conflicts potentially pose fundamental challenges to this fossil oil- and gas-based industry (see Table 1). We characterize the regulatory conditions as strong, stable and coherent. The fields' coordination mechanism can be described as highly sophisticated, stable and coherent. The market for bulk products is populated by an oligopoly of a few multinationals in fierce global price competition. Fine chemicals are also produced by SMEs for a multitude of global, national and niche markets. Therefore, rather short value chains (fuels) coexist with long and nested ones (e.g. pharmaceuticals) in which producers are far removed from end users. The capital- and knowledge-intensive industry follows a tradition of actors' co-location in industrial districts and clusters.

The bio-based share in the manufacture of organic chemicals was about 10 % in EU28 in 2008 (Porc et al., 2020). Value added in EU manufacturing of bio-based chemicals was found to be stable for the period 2010 to 2019 (Mubareka et al., 2023). Meanwhile the global production capacities have more than doubled between 2011 and 2019 (de Guzman, 2020). In Europe, the legitimacy of

Table 1
Field conditions in the chemical industry field.

Field conditions	Characterisation
Institutional logics	**Settled** logics as an indispensable primary industry in Europe; competitive threats come from (partially less regulated) catching up or resource-rich world regions while the legitimacy threat steams from climate change (Chiappinelli et al., 2021; ICIS, 2019; Oxford Economics, 2019).
Regulatory institutionalisation	**Strong, stable, coherent** (regional, national, international levels) with respect to workers' safety, product toxicity, environment & health protection; comprehensive norms & standards, quality testing and certification. So far, no certification, labels or other identifiers for green chemistry or circular processes exist (DeVierno Kreuder et al., 2017; Loste et al., 2020). Prominent actors are heavily involved in shaping the European innovation policy and technological choices in other sectors, such as energy, water or mobility (Barthelemy and Agyeman-Budu, 2016).
Field-level coordination mechanism	**Highly sophisticated, stable, coherent** • Unified national and European industry associations and unions; very well established exchange channels (fairs, conferences, platforms); strong policy-industry relations developed historically; strong collaboration of industry with public research units, institutes of academic & professional education as well as original equipment manufacturers (OEM) important for the engineering of pilot or demonstration facilities and upscaling (Nelson and Rosenberg, 1993; Warner, 2015). • Upstream: predominantly inorganic materials and fossil fuels are procured in the form of stable, year-round flows of large amounts of uniform feedstocks from few suppliers; • Production of standardised bulk and speciality products for global markets and customers in a large diversity of industries; catalysis represents about 80 % of processes, leaving 20 % to polymerization; steam cracking and distillation of ethane and naphtha into its derivatives (olefins and aromatics) is the basic process for the production of high value chemicals (Chiappinelli et al., 2021); collaboration with 'site operators' who offer professional project development, administrative and safety services, waste (water) treatment, etc.; • Downstream: often close vicinity to main customers of basic inorganics, petrochemicals, polymers, agro-chemicals, specialties, cosmetics and pharmaceuticals (Oxford Economics, 2019); diverse value nets with short and long chains.
Field core population	**Relative homogeneity** of the industry with two main groups: global multinationals and SMEs (Oxford Economics, 2019). Value chain positions of industrial actors differ but most are far removed from end-consumers.
Resources	Industrial districts and clusters facilitate actors' co-location with refineries and crackers at the core and internal pipeline connections. Almost all companies have in-house laboratories (VCI, 2019; VNCI, 2020). Patents and IP licenses are important resources and public research infrastructures are well developed.

Table 2
Engagement in institutional work in the chemical industry field.

Form	Specification	Institutional work in detail	Actor characteristics & positions Field position power	 other	 Opera-tional base
Discursive	Participation in high-level policy discourses	• Participation in elite circles, think tank discussions on climate change adaptation strategies and a bio-based economy	I	I, R	BG PI
	Consulting ministries & public authorities	• Consulting European Commission officials on texts for biotechnology research calls	R		PI
		• Engagement in various committees with decision-making powers on STI policy and funds for biotechnology R&D		R	PI
	Shaping norms	• Initiating a new norming committee for the standardisation of a specific substance (bio-based substitutes)		I	BG
	Lobbying for	• Political attention to the lack of risk and growth capital; the behaviour of domestic pension funds, banks and capital owners and an alignment of financial streams with sustainability objectives	X	I	BG
		• Specific investment subsidies, regional level	R	R	BG PI
		• Policy attention at the regional, national and European levels for a changed industrial policy, sustainable and resilient value chains	I, X	X	BG PI
		• Biotechnology promotion, R&D funds		I, R	BG PI
		• The use of food crops in industry		I	PI
	Awareness raising	•… among politicians on SME needs, suitable STI instruments and sequences of bioeconomy promotion	R	R	BG PI
Relational	Reconfiguring value chains	•… away from fossil feedstocks, establishing new co-operations	I	I	BG
	Mobilising allies	•… in the financial sector to get green innovation financed	X		BG
		•… from various industries to support regulatory change in favour of hydrogen production		R	BG
	Establishing consortia, networks and clusters	•… to advance the use of GMOs in industry	R	I	BG PI
		•… with SMEs and other industries to end the use of fossil feedstocks	I		BG
	Joining consortia, networks and clusters	•… to access information, build leverage to access R&D funds, or build power to counter large competitors	I, R	I, R, N	BG PI
Material	Resource acquisition and investment in the implementa-tion of R&D with the aim to change current practices and logics	• Application for R&D funding with the aim to build legitimacy via demonstration or pilot plants	I, R, N	I, R	BG PI
		• R&D aiming at a proof of concept on the potentials of renewables (non-GMO und non-food) for green chemistry and new products		I, R, N	BG PI
		• R&D for a proof of concept regarding the use of GMOs in industry for hydrogen production, biofuels, synthetic fuels	I, R	R	BG
	Acquisition of risk or growth capital for the demonstration of new practices	• Mobilisation of private capital or investments for a prove of concept in view of a revision of norms or feedstock classifications	R, N	I	BG PI
	Supporting start-ups	• Facilitation of access to lab space and finance for start-ups in order to turn new technological solutions into real business cases		R	BG
	Internal principles and practice	• Establishment of clear company principles to exclude dealing with GMO and food as feedstock		I	BG

Note: *I* = Industry, *R* = Research, *N* = industry-specific Intermediaries, *X* = cross-industry Intermediaries, BG = “born green”, PI = “progressive incumbents”.

bio-based alternatives has been weakened by struggles over the use of biotech applications in agriculture and the food-versus-fuel debate that questions the use of food crops in the production of chemicals (Wilde and Hermans, 2021a). Actors from the emerging bioeconomy segment display a considerable heterogeneity. We found new entrants from paper plants, vegetable oil and sugar mills and organic waste processing. Start-ups are exploring the potential of speciality feedstocks or the use of algae.

Table 2 provides an overview of the various categories of institutional work that actors from the bioeconomy segment in the chemical industry reported. The position of strong actors in the densely networked industry field allows for discursive institutional work in the form of participation in the discussions of elite circles, think tanks and policy circles shaping public bioeconomy promotion and other policies. The non-powerful actors are engaged in types of institutional work that facilitate access to laboratory facilities and financial support for start-ups and improving the viability of renewable, non-GMO, and non-food resources for applications in green chemistry and new product development. Respondents also reported networking at the EU level to influence R&D call texts, shape norms and engage in awareness raising among politicians. These efforts complement lobbying activities reported from all actor types.

Relational work was reported in relation to emerging new technologies, such as the use of GMOs, or new feedstocks and value chain restructuring. Allies are identified and mobilised through the formation of consortia and networks. New actors – typically with considerable economic weight, a number of patents or access to biomass – were mobilised to join the field and support demanding ambitions. The evidence from actors' engagement in material work supports the impression that, overall, old and new actors aim to build new resources for new practices. Access to (mainly financial) resources is perceived as vital in this industry's capital- and knowledge-intensive operational tradition, as exemplified by the following statement:

- "I want that to change … even if it takes five years.... We want to build the first European biorefinery for X [product]." (RD28N)
- "We are working to green chemistry. … the next step, we're talking about demo, maybe [this requires] 250 million Euros." (RN15R)

4.2. Field conditions and institutional work in the plastic industry

The field conditions of polymer compounders and converters are characterised by an institutional logic that has become increasingly disputed (see Table 3). A medium to high amount of "regulatory multiplicity" is diagnosed because quality norms are fragmented over a wide range of industries. Regulations are tightening globally especially for plastic packaging and consumer products. Field level coordination mechanism can be characterised by a sophisticated network of industry associations at the national and international levels and well-established relational channels. There are strong ties and co-location arrangements with the chemical industry. Bulk and niche markets co-exist with complex value chains for composite materials. The field population of polymer compounders and converters is dominated by SMEs and can be classified as rather homogeneous. The resource endowment of the field does not include special facilities and only few dedicated public research institutes. Actors in the bioeconomy segment either experiment with biopolymers on demand or exclusively deal with biopolymers. Highly refined fossil-based materials are difficult to compete with (Matthews et al., 2021). A large number of bio-based plastics are still in the R&D and pilot plant stage (Siracusa and Blanco, 2020). Likewise, a circular resource flow of some bio-based polymers is feasible, but it is in an embryonic technical state.

The disputed logic of the plastics industry is countered chiefly in the material realm (see Table 4). The acquisition of financial resources and investments are meant to create evidence and new standards for recycled plastic and improved functionalities of new bio-based polymers. Considerable experimentation with new inputs contributes new knowledge and evidence that is also used to challenge existing regulation and practices, e.g. for waste disposal.

Table 3
Field conditions in the polymer processing industry field.

Field conditions	Characterisation
Institutional logics	**Disputed** logics fighting competitive threats from (partially less regulated) other world regions and with legitimacy threats in the face of rising societal concerns about plastics pollution, climate change and biodiversity preservation (EU, 2020b; Material Economics, 2019; Paletta et al., 2019); circularity and degradability options can be in conflict with material, energy and economic efficiency (PlasticsEurope, 2020).
Regulatory institutionalisation	Medium-level, tightening regulation of operations with fragmented and incomplete regulation of product properties in a wide range of different industries and an increasing number of selective bans in different countries; high consumer protection for the use of plastics in food contact packaging, toys and cosmetics; increasing alertness to degradability in human bodies and nature, hormone-active additives, cumulative effects (PlasticEurope Germany, 2020); increasing testing and certification of bio-based, recycled polymeric content and/or biodegradable plastics (Rosenboom et al., 2022); as production typically occurs on demand, customers often directly impose their own standards; waste sorting and treatment prescriptions for post-consumer plastic packaging in Europe are tightening (Directive (EU) 2018/852; Kabasci, 2020).
Field-level coordination mechanism	**Sophisticated, stable, coherent** • National and European associations; some well-established relational channels (fairs, conferences, platforms) exist while challenges for circularity now expose a weak basis for collaborative engagement (Hsu et al., 2022); medium level of policy-industry relations; some industry relations with public research; • Upstream: the predominant feedstocks are petroleum and natural gas compounds (Geyer, 2020) with about 12 % (mostly pre-consumer) recycled polymers; mechanical and chemical recycling is picking up recently (Chiappinelli et al., 2021; Conversio, 2018); global sourcing of specialities needed as uniform bulk feedstocks are adjusted by a wide variety of additives; • Production: Mixing and blending of polymers and additives, colouring, production of final products by blow moulding, extrusion, injection moulding and stabilisation or 3D printing; production of composite with carbon or natural fibres; the versatile materials are used for virtually any kind of consumer product (Schirmeister and Mülhaupt, 2022); locations are typically close to feedstock suppliers; • Downstream: diverse value nets with short and long chains connect producers to customers of global bulk products or specialities for small market niches (Chinthapalli et al., 2019); markets are fragmented (OECD, 2021); main product segments are packaging, building construction materials, vehicle components, electrical and electronic industry, agriculture, household goods, leisure and sports (PlasticsEurope, 2020); biodegradation is possible for a few fossil-based and biopolymers under specific environmental conditions (Geyer, 2020); the EU27 average recycling rate for post-consumer plastic packaging waste was 14 % in 2017 (Antonopoulos et al., 2021).
Field core population Resources	**Relative homogeneity** as SMEs represent about 95 % of the industry in Europe (e.g. GTAI, 2021; Dutch Federation NRK, 2021). The overall European plastic industry (incl. the chemical industry's value added in producing polymers) ranks 7th in terms of gross value added (PlasticsEurope, 2019). Data on the volumes of plastic components in downstream industries is hardly available (Hsu, 2022). For over 10′000 plastic-related substances there are critical knowledge and data gaps (Wiesinger et al., 2021). Typically, SMEs have limited in-house formal R&D and collaborate with universities and application-oriented research institutes (Dispan, 2013). Specific recipes are rarely patented or licensed, but often protected by trademarks.

Table 4
Engagement in institutional work in the polymer processing industry field.

Form	Specification	Institutional work in detail	Actor characteristics & positions: Field positions power	Field positions other	Operational base
Discursive	Consulting ministries & public authorities	•Consulting ministries on a "transition agenda" for plastic waste	I		PI
	Shaping norms	•Engaging in norming committees	I	I	BG PI
	Lobbying for	•Biopolymer promotion	N	I	BG PI
	Awareness raising	•… on the key differences, the pros and cons of bio-based and biodegradable biopolymers	I		PI
		•… among customers and end users regarding necessary and desired functionalities of packaging	N	I	BG PI
Relational	Reconfiguring value chains	•… upstream with a social agenda for raw material suppliers in developing countries	I		PI
		•Establishing contacts to waste collectors and operators of recycling facilities			
	Joining overar-ching networks	•Joining Ellen MacArthur Foundation and other fora	I		PI
	Mobilising allies	•… to explore new kinds of knowledge and competences together	I, N	X	PI
	Establishing consortia, net-works, clusters	•Contacting allies for the proactive establishment of a global plastic protocol	I	I	BG PI
	Joining consor-tia, networks and clusters	•… to participate in information sharing, build leverage and collaboration to access R&D funds and to advance associated visions	I, R	I, R, X	BG PI
	Excluding actors	•Consciously excluding MNCs and large-scale research institutes		R	BG
	Strengthening collaboration	•between public and private actors regarding climate change strategies	X		BG
		•… among allies via the promotion of a cooperative culture / new mind set	X	I, R	BG PI
Material	Acquiring resources and investing in R&D to change established practices, norms and measurement protocols	•Submitting R&D proposals to expand experimentation with new materials and get them instituted in markets	I, R	I	PI
		•Production of evidence for the revision of European norms and waste disposal regulation for (a) compostable materials and (b) recycling of bio-based polymers		I	BG PI
		•R&D to improve the functionality of biopolymers, compostability / recyclability of biopolymers with paper	I	I, N	BG PI
		•Scaling up new processes and production of biopolymers, products, recycling or composting		I, R	BG PI
		•R&D on quality standards for recycled plastic in order to change common and own practices	I		PI
	Facilitating market entry	•Acting as a launching customer for innovative (partially) bio-based offerings	X	X	BG PI
	Investing upstream for the availability of recycled inputs	•… in start-ups and innovative SME, supporting upscaling new technologies to improve waste sorting and the availability of recyclates as feedstock in own production	I	N	BG PI
	Building know-ledge resources	•Organising life events on properties and the processing of biopolymers, distributing show case products	N	I	BG PI
	Exchanging inputs	•Using locally grown feedstocks •Using renewable feedstocks •Using waste •Using recycled materials	I	I, R	BG PI

Note: *I* = Industry, *R* = Research, *N* = industry-specific Intermediaries, *X* = cross-industry Intermediaries, BG = "born green", PI = "progressive incumbents".

- *"[We are]… engaging with small innovative [waste sorting] companies … we are partners to scale it up. Also by creating a guarantee of uptake of their output… . And we would help with the R&D process, upscaling it with expertise and also financially. … So it's costing us … but that is okay if we can really drive the change and make sure that we get new standards." (RN19I)*
- *"… we produce this tray of this material … and it's tested now by the paperboard industry to recycle in paper." (RN14I)*
- *"… the main hurdle is, I think, not regulation but more the business cases. … We try and will try to stimulate this more and more by being a launching customer." (RN17X)*

Meanwhile, relational work strengthens specific networks and involves mobilising new partners, excluding specific others or reorganising value chains. In the Netherlands, all three types of actors were involved in efforts to establish a new cooperation and sharing culture among SMEs. Relational and material forms of institutional work are combined to speed up change. Engagement in discursive work is markedly weaker. Actors try to reach out to ministries, consumers and civil society to gain support.

4.3. Field conditions and institutional work in the construction materials industry

The institutional logics in the field of construction materials are settled with a strong focus on material durability and standardisation, which led to the dominant practices involving energy-intensive steel, cement and bricks (see Table 5). National and local construction codes, insurances and liability laws promote risk minimisation (Repolho, 2017). Regulative prescriptions are strong and fragmented across various administrative levels. Organisational exchange mechanism are stable but incoherent and fragmented. From within the group of industry associations, only the voices of steel and cement producers occasionally make it into mainstream media. Innovative collaborations and value chains are often project-based and involve architects, planners, contractors and artisans. Some operations are quite capital intensive and are undertaken by large firms but SMEs dominate the field. There is not much investment in public research on fossil and bio-based construction materials.

The bioeconomy segment gains legitimacy in some parts of Europe. In spite of their products with long traditions (wood, straw, reed), most actors survive in niche markets. Actors' heterogeneity matches the broad range of products. The increasing input competition for renewable resources from other industries (bioenergy, packaging, textiles) does not help. Debates on land use and potential biodiversity losses also limit "born green" actors' legitimacy to challenge the field's institutional logics. We found no border-crossing actors from other fields in the core population.

Institutional work done within the construction materials industry stretches over a wide array of activities (see Table 6). However, the overall actor engagement is rather low compared to the reports from the other fields. All actor types address politicians and lobby for change, but ambitions to end the use of energy-intensive, fossil-based or cheaply imported construction materials are not perceived to generate much resonance in the discursive realm. The overall fragmentation appears to also exert a strong impact on the relational activities in the sense that actors behave as if there was no alternative to focussing on results they can achieve on their own.

Actors' engagement in material work is comparatively low as well. Industrial actors' investments in R&D are meant to build resources in terms of evidence for new norms, certificates or qualified graduates. They struggle at various frontiers as exemplified by the following example statements:

- "And if we lack knowledge, we have to try to develop it." (RD32I)
- "My boss said, 'Think about, what could we do for the future. … In view of the promises we made in Paris - we have to change'. … We made a big investment … we believe." (RN18I)

Table 5
Field conditions in the construction materials industry field.

Field conditions	Characterisation
Institutional logics	**Settled** logics with national and regional flavours focussed on material durability and standardisation; no major competitive or legitimacy threat but some societal attention for health aspects; public authorities increasingly raise demands for material circularity and energy efficiency; the New European Bauhaus initiative is an effort to advance sustainability, inclusion and beauty in European constructions (EC, 2023).
Regulatory institutionalisation	**Strong, fragmented** regulation is focussed on safety (fire protection), material durability (strong liability) and non-toxicity of products; policies with tightening GHG emission, energy efficiency prescriptions and regulations for construction projects differ across European countries and regions and can be further specified during public procurement at sub-regional levels (Weber and Schaper-Rinkel, 2017); a new European construction products regulation is under discussion (EC, 2021); specific environmental regulations exist for related mining, quarrying, logging activities; EU standardisation, inadequate norms and testing procedures adopted from other industries can impede market access of improved building materials; upon European decision (Directive (EU) 2018/844), each EU Member is now obliged to reach a highly energy efficient and decarbonised building stock by 2050.
Field-level coordination mechanism	**Fragmented, stable, incoherent** • Several national and European associations co-exist; established trade union, fragmented relational channels (fairs, conferences, platforms); • Upstream: Mostly steel and cement are used in modern construction; local and regional raw materials include a wide variety of sands, gravel, stones, minerals, industrial by-products and waste streams, wood, natural fibres, and complementary inputs mainly sourced nationally, if not regionally; • Production: very divers material inputs, production processes and outputs like concrete and pre-fabricated parts, sand, lumber, gypsum, binding agents, bricks and tiles, wood, panel products, rocks, alongside prefabricated components or modules with wood, glass, metal and plastic products; shortages of materials and craftsmanship occur (e.g. BBS, 2019); innovation is driven by architects (Lieftink et al., 2019), digitalisation (Papadonikolaki, 2018), servitisation (Pelli and Lähtinen, 2020); material recycling gains importance (Conde et al., 2022); supplier-contractor relationships are often long-lasting, place-based and tight-knit (Granovetter, 1985); • Downstream: Industrial actors supply materials to public and private construction sites, (wholesale) traders and manufacturers of building components; complex interdependencies between construction companies and input networks have been described (Dubois and Gadde, 2002; Mokhlesian and Holmén, 2012); short and long value chains.
Field core population	**High heterogeneity** of the industry; micro enterprises and SME dominate the construction materials segment while construction includes a larger share of large companies (Eurostat, 2020); the whole construction sector accounted for 2.3 % of total employment in the EU in 2018; industrial actors mostly hold positions near the bottom of value chains.
Resources	Larger private actors drive R&D in collaboration with a few public research units, testing laboratories, universities and application-oriented technology centres; complex interdependencies typically lead to incremental adjustment processes directed at material, time and energy savings (Basten and Engelke, 2016; Czarnecki and Van Gemert, 2017); new materials and processes are rarely patented or licensed, rather protected by trademarks.

Table 6
Engagement in institutional work in the construction materials industry field.

Form	Specification	Institutional work in detail	Actor characteristics & positions		
			Field position		Opera-tional base
			power	other	
Discursive	Consulting ministries & public authorities	•… during strategy drafting for forest resource management or for regional bioeconomy promotion •… policy makers on the design of promotional schemes for bio-based construction materials	N	R	BG
	Shaping norms	•Engaging in norming committees	I, R		PI
	Lobbying for	•… more consistency of climate change and bioeconomy policies •… sustainability-sensitive evaluation standards in construction and for construction materials in view of climate change – nationally and in Brussels	I	I, R	BG PI
		•… de-bureaucratisation of building standards and model building regulations •… revised norms and testing procedures at the national level via an industry association •… procurement of green buildings/infrastructures, demonstration projects, bioeconomy showcases	I	I	BG PI
		•… investment in a dedicated university chair for wood-based construction	N		BG
	Awareness raising	•… among politicians on STI policy specifics for a bioeconomy	I	I, R, N, X	BG PI
		•… among politicians on agricultural and forest policies and the impact on the industry	I, N		BG PI
		•… by the involvement of the general public in decision-making on infrastructure		X	PI
Relational	Mobilising allies	•… internationally in view of European agricultural and forest policies	N	I	BG
		•… for strengthened bioeconomy innovation	I		BG PI
	Aligning allies	•… in industry to get political attention for the benefits of bioeconomy promotion	R		BG
	Establishing consortia, networks, clusters	•Cluster formation	N		BG
		•Building networks for synergy creation	I, R	I, N	BG
	Joining consortia, networks, clusters	•Joining or supporting place-based cooperation networks in order to access more information and counter the "concrete-lobby"	I	I, R, N	BG PI
	Strengthening collaboration	•Supporting information exchange, coordination of innovation endeavours	N	N, X	BG
Material	R&D to change practices, norms and measurement protocols	•… for the development of bio-based construction materials and change of own practices	I, R	R	BG PI
		•Experimentation with new materials and processing in order to achieve a proof of concept and change practices	I	I, R, X	BG PI
	Producing evidence for the revision of regulation	•Investing in evidence production, new measurement procedures, certification, LCA calculation	I	I	BG PI
	Building knowledge resources	•Launching practice-based information events, further education offers in terms of practical training on bio-based materials; supporting student projects on wood-based construction	I		PI
	Facilitating innovation	•Facilitating other actors' material and product testing in view of a wider use of new bio-based materials and transformed practices		R	BG
	Internal principles	•Reorienting research operations in view of bio-based materials and increased environmental sustainability		R	BG

Note: I = Industry, R = Research, N = industry-specific Intermediaries, X = cross-industry Intermediaries, BG = "born green", PI = "progressive incumbents".

- "The issues is the rules …. We have of course fulfilled the European standards, but if you have fulfilled the European standards, you ought to go through the UK standards locally on top of that. The European standards in the Netherlands depend on the zone you're in …. I went to the Dutch government. I went to Brussels. I spoke to all those guys a year ago." (RN5I)

When bio-based solutions are to leave their niches and succeed in a wider market, actors face challenges that materialise as a marathon.

5. Discussion: comparison and synthesis

In this section we synthesise our results and discuss them in view of the study's aspired contributions to bioeconomy, institutional and transition research. Firstly, we reflect on insights derived through the operationalisation of field conditions and the exploration of bioeconomy actors' institutional work. Secondly, we discuss the findings on characteristics and engagement of bioeconomy actors against knowledge built in transition studies. The article terminates with policy implications, limitations of this study and concluding remarks.

5.1. Field conditions and institutional work

More than 10 years after the concept of a bioeconomy was introduced with much optimism at the European policy agenda, its definition and delineations are still not settled (e.g. Stegmann et al., 2020). The concept touches upon multiple interrelated societal functions and a meaningful study of transition must, therefore, be based on sectors, industries or their bioeconomy segments (Edler et al., 2021; Wydra et al., 2021). While common economic statistics are unsuitable to depict bioeconomy progress, the institutional perspective invites us to examine how novel arrangements gain traction and legitimacy in a social field. Organization theory analysis looks out to the predominant sources of pressures for actors' institutional conformity to identify field borders. In contrast to the concept of issue fields in the discursive realm, this study is built on the construct of an exchange field with material interactions (Zietsma et al., 2017). From this perspective, bioeconomy actors are challenged to form meaning for their offerings and new market categories within a multitude of pre-existing fields.

Research on typologies of institutions and fields are widely perceived as an important area in institutional theory (e.g. Glynn and D'Aunno, 2023). This study represents a new effort in specifying the relevant field conditions based on macro-institutions: we propose specific industries' logics, regulations and exchange mechanism to be decisive for the constitution of differing field identities. In order to operationalise the field concept and allow for empirical inter-field comparisons, we proposed to also characterise the composition of the core actor population and the field's endowment with resources. Hence, it becomes possible to observe how field conditions shape the resulting forms of institutional work and to compare industrial exchange fields.

Building on the work of Meyer and Scott (1983) and Dorado (2005), we can frame results into three broad categories of field conditions, depending on the combination of characteristics of three institutional field conditions (Fig. 5). A summary characterisation of the conditions within the three different industrial fields is contrasted with summarised institutional work reactions from the fields' bioeconomy segments in Table 7.

The institutional logics are settled in the chemical industry field while regulatory institutionalisation is high. These conditions provide strong incentives towards compliance with established institutional norms. Highly sophisticated, stable, and coherent exchange mechanism keep the established logics in place. Not even the 'born greens' organisations challenge the established paradigms of large-scale production with homogeneous feedstocks in capital-intensive processes but focus on fossil fuel replacement by renewable inputs. In consequence, we label this type of field conditions as a **barricading institutional environment**. From the perspective of transition theory, such conditions would be evaluated as a dominant socio-technical regime in which there is a strong "alignment between technologies, policies, user patterns, infrastructures, and cultural discourses" (Geels, 2019, p. 3). Institutional work reactions from the bioeconomy include industrial actors, researchers and intermediaries engaging in discursive work at the elite level with the aim to secure access to (public) R&D funds and investment capital. Relational work targets industries from related fields, like the paper industry or hydrogen production, which are deemed to be highly compatible with the institutional logics of the chemical industry. With due acknowledgement of the high resource endowment and the homogenous field composition of the chemical industry, it becomes clearer that actors of the dominant regime are so strong that, through the concept of the bioeconomy, they rather begin to transform weaker neighbouring fields (agriculture, forestry and waste processing sectors). This result is consistent with the work of Furnari (2016) on resource dependence relations: actors in the dominant field tend to disrupt institutions in the weaker field.

Within the construction materials field, institutional logics are also settled and the regulatory institutionalisation is also strong. In contrast to the chemical industry field's conditions, however, relevant regulations are fragmented along regional and national lines leading to a high degree of "regulatory multiplicity". The presence of multiple industry associations, only exacerbates the problem of fragmentation. We label this as an **exhausting institutional environment**. With such field conditions actors suffer from 'opportunity-ambiguity dilemmas' that hinder their collective action (Lo et al., 2020). A certain degree of complex and contradictory demands from institutional conditions can be managed by actors with sufficient capacity to invest in compliance or sufficient leverage to negotiate workable compromises. Other actors with less developed resources may have to conclude that they simply cannot meet or change the diverse requirements for conformity, are forced out or voluntarily leave the field (Oliver, 1991; Raaijmakers et al., 2015). The support of intermediaries, discursive and relational work appear to be crucial to advance transitions under fragmented field conditions.

The field conditions for polymer compounders and converters are characterised by struggle over institutional logics while regulatory institutionalisation is moderate. These conditions have opened up the field for considerable experimentation. While testing alternatives, "progressive incumbents" try to maintain legitimacy vis-à-vis consumers through the mobilisation of allies in the waste

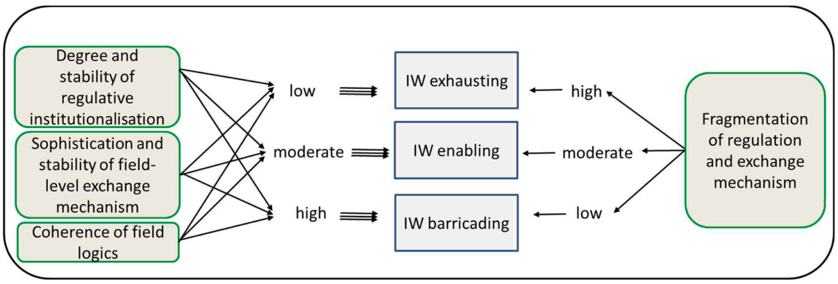


Fig. 5. Relations of relevant field conditions and institutional work. Note: IW = institutional work
Source: Adapted from Dorado, 2005.

Table 7
Comparison of field conditions and institutional work reactions.

Field conditions	Chemical industry Barricading	Polymer processing industry Enabling	Construction materials industry Exhausting
Institutional logics	Settled	Disputed	Settled
Regulatory insti-tutionalisation	Strong, stable, coherent	Medium, tightening, fragmented	Strong, fragmented
Field-level coordination mechanism	Highly sophisticated, stable, coherent	Sophisticated, stable, coherent	Fragmented, stable, incoherent
Field core popu-lation (industry)	Relatively homogeneous	Relatively homogeneous	Highly heterogeneous
Resource endowment	High	Low	Low
Institutional work in the fields' bioeconomy segments			
Discursive	High	Low	Medium
Relational	Medium to high	High	Low
Material	Medium	High	Low

collection and processing sector and strengthened recycling of fossil-fuel-based products. "Born green" actors work straight on bio-based, biodegradable or recyclable alternatives and mobilise new partners in the primary sector or civil society. Condition in the polymer processing field thus induce all bioeconomy actors to undertake intensive relational and material work aimed at disrupting existing institutions and creating new regulations, relations and products. We label these conditions as an **enabling institutional**

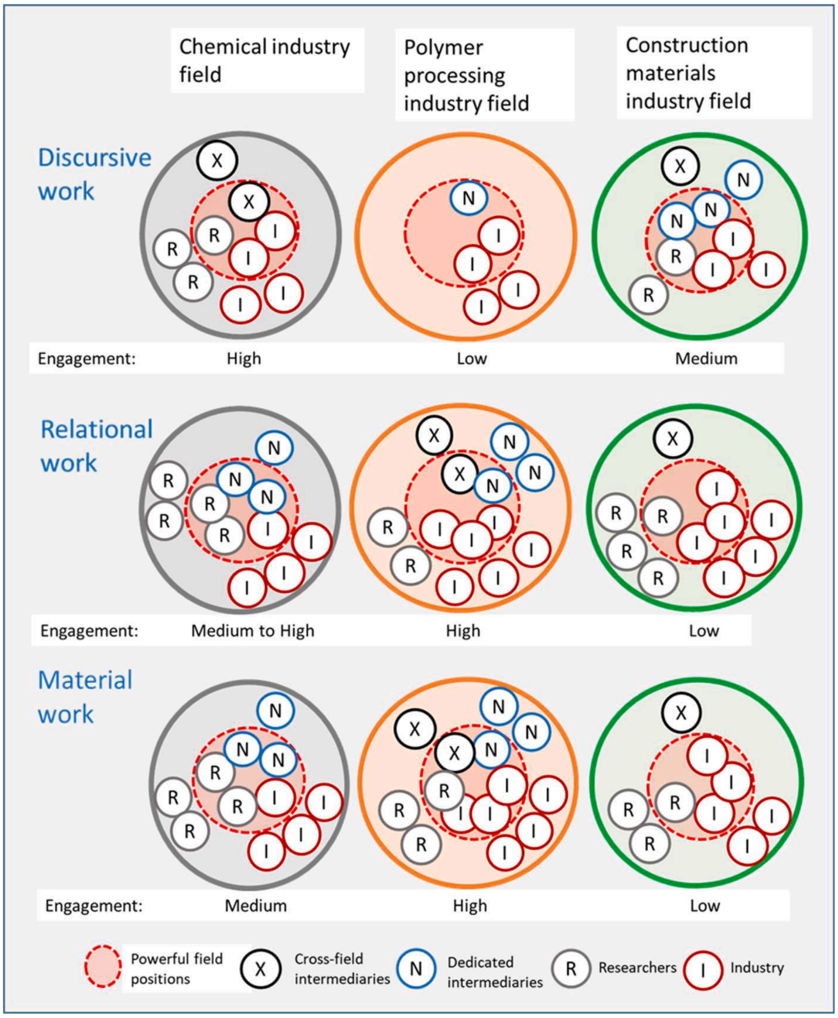


Fig. 6. Forms of institutional work by exchange field with specification of the relevant actor types' power position
Note: The categories chosen for the specification of the three forms of institutional work in the Section 4 result tables were used for a visual representation of actor types involved. Small rings, indicating the type of actor, are positioned in the centre or border area of rings according to their power position.

environment. This reading of results supports prior studies on heterogeneity's effect on institutional work (Fuenfschilling and Truffer, 2016; Hoogstraaten et al., 2020). Multiple small-scale efforts may develop "by growing, replicating, partnering, instrumentalising, and embedding" (Loorbach et al., 2020, p. 258) or "synchronization, amplification, and integration" (Mäkitie et al., 2022) and gain collective momentum for transition.

The typology proposed serves to systematically compare conditions across fields and helps to better understand different pattern of institutional work undertaken by core actors from bioeconomy sub-fields. It must be stressed that the labels signify relative categories and not absolute ones: classifying the field conditions of the chemical industry as "barricading" is done in comparison to conditions in the other two industries' fields. Accordingly, the characterisation of unfavourable ("barricading" or "exhausting") industrial exchange field conditions does not preclude the possibility that exceptional entrepreneurs successfully initiate disruptive change. That is possible - but not very likely to happen. We also emphasise that the typology does not negate the existence of industry-external (landscape) factors, pressures, alternative visions or novelties impacting specific industrial exchange fields and changing them over time (e.g. Herrfahrdt-Pähle et al., 2020; Loorbach et al., 2017; Schot and Geels, 2007). These factors undeniably hold the potential to spur or prevent field-level change, potentially transforming unfavourable into more enabling conditions for actor's institutional work.

5.2. *The influence of actors' characteristics on institutional work in the bioeconomy*

In line with the growing attention for actor agency in transition sciences, we took a closer look at the relevance of actor characteristics and their individual positions within a field. We have differentiated "born green" actors from "progressive incumbents", the former specialising solely in bio-based products, while the latter just started adding bio-based alternatives to a range of existing fossil-based products. In addition, we have made a distinction between organisation types (intermediaries, research and business units), and the relative power of actor positions within the field (a combination of size, access to resources and networks but also their perceived legitimacy).

When assessing our results in the light of actor characteristics it becomes clear that, when powerful actors are undertaking institutional work in a field, then other actors of the same type are mostly engaged as well – except for high level discursive or relational work, where weaker actors simply don't have access (see Fig. 6). Whether in power positions or not: every type of actor (from industry, research or intermediation) appears to be engaged in the range of activities that fit their organisation's capacities and strategic interest best. Institutional work aimed at changing norms and value chains are activities industrial actors report while researchers and intermediaries do not. Researchers – whether focussed on renewable or fossil resources - were found to primarily follow research calls and the interests of their partners in industry (see also related evidence from Bogner and Dahlke, 2022). Intermediaries, "born green" or not, accomplish the tasks mandated to them and actively facilitate contacts (see also Powell et al., 2017).

Dedicated intermediaries and researchers were observed performing institutional work that benefits new and non-powerful actors. In the chemical and the construction materials fields, this took the form of facilitating access to lab space for material and product testing in view of a wider use of new bio-based materials. Similarly, intermediaries acting as "launching customer" for innovative offerings of start-ups or SMEs support market development as well as awareness raising in the field. They may also facilitate access to production space or financing. A single "powerful" researchers was found "aligning" actors, that is: structuring the bioeconomy segment of the field by clarifying roles and positions, and by making sure that a bioeconomy strategy was clear to all relevant stakeholders and shared.

Being a large organisation is no precondition to being powerful. Some actors with very powerful voices in the discursive realm were located at small intermediaries, in line with results from Gliedt et al. (2018) and Kivimaa et al. (2019). Other small actors owe their comparatively central network position to inspirational or relation-building capabilities. Some SME entrepreneurs tend to act, not talk, and were found to silently launch disruptive change initiatives through material work. In this sense, results are another empirical confirmation of recent work on the nature and diverse origins of power (e.g. Kok et al., 2021).

Findings support transition studies that warn against applying the niche–regime dichotomy too strictly, call for more attention for 'hybrid' and other types of actors or observe shifts of actors' policy positions over time (De Haan and Rotmans, 2018; Ruggiero et al., 2021; Vormedal et al., 2023). Actor behaviour in bioeconomy segments of three industrial field shows that "born green" actors are not necessarily the radical outsiders that one would expect to inhabit a socio-technical niche (Van de Poel, 2000). Instead both "born green" and "progressive incumbents" mostly favour incremental change and are rarely interested in forceful disruption. Both groups engage in adapting existing institutions and creating new ones that better fit with (partially) bio-based product alternatives. We explain this result through the specific context of the bioeconomy: renewable feedstocks grow regular (season by season), slow, and cannot be scaled or hurried at will. Some old, large, "born green" companies eventually have considerable control over their upstream input flow and the primary sector is not known for welcoming radical change initiatives.

5.3. *Policy implications for the advancement of a bioeconomy*

Earlier work on the bioeconomy highlighted that cascading biomass flows across sectoral and industrial boundaries require a radical and disruptive re-organisation of existing value chains (Golembiewski et al., 2015). Van Lancker et al. (2016) stress (1) the complex knowledge base required, (2) high technology switching costs and workload with regulative institutions as well as (3) fragmented policy schemes hampering innovation processes within the bioeconomy. Our results refine these findings by showing how institutional conditions differ markedly for actors in the bioeconomy segments of different industries. While different types of actors try to create favourable conditions for their innovation advancing efforts, they enact different agency pattern without significant cross-field coordination.

These insights have implications for policy because they underline the need for strengthened, differentiated and yet harmonised strategies. Asking for field conditions that enable institutional work towards SDG attainment leads to two important points. Firstly, we highlight unequal power relations between industrial fields alongside the competition for renewable inputs (see also Andersen et al., 2020). Under current conditions renewable resources from agriculture and forestry are most likely absorbed by those industrial fields and actor groups where economic and political power is high. The chemical industry's barricading conditions in North-Western Europe not only hamper innovation in the bioeconomy segment but also experimentation in downstream industries. To change barricading field conditions, policy makers can draw inspiration from research on efforts to break up or accelerate the demise of existing unsustainable sociotechnical regimes or to initiate a managed erosion of lock-in conditions (e.g. Kivimaa et al., 2021; Rosenbloom and Rinscheid, 2020; van Oers et al., 2021). Important measures may include a significantly strengthened involvement of civil society organisations as recently proposed upon a transition failure diagnosis in spite of substantial German bioeconomy promotion (Lühmann and Vogelpohl, 2023).

The enabling legitimacy crisis in the polymer processing industry has been created by civil society in collaboration with research and media. Our results show that it is supported by direct customer contact in short value chains. As a second point, we highlight strong field-level coordination mechanism as decisive assets where the field's resource endowment is low and few powerful actors exist in research and industry. Disruptive technology-based innovations might be comparatively less likely in the bioeconomy than in other economic arenas. Still, innovation is fostered by progressive incumbents as well as by "born green" actors. Actors build on a broadened variety of feedstocks, new biochemical knowledge on input properties and new processing technologies. Policy can directly support actors' relational and material work in fields with enabling and exhausting conditions. Concerned decision-makers should consider the design of new mechanism for an accelerated modernisation of norms and regulations and strengthened cross-field consistency.

5.4. Limitations and future research

While the characterisation of field conditions appear sufficient for the cross-field analysis undertaken in North-Western Europe, additional cultural, historic, political and economic aspects will probably require consideration where the analysis is meant to cover a wider geographic area or broader array of industrial fields. Heiberg et al. (2022) provided some evidence on differing transition trajectories in the water sector despite very similar global regime structures and landscape pressure. A typology based on the life-cycle of fields as proposed by Greenwood and Suddaby (2006) or Navis and Glynn (2010) can still be relevant in other cases. With respect to the substitution of fossil inputs and consequential technological renewal in the focus industries of this study, we concluded that a framing of the bioeconomy segments as new fields would have been inadequate or premature.

The observed empirical evidence across actor types clearly requires further research because the sample size for specific subsections of the actor population was comparatively small. We came across multiple "hybrid" actors with double roles during interviewing, like researchers *also* being entrepreneurs. People also change positions during their professional careers and ultimately adhere to mixed professional logics. These findings are in line with Fischer and Newig who concluded from their literature review "that actor roles in transitions are erratic, since their roles can change over the course of time, and that actors can belong to different categories" (2016, p. 475).

6. Conclusion

Different forms of institutional work are important for sustainability-directed innovations to gain a foothold in established industries. This paper present a novel conceptual model that explains how pattern of (discursive, relational and material) institutional work are influenced and shaped by (a) institutional conditions within the industrial sector and (b) the characteristics and position of an actor within the field. We applied this conceptual model in and around three industries that play an important role in the emerging bioeconomy in North-Western Europe: (1) the chemical industry, (2) the polymer processing industry and (3) the construction materials industry. Based on four distinct aspects of conditions, the study contributes a new typology to field theory. Meanwhile the analysis of actors' institutional work engagement led to the conclusion that every type of actor (from industry, research or intermediation) tends to be engaged in a range of activities that fits the respective organisation's capacities and strategic interests best. A distinction between 'born green' actors and progressive incumbents, however, did not provide a clear justification for this distinction in the study of transition towards an emerging bioeconomy. Our comparison of different industries highlighted that institutional field conditions can vary significantly. This finding promotes the formulation of specific bioeconomy policies that can either support actors to break through 'barricading' conditions, or facilitate their relational and material work in fields with 'enabling' or 'exhausting' conditions.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Frans Hermans reports financial support was provided by Leibniz Institute of Agricultural Development in Transition Economies. Kerstin Wilde reports a relationship with Leibniz Institute of Agricultural Development in Transition Economies that includes: employment, non-financial support, speaking and lecture fees, and travel reimbursement.

Acknowledgments

This study was financed through the TRAFOBIT's The Role and Functions of Bioclusters in the Transition to a Bioeconomy project (031B0020) under the German Federal Ministry of Education and Research's call, "Bioökonomie als gesellschaftlicher Wandel". We could not have achieved our results without the leading-edge Cluster Bioeconomy in Germany and Biobased Delta in the Netherlands. Moreover, our deep appreciation goes to all respondents. We are also thankful for the suggestions and advice generously offered by two anonymous reviewers.

Appendix

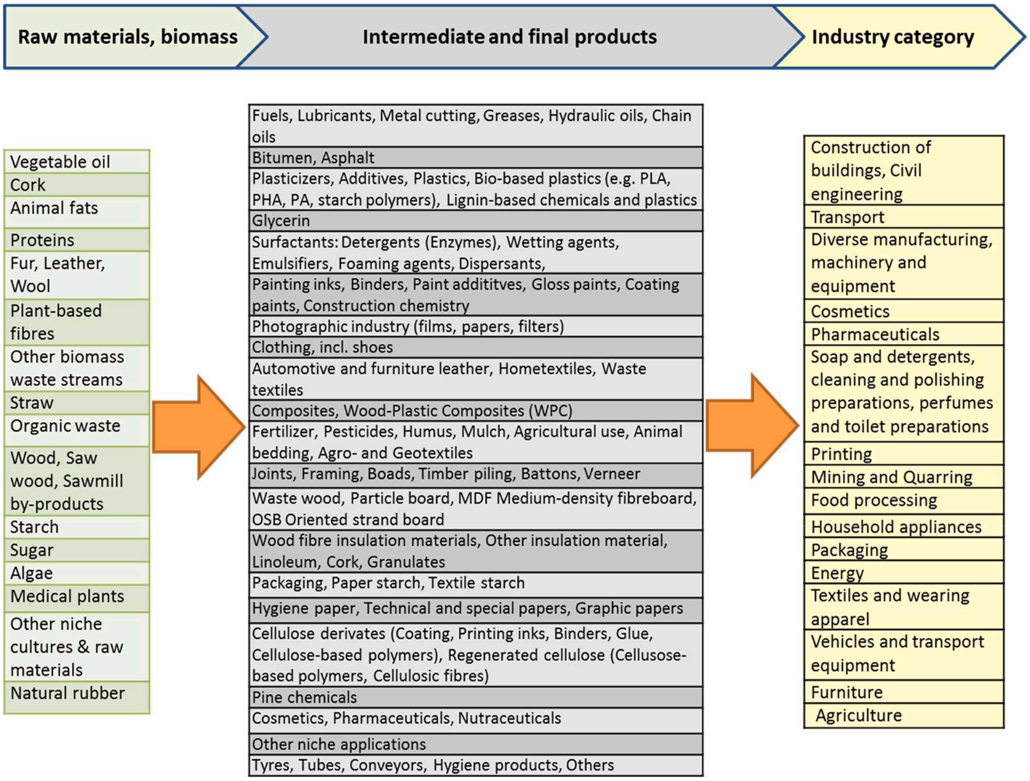


Fig. A.1. Use of renewable resources in European industries.
Source: Own visualisation based Raschka and Carus, 2014.

References

Alvesson, M., Spicer, A., 2019. Neo-institutional theory and organization studies: a mid-life crisis? Organ. Stud. 40 (2), 199–218. https://doi.org/10.1177/0170840618772610.

Andersen, A.D., Steen, M., Mäkitie, T., Hanson, J., Thune, T.M., Soppe, B., 2020. The role of inter-sectoral dynamics in sustainability transitions: a comment on the transitions research agenda. Environ. Innov. Soc. Transit. 34, 348–351. https://doi.org/10.1016/j.eist.2019.11.009.

Andrews-Speed, P., 2016. Applying institutional theory to the low-carbon energy transition. Energy Res. Soc. Sci. 13, 216–225. https://doi.org/10.1016/j.erss.2015.12.011.

Antonopoulos, I., Faraca, G., Tonini, D., 2021. Recycling of post-consumer plastic packaging waste in the EU: recovery rates, material flows, and barriers. Waste Manage. 126, 694–705. https://doi.org/10.1016/j.wasman.2021.04.002.

Avelino, F., 2021. Theories of power and social change. Power contestations and their implications for research on social change and innovation. J. Political Power 14 (3), 425–448. https://doi.org/10.1080/2158379X.2021.1875307.

Barthelemy, P., Agyeman-Budu, E., 2016. European chemical industry's contribution to sustainable development. Curr. Opin. Green Sustain. Chem. 1, 28–32. https://doi.org/10.1016/j.cogsc.2016.08.002.

Basten, M., Engelke, C., 2016. Die Schere geht Auf. Bundesverband Baustoffe - Steine und Erden e.V., Berlin, pp. 24–26 baustoffmarkt 5. https://www.baustoffindustrie.de/fileadmin/user_upload/bbs/Dateien/Downloadarchiv/Bauwirtschaft/baustoffmarkt_0516_S24-26.pdf (accessed 28 October 2021).

Battilana, J., Leca, B., Boxenbaum, E., 2009. How actors change institutions: towards a theory of institutional work. Acad. Manag. Ann. 3 (1), 65–107. https://doi.org/10.5465/19416520903053598.

Battilana, J., Casciaro, T., 2012. Change agents, networks, and institutions: a contingency theory of organizational change. Acad. Manage J. 55 (2), 381–398. https://doi.org/10.5465/amj.2009.0891.

Beckert, J., 2010. How do fields change? The interrelations of institutions, networks, and cognition in the dynamics of markets. Organ. Stud. 31 (5), 605–627. https://doi.org/10.1177/0170840610372184.
Bergek, A., Hekkert, M., Jacobsson, S., Markard, J., Sandén, B., Truffer, B., 2015. Technological innovation systems in contexts: conceptualizing contextual structures and interaction dynamics. Environ. Innov. Soc. Transit. 16, 51–64. https://doi.org/10.1016/j.eist.2015.07.003.
Biygautane, M., Clegg, S., Al-Yahya, K., 2020. Institutional work and infrastructure public–private partnerships (PPPs): the roles of religious symbolic work and power in implementing PPP projects. Account. Audit. Accoun. 33 (5), 1077–1112. https://doi.org/10.1108/AAAJ-04-2019-3982.
Boenink, M., Kudina, O., 2020. Values in responsible research and innovation: from entities to practices. J. Responsible Innov. 7 (3), 450–470. https://doi.org/10.1080/23299460.2020.1806451.
Bogner, K., Dahlke, J., 2022. Born to transform? German bioeconomy policy and research projects for transformations towards sustainability. Ecol. Econ. 195, 107366 https://doi.org/10.1016/j.ecolecon.2022.107366.
Boxenbaum, E., Jonsson, S., 2017. Isomorphism, diffusion and decoupling: concept evolution and theoretical challenges (Eds.). In: Greenwood, R., Meyer, R.E., Lawrence, T.B., Oliver, C. (Eds.), The Sage Handbook of Organizational Institutionalism. Sage Publications, London, pp. 79–104. second ed. http://digital.casalini.it/9781526415059.
Bröring, S., Laibach, N., Wustmans, M., 2020. Innovation types in the bioeconomy. J. Clean. Prod. 266, 121939 https://doi.org/10.1016/j.jclepro.2020.121939.
Bundesverband Baustoffe – Steine und Erden e. V. (BBS), 2019. bbs-Zahlenspiegel 2019. Daten und Fakten zur Baustoff-, Steine-und-Erden-Industrie. Berlin: BBS. https://www.baustoffindustrie.de/fileadmin/user_upload/bbs/Dateien/Downloadarchiv/Konjunktur/Zahlenspiegel_2019.pdf (accessed 18 October 2021).
Chiappinelli, O., Gerres, T., Neuhoff, K., Lettow, F., de Coninck, H., Felsmann, B., Zetterberg, L., 2021. A green COVID-19 recovery of the EU basic materials sector: identifying potentials, barriers and policy solutions. Clim. Policy 21 (10), 1328–1346. https://doi.org/10.1080/14693062.2021.1922340.
Chinthapalli, R., Skoczinski, P., Carus, M., Baltus, W., de Guzman, D., Käb, H., Ravenstijn, J., 2019. Biobased building blocks and polymers—Global capacities, production and trends, 2018–2023. Ind. Biotechnol. 15 (4), 237–241. https://doi.org/10.1089/ind.2019.29179.rch.
Conde, Á., Sutherland, A.B., Fraser, M., Roemers, G., Sosa, L. Rohmer, M., 2022. Circularity gap report: built environment, the Netherlands. https://www.circularity-gap.world/sectors#download (accessed 17 June 2023).
Conversio (2018) Material flow analysis plastics in Germany 2017. Conversio Market & Strategy GmbH, Mainaschaff. https://www.conversio-gmbh.com/en/news/material-flow-analysis-plastics-in-germany (accessed 31 October 2021).
Czarnecki, L., Van Gemert, D., 2017. Innovation in construction materials engineering versus sustainable development. B. Pol. Acad. Sci.-Tec. 65 (6), 765–771. https://doi.org/10.1515/bpasts-2017-0083.
Dalpiaz, E., Rindova, V., Ravasi, D., 2016. Combining logics to transform organizational agency: blending industry and art at Alessi. Admin. Sci. Quart. 61 (3), 347–392. https://doi.org/10.1177/0001839216636103.
de Guzman, D., 2020. Updated executive summary and market review May 2020 – originally published February 2020, nova-Institut, Hürth. www.bio-based.eu (accessed 31 October 2021).
De Haan, F.J., Rotmans, J., 2018. A proposed theoretical framework for actors in transformative change. Technol. Forecast. Soc. Change 128, 275–286. https://doi.org/10.1016/j.techfore.2017.12.017.
Delbridge, R., Edwards, T., 2013. Inhabiting institutions: critical realist refinements to understanding institutional complexity and change. Organ. Stud. 34 (7), 927–947. https://doi.org/10.1177/0170840613483805.
DeVierno Kreuder, A., House-Knight, T., Whitford, J., Ponnusamy, E., Miller, P., Jesse, N., Nelowet Grice, L., 2017. A method for assessing greener alternatives between chemical products following the 12 principles of green chemistry. ACS *Sustain. Chem. Eng* 5 (4), 2927–2935. https://doi.org/10.1021/acssuschemeng.6b02399.
Dietz, T., Börner, J., Förster, J.J., Von Braun, J., 2018. Governance of the bioeconomy: a global comparative study of national bioeconomy strategies. Sustainability 10 (9), 3190. https://doi.org/10.3390/su10093190.
Dispan, J., 2013. Kunststoffverarbeitung in Deutschland. Branchenreport 2013. Informationsdienst des IMU Instituts 4. IMU Institut, Stuttgart. https://www.imu-institut.de/data/publication/kunststoffverarbeitung-in-deutschland-1 (accessed 1 November 2021).
DiMaggio, P.J., Powell, W.W., 1983. The iron cage revisited: institutional isomorphism and collective rationality in organizational fields. Am. Sociol. Rev. 147–160. https://doi.org/10.2307/2095101.
DiMaggio, P.J., Powell, W.W., 1991. Introduction (Eds.). In: DiMaggio, P.J., Powell, W.W. (Eds.), The New Institutionalism in Organizational Analysis. University of Chicago Press, Chicago, pp. 1–39.
Dorado, S., 2005. Institutional work, partaking, and convening. Organ. Stud. 26 (3), 385–414. https://doi.org/10.1177/0170840605050873.
Dorado, S., 2013. Small groups as context for institutional work: an exploration of the emergence of commercial microfinance in Bolivia. Organ. Stud. 34 (4), 533–557. https://doi.org/10.1177/0170840612470255.
Dosi, G., Malerba, F., Marsili, O., Orsenigo, L., 1997. Industrial structures and dynamics: evidence, interpretations and puzzles. Ind. Corp. Change 6 (1), 3–24. https://doi.org/10.1093/icc/6.1.3.
Dubois, A., Gadde, L.E., 2002. The construction industry as a loosely coupled system: implications for productivity and innovation. Constr. Manag. Econ. 20 (7), 621–631. https://doi.org/10.1080/01446190210163543.
Dutch Federation of the Rubber and Plastics Industry, Federatie Nederlandse Rubber– en Kunststofindustrie (NRK) 2020 website https://www.nrk.nl/english (accessed 27 June 2021).
Duygan, M., Kachi, A., Oliveira, T.D., Rinscheid, A., 2021. Introducing the Endowment-Practice-Institutions (EPI) framework for studying agency in the institutional contestation of socio-technical regimes. J. Clean. Prod. 296, 126396 https://doi.org/10.1016/j.jclepro.2021.126396.
Edler, J., Köhler, J.H., Wydra, S., Salas-Gironés, E., Schiller, K., Braun, A., 2021. Dimensions of systems and transformations: towards an integrated framework for system transformations. Working Paper Sustainability and Innovation, No. S03/2021. https://www.econstor.eu/handle/10419/238275 (accessed 4 November 2021).
Ekman, P., Röndell, J., Kowalkowski, C., Raggio, R.D., Thompson, S.M., 2021. Emergent market innovation: a longitudinal study of technology-driven capability development and institutional work. J. Bus. Res. 124, 469–482. https://doi.org/10.1016/j.jbusres.2020.10.061.
Elzen, B., Van Mierlo, B., Leeuwis, C., 2012. Anchoring of innovations: assessing Dutch efforts to harvest energy from glasshouses. Environ. Innov. Soc. Transit. 5, 1–18. https://doi.org/10.1016/j.eist.2012.10.006.
Etikan, I., Musa, S.A., Alkassim, R.S., 2016. Comparison of convenience sampling and purposive sampling. Am. J. Theor. Appl. 5 (1), 1–4. https://doi.org/10.11648/j.ajtas.20160501.11.
European Commission (2020). Table of radical innovations breakthroughs. https://ec.europa.eu/info/sites/info/files/research_and_innovation/knowledge_publications_tools_and_data/documents/ec_rtd_radical-innovation_poster_052019.pdf (accessed 27 July 2022).
European Commission (EC), 2020. A new circular economy action plan for a cleaner and more competitive Europe. (COM (2020) 98 final). Brussels. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0098&from=EN (accessed 19 October 2021).
European Commission (EC), 2021. Roadmap for the implementation of the Construction Products Regulation (CPR). https://ec.europa.eu/docsroom/documents/45224 (accessed 17 June 2023).
European Commission, Directorate-General for Research and Innovation (EC), 2022. European bioeconomy policy – stocktaking and future developments – Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Publications Office of the European Union. https://data.europa.eu/doi/10.2777/997651.
European Commission (EC), 2023. New European bauhaus progress report. https://new-european-bauhaus.europa.eu/about/progress-report_en (accessed 17 June 2023).
Eurostat, 2020. Construction of buildings statistics - NACE Rev. 2. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Construction_of_buildings_statistics_-_NACE_Rev._2 (accessed 30 Mai 2022).

Eversberg, D., Fritz, M., 2022. Bioeconomy as a societal transformation: mentalities, conflicts and social practices. Sustain. Prod. Consum. 30, 973–987. https://doi.org/10.1016/j.spc.2022.01.021.

Fischer, L.B., Newig, J., 2016. Importance of actors and agency in sustainability transitions: a systematic exploration of the literature. Sustain.-Basel 8 (5), 476. https://doi.org/10.3390/su8050476.

Fligstein, N., Dauter, L., 2007. The sociology of markets. Annu. Rev. Sociol. 33 (1), 105–128. https://doi.org/10.1146/annurev.soc.33.040406.131736.

Friedland, R., Alford, R., 1991. Bringing society back in (Eds.). In: Powell, W., DiMaggio, P. (Eds.), The New Institutionalism in Organizational Analysis. University of Chicago Press, Chicago, pp. 232–263.

Friedland, R., Arjaliès, D.L., 2021. Putting things in place: institutional objects and institutional logics. In: Lounsbury, M., Anderson, D. A., Spee, P. (Eds.), On Practice and Institution: New Empirical Directions, Vol. 71. Emerald Publishing Limited, Bingley, pp. 45–86.

Fuenfschilling, L., 2019. An institutional perspective on sustainability transitions, in: Boons, F., McMeekin, A. (Eds.), Handbook of Sustainable Innovation. Edward Elgar Publishing, Cheltenham, pp. 219–236.

Fuenfschilling, L., Truffer, B., 2014. The structuration of socio-technical regimes. Conceptual foundations from institutional theory. Res. Pol. 43 (4), 772–791. https://doi.org/10.1016/j.respol.2013.10.010.

Fuenfschilling, L., Truffer, B., 2016. The interplay of institutions, actors and technologies in socio-technical systems - an analysis of transformations in the Australian urban water sector. Technol. Forecast. Soc. Change 103, 298–312. https://doi.org/10.1016/j.techfore.2015.11.023.

Furnari, S., 2016. Institutional fields as linked arenas: inter-field resource dependence, institutional work and institutional change. Hum. Relat. 69 (3), 551–580. https://doi.org/10.1177/0018726715605555.

Galvan, M.G., Cuppen, E., Taanman, M., 2020. Exploring incumbents' agency: institutional work by grid operators in decentralized energy innovations. Environ. Innov. Soc. Transit. 37, 79–92. https://doi.org/10.1016/j.eist.2020.07.008.

Garud, R., Hardy, C., Maguire, S., 2007. Institutional work as embedded agency: an introduction to the special issue. Organ. Stud. 28 (7), 957–969. https://doi.org/10.1177/0170840607078958.

Garud, R., Gehman, J., Kumaraswamy, A., 2011. Complexity arrangements for sustained innovation: lessons from 3M Corporation. Organ. Stud. 32 (6), 737–767. https://doi.org/10.1177/0170840611410810.

Geels, F.W., 2019. Socio-technical transitions to sustainability: a review of criticisms and elaborations of the multi-level perspective. Curr. Opin. Environ. Sustain. 39, 187–201. https://doi.org/10.1016/j.cosust.2019.06.009.

Geels, F.W., Elzen, B., Green, K., 2004. General introduction: system innovation and transitions to sustainability (Eds.). In: Elzen, B., Geels, F.W., Green, K. (Eds.), System Innovation and the Transition to Sustainability. Edward Elgar Publishing, Cheltenham, pp. 1–16.

Geels, F.W., 2020. Micro-foundations of the multi-level perspective on socio-technical transitions: developing a multi-dimensional model of agency through crossovers between social constructivism, evolutionary economics and neo-institutional theory. Technol. Forecast. Soc. Change 152, 119894. https://doi.org/10.1016/j.techfore.2019.119894.

Genus, A., Mafakheri, F., 2014. A neo-institutional perspective of supply chains and energy security: bioenergy in the UK. Appl. Energ. 123, 307–315. https://doi.org/10.1016/j.apenergy.2014.01.084.

Geyer, R., 2020. Production, use, and fate of synthetic polymers (Ed.). In: Letcher, T.M. (Ed.), Plastic Waste and Recycling. Academic Press, Cambridge, pp. 13–32.

Gliedt, T., Hoicka, C.E., Jackson, N., 2018. Innovation intermediaries accelerating environmental sustainability transitions. J. Clean. Prod. 174, 1247–1261. https://doi.org/10.1016/j.jclepro.2017.11.054.

Glynn, M.A., D'Aunno, T., 2023. An intellectual history of institutional theory: looking back to move forward. Acad. Manag. Ann. 17 (1), 301–330. https://doi.org/10.5465/annals.2020.0341.

Göswein, V., Reichmann, J., Habert, G., Pittau, F., 2021. Land availability in Europe for a radical shift toward bio-based construction. Sustain. Cities Soc. 70, 102929 https://doi.org/10.1016/j.scs.2021.102929.

Golembiewski, B., Sick, N., Bröring, S., 2015. The emerging research landscape on bioeconomy: what has been done so far and what is essential from a technology and innovation management perspective? Innov. Food Sci. Emerg. 29, 308–317. https://doi.org/10.1016/j.ifset.2015.03.006.

Granovetter, M., 1985. Economic action and social structure: the problem of embeddedness. Am. J. Sociol. 91 (3), 481–510. https://doi.org/10.1086/228311.

Greenwood, R., Suddaby, R., 2006. Institutional entrepreneurship in mature fields: the big five accounting firms. Acad. Manage. J. 49 (1), 27–48. https://doi.org/10.5465/amj.2006.20785498.

Grin, J., Rotmans, J., Schot, J., 2010. Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change. Routledge.

Grouiez, P., Debref, R., Vivien, F.D., Befort, N., 2023. The complex relationships between non-food agriculture and the sustainable bioeconomy: the French case. Ecol. Econ. 214, 107974 https://doi.org/10.1016/j.ecolecon.2023.107974.

Gümüsay, A.A., Smets, M., Morris, T., 2020. God at work": engaging central and incompatible institutional logics through elastic hybridity. Acad. Manage J. 63 (1), 124–154. https://doi.org/10.5465/amj.2016.0481.

Guest, G., MacQueen, K.M., Namey, E.E., 2011. Applied Thematic Analysis. Sage Publications, London.

Hallett, T., Hawbaker, A., 2021. The case for an inhabited institutionalism in organizational research: interaction, coupling, and change reconsidered. Theory Soc. 50 (1), 1–32. https://doi.org/10.1007/s11186-020-09412-2.

Hallett, T., Ventresca, M.J., 2006. Inhabited institutions: social interactions and organizational forms in Gouldner's Patterns of Industrial Bureaucracy. Theor. Soc. 35, 213–236. https://doi.org/10.1007/s11186-006-9003-z.

Hampel, C.E., Lawrence, T.B., Tracey, P., 2017. In: Greenwood, R., Meyer, R.E., Lawrence, T.B., Oliver, C. (Eds.), Institutional Work: Taking Stock and Making It Matter 558–590 (Eds.)second ed. http://digital.casalini.it/9781526415059.

Hardy, C., Maguire, S., 2017. Institutional Work and Change in Fields, in: Greenwood, R., Meyer, R.E., Lawrence, T.B., Oliver, C. (Eds.), The Sage Handbook of Organizational Institutionalism, second ed. Thousand Oaks, London, pp. 261–280. http://digital.casalini.it/9781526415059.

Heiberg, J., Truffer, B., Binz, C., 2022. Assessing transitions through socio-technical configuration analysis–a methodological framework and a case study in the water sector. Res. Pol. 51 (1), 104363 https://doi.org/10.1016/j.respol.2021.104363.

Helfen, M., Sydow, J., 2013. Negotiating as institutional work: the case of labour standards and international framework agreements. Organ. Stud. 34 (8), 1073–1098. https://doi.org/10.1177/0170840613492072.

Hermans, F., 2018. The potential contribution of transition theory to the analysis of bioclusters and their role in the transition to a bioeconomy. Biofuel. Bioprod. Biorefin. 12 (2), 265–276. https://doi.org/10.1002/bbb.1861.

Hermans, F.L., 2021. Bioclusters and sustainable regional development, in: Sedita, S.R., Blasi, S. (Eds.), Rethinking Clusters. Sustainable Development Goals Series. Springer, Cham., pp. 81–91. 10.1007/978-3-030-61923-7_6.

Hermans, F., Geerling-Eiff, F., Potters, J., Klerkx, L., 2019. Public-private partnerships as systemic agricultural innovation policy instruments–Assessing their contribution to innovation system function dynamics. NJAS-Wagen. J. Life Sci. 88, 76–95. https://doi.org/10.1016/j.njas.2018.10.001.

Herrfahrdt-Pähle, E., Schlüter, M., Olsson, P., Folke, C., Gelcich, S., Pahl-Wostl, C., 2020. Sustainability transformations: socio-political shocks as opportunities for governance transitions. Glob. Environ. Change 63, 102097. https://doi.org/10.1016/j.gloenvcha.2020.102097.

Hilgers, M., Mangez, E., 2014. Introduction to Pierre Bourdieu's theory of social fields (Eds.). In: Hilgers, M., Mangez, E. (Eds.), Bourdieu's Theory of Social fields: Concepts and Applications. Routledge, New York, pp. 1–36.

Hinings, C.R., Logue, D.M., Zietsma, C., 2017. Fields, institutional infrastructure and governance (Eds.). In: Greenwood, R., Meyer, R.E., Lawrence, T.B., Oliver, C. (Eds.), The Sage Handbook of Organizational Institutionalism. Thousand Oaks, London, pp. 216–245. second ed. http://digital.casalini.it/9781526415059.

Hipp, A., Binz, C., 2020. Firm survival in complex value chains and global innovation systems: evidence from solar photovoltaics. Res. Pol. 49 (1), 103876 https://doi.org/10.1016/j.respol.2019.103876.

Hodgson, G.M., 2006. What are institutions? J. Econ. Issues 40 (1), 1–25. https://doi.org/10.1080/00213624.2006.11506879.

Hoogstraaten, M.J., Frenken, K., Boon, W.P., 2020. The study of institutional work and its implications for transition studies. Environ. Innov. Soc. Transit. 36, 114–136. https://doi.org/10.1016/j.eist.2020.05.004.

Hsu, W.T., Domenech, T., McDowall, W., 2022. Closing the loop on plastics in Europe: the role of data, information and knowledge. Sustain. Prod. Consum. 33, 942–951. https://doi.org/10.1016/j.spc.2022.08.019.

Huttunen, S., Kaljonen, M., Lonkila, A., Rantala, S., Rekola, A., Paloniemi, R., 2021. Pluralising agency to understand behaviour change in sustainability transitions. Energy Res. Soc. Sci. 76, 102067. https://www.sciencedirect.com/science/article/pii/S2214629621001602.

Independent Commodity Intelligence Services (ICIS), 2019. Special report: top 100 chemical companies. https://www.icis.com/explore/resources/icis-top-100-chemical-companies-of-2019/ (accessed 23 October 2020).

Jones, C., Lee, J.Y., Lee, T., Haack, P., Sieweke, J., Wessel, L., 2019. Institutionalizing place: materiality and meaning in Boston's north end. Microfoundations of Institutions. Emerald Publishing Limited, Bingley, pp. 211–239.

Jones, C., Meyer, R., Höllerer, M.A., Jancsary, D., Greenwood, R., Meyer, R.E., Lawrence, T.B., Oliver, C., 2017. The material and visual basis of institutions. The Sage Handbook of Organizational Institutionalism. Sage Publications, London, pp. 621–646 second ed. http://digital.casalini.it/9781526415059.

Kabasci, S., 2020. Biobased plastics (Ed.). In: Letcher, T.M. (Ed.), Plastic Waste and Recycling. Academic Press, London, pp. 67–96.

Kardung, M., Cingiz, K., Costenoble, O., Delahaye, R., Heijman, W., Lovrić, M., Zhu, B.X., 2021. Development of the circular bioeconomy: drivers and indicators. Sustain.-Basel 13 (1), 413. https://doi.org/10.3390/su13010413.

Kern, F., Rogge, K.S., 2018. Harnessing theories of the policy process for analysing the politics of sustainability transitions: a critical survey. Environ. Innov. Soc. Transit. 27, 102–117. https://doi.org/10.1016/j.eist.2017.11.001.

Kivimaa, P., Boon, W., Hyysalo, S., Klerkx, L., 2019. Towards a typology of intermediaries in sustainability transitions: a systematic review and a research agenda. Res. Pol. 48 (4), 1062–1075. https://doi.org/10.1016/j.respol.2018.10.006.

Kivimaa, P., Laakso, S., Lonkila, A., Kaljonen, M., 2021. Moving beyond disruptive innovation: a review of disruption in sustainability transitions. Environ. Innov. Soc. Transit. 38, 110–126. https://doi.org/10.1016/j.eist.2020.12.001.

Köhler, J., Geels, F.W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Wells, P., 2019. An agenda for sustainability transitions research: state of the art and future directions. Environ. Innov. Soc. Transit. 31, 1–32. https://doi.org/10.1016/j.eist.2019.01.004.

Kok, K.P., Loeber, A.M., Grin, J., 2021. Politics of complexity: conceptualizing agency, power and powering in the transitional dynamics of complex adaptive systems. Res. Pol. 50 (3), 104183 https://doi.org/10.1016/j.respol.2020.104183.

Kump, B., 2023. Lewin's field theory as a lens for understanding incumbent actors' agency in sustainability transitions. Environ. Innov. Soc. Transit. 46, 100683 https://doi.org/10.1016/j.eist.2022.11.008.

Lawrence, T.B., Suddaby, R., 2006. Institutions and institutional work, in: Clegg, S.R., Hardy, C., Lawrence, T.B., Nord, W.R. (Eds.), Handbook of Organization Studies, second ed. Sage Publications, London, pp. 215–254.

Lawrence, T., Suddaby, R., Leca, B., 2011. Institutional work: refocusing institutional studies of organization. J. Manage. Inquiry 20 (1), 52–58. https://doi.org/10.1177/10564926103872.

Leeuwis, C., Aarts, N., 2011. Rethinking communication in innovation processes: creating space for change in complex systems. J. Agric. Educ. Ext. 17 (1), 21–36. https://doi.org/10.1080/1389224X.2011.536344.

Levy, D., Scully, M., 2007. The institutional entrepreneur as modern prince: the strategic face of power in contested fields. Organ. Stud. 28 (7), 971–991. https://doi.org/10.1177/0170840607078109.

Lewin, K., 1951. Field theory in social science. Selected Theoretical Papers. Harpers *(Edited by DorwinCartwright)*.

Lieftink, B., Smits, A., Lauche, K., 2019. Dual dynamics: project-based institutional work and subfield differences in the Dutch construction industry. Int. J. Proj. Manag. 37 (2), 269–282. https://doi.org/10.1016/j.ijproman.2018.03.005.

Lizardo, O., Haack, P., Sieweke, J., Wessel, L., 2019. Specifying the "what" and separating the "how": doings, sayings, codes, and artifacts as the building blocks of institutions. In: Microfoundations of Institutions, 65. Emerald Publishing Limited, Bingley, pp. 217–234. https://doi.org/10.1108/S0733-558×2019000065A021.

Lo, J.Y., Nag, R., Xu, L., Agung, S.D., 2020. Organizational innovation efforts in multiple emerging market categories: exploring the interplay of opportunity, ambiguity, and socio-cognitive contexts. Res. Pol. 49 (3), 103911 https://doi.org/10.1016/j.respol.2019.103911.

Löhr, M., Chlebna, C., Mattes, J., 2022. From institutional work to transition work: actors creating, maintaining and disrupting transition processes. Environ. Innov. Soc. Transit. 42, 251–267. https://doi.org/10.1016/j.eist.2021.12.005.

Loorbach, D., Frantzeskaki, N., Avelino, F., 2017. Sustainability transitions research: transforming science and practice for societal change. Annu. Rev. Env. Resour. 42, 599–626. https://doi.org/10.1146/annurev-environ-102014-021340.

Loorbach, D., Wittmayer, J., Avelino, F., von Wirth, T., Frantzeskaki, N., 2020. Transformative innovation and translocal diffusion. Environ. Innov. Soc. Transit. 35, 251–260. https://doi.org/10.1016/j.eist.2020.01.009.

Loste, N., Roldán, E., Giner, B., 2020. Is Green Chemistry a feasible tool for the implementation of a circular economy? *Environ. Sci. Pollut.* Res. 27 (6), 6215–6227. https://doi.org/10.1007/s11356-019-07177-5.

Lühmann, M., Vogelpohl, T., 2023. The bioeconomy in Germany: a failing political project? Ecol. Econ. 207, 07783. https://doi.org/10.1016/j.ecolecon.2023.107783.

Mäkitie, T., Hanson, J., Steen, M., Hansen, T., Andersen, A.D., 2022. Complementarity formation mechanisms in technology value chains. Res. Pol. 51 (7), 104559 https://doi.org/10.1016/j.respol.2022.104559.

Magnusson, T., Werner, V., 2023. Conceptualisations of incumbent firms in sustainability transitions: insights from organisation theory and a systematic literature review. Bus. Strateg. Environ. 32 (2), 903–919. https://doi.org/10.1002/bse.3081.

Maguire, S., Hardy, C., Lawrence, T.B., 2004. Institutional work in emerging fields: HIV/AIDS treatment advocacy in Canada. Acad. Manage J. 47 (5), 657–679. https://doi.org/10.5465/20159610.

Markard, J., Geels, F.W., Raven, R., 2020. Challenges in the acceleration of sustainability transitions. Environ. Res. Lett. 15 (8), 081001 https://doi.org/10.1088/1748-9326/ab9468.

Material Economics, 2019. Industrial Transformation 2050: Pathways to Net-Zero Emissions from EU Heavy Industries. University of Cambridge, Institute for Sustainability Leadership (CISL), Cambridge. https://materialeconomics.com/latest-updates/industrial-transformation-2050 (accessed: 20 February 2023).

Matthews, C., Moran, F., Jaiswal, A.K., 2021. A review on European Union's strategy for plastics in a circular economy and its impact on food safety. J. Clean. Prod. 283, 125263 https://doi.org/10.1016/j.jclepro.2020.125263.

Meyer, J.W., Scott, W.R., 1983. Organizational Environments. Sage Publications, Beverly Hills.

Micelotta, E., Lounsbury, M., Greenwood, R., 2017. Pathways of institutional change: an integrative review and research agenda. J. Manag. 43 (6), 1885–1910. https://doi.org/10.1177/0149206317699522.

Mokhlesian, S., Holmén, M., 2012. Business model changes and green construction processes. Constr. Manag. Econ. 30 (9), 761–775. https://doi.org/10.1080/01446193.2012.694457.

Monteiro, P., Nicolini, D., 2015. Recovering materiality in institutional work: prizes as an assemblage of human and material entities. J. Manag. Inquiry 24 (1), 61–81. https://doi.org/10.1177/1056492614546221.

Mubareka, S., Giuntoli, J., Sanchez Lopez, J., Lasarte Lopez, J., M'barek, R., Ronzon, T., Avraamides, M., 2023. Trends in the EU bioeconomy. JRC Science for Policy Report. Luxembourg: Publications Office of the European Union. https://data.europa.eu/doi/10.2760/835046.

Navis, C., Glynn, M.A., 2010. How new market categories emerge: temporal dynamics of legitimacy, identity, and entrepreneurship in satellite radio, 1990–2005. Admin. Sci. Quart. 55 (3), 439–471. https://doi.org/10.2189/asqu.2010.55.3.439.

Nelson, R.R., Rosenberg, N., 1993. Technical innovation and national systems (Ed.). In: Nelson, R.R. (Ed.), National Innovation systems: a Comparative Analysis. Oxford University, New York, Oxford, pp. 3–23.

OECD, 2021. Policies to Reduce Microplastics Pollution in Water. Focus on Textiles and Tyres. OECD, Paris. https://doi.org/10.1787/7ec7e5ef-en.

Oliver, C., 1991. Strategic responses to institutional processes. Acad. Manage. Rev. 16 (1), 145–179. https://doi.org/10.5465/amr.1991.4279002.

Oxford Economics, 2019. The global chemical industry: catalyzing growth and addressing our world's sustainability challenges. Report for the International Council of Chemical Associations (ICCA). Oxford Economics, Oxford. https://www.oxfordeconomics.com/recent-releases/the-global-chemical-industry-catalyzing-growth-and-addressing-our-world-sustainability-challenges (accessed 1 November 2021).

Paletta, A., Leal Filho, W., Balogun, A.L., Foschi, E., Bonoli, A., 2019. Barriers and challenges to plastics valorisation in the context of a circular economy: case studies from Italy. J. Clean. Prod. 241, 118149 https://doi.org/10.1016/j.jclepro.2019.118149.

Papadonikolaki, E., 2018. Loosely coupled systems of innovation: aligning BIM adoption with implementation in Dutch construction. J. Manage. Eng. 34 (6), 05018009 https://doi.org/10.1061/(ASCE)ME.1943-5479.0000644.

Pelli, P., Lähtinen, K., 2020. Servitization and bioeconomy transitions: insights on prefabricated wooden elements supply networks. J. Clean. Prod. 244, 118711 https://doi.org/10.1016/j.jclepro.2019.118711.

PlasticsEurope, 2019. *Plastics – the facts 2019. An analysis of European plastics production, demand and waste data. PlasticsEurope, Brussels.* https://plasticseurope.org/wp-content/uploads/2021/10/2019-Plastics-the-facts.pdf (accessed 8 August 2022).

PlasticsEurope, 2020. Plastics – the facts 2020. *An analysis of European plastics production, demand and waste data. PlasticsEurope AISBL and European Association of Plastic Recycling and Recovery Organisation (EPRO), Brussels.* https://www.plasticseurope.org/en/resources/publications/4312-plastics-facts-2020/ (accessed 11 January 2021).

PlasticEurope Germany, 2020. Statusbericht der deutschen Kreislaufwirtschaft. PlasticsEurope Deutschland e. V., Frankfurt am Main. https://plasticseurope.org/de/wp-content/uploads/sites/3/2021/11/Statusbericht_der_deutschen_Kreislaufwirtschaft_2020.pdf (accessed 15 September 2023).

Porc, O., Hark, N., Carus, M., Dammer, L., Bic, D.C., Knapsack, C., 2020. European bioeconomy in figures. https://biconsortium.eu/sites/biconsortium.eu/files/documents/European/20Bioeconomy/20in/20Figures/202008/20-/202018.pdf (accessed 8 August 2022).

Powell, W.W., Oberg, A., Korff, V., Oelberger, C., Kloos, K., 2017. Institutional analysis in a digital era: mechanisms and methods to understand emerging fields (Eds.). In: Krücken, G., Mazza, C., Meyer, R.E., Walgenbach, P. (Eds.), New Themes in Institutional Analysis. Edward Elgar Publishing, Northampton, UK, pp. 305–344.

Raaijmakers, A.G., Vermeulen, P.A., Meeus, M.T., Zietsma, C., 2015. I need time! Exploring pathways to compliance under institutional complexity. Acad. Manage J. 58 (1), 85–110. https://doi.org/10.5465/amj.2011.0276.

Raschka, A., Carus, M., 2014. Industrial Material Use of Biomass in Europe 2013. https://renewable-carbon.eu/publications/product/industrial-material-use-of-biomass-in-europe-2013-/e2/88/92-graphic/ (accessed 7 August 2021).

Repolho, J.V., 2017. Local experiments in transition processes to increasing circularity in the building sector. Master Thesis at Aalburg University. https://projekter.aau.dk/projekter/files/268197471/JVR_20171219_Msc_thesis_Sustainable_cities.pdf (accessed 1 November 2021).

Riedy, C., 2022. Discursive work: ethical meaning-making as a transformative practice for sustainable futures. Sustain. Sci. 17 (2), 541–554. https://doi.org/10.1007/s11625-021-00978-z.

Rosenbloom, D., Rinscheid, A., 2020. Deliberate decline: an emerging frontier for the study and practice of decarbonization. Wiley Interdiscip. Rev. Clim. Change 11 (6), e669. https://doi.org/10.1002/wcc.669.

Rosenboom, J.G., Langer, R., Traverso, G., 2022. Bioplastics for a circular economy. Nat. Rev. Mater. 7 (2), 117–137. https://doi.org/10.1038/s41578-021-00407-8.

Ruggiero, S., Kangas, H.L., Annala, S., Lazarevic, D., 2021. Business model innovation in demand response firms: beyond the niche-regime dichotomy. Environ. Innov. Soc. Transit. 39, 1–17. https://doi.org/10.1016/j.eist.2021.02.002.

Schirmeister, C.G., Mülhaupt, R., 2022. Closing the carbon loop in the circular plastics economy. Macromol. Rapid Commun. 43 (13), 2200247 https://doi.org/10.1002/marc.202200247.

Schot, J., Geels, F.W., 2007. Niches in evolutionary theories of technical change: a critical survey of the literature. J. Evol. Econ. 17, 605–622. https://doi.org/10.1007/s00191-007-0057-5.

Scott, W.R., 2003. Institutional carriers: reviewing modes of transporting ideas over time and space and considering their consequences. Ind. Corp. Change 12 (4), 879–894. https://doi.org/10.1093/icc/12.4.879.

Scott, W.R., 2008. Institutions and Organizations: Ideas and Interests. Sage Publications, Thousand Oaks third ed.

Siracusa, V., Blanco, I., 2020. Bio-polyethylene (Bio-PE), Bio-polypropylene (Bio-PP) and Bio-poly (ethylene terephthalate) (Bio-PET): recent developments in bio-based polymers analogous to petroleum-derived ones for packaging and engineering applications. Polymers (Basel) 12 (8), 1641. https://doi.org/10.3390/polym12081641.

Smith, B.D., 2007. Niche construction and the behavioral context of plant and animal domestication. Evol. Anthropol. Issues News Rev. 16 (5), 188–199. https://doi.org/10.1002/evan.20135.

Sotarauta, M., Suvinen, N., Jolly, S., Hansen, T., 2021. The many roles of change agency in the game of green path development in the North. Eur. Urban Reg. Stud. 28 (2), 92–110. https://doi.org/10.1177/0969776420944995.

Spekreijse, J., Lammens, T., Parisi, C., Ronzon, T., Vis, M., 2019. Insights into the European market for bio-based chemicals, EUR 29581 EN, Luxembourg: publications Office of the European Union. https://publications.jrc.ec.europa.eu/repository/handle/JRC112989 (accessed 20 February 2023).

Stark, S., Biber-Freudenberger, L., Dietz, T., Escobar, N., Förster, J.J., Henderson, J., Börner, J., 2022. Sustainability implications of transformation pathways for the bioeconomy. Sustain. Prod. Consum. 29, 215–227. https://doi.org/10.1016/j.spc.2021.10.011.

Stegmann, P., Londo, M., Junginger, M., 2020. The circular bioeconomy: its elements and role in European bioeconomy clusters. Resour. Conserv. Recy. X 6, 100029. https://doi.org/10.1016/j.rcrx.2019.100029.

Sunio, V., Gaspay, S., Guillen, M.D., Mariano, P., Mora, R., 2019. Analysis of the public transport modernization via system reconfiguration: the ongoing case in the Philippines. Transp. Res. Policy Pract. 130, 1–19. https://doi.org/10.1016/j.tra.2019.09.004.

Thornton, P.H., Ocasio, W., 1999. Institutional logics and the historical contingency of power in organizations: executive succession in the higher education publishing industry, 1958–1990. Am. J. Sociol. 105 (3), 801–843. https://doi.org/10.1086/210361.

Turnheim, B., Sovacool, B.K., 2020. Forever stuck in old ways? Pluralising incumbencies in sustainability transitions. Environ. Innov. Soc. Transit. 35, 180–184. https://doi.org/10.1016/j.eist.2019.10.012.

Van Assche, K., Duineveld, M., Beunen, R., Valentinov, V., Gruezmacher, M., 2022. Material dependencies: hidden underpinnings of sustainability transitions. J. Environ. Pol. Plan. 24 (3), 281–296. https://doi.org/10.1080/1523908X.2022.2049715.

Van de Poel, I., 2000. On the role of outsiders in technical development. Technol. Anal. Strateg. 12 (3), 383–397. https://doi.org/10.1080/09537320050130615.

Van Lancker, J., Wauters, E., Van Huylenbroeck, G., 2016. Managing innovation in the bioeconomy: an open innovation perspective. Biomass Bioenerg. 90, 60–69. https://doi.org/10.1016/j.biombioe.2016.03.017.

van Mossel, A., van Rijnsoever, F.J., Hekkert, M.P., 2018. Navigators through the storm: a review of organization theories and the behavior of incumbent firms during transitions. Environ. Innov. Soc. Transit. 26, 44–63. https://doi.org/10.1016/j.eist.2017.07.001.

van Oers, L., Feola, G., Moors, E., Runhaar, H., 2021. The politics of deliberate destabilisation for sustainability transitions. Environ. Innov. Soc. Transit. 40, 159–171. https://doi.org/10.1016/j.eist.2021.06.003.

Verband der Chemischen Industrie (VCI), 2019. Auf einen blick - chemische industrie 2018. VCI, Frankfurt am Main. https://www.vci.de/vci/downloads-vci/publikation/chemische-industrie-auf-einen-blick.pdf (accessed 23 October 2020).

Vereniging van de Nederlandse Chemische Industrie (VNCI), 2020. Over de chemie. https://www.vnci.nl/over-de-chemie (accessed 23 October 2020).

Vormedal, I., Bjander, J., Larsen, M.L., Lindberg, M.B., 2023. Technological change and the politics of decarbonization: a *re*-making of vested interests? Environ. Innov. Soc. Transit. 47, 100725 https://doi.org/10.1016/j.eist.2023.100725.

Warner, M., 2015. What makes scale-up of industrial biotechnology so difficult? http://www.biofuelsdigest.com/bdigest/2015/12/02/what-makes-scale-up-of-industrial-biotechnology-sodi_cult/(accessed 6 July 2020).

Weber, K.M., Schaper-Rinkel, P., 2017. European sectoral innovation foresight: identifying emerging cross-sectoral patterns and policy issues. Technol. Forecast. Soc. Change 115, 240–250. https://doi.org/10.1016/j.techfore.2016.09.007.

Wiesinger, H., Wang, Z., Hellweg, S., 2021. Deep dive into plastic monomers, additives, and processing aids. Environ. Sci. Technol. 55 (13), 9339–9351. https://doi.org/10.1021/acs.est.1c00976.

Wijen, F., Ansari, S., 2007. Overcoming inaction through collective institutional work: insights from regime theory. Organ. Stud. 28 (7), 1079–1100. https://doi.org/10.1177/0170840607078115.
Wilde, K., Hermans, F., 2021a. Deconstructing the attractiveness of biocluster imaginaries. J. Environ. Pol. Plan. 23 (2) https://doi.org/10.1080/1523908X.2021.1891872.
Wilde, K., Hermans, F., 2021b. Innovation in the bioeconomy: perspectives of entrepreneurs on relevant framework conditions. J. Clean. Prod 314, 127979. https://doi.org/10.1016/j.jclepro.2021.127979.
Wittmayer, J.M., Avelino, F., van Steenbergen, F., Loorbach, D., 2017. Actor roles in transition: insights from sociological perspectives. Environ. Innov. Soc. Transit. 24, 45–56. https://doi.org/10.1016/j.eist.2016.10.003.
Wohlin, C., 2014. Guidelines for snowballing in systematic literature studies and a replication in software engineering. In: Proceedings of the 18th International Conference on Evaluation and Assessment in Software Engineering - EASE ', 14, pp. 1–10. https://doi.org/10.1145/2601248.2601268.
Wooten, M., Hoffman, A.J., 2017. Organizational fields past, present and future (Eds.). In: Greenwood, R., Oliver, C., Sahlin, K., Suddaby, R. (Eds.), The Sage Handbook of Organizational Institutionalism. Sage Publications, London, pp. 55–74. http://digital.casalini.it/, 978152641 5059 fields asrelational space.
Wydra, S., Hüsing, B., Köhler, J., Schwarz, A., Schirrmeister, E., Voglhuber-Slavinsky, A., 2021. Transition to the bioeconomy–analysis and scenarios for selected niches. J. Clean. Prod. 294, 126092 https://doi.org/10.1016/j.jclepro.2021.126092.
Zhao, E.Y., Fisher, G., Lounsbury, M., Miller, D., 2017. Optimal distinctiveness: broadening the interface between institutional theory and strategic management. Strateg. Manag. J. 38 (1), 93–113. https://doi.org/10.1002/smj.2589.
Zietsma, C., Lawrence, T.B., 2010. Institutional work in the transformation of an organizational field: the interplay of boundary work and practice work. Admin. Sci. Quart. 55 (2), 189–221. https://doi.org/10.2189/asqu.2010.55.2.189.
Zietsma, C., Groenewegen, P., Logue, D.M., Hinings, C.R., 2017. Field or fields? Building the scaffolding for cumulation of research on institutional fields. Acad. Manag. Ann. 11 (1), 391–450. https://doi.org/10.5465/annals.2014.0052.

Further readings

Archer, M.S., 1995. Realist Social Theory: The Morphogenetic Approach. Cambridge University Press, Cambridge.
Geels, F.W., Schot, J., 2000. Typology of sociotechnical transition pathways. Res. Pol. 36 (3), 399–417. https://doi.org/10.1016/j.respol.2007.01.003.
Germany Trade & Invest (GTAI), 2021. Plastics industry – industry and market numbers. https://www.gtai.de/gtai-en/invest/industries/materials-processing/plastics#77334 (accessed 27 June 2021).

3 Discussion and conclusions

The bioeconomy mission of STI policies in Europe envisages broad-based sustainability transitions in order to radically change current approaches to production, consumption and disposal of biological resources and thereby advance SDG attainment. The mission addresses the deep structural entrenchment of production modes, value chains, product use and disposal practices that are based on fossil fuel extraction. The socio-material bases of established practices do have a long history and are shaped under conditions of global power imbalances (Arora and Stirling, 2023). Systemic change, therefore, calls for concerted action across governance levels as well as for substantial and dogged efforts of different stakeholder groups around the globe. This thesis analysed perspectives and institutional work of core bioeconomy stakeholders at the local and regional level of several regions in North-Western Europe. The results of questioning into bioeconomy stakeholders' sociotechnical imaginaries, entrepreneurs' evaluation of perceived context conditions and different stakeholders' institutional work have been discussed separately above. This section contains reflections on the insights that emerge from the combination of main findings.

3.1 Stalled transition

Based on the analysis of bioeconomy discourses and their representation of three distinct sociotechnical imaginaries (bioecology, bioresources, biotech), we found a large majority of respondents in two European biocluster regions subscribing to a mixed bioecology-bioresource-narrative. It goes along with the rejection of any policy or innovation endeavour that aims to disrupt the status quo in a speedy or substantial manner. A good life for everybody shall come about through a transition to a more sustainable mode of production without anybody being forced to make difficult choices or embark on radical life style changes. This narrative mirrors the European 2018-version of a bioeconomy strategy. The latter confirms the original objective to replace fossil resources with renewable biomass but also highlights the need to restrict the use of biomass to the boundaries of healthy ecosystems. As highlighted by Giuntoli et al. (2023), a utilitarian view of nature and the economic growth perspective dominate. A longitudinal analysis of online bioeconomy debates in Europe meanwhile diagnosed a discursive lock-in with positions that were simplified and polarised. Starke et al. (2023) contrasted an economic growth-oriented 'Green future' coalition with a 'Planetary boundaries' coalition that is highlighting environmental trade-offs.

The group of actors subscribing to the dominant bioecology-bioresource-narrative (see section 2.1) was composed of a very diverse set of stakeholders, including government officials, political actors in regional development, environmental NGOs, innovative SMEs, R&D service providers and university professors. However, the larger group of bioeconomy entrepreneurs interviewed separately (section 2.2) pointed to substantial innovation hurdles on that path. Policy was expected to initiate serious societal discourse on realistic objectives and the necessary changes in customer demand preferences. Governments were called on to design fiscal measures which could lead to conducive fossil-versus-biobased and global-versus-local factor price relations. The main responsibility for unfavourable conditions holding back bioeconomy innovation was located at national and international governance levels . Some entrepreneurs were in favour of outright market control and use restrictions for fossil feedstocks. According to their evaluation, neither 'pull' incentives nor 'push' forces were sufficiently institutionalised for industrial actors to abandon current (fossil-fuel-based) production routines or trustfully launch biobased innovation endeavours.

It follows that a lack of a societal consensus over the significance and definition of problems or attainable objectives (the first article's diagnosis) is perceived by bioeconomy entrepreneurs as an innovation hurdle. Innovation willingness and innovation capacities of actors were not identified as holding back transitions. Instead entrepreneurs across all three industries and two cluster regions highlighted blurred objectives of bioeconomy promotion, insufficient competence and effort in policy design and the orchestration of its implementation across different sectors and multiple governance levels to cause stalled transition. Deficits of "comprehensiveness", "credibility", and "consistency of elements" are diagnosed with respect to the perceived bioeconomy policy. The results of sections 2.1 and 2.2 concur: „No significant change“ is most likely to happen. In essence, findings from the bottom-up analysis correspond to the shortcomings discussed by Rogge and Reichardt (2016) in view of the decarbonisation of energy supply in Europe. They proposed that a policy objective to redirect and accelerate technological change towards sustainability objectives, calls for an extended, interdisciplinary policymix concept.

The research approach of article three resulted in a more nuanced picture of the industry-differentiated context conditions in the three industries' exchange fields. We identified comparatively 'barricading' conditions in the chemical industry and comparatively 'exhausting' conditions for actors' institutional work in the construction materials industry. Thus, the surface phenomenon of stalled transition can obviously be caused by different sets or types of field conditions in the background. Different pattern of bioeconomy actors' institutional work provide evidence for decisive distinctions between exchange fields. If confirmed by further studies in other industries, these findings might prove extremely useful for policy-makers: they point to different leverage points. Dedicated policies could re-shape field conditions and thereby incapacitate specific institutional transition hurdles. Industry-specific bioeconomy promotion can empower and support those actors who already invest own resources and have a strong interest in sustainability transition – whether these are progressive incumbents, young or old 'born green' actors.

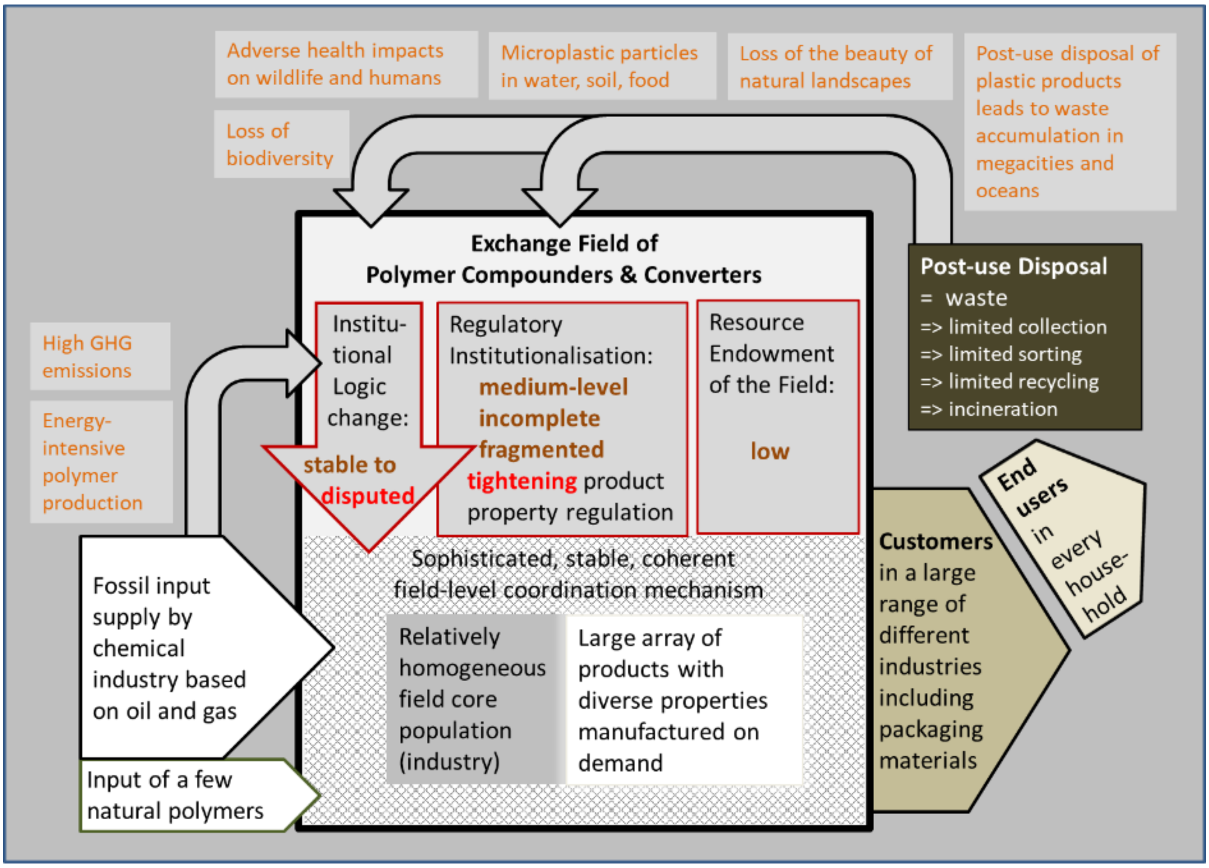
3.2 Evolving transition

The incongruities of a variety of institutions at national and international levels as well as blockading factors in the relevant quality assurance regimes of IS were often mentioned during interviews with entrepreneurs. Analysing the institutional field conditions prevalent in the chemical, plastic and construction materials industries separately in section 2.3, led to the identification of comparatively 'enabling' conditions in the exchange field of polymer compounders and converters (in short: plastic industry). It is important to underline once again that 'enabling' is a relative term in comparison to the institutional field conditions in two other industries. All three industrial fields were only studied in North-Western Europe. We did also not mean to imply that field conditions of the plastic industry are in an optimal shape for sustainability transition.

Figure 9 visualises the field-external forces that would be labelled 'pressures at the socio-technical landscape level' within an MLP-based study. Using the field concept allows to link these forces to empirical observations of institutional logic change and tightening regulation in the exchange field under study. Relevant influences on the plastic industry's field logics originate mainly from new scientific evidence, media coverage of plastic waste mountains, and societal activism on post-use impact. The fact that the diverse product range of the industry brings virtually every citizen in daily contact with a few plastic items might be decisive for the comparatively high societal awareness and the emergence of transformative forces. In comparison with the other two industries under study, it clearly follows that the position on an industry in a specific value chain or value network must be included in the analysis that serves to inform bioeconomy policy.

The main institutionalised plastic post-use disposal pattern not only impact the plastic industry's field: they also erode the legitimacy of upstream and some segments of downstream exchange partners. The same applies to the associated global emissions. Karali et al. (2024) recently published widely noted evidence: in 2019 the equivalent of 600 coal-fired power plants' emissions were released along the plastic value chain. More than two thirds of these emissions occur prior to polymerization - outside the field of polymer compounders and converters. The disputed field logics encourage governments to set use restrictions, tighten and round the porous regulation for plastic products and additives (see e.g. Wiesinger et al., 2021).

Figure 9 The exchange fields of polymer converters and (field-external) transformative forces



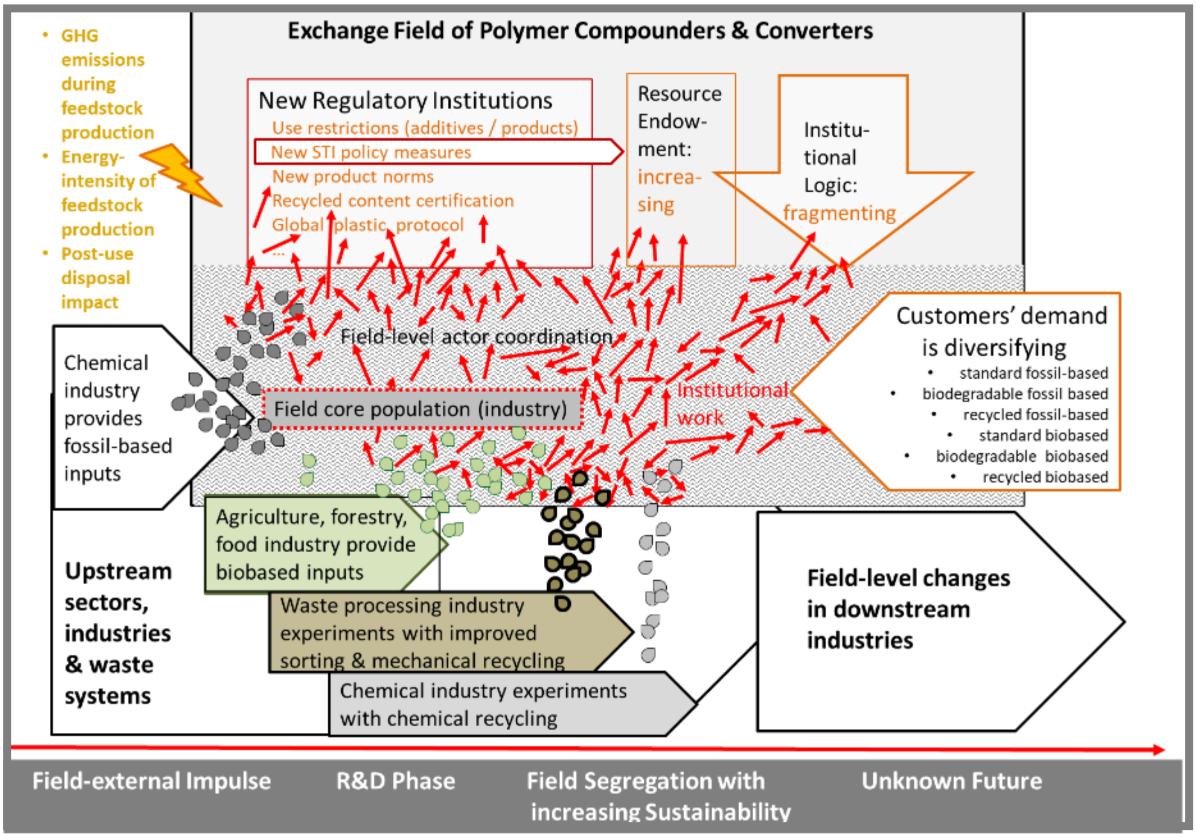
Combining insight from articles two and three, the emergent change of field conditions can be visualised with actor engagement (see Figure 10). The material, relational and discursive institutional work of core field actors has been documented in section 2.3. Material work makes use of R&D results on biobased inputs, mechanically or chemically recycled fossil feedstocks to revise unsuitable norms and testing protocols. Actors also promote completely new regulatory institutions (norms, laws, policies) on biobased and recycled feedstocks. Product and quality testing standards are of very high relevance to all entrepreneurs of the industry because they strengthen producers' legitimacy on global markets. In view of standards and norming, incumbents and bioeconomy innovators often have congruent interests in new research insights. A multitude of concerns can be addressed with joint forces, such as "continued confusion regarding terminology" (Fletcher et al., 2021), „unobservable quality" causing „costly signalling" (Baskoro et al., 2024) or "environmental anarchy" resulting from limited public awareness on the degradability of polymers (Nizamuddin et al., 2024). New knowledge then represents a new field resource. The same applies to new bioeconomy-promoting or sustainability-driven STI policy measures, like e.g. circularity promotion, R&D incentives or market entry support for new sustainable products.

Most actors in the plastic industry still have limited experience with new biobased feedstocks (e.g. Wesseling et al., 2017). As the group of industrial core actors is dominated by SMEs and nobody has a perfect solution to scale, field-internal and cross-field experimentation and R&D efforts set off (e.g. Coates and Getzler, 2020; Cywar et al., 2022; Law and Narayan, 2022; Shi et al., 2024; Uekert et al., 2023). Available evidence confirms that access to new feedstocks represents a major bottleneck of progressive incumbents. This challenge induces much of the observed actor efforts to restructure and extend their value chain relations, as also observed by Foschi et al. (2023).

Product and process innovations in the European plastic industry are mostly unfolding in niche markets and in close cooperation with pioneering customers. Here, trust in informal institutions among known partners can compensate for the lack of adequate formal institutionalisation of quality norms (see also Webb et al. 2020). As their context conditions change with tightening regulation, the demand of customers adapts in such a way that small markets opportunities for biobased, biodegradable and recycled plastic have emerged. These developments are part of ongoing - 'normal' - market evolution but apparently occur at a comparatively large scale. Hence, the field of polymer conversion is in a process of segregation where different types of core actors specialise in handling different new feedstocks.

The respective environments are different from what is termed a „technological niche" in the MLP (e.g. Geels and Schot, 2007). The existence of the latter requires some kind of 'protection' on the basis of either the strength of a group of powerful industrial players or policy. National and regional governments may enact either dedicated exemptions of normal regulation and standards or technology-specific R&D support schemes and infrastructural arrangements (see Smith and Raven, 2012). These kind of technology-specific shielding mechanism have not been observed in the field of polymer compounders – at least not to an extent beyond 'normal' regional/national innovation and growth promotion. Future research will have to explore in which cases it may really be useful to „keep landscape and niche interactions as separate variables that can interact with the regime in different ways" (Geels and Schot, 2007, 402).

Figure 10 Institutional work in the exchange fields of polymer converters and signs of behavioural change among direct value chain partners



The article in section 2.3 proposed that an industry's field conditions, combined with the actors' characteristics, shape the pattern of institutional work. It has to be underlined that this statement does not imply that materialities like the Earth's biophysical limits to biomass production and the absorption of noxious matter were irrelevant. A given bio-based resource endowment of a place, region, country is to be understood as part of a set of background (or 'landscape') factors which have enabled and shaped the emerging socio-economic systems and unique metabolic relationships with the natural world (e.g. Haberl et al., 2021; Haberl et al., 2023; Muscat et al., 2021b). This interaction is especially relevant for prospects of transition towards a bioeconomy (Schlaile et al., 2024). As observed by Foschi et al. (2023), the 20 European compounding sites are mostly backwards-integrated on intermediate or even base chemicals. It is therefore not the bio-based resource endowment of a place that led to its establishment in a specific location but the logistic arrangements of the upstream industry. Therefore, institutional work of bioeconomy actors in this branch of industry has to also address missing or misaligned infrastructural conditions in most locations. Respective facilities are subsumed in a fields' resource endowment.

Figure 10 hints at functional and structural couplings between industries. Earlier research has provided evidence for multi-system interactions across geographic boundaries socio-technological systems, fields, and countries (e.g. Andersen et al., 2020; Arora and Stirling, 2023; Grimm and Walz, 2024; Rosenbloom and Rinscheid, 2020). Accordingly, weaker fields (like those of the plastic and construction materials industries) may be dominated by stronger ones with ample resources and power concentration. Recent research affirms the relevance of concentrations of influence, privilege and power on transition within and across fields (Geels and Gregory, 2024; Kloo et al., 2024; Kok et al, 2021). During their study of the interface of residential storage systems and electric vehicles in Germany, Käsbohrer et al. (2024), for example, found resource-rich incumbents from adjacent fields approaching the new market segment. These powerful actors were aiming to gain new knowledge, eventually integrate disruptive technologies with attractive market prospects, and strengthen their own legitimacy. Once the traditional logics of the adjacent field of industry is experiencing pressure on sustainability grounds, this behavioural pattern suggests itself.

In the case of polymer compounders and converters, some powerful customers were mentioned by interviewees to strengthen their position in the field by also acting as suppliers of (used / recycled) new feedstocks. Suitable biobased feedstocks were found hard to access, may take years to grow in the required quantities or to explore in view of performance-advantaged properties. Biobased feedstock supplies also have a seasonal rhythm and create new challenges in terms of biomass pre-processing and storage. Actors are eventually forced to deal with large numbers of feedstock suppliers where, previously, they could rely on very few suppliers of standardised bulk polymers. Therefore, figure 10 is meant to also visualise polymer compounders and converters subjected to considerable tension: a field being simultaneously squeezed and torn apart by dynamics in downstream and upstream fields. While a segment of consumers and part of the plastic industry's customers look out for more sustainable solutions, there is struggle in and with the upstream sectors and industries on which type of feedstock truly is a sustainable solution, who has to change established practices, and who can appropriate which share of profits. With diverse sets of economic value networks involved, the direction of the field's evolution might *not* be determined inside the field.

3.3 Agency in transition

In transition studies, institutional work has been characterised as one of the actors' core activities in order to influence the dominant regime (Löhr et al., 2022). As already underlined by Markard et al. (2016), firms, industries and technologies only expand and survive with societal legitimacy. The transition case description of Kukk et al. (2016), for example, perfectly describes institutional power play in the context of health sector innovation. It also highlights that entrepreneurs often cannot change relevant institutions directly and need to act strategically. From the perspective of neo-institutional theory, it is indispensable for all core actors to establish the legitimacy of their undertakings within the field. Otherwise, their membership might be questioned. Entrepreneurship research, by contrast, understands institutional work as part and parcel of enterprising behaviour. The opportunities of interest to entrepreneurs may result from ideas and beliefs about things "favourable to the achievement of possible valuable ends" (Sarasvathy et al., 2010, p. 143). They represent promising and actionable occasions or resources to generate new products, companies, markets, or institutions. IS research identifies entrepreneurial actors with the act of transforming inventions into what can (with societal evaluation) be called innovation (ex-post) and institutional work is necessarily included in entrepreneurial efforts in this stream of research as well.

In a study on the bioeconomy, it is also worth noting that stereotyped „normal" entrepreneurs can hardly be contrasted in a convincing way with social, green, sustainability-driven or transformational entrepreneurs (e.g. Halberstadt et al., 2024). Usually, there's a multitude of different groups of incumbents (Kump, 2023; Stirling, 2019; Turnheim and Sovacool, 2020). Most scholars meanwhile concluded that sustainability transitions of whole industries and socio-economic systems requires mutual coevolution of new entrants and incumbents (e.g. Haldar, 2019). As shown in section 2.3, core movers of sustainable production and consumption may be found in both groups. While transition research has so far been focussed on 'radical' innovation, future research will reveal whether a focus on 'epistemic outsiders' (Spatan et al., 2024) is in fact helpful. These actors have been labelled 'extreme' in the entrepreneurship research stream (Johannisson and Wigren, 2006) and are a rare phenomenon.

3.4 Outlook on future research on an emerging bioeconomy

While a central concern of the MLP is the explanation for the origin of radical innovation in specific socio-technical systems, IS research is often meant to explain superior or sub-standard national, regional or sectoral innovation performance. Both of these questions are fundamentally different from the quest for systemic change towards a bioeconomy. This research contributes to a (relatively) new stream of transition literature with a focus on agency, the perspectives and interests of individuals. While discourse analysis is a firmly established research method, it is the application of Q-methodology that allows to investigate the take-up of general societal discourses by specific actor populations. The data basis of the article in section 2.1 could have been larger if the onset of the corona crisis had not forced potential respondents into their home offices. However, the absolute sample size is of minor relevance in Q-methodology. A broad range of perspectives held by different actor types were covered and used for the identification of statistically distinct discourses. The methodology might increasingly be used to compare imaginaries across administrative scales (e.g. Parkins and Sherren, 2021). It could also be employed to analyse the logics of one sector and sociotechnical imaginaries in a specific segment of an emerging bioeconomy.

According to article 2 results, STI policies at the European, national and regional levels designed in support of a bioeconomy do not match the expectations and needs of entrepreneurs connected by bioeconomy cluster initiatives in North-Western Europe. Their call for consistent policy formulation and implementation confirms the malfunction diagnosis of concerned researchers (e.g. Mazzucato; 2018; Chaminade, 2020; Diercks et al., 2019; Nong et al., 2020). Could the empirical evindence have been stronger with a quantitative research design? Some arguments support a negative response:

- As explained by e.g. Wackerbauer (2020), empirical investigations of an emergent bioeconomy are severly hampered by the current organisation of standards economic statistics which do not account for specific types of inputs of a product.
- The original intention to use European standard industry classification system (NACE) to sort cluster members could have built on Ehrenfeld and Kropfhäußer (2017). It was abandoned when

it became obvious that single companies would have to be registered with several codes. The expected results would have hardly contributed valuable insight.

- Analysis of some quantitative data from the German cluster members might have been possible because member fees required proper recording. In the Dutch case, cluster membership was intentionally kept fluid: those companies active in cluster initiatives at a given point of time were referred to as members by the cluster leadership. No central registry was maintained.

Dedicated conceptual aproaches (e.g. Sturm et al., 2023) or web-mining and machine learning techniques (see e.g. Kriesch and Losacker, 2024) may help to overcome these challenges. However, it remains a unique feature of qualitative research to support the exploration of a new field. It can provide perspectival knowledge through detailed, contextualised and insightful information.

It is possible to adjust the MLP for a better fit with transitions in larger-scale consumption-production systems (Geels et al., 2023). The resulting 'big picture' is, nevertheless, precluding relevant insight into agency. It does not answer why and when actors invest own resources in institutional work. Building on a different stream of research (Fuenfschilling, 2019; Fuenfschilling and Truffer, 2014), the institutionalisation of specific regime structures was studied in greater detail. Article 3 aimed at a more accurate depiction of the reality within specific industries. Attention was drawn to the different positions that specific branches of industry occupy in increasingly complex and global value networks. Moreover, specific field-external factor constellations were highlighted because they hold the potential to spur or prevent field-level change. Logic shifts in specific branches of industry appear to be a fruitful ground for new insight. What are triggers for behavioural changes of consumers? Formal and informal institutional voids seem to attract increasing interest in transition research as well as in the entrepreneurship literature (e.g. Daou et al., 2024; Doh et al., 2017; Webb et al., 2020). Both are highly relevant for an improved understanding of an emerging bioeconomy.

The relations between the primary sector and specific bioeconomy segments of industry are not explored in this thesis. They are definitely of utmost relevance for the further promotion of transitions towards a bioeconomy and may be addressed by experts in plant-, animal- and mushroom-based production lines or waste processing. However, different options to segregate the analysis in line with feedstocks are bound to strengthen a reductionist perception of the societal and ecological functions of seascapes and landscapes. Joxe and Bahers (2024) recently proposed to combine socioecological analysis of biomass flows with the relevant sociopolitical dimensions instead. This appears to be a promising research avenue - especially in view of a circular bioeconomy.

3.5 Conclusion

With the broad and multi-facetted concept of a "bioeconomy", it is important to properly define what is meant by the concept, who is concerned and what the potential implication of a sustainability transition are in the context of specific regions and global biophysical limits. As shown in section 2.1, the socio-technical imaginaries connected to the term and proclaimed goals are highly diverse, partially conflicting or unrealistic. This dissertation helps to identify some of the overlapping discourse elements that could be used to build societal legitimacy for considerable regulatory, behavioural and policy adjustments that are necessary for a sustainability transition.

The perspectives of actors in newly emerging cross-industry value chains of a bioeconomy differ from common expectations as shown in section 2.2. While place-based promotion efforts are important, entrepreneurial actors underlined the need for strengthened attention to regional, national, and international conditions: they perceive innovation opportunities blocked by unfavourable or misaligned institutions. Modernised and faster norming, testing and certification mechanism for new biobased products appear to be of crucial importance. Moreover, transformation-oriented innovation policy is challenged to more consistently channel efforts towards the retrenchment of practices based on fossil resource extraction, end tolerance of unjust economic privileges and irresponsible behaviour.

Insights from neo-institutional theory hold the potential to facilitate an improved understanding of 'transitions-in-the-making' and the agency at work. Entrepreneurial actors interactive learning, technological experimentation and institutional work appears to be triggered by disputed field logics especially when the industry is dominated by SMEs, customers are divers and the value chain is comparatively short. The typology differentiating barricading, exhausting and enabling institutional environments in specific industries might have to be complemented with insights from other places and industries. However, it opens up new research perspective on dynamics and multi-system interactions in sustainability transitions. The typology also provides substance to the first articles' argument: as conditions can differ substantially between branches of industry, there is not a single bioeconomy. Policy initiatives promoting an emerging bioeconomy, thus, require high attention to differing value networks and the prevailing institutional conditions in specific sectors and different branches of industry.

4 Summary

This thesis explores the vantage points and contextualised activities of bioeconomy actors. More specific, it asks how bioeconomy stakeholders' sociotechnical imaginaries, their perception of context conditions and their institutional work contribute to the current status of an emerging bioeconomy. Theoretical concepts from institution theory, IS and STS research were employed to study:

a) The relevant varieties of sociotechnical imaginaries that shape stakeholder attitudes towards bioclusters and the bioeconomy;
b) Industrial actors' perceptions of those context conditions, that shape their assessment of the desirability and feasibility of bioeconomy opportunity structuration and exploitation;
c) The patterns of the main bioeconomy actors' institutional work that emerge in response to institutional conditions in different industries.

Empirical research focussed on stakeholder in and around two old and similar bioeconomy clusters in North-Western Europe. Interviews and survey data were subjected to quantitative and qualitative analysis. Main results consist of the following components:

- Five distinct narratives were identified to exist in the cluster regions combining different elements of the three guiding sociotechnical imaginaries of a bioeconomy, namely: 'bioecology', bioresources' and 'biotech'. The narrative supported by most and a broad range of respondents combines high appreciation of the bioecology and bioresource imaginaries. As certain imaginaries are rejected by each narrative, controversial relations of the distinct storylines and supporting actor groups emerged in both bioeconomy cluster regions. The popularity of the cluster concept meanwhile helped the bioeconomy concept to gain traction.
- The identification of hurdles to and drivers of strengthened, bioeconomy-related innovation capabilities and opportunities perceived by industrial actors in the chemical, polymer compounding and processing, and construction materials producing industries led to evidence for actors' perception being strongly coined by conditions in the wider socio-economic framework, the shape of value networks and actors' positions therein. Their innovation willingness and innovation capacities were found to mutually reinforce each other. According to bioeconomy experts, neither 'pull' incentives nor 'push' forces have been adequately institutionalised to prompt a re-evaluation of current fossil-fuel-based production routines or to offer strong prospects for the success of biobased innovations.
- The exchange field concept was operationalised for empirical study of the three industries and inter-field comparisons. The differing institutional field conditions led to a differentiation of ‚barricading', ‚enabling', and ‚exhausting' environments with respect to actors' (discursive, relational and material) institutional work. Thus, specific combinations of field conditions may spur, impede or prevent actor-driven field-level change. Findings on the characteristics of ‚born green' actors or ‚progressive incumbents' and the differing pattern of institutional work by actors from industry, research and intermediation support those transition scholars who call for more attention to 'hybrid' actors or observe shifts of actors' positions over time.

Policy initiatives promoting an emerging bioeconomy, thus, require high attention to differing value networks and the prevailing institutional conditions in specific sectors and different branches of industry. Based on overall results, multi-system interactions were highlighted to be especially relevant for further research on sustainability transitions towards an emerging bioeconomy.

5 Zusammenfassung

Diese Dissertation untersucht die Perspektiven und kontextualisierten Aktivitäten von Bioökonomie-Akteuren. Konkret geht es um die Frage, wie die soziotechnischen Vorstellungen von Akteuren, ihre Wahrnehmung von Kontextbedingungen und ihre institutionelle Arbeit zum aktuellen Status einer entstehenden Bioökonomie beitragen. Mit theoretische Konzepten aus der Institutionentheorie und der Transitionsforschung wurden untersucht:

a) Die relevanten Varianten soziotechnischer Vorstellungen, die die Einstellung der Interessengruppen zu Bioclustern und der Bioökonomie prägen;
b) Die Wahrnehmung der Kontextbedingungen durch industrielle Akteure, ihre Bewertung der Attraktivität und Durchführbarkeit von Maßnahmen zur Strukturierung und Ausnutzung von Innovationsmöglichkeiten;
c) Die Muster der institutionellen Arbeit von Akteuren, die in Reaktion auf unterschiedliche institutionelle Kontextbedingungen in verschiedenen Industriebranchen entstehen.

Empirisch konzentriert sich die Arbeit auf Stakeholder in und um zwei alte und ähnliche Bioökonomie-Cluster in Nordwesteuropa. Interviews und Umfragedaten wurden quantitativen und qualitativen Analysen unterzogen. Die Hauptergebnisse bestehen aus den folgenden Komponenten:

- In den Clusterregionen wurden fünf unterschiedliche Narrative identifiziert, die verschiedene Elemente der drei soziotechnischen Vorstellungskonzepte einer Bioökonomie kombinieren, nämlich „Bioökologie", „Bioressourcen" und „Biotechnologie". Die von den meisten und einem breiten Spektrum der Befragten unterstützte Erzählung verbindet eine hohe Wertschätzung der Bioökologie- und Bioressourcenvorstellungen. Da bestimmte Vorstellungen in jedem der Narrative abgelehnt werden, entstehen kontroverse Beziehungen zwischen den unterschiedlichen Zukunftserzählungen und ihren jeweiligen Unterstützern. Die Popularität des Cluster-Konzepts trägt dennoch dazu bei, das Bioökonomie-Konzept zu verankern.
- Die Identifizierung von Hürden und Treibern von bioökonomiebezogenen Innovationsfähigkeiten und -chancen, die von industriellen Akteuren in der Chemie-, Plastik- und Baustoffindustrie wahrgenommen werden, führte zu Belegen dafür, dass die Wahrnehmung der Akteure stark von den Rahmenbedingungen des Weiteren makroökonomischen und internationalen Umfelds, der Struktur von Wertschöpfungsnetzwerken und den jeweiligen Positionen der Akteure geprägt ist. Die Innovationsbereitschaft und die Innovationskapazitäten industrieller Akteure stärken sich gegenseitig. Ihrer Meinung nach seien weder „Pull"-Anreize noch „Push"-Kräfte ausreichend institutionalisiert, um aktuelle (auf fossilen Brennstoffen basierende) Produktionsabläufe zu überdenken oder gute Erfolgsaussichten für biobasierte Innovationen zu bieten.
- Das Konzept eines institutionellen Austauschfeldes wurde für eine vergleichende empirische Analyse der drei Industrien operationalisiert. Die unterschiedlichen institutionellen Feldbedingungen wurden in Bezug auf die institutionelle Arbeit der Akteure (diskursiv, relational und materiell) als ‘verbarrikadierte’, ‘ermöglichende’ und ‘erschöpfende’ Umgebungen charakterisiert. Somit können spezifische Kombinationen von Feldbedingungen akteursgesteuerte Veränderungen in einem institutionellen Feld anregen, be- oder verhindern.

  Erkenntnisse zu den Merkmalen von ‘grün-geborenen’-Akteuren bzw. ‘progressiven etablierten Unternehmen’ und den verschiedenen Mustern institutioneller Arbeit von Akteuren aus Industrie, Forschung und Intermediation stützen Stimmen aus der

Transitionsforschung, die mehr Aufmerksamkeit für „hybride“ Typen von Akteuren fordern oder Verschiebungen von Akteurspositionen im Zeitverlauf beobachten.

Politische Initiativen zur Förderung einer entstehenden Bioökonomie erfordern folglich viel Aufmerksamkeit für unterschiedliche Wertschöpfungsnetzwerke und die institutionellen Bedingungen in spezifischen Sektoren, Industrien und Industriebranchen. Auf der Basis der Gesamtergebnisse empfehlen sich insbesondere Multisystem-Interaktionen als besonders relevant für weitere Erforschung von Nachhaltigkeitstransformation in Richtung einer Bioökonomie.

6 References

Ács, Z.J., Autio, E., Szerb, L., 2014. National systems of entrepreneurship: measurement issues and policy implications. Res. Pol. 43(3), 476–494. https://doi.org/10.1016/j. respol.2013.08.016.

Aguilar, A., Twardowski, T., Wohlgemuth, R., 2019. Bioeconomy for sustainable development. Biotechnol. J. 14(8), 1800638. https://doi.org/10.1002/biot.201800638.

Albrecht, K., Ettling, S., 2014. Bioeconomy strategies across the globe. Rural 21. The Int. J. Rural Dev. 48(3), 10-13. Available at http://www.rural21.com/english/current-issue/detail/article/bioeconomy-strategies-across-the-globe-00001224/.

Alvarez, S.A., Barney, J.B., 2013. Epistemology, opportunities, and entrepreneurship: comments on Venkataraman et al. (2012) and Shane (2012). Acad. Manag. Rev. 38(1), 154–157. https://doi.org/10.5465/amr.2012.0069.

Alvesson, M., Spicer, A., 2019. Neo-institutional theory and organization studies: a mid-life crisis? Organ. Stud. 40(2), 199–218. https://doi.org/10.1177/0170840618772610.

Amdam, R.P., Lunnan, R., Bjarnar, O., Halse, L.L., 2020. Keeping up with the neighbors: The role of cluster identity in internationalization. J. World Bus. 55(5), 101125. https://doi.org/10.1016/j.jwb.2020.101125.

Andersen, A.D., Gulbrandsen, M., 2020. The innovation and industry dynamics of technology phase-out in sustainability transitions: Insights from diversifying petroleum technology suppliers in Norway. Energy Res. Soc. Sci. 64, 101447. https://doi.org/10.1016/j.erss.2020.101447.

Andersen, A.D., Steen, M., Mäkitie, T., Hanson, J., Thune, T.M., Soppe, B., 2020. The role of inter-sectoral dynamics in sustainability transitions: a comment on the transitions research agenda. Environ. Innov. Soc. Transit. 34, 348–351. https://doi.org/10.1016/j.eist.2019.11.009.

Andrews-Speed, P., 2016. Applying institutional theory to the low-carbon energy transition. Energy Res. Soc. Sci. 13, 216–225. https://doi.org/10.1016/j.erss.2015.12.011.

Antonopoulos, I., Faraca, G., Tonini, D., 2021. Recycling of post-consumer plastic packaging waste in the EU: recovery rates, material flows, and barriers. Waste Manage. 126, 694–705. https://doi.org/10.1016/j.wasman.2021.04.002.

Archer, M.S., 1995. Realist Social Theory: The Morphogenetic Approach. Cambridge: Cambridge University Press.

Arora, S., Stirling, A., 2023. Colonial modernity and sustainability transitions: A conceptualisation in six dimensions. Environ. Innov. Soc. Trans. 48, 100733. https://doi.org/10.1016/j.eist.2023.100733.

Arts, B., Buizer, M., 2009. Forests, discourses, institutions: A discursive-institutional analysis of global forest governance. For. Policy Econ. 11(5–6), 340–347. https://doi.org/10.1016/j.forpol.2008.10.004.

Asheim, B.T., Isaksen, A., Trippl, M., 2020. The role of the Regional Innovation System approach in contemporary regional policy: is it still relevant in a globalised world?. In: Asheim, B. (Ed.). Regions and Innovation Policies in Europe, pp. 12-29. Edward Elgar. https://doi.org/10.4337/9781789904161.

Avelino, F., 2021. Theories of power and social change. Power contestations and their implications for research on social change and innovation. J. Polit. Power 14(3), 425–448. https://doi.org/10.1080/2158379X.2021.1875307.

Ayrapetyan, D., Hermans, F., 2020. Introducing a multiscalar framework for biocluster research: a meta-analysis. Sustainability 12(9), 3890. https://doi.org/10.3390/ su12093890.

Balanzó-Guzmán, A., Ramos-Mejía, M., 2023. Towards epistemic diversity in sustainability transitions: an exploration of hybrid socio-technical systems. Sustain. Sci. 18(6), 2511-2531. https://doi.org/10.1007/s11625-023-01370-9.

Balland, P.A., Belso-Martínez, J.A., Morrison, A., 2016. The dynamics of technical and business knowledge networks in industrial clusters: embeddedness, status, or proximity? Econ. Geogr. 92(1), 35–60. https://doi.org/10.1080/ 00130095.2015.1094370.

Barley, S.R., Tolbert, P.S., 1997. Institutionalization and structuration: Studying the links between action and institution. Organ. Stud. 18(1), 93-117. https://doi.org/10.1177/017084069701800106.

Befort, N., 2020. Going beyond definitions to understand tensions within the bioeconomy: the contribution of sociotechnical regimes to contested fields. Technol. Forecast. Soc. Change 153. https://doi.org/10.1016/j.techfore.2020.119923.

Berg, S., Cloutier, L.M., Bröring, S., 2018. Collective stakeholder representations and perceptions of drivers of novel biomass-based value chains. J. Clean. Prod. 200, 231–241. https://doi.org/10.1016/j.jclepro.2018.07.304.

Bergek, A., Hekkert, M., Jacobsson, S., Markard, J., Sandén, B., Truffer, B., 2015. Technological innovation systems in contexts: Conceptualizing contextual structures and interaction dynamics. Environ. Innov. Soc. Transit. 16, 51-64. https://doi.org/10.1016/j.eist.2015.07.003.

Bergek, A., Jacobsson, S., 2003. The emergence of a growth industry: a comparative analysis of the German, Dutch and Swedish wind turbine industries. In: Metcalfe, S., Cantner, U. (Eds.) Change, transformation and development, pp. 197-228. Heidelberg: Physica/Springer.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., Rickne, A., 2005. Analysing the dynamics and functionality of sectoral innovation systems. The Proceedings of the DRUID Tenth Anniversary Summer Congerence. Available at https://imit.se/wp-content/uploads/2016/02/2007_152.p.

Barthelemy, P., Agyeman-Budu, E., 2016. European chemical industry's contribution to sustainable development. Curr. Opin. Green Sustain. Chem. 1, 28–32. https://doi.org/10.1016/j.cogsc.2016.08.002.

Baskoro, M.L., Tjahjono, B., Beltran, M., Bogush, A., Wang, Y., 202. The imperative of communication signals in boosting business strategies of the bioplastic packaging industry. Bus. Strateg. Environ. 33(2), 307-334. https://doi.org/10.1002/bse.3490.

Basten, M., Engelke, C., 2016. Die Schere geht auf. Bundesverband Baustoffe - Steine und Erden e.V., Berlin, pp. 24–26. baustoffmarkt 5. Available at https://www.baustoffindustrie.de/fileadmin/user_upload/bbs/Dateien/Downloadarchiv/Bauwirtschaft/baustoffmarkt_0516_S24-26.pdf.

Bauer, F., 2018. Narratives of biorefinery innovation for the bioeconomy: Conflict, consensus or confusion? Environ. Innov. Soc. Transit. 28, 96–107. https://doi.org/10.1016/j.eist.2018.01.005.

Beckert, J., 2010. How do fields change? The interrelations of institutions, networks, and cognition in the dynamics of markets. Organ. Stud. 31(5), 605–627. https://doi.org/10.1177/0170840610372184.

Beers, P.J., Veldkamp, A., Hermans, F., van Apeldoorn, D., Vervoort, J. M., Kok, K., 2010. Future sustainability and images [special issue: Landscape visions]. Futures 42(7), 723–732. https://doi.org/10.1016/j.futures.2010.04.017.

Befort, N., 2020. Going beyond definitions to understand tensions within the bioeconomy: The contribution of sociotechnical regimes to contested fields. Technol. Forecast. Soc. Change 153, 119923. https://doi.org/10.1016/j.techfore.2020.119923.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., Rickne, A., 2005. Analysing the dynamics and functionality of sectoral innovation systems. The Proceedings of the DRUID Tenth Anniversary Summer Congerence. Available at https://imit.se/wp-content/uploads/2016/02/2007_152.pdf.

Bergek, A., Hekkert, M., Jacobsson, S., Markard, J., Sandén, B., Truffer, B., 2015. Technological innovation systems in contexts: conceptualizing contextual structures and interaction dynamics. Environ. Innov. Soc. Transit. 16, 51–64. https://doi.org/10.1016/j.eist.2015.07.003.

Berkhout, F., Smith, A., Stirling, A., 2004. Socio-technological regimes and transition contexts. In: Elzen, B., Geels, F.W., Green, K. (Eds.). System innovation and the transition to sustainability. Theory, evidence and policy, pp. 48–75. Cheltenham: Edward Elgar.

Bioeconomy Council, 2015. Bioeconomy policy – Synopsis and analysis of strategies in the G7. Berlin: Bioeconomy Council. Available at https://knowledge4policy.ec.europa.eu/publication/bioeconomy-policy-synopsis-analysis-strategies-g7_en.

Birch, K., 2017. Innovation, regional development and the life sciences; beyond clusters. Routledge.

Birch, K., Levidow, L., Papaioannou, T., 2014. Self-fulfilling prophecies of the European knowledge-based bio-economy: the discursive shaping of institutional and policy frameworks in the bio-pharmaceuticals sector. J. Knowl. Econ. 5(1), 1–18. https://doi.org/10.1007/s13132-012-0117-4.

Bitektine, A., Haack, P., 2015. The "macro" and the "micro" of legitimacy: toward a multilevel theory of the legitimacy process. Acad. Manag. Rev. 40(1), 49–75. https://doi.org/10.5465/amr.2013.0318.

Biygautane, M., Clegg, S., Al-Yahya, K., 2020. Institutional work and infrastructure public–private partnerships (PPPs): the roles of religious symbolic work and power in implementing PPP projects. Account. Audit. Accoun. 33(5), 1077–1112. https://doi.org/10.1108/AAAJ-04-2019-3982.

Bocken, N.M., Geradts, T.H., 2020. Barriers and drivers to sustainable business model innovation: organization design and dynamic capabilities. Long Range Plan. 53(4), 101950. https://doi.org/10.1016/j.lrp.2019.101950.

Boekholt, P., 2010. The evolution of innovation paradigms and their influence on research, technological development and innovation policy instruments. In: Smits, R. E., Kuhlmann, S., Shapira, P. (Eds.), The Theory and Practise of Innovation Policy, pp. 333–361. Cheltenham: Edward Elgar. https://doi.org/10.4337/ 9781849804424.00022.

Boenink, M., Kudina, O., 2020. Values in responsible research and innovation: from entities to practices. J. Responsible Innov. 7(3), 450–470. https://doi.org/10.1080/23299460.2020.1806451.
Bogner, K., Dahlke, J., 2022. Born to transform? German bioeconomy policy and research projects for transformations towards sustainability. Ecol. Econ. 195, 107366 https://doi.org/10.1016/j.ecolecon.2022.107366.
Borrás, S., Schwaag Serger, S., 2022. The design of transformative research and innovation policy instruments for grand challenges: The policy-nesting perspective. Sci. Publ. Policy 49(5), 659-672. https://doi.org/10.1093/scipol/scac017.
Boschma, R., Coenen, L., Frenken, K., Truffer, B., 2017. Towards a theory of regional diversification: Combining insights from evolutionary economic geography and transition studies. Reg. Stud. 51(1), 31–45. https://doi.org/10.1080/00343404. 2016.1258460.
Bosman, R., Rotmans, J., 2016. Transition governance towards a bioeconomy: a comparison of Finland and The Netherlands. Sustainability 8(10), 1017. https://doi. org/10.3390/su8101017.
Boxenbaum, E., Jonsson, S., 2017. Isomorphism, diffusion and decoupling: concept evolution and theoretical challenges. In: Greenwood, R., Meyer, R.E., Lawrence, T.B., Oliver, C. (Eds.). The Sage Handbook of Organizational Institutionalism, pp. 79–104, second edition. London: Sage Publications. http://digital.casalini.it/9781526415059.
Braczyk, H.-J.; Cooke, P., Heidenreich, M., 1998. Regional innovation systems. London: UCL Press.
Breschi, S., Malerba, F., 1997. Sectoral Innovation Systems: Technological Regimes, Schumpeterian Dynamics, and Spatial Boundaries. In: Edquist, C. (Ed.). Systems of Innovation – Technologies, Institutions and Organizations, pp. 130-156. London: Pinter.
Bröring, S., Laibach, N., Wustmans, M., 2020. Innovation types in the bioeconomy. J. Clean. Prod. 266, 121939 https://doi.org/10.1016/j.jclepro.2020.121939.
Brown, S.R., 1980. Political subjectivity, applications of Q methodology in political science. Yale University Press.
Brunori, Gianluca, 2013. Biomass, biovalue and sustainability: some thoughts on the definition of the bioeconomy. EuroChoices 12(1), 48–52. https://doi.org/10.1111/ 1746-692X.12020.
Bruton, G.D., Ahlstrom, D., Li, H.L., 2010. Institutional theory and entrepreneurship: where are we now and where do we need to move in the future?. Entrep. Theory Pract. 34(3), 421-440. https://doi.org/10.1111/j.1540-6520.2010.00390.x.
Bugge, M.M., Hansen, T., Klitkou, A., 2016. What is the bioeconomy? A review of the literature. Sustainability, 8(7), 691. https://doi.org/10.3390/su8070691.
Bundesministerium für Bildung und Forschung (BMBF), 2014. Wegweiser Bioökonomie - Forschung für biobasiertes und nachhaltiges Wirtschaftswachstum. Berlin: BMBF.
Bundesministerium für Ernährung und Landwirtschaft (BMEL), 2014. Nationale Politikstrategie Biookonomie. ̈ BMEL, Berlin. Available at https://biooekonomie.de/sites/default/files/files/2016-09/npsb.pdf.
Bundesministerium für Ernährung und Landwirtschaft (BMEL), 2016. Fortschrittsbericht zur Nationalen Politikstrategie Bioökonomie. Bundesministerium für Ernährung und Landwirtschaft. Berlin: BMEL. Available at https://www.ressourcenwende.net/wp-content/uploads/2020/04/Fortschrittsbericht-zur-Nationalen-Politikstrategie-Biooekonomie_2016-1.pdf.
Bundesministerium für Ernährung und Landwirtschaft (BMEL), 2020. Nationale Politikstrategie Biookonomie. Berlin: BMEL. Available at https://www.bmel.de/SharedDocs/Downloads/DE/Broschueren/nationale-biooekonomiestrategie-langfassung.pdf?__blob=publicationFile&v=5.
Bundesverband Baustoffe – Steine und Erden e. V. (BBS), 2019. bbs-Zahlenspiegel 2019. Daten und Fakten zur Baustoff-, Steine-und-Erden-Industrie. Berlin: BBS. Available at https://www.baustoffindustrie.de/fileadmin/user_upload/bbs/Dateien/Downloadarchiv/Konjunktur/Zahlenspiegel_2019.pdf.
Burnham, M., Eaton, W., Selfa, T., Hinrichs, C., Feldpausch-Parker, A., 2017. The politics of imaginaries and bioenergy subniches in the emerging northeast U.S. Bioenergy economy. Geoforum 82, 66–76. https://doi.org/10.1016/j.geoforum.2017.03.022.
Carlsson, B., Stankiewicz, R., 1991. On the nature, function and composition of technological systems. J. Evol. Econ. 1, 93–118. https://doi.org/10.1007/BF01224915.
Carraresi, L., Berg, S., Bröring, S., 2018. Emerging value chains within the bioeconomy: structural changes in the case of phosphate recovery. J. Clean. Prod. 183, 87–101. https://doi.org/10.1016/j.jclepro.2018.02.135.
Carrozza, C., 2015. Democratizing expertise and environmental governance: Different approaches to the politics of science and their relevance for policy analysis. J. Environ. Policy Plan. 17(1), 108–126. https://doi.org/10.1080/ 1523908X.2014.914894.

Carus, M., Raschka, A., Iffland, K., Dammer, L., Essel, R., Piotrowski, S., 2016. How to shape the next level of the European bio-based economy?: the reasons for the delay and the prospects of recovery in Europe. Nova Institute. Available at https://renewable-carbon.eu/publications/page/18/.

Casau, M., Dias, M.F., Matias, J.C., Nunes, L.J., 2022. Residual biomass: A comprehensive review on the importance, uses and potential in a circular bioeconomy approach. Resources 11(4), 35. https://doi.org/10.3390/resources11040035.

Chaminade, C., 2020. Innovation for what? Unpacking the role of innovation for weak and strong sustainability. J. Sustain. Res. 2(1). https://doi.org/10.20900/jsr20200007.

Chiappinelli, O., Gerres, T., Neuhoff, K., Lettow, F., de Coninck, H., Felsmann, B., Zetterberg, L., 2021. A green COVID-19 recovery of the EU basic materials sector: identifying potentials, barriers and policy solutions. Clim. Policy 21(10), 1328–1346. https://doi.org/10.1080/14693062.2021.1922340.

Chinthapalli, R., Skoczinski, P., Carus, M., Baltus, W., de Guzman, D., Käb, H., Ravenstijn, J., 2019. Biobased building blocks and polymers—Global capacities, production and trends, 2018–2023. Ind. Biotechnol. 15(4), 237–241. https://doi.org/10.1089/ind.2019.29179.rch.

Chowdhury, M.M.H., Quaddus, M.A., 2021. Supply chain sustainability practices and governance for mitigating sustainability risk and improving market performance: a dynamic capability perspective. J. Clean. Prod. 278. https://doi.org/10.1016/j. jclepro.2020.123521.

Chung, C.C., 2018. Technological innovation systems in multi-level governance frameworks: the case of Taiwan's biodiesel innovation system (1997–2016). J. Clean. Prod. 184, 130–142. https://doi.org/10.1016/j.jclepro.2018.02.185.

Clemens, E.S., Cook, J.M., 1999. Politics and institutionalism: Explaining durability and change. Annual Rev. Sociol. 25(1), 441-466. https://doi.org/10.1146/annurev.soc.25.1.441.

Coates, G.W., Getzler, Y.D., 2020. Chemical recycling to monomer for an ideal, circular polymer economy. Nat. Rev. Material 5(7), 501-516. https://doi.org/10.1038/s41578-020-0190-4.

Coenen, L., Díaz López, F.J., 2010. Comparing systems approaches to innovation and technological change for sustainable and competitive economies: an explorative study into conceptual commonalities, differences and complementarities. J. Clean. Prod. 18(12), 1149–1160. https://doi.org/10.1016/j.jclepro.2010.04.003.

Conde, Á., Sutherland, A.B., Fraser, M., Roemers, G., Sosa, L. Rohmer, M., 2022. Circularity gap report: built environment, the Netherlands. Available at https://www.circularitygap.world/sectors#download.

Conversio, 2018. Material flow analysis plastics in Germany 2017. Conversio Market & Strategy GmbH, Mainaschaff. Available at https://www.conversio-gmbh.com/en/news/ material-flow-analysis-plastics-in-germany.

Crossan, M.M., Apaydin, M., 2010. A multi-dimensional framework of organizational innovation: a systematic review of the literature. J. Manag. Stud. 47(6), 1154–1191. https://doi.org/10.1111/j.1467-6486.2009.00880.x.

Cywar, R.M., Rorrer, N.A., Hoyt, C.B., Beckham, G.T., Cehn, E.Y.-X., 2022. Bio-based polymers with performance-advantaged properties. Nat. Rev. Mater 7, 83–103. https://doi.org/10.1038/s41578-021-00363-3.

Czarnecki, L., Van Gemert, D., 2017. Innovation in construction materials engineering versus sustainable development. B. Pol. Acad. Sci.-Tec. 65(6), 765–771. https://doi.org/10.1515/bpasts-2017-0083.

Dahiya, S., Kumar, A.N., Sravan, J.S., Chatterjee, S., Sarkar, O., Mohan, S.V., 2018. Food waste biorefinery: sustainable strategy for circular bioeconomy. Bioresour. Technol. 248, 2–12. https://doi.org/10.1016/j.biortech.2017.07.176.

Daioglou, V., Doelman, J.C., Wicke, B., Faaij, A., van Vuuren, D.P., 2019. Integrated assessment of biomass supply and demand in climate change mitigation scenarios. Glob. Environ. Change 54, 88–101. https://doi.org/10.1016/j. gloenvcha.2018.11.012.

Dalpiaz, E., Rindova, V., Ravasi, D., 2016. Combining logics to transform organizational agency: blending industry and art at Alessi. Admin. Sci. Quart. 61(3), 347–392. https://doi.org/10.1177/0001839216636103.

Daly, J., Kellehear, A., Gliksman, M., 1997. The Public Health Researcher: A Methodological Guide. Melbourne, Australia: Oxford University Press.

Daou, A., Salamoun, R., Abdallah, C., 2024. Institutional voids and business model convergence in the recycling industry. Environ. Innov. Soc. Transit. *52*, 100882. https://doi.org/10.1016/j.eist.2024.100882.

Davidsson, P., 2015. Entrepreneurial opportunities and the entrepreneurship nexus: a reconceptualization. J. Bus. Ventur. 30(5), 674–695. https://doi.org/10.1016/j. jbusvent.2015.01.002.

De Besi, M., McCormick, K., 2015. Towards a bioeconomy in Europe: National, regional and industrial strategies. Sustainability 7(8), 10461–10478. https://doi.org/10.3390/su70810461.

de Guzman, D., 2020. Updated executive summary and market review May 2020 – originally published February 2020, Hürth: nova-Institut. Available at www.bio-based.eu.
De Haan, F.J., Rotmans, J., 2018. A proposed theoretical framework for actors in transformative change. Technol. Forecast. Soc. Change 128, 275–286. https://doi.org/10.1016/j.techfore.2017.12.017.
Delbridge, R., Edwards, T., 2013. Inhabiting institutions: critical realist refinements to understanding institutional complexity and change. Organ. Stud. 34(7), 927–947. https://doi.org/10.1177/0170840613483805.
de Vargas Mores, G., Finocchio, C.P.S., Barichello, R., Pedrozo, E.A., 2018. Sustainability and innovation in the Brazilian supply chain of green plastic. J. Clean. Prod. 177, 12–18. https://doi.org/10.1016/j.jclepro.2017.12.138.
Demirel, P., Li, Q.C., Rentocchini, F., Tamvada, J.P., 2019. Born to be green: new insights into the economics and management of green entrepreneurship. Small Bus. Econ. 52(4), 759–771. https://doi.org/10.1007/s11187-017-9933-z.
Devaney, L., Henchion, M., 2018. Consensus, caveats and conditions: international learnings for bioeconomy development. J. Clean. Prod. 174, 1400–1411. https://doi. org/10.1016/j.jclepro.2017.11.047.
DeVierno Kreuder, A., House-Knight, T., Whitford, J., Ponnusamy, E., Miller, P., Jesse, N., Nelowet Grice, L., 2017. A method for assessing greener alternatives between chemical products following the 12 principles of green chemistry. ACS Sustain. Chem. Eng 5(4), 2927–2935. https://doi.org/10.1021/acssuschemeng.6b02399.
Diakosavvas, D., Frezal, C., 2019. Bio-economy and the sustainability of the agriculture and food system. https://www.oecdilibrary.org/content/paper/d0ad045d-en.
Díaz-García, C., González-Moreno, Á., Sáez-Martínez, F.J., 2015. Eco-innovation: insights from a literature review. Innovation 17(1), 6–23. https://doi.org/10.1080/ 14479338.2015.1011060.
Diercks, G., Larsen, H., Steward, F., 2019. Transformative innovation policy: addressing variety in an emerging policy paradigm. Res. Pol. 48(4), 880–894. https://doi.org/ 10.1016/j.respol.2018.10.028.
Dietz, T., Börner, J., Förster, J.J., Von Braun, J., 2018. Governance of the bioeconomy: a global comparative study of national bioeconomy strategies. Sustainability 10(9), 3190. https://doi.org/10.3390/su10093190.
Dietz, T., Jovel, K.R., Deciancio, M., Boldt, C., Börner, J., 2023. Towards effective national and international governance for a sustainable bioeconomy: A global expert perspective. EFB Bioeconomy J. 3, 100058. https://doi.org/10.1016/j.bioeco.2023.100058.
DiMaggio, P.J., Powell, W.W., 1983. The iron cage revisited: institutional isomorphism and collective rationality in organizational fields. Am. Sociol. Rev. 147–160. https://doi.org/10.2307/2095101.
DiMaggio, P.J., Powell, W.W., 1991. Introduction. In: DiMaggio, P.J., Powell, W.W. (Eds.). The New Institutionalism in Organizational Analysis, pp. 1–39. Chicago: University of Chicago Press.
Dispan, J., 2013. Kunststoffverarbeitung in Deutschland. Branchenreport 2013. Informationsdienst des IMU Instituts 4. , Stuttgart: IMU Institut. Available at https://www.imuinstitut.de/data/publication/kunststoffverarbeitung-in-deutschland-1.
Doh, J., Rodrigues, S., Saka-Helmhout, A., Makhija, M., 2017. International business responses to institutional voids. J. Int. Bus. Stud. 48, 293-307. https://doi.org/10.1057/s41267-017-0074-z.
Dorado, S., 2005. Institutional work, partaking, and convening. Organ. Stud. 26 (3), 385–414. https://doi.org/10.1177/0170840605050873.
Dorado, S., 2013. Small groups as context for institutional work: an exploration of the emergence of commercial microfinance in Bolivia. Organ. Stud. 34(4), 533–557. https://doi.org/10.1177/0170840612470255.
Dosi, G., 1982. Technological paradigms and technological trajectories. Res. Pol. 11, 147–62. https://doi.org/10.1016/0048-7333(82)90016-6.
Dosi, G., Malerba, F., Marsili, O., Orsenigo, L., 1997. Industrial structures and dynamics: evidence, interpretations and puzzles. Ind. Corp. Change 6(1), 3–24. https://doi.org/10.1093/icc/6.1.3.
Drucker, P., 2014. Innovation and Entrepreneurship. Routledge.
Dryzek, J.S., 2005. The politics of the earth: Environmental discourses (2nd edition). Oxford University Press. (Original work published 1997).
Dubois, A., Gadde, L.E., 2002. The construction industry as a loosely coupled system: implications for productivity and innovation. Constr. Manag. Econ. 20(7), 621–631. https://doi.org/10.1080/01446190210163543.
Dubois, O., Gomez San Juan, M., 2016. How sustainability is addressed in official bioeconomy strategies at international, national and regional levels: An overview. Environ. Nat. Resour. Manag., Working Paper

(FAO) eng no. 63. Available at https://openknowledge.fao.org/server/api/core/bitstreams/bde2be3e-19da-4af7-805d-6cf0dc447b96/content.
Dutch Federation of the Rubber and Plastics Industry, Federatie Nederlandse Rubber– en Kunststofindustrie (NRK) 2020 website. Available at https://www.nrk.nl/english.
Duygan, M., Kachi, A., Oliveira, T.D., Rinscheid, A., 2021. Introducing the Endowment-Practice-Institutions (EPI) framework for studying agency in the institutional contestation of socio-technical regimes. J. Clean. Prod. 296, 126396. https://doi.org/10.1016/j.jclepro.2021.126396.
Duygan, M., Stauffacher, M., Meylan, G., 2021. What constitutes agency? Determinants of actors' influence on formal institutions in Swiss waste management. Technol. Forecast. Soc. Change 162. https://doi.org/10.1016/j.techfore.2020.120413.
Eaton, W.M., Gasteyer, S.P., Busch, L., 2014. Bioenergy futures: Framing sociotechnical imaginaries in local places. Rural Sociol. 79(2), 227–256. https://doi.org/10.1111/ruso.12027.
Ebbekink, M., Lagendijk, A., 2013. What's next in researching cluster policy: Place-based governance for effective cluster policy. Eur. Plan. Stud. 21(5), 735–753. https://doi.org/10.1080/09654313.2013.734460.
Edler, J., Georghiou, L., 2007. Public procurement and innovation. Resurrecting the demand side. Res. Pol. 36(7), 949–963. https://doi.org/10.1016/j. respol.2007.03.003.
Edler, J., Köhler, J.H., Wydra, S., Salas-Gironés, E., Schiller, K., Braun, A., 2021. Dimensions of systems and transformations: towards an integrated framework for system transformations. Working Paper Sustainability and Innovation, No. S03/2021. Available at https://www.econstor.eu/handle/10419/238275.
Edquist, C., 1997. Systems of innovation. Technologies, institutions and organizations. London, UK and New York, USA: Pinter.
Edquist, C., 2004. Reflections on the systems of innovation approach. Science and public policy 31(6), 485-489. https://doi.org/10.3152/147154304781779741.
Edquist, C., 2005. Systems of Innovation: Perspectives and Challenges. In Fagerberg, J., Mowery, D., Nelson, R.R. (Eds.). Oxford Handbook of Innovation, pp. 181-208. Oxford University Press.
Edquist, C., 2011. Design of innovation policy through diagnostic analysis: identification of systemic problems (or failures). Industrial and Corporate Change 20: 1725–1753. https://doi.org/10.1093/icc/dtr060.
Ehrenfeld, W., Kropfhäußer, F., 2017. Plant-based bioeconomy in Central Germany–a mapping of actors, industries and places. Technol. Anal. Strat. Manag. 29(5), 514–527. https://doi.org/10.1080/09537325.2016.1140135.
Ekman, P., Röndell, J., Kowalkowski, C., Raggio, R.D., Thompson, S.M., 2021. Emergent market innovation: a longitudinal study of technology-driven capability development and institutional work. J. Bus. Res. 124, 469–482. https://doi.org/10.1016/j.jbusres.2020.10.061.
El-Chichakli, B., von Braun, J., Lang, C., Barben, D., Philp, J., 2016. Policy: Five cornerstones of a global bioeconomy. Nature 535(7611), 221-223. https://doi.org/10.1038/535221a.
Elzen, B., Van Mierlo, B., Leeuwis, C., 2012. Anchoring of innovations: assessing Dutch efforts to harvest energy from glasshouses. Environ. Innov. Soc. Transit. 5, 1–18. https://doi.org/10.1016/j.eist.2012.10.006.
Etikan, I., Musa, S.A., Alkassim, R.S., 2016. Comparison of convenience sampling and purposive sampling. Am. J. Theor. Appl. Stat. 5(1), 1–4. https://doi.org/10.11648/j.ajtas.20160501.11.
European Commission (EC), 2012. Innovating for Sustainable Growth: a Bioeconomy for Europe (COM (2012) 60). Brussels: European Commision. Available at https://op.europa.eu/en/publication-detail/-/publication/1f0d8515-8dc0-4435-ba53- 9570e47dbd51.
European Commission (EC), Directorate-General for Research and Innovation, 2015. Sustainable agriculture, forestry and fisheries in the bioeconomy - A challenge for Europe, 4th SCAR Foresight Exercise. Brussels: European Commision. Available at https://scar-europe.org/images/SCAR-Documents/4th_SCAR_Foresight_Exercise.pdf.
European Commission (EC), 2016. Horizon 2020 annual monitoring report 2015. SWD (2016) 376 final. Brussels: European Commision. Available at https://www.umc.edu.dz/images/_h2020_annual_monitoring_report%202015.pdf.
European Commission (EC), 2019. Regional Innovation Scoreboard 2019. Luxembourg: Publications Office of the European Union. Available at https://ec.europa.eu/growth/industry/innovation/facts-figures/regional_en.
European Commission (EC), 2020. Table of radical innovations breakthroughs. Available at https://op.europa.eu/en/publication-detail/-/publication/6f8fe448-9899-11e9-b2f2-01aa75ed71a1.
European Commission (EC), 2020. A new circular economy action plan for a cleaner and more competitive Europe. (COM (2020) 98 final). Brussels: European Commission. Available at

https://knowledge4policy.ec.europa.eu/publication/communication-com202098-new-circular-economy-action-plan-cleaner-more-competitive_en.
European Commission (EC), 2021. Roadmap for the implementation of the Construction Products Regulation (CPR). Available at https://ec.europa.eu/docsroom/documents/ 45224.
European Commission, Directorate-General for Research and Innovation (EC), 2022. European bioeconomy policy – stocktaking and future developments – Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Publications Office of the European Union. Available at https://data.europa.eu/doi/10.2777/997651.
European Commission (EC), 2023. New European bauhaus progress report. Available at https://new-european-bauhaus.europa.eu/about/progress-report_en.
European Commission, Directorate-General for Research and Innovation (EC-DG R&I), 2018. A sustainable bioeconomy for Europe – Strengthening the connection between economy, society and the environment – Updated bioeconomy strategy. Available at https://data.europa.eu/doi/10.2777/792130.
European Commission, Directorate-General for Research and Innovation (EC-DG R&I), 2020. How the bioeconomy contributes to the European Green Deal. Brussels: Publications Office of the European Union. Available at https://data.europa.eu/doi/10.2777/67636.
Eurostat, 2020. Construction of buildings statistics - NACE Rev. 2. Available at https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Construction_of_buildings_statistics_-_NACE_Rev._2.
Eversberg, D., Fritz, M., 2022. Bioeconomy as a societal transformation: mentalities, conflicts and social practices. Sustain. Prod. Consum. 30, 973–987. https://doi.org/10.1016/j.spc.2022.01.021.
Farla, J., Markard, J., Raven, R., Coenen, L., 2012. Sustainability transitions in the making: a closer look at actors, strategies and resources. Technol. Forecast. Soc. Change 79(6), 991–998. https://doi.org/10.1016/j.techfore.2012.02.001.
Faulconbridge, J., Muzio, D., 2019. Field partitioning: the emergence, development and consolidation of subfields. Organ. Stud. 0170840619855745. https://doi.org/10.1177/0170840619855745.
Fevolden, A.M., Coenen, L., Hansen, T., Klitkou, A., 2017. The role of trials and demonstration projects in the development of a sustainable bioeconomy. Sustainability 9(3), 419. https://doi.org/10.3390/su9030419.
Fischer, L.B., Newig, J., 2016. Importance of actors and agency in sustainability transitions: a systematic exploration of the literature. Sustain. 8(5), 476. https://doi.org/10.3390/su8050476.
Fletcher, C.A., Niemenoja, K., Hunt, R., Adams, J., Dempsey, A., Banks, C.E., 2021. Addressing stakeholder concerns regarding the effective use of bio-based and biodegradable plastics. Resources 10(10), 95. https://doi.org/10.3390/resources10100095.
Fligstein, N., Dauter, L., 2007. The sociology of markets. Annu. Rev. Sociol. 33 (1), 105–128. https://doi.org/10.1146/annurev.soc.33.040406.131736.
Fløysand, A., Jakobsen, S.-E., Bjarnar, O., 2012. The dynamism of clustering: Interweaving material and discursive processes. Geoforum 43(5), 948–958. https://doi.org/10.1016/j.geoforum.2012.05.002.
Foschi, E., Aureli, S., Paletta, A., 2023. Linking bioeconomy, circular economy, and sustainability: Trends, gaps and future orientation in the bio-based and biodegradable plastics industry: Linking bioeconomy, circular economy, and sustainability. European J. Soc. Impact Circular Econ. 4(2), 16-31. https://doi.org/10.13135/2704-9906/7154.
Foucault, M., 1994. Power. New York: The New Press.
Frantzeskaki, N., Loorbach, D., Meadowcroft, J., 2012. Governing societal transitions to sustainability. Int. J. Sustain. Dev. 15(1-2), 19-36. https://doi.org/10.1504/IJSD.2012.044032.
Freeman, C., 1987. Technology Policy and Economic Performance – Lessons from Japan. Science Policy Research Unit, University of Sussex. London and New York: Pinter.
Freeman, C., 1988. The economics of industrial innovation. London: Pinter.
Friedland, R., Alford, R.R., 1991. Bringing society back in: Symbols, practices, and institutional contradictions. In: Powell, W.W., DiMaggio, P.J. (Eds.). The new institutionalism in organizational analysis, pp. 232-263. Chicago: University of Chicago Press.
Friedland, R., Arjaliès, D.L., 2021. Putting things in place: institutional objects and institutional logics. In: Lounsbury, M., Anderson, D. A., Spee, P. (Eds.). On Practice and Institution: New Empirical Directions, Vol. 71, pp. 45–86. Bingley: Emerald Publishing Limited.
Frisvold, G.B., Moss, S.M., Hodgson, A., Maxon, M.E., 2021. Understanding the US bioeconomy: a new definition and landscape. Sustainability 13(4), 1627. https:// doi.org/10.3390/su13041627.

Fritsche, U., Brunori, G., Chiaramonti, D., Galanakis, C., Hellweg, S., Matthews, R., Panoutsou, C., 2020. Future Transitions for the Bioeconomy towards Sustainable Development and a Climate-Neutral Economy - Knowledge Synthesis Final Report. Luxembourg: Publications Office of the European Union.

Fritsche, U, Rösch, C., 2020. The Conditions of a Sustainable Bioeconomy). In: Pietzsch, J. (Ed.). Bioeconomy for Beginners, pp. 177–202. Berlin, Heidelberg: Springer.

Fuenfschilling, L., 2019. An institutional perspective on sustainability transitions, in: Boons, F., McMeekin, A. (Eds.), Handbook of Sustainable Innovation, pp. 219–236. Cheltenham: Edward Elgar Publishing.

Fuenfschilling, L., Binz, C., 2018. Global socio-technical regimes. Res. Pol. 47(4), 735-749. https://doi.org/10.1016/j.respol.2018.02.003.

Fuenfschilling, L., Truffer, B., 2014. The structuration of socio-technical regimes. Conceptual foundations from institutional theory. Res. Pol. 43(4), 772–791. https://doi.org/10.1016/j.respol.2013.10.010.

Fuenfschilling, L., Truffer, B., 2016. The interplay of institutions, actors and technologies in socio-technical systems - an analysis of transformations in the Australian urban water sector. Technol. Forecast. Soc. Change 103, 298–312. https://doi.org/10.1016/j.techfore.2015.11.023.

Furnari, S., 2016. Institutional fields as linked arenas: inter-field resource dependence, institutional work and institutional change. Hum. Relat. 69(3), 551–580. https://doi.org/10.1177/0018726715605555.

Galliano, D., Nadel, S., 2015. Firms' eco-innovation intensity and sectoral system of innovation: the case of French industry. Ind. Innovat. 22(6), 467–495. https://doi. org/10.1080/13662716.2015.1066596.

Galvan, M.G., Cuppen, E., Taanman, M., 2020. Exploring incumbents' agency: institutional work by grid operators in decentralized energy innovations. Environ. Innov. Soc. Transit. 37, 79–92. https://doi.org/10.1016/j.eist.2020.07.008.

Garud, R., Hardy, C., Maguire, S., 2007. Institutional work as embedded agency: an introduction to the special issue. Organ. Stud. 28(7), 957–969. https://doi.org/10.1177/0170840607078958.

Garud, R., Gehman, J., Kumaraswamy, A., 2011. Complexity arrangements for sustained innovation: lessons from 3M Corporation. Organ. Stud. 32(6), 737–767. https://doi.org/10.1177/0170840611410810.

Geels, F.W., 2004. From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. Res. Pol. 33(6-7), 897-920. https://doi.org/10.1016/j.respol.2004.01.015.

Geels, F.W., 2005. Technological Transitions and System Innovations: A Co-evolutionary and Socio-Technical Analysis. Cheltenham: Edward Elgar.

Geels, F.W., 2014. Reconceptualising the co-evolution of firms-in-industries and their environments: Developing an inter-disciplinary Triple Embeddedness Framework. Res. Pol. 43(2), 261-277. https://doi.org/10.1016/j.respol.2013.10.006.

Geels, F.W., 2019. Socio-technical transitions to sustainability: a review of criticisms and elaborations of the multi-level perspective. Curr. Opin. Environ. Sustain. 39, 187–201. https://doi.org/10.1016/j.cosust.2019.06.009.

Geels, F.W., 2020. Micro-foundations of the multi-level perspective on socio-technical transitions: developing a multi-dimensional model of agency through crossovers between social constructivism, evolutionary economics and neo-institutional theory. Technol. Forecast. Soc. Change 152, 119894. https://doi.org/10.1016/j. techfore.2019.119894.

Geels, F.W., Elzen, B., Green, K., 2004. General introduction: system innovation and transitions to sustainability. In: Elzen, B., Geels, F.W., Green, K. (Eds.). System innovation and the transition to sustainability: theory, evidence and policy, p. 1-16. Cheltenham: Edward Elgar.

Geels, F.W., Gregory, J., 2024. Explaining varying speeds of low-carbon reorientation in the United Kingdom's steel, petrochemical, and oil refining industries: A multi-dimensional comparative analysis and outlook. Energy Res. Soc. Sci. 111, 103488. https://doi.org/10.1016/j.erss.2024.103488.

Geels, FW., Kern, F., Clark, W.C., 2023. Sustainability transitions in consumption-production systems. 120(47), e2310070120. https://doi.org/10.1073/pnas.2310070120.

Geels, F.W., Schot, J., 2007. Typology of sociotechnical transition pathways. Res. Pol. 36(3), 399–417. https://doi.org/10.1016/j.respol.2007.01.003.

Geels, F.W., Sovacool, B.K., Schwanen, T., Sorrell, S., 2017. Sociotechnical transitions for deep decarbonization. Science 357(6357), 1242-1244. https://doi.org/10.1126/science.aao3760.

Geels, F.W., Turnheim, B., 2022. The Great Reconfiguration. Cambridge University Press.

Genus, A., Mafakheri, F., 2014. A neo-institutional perspective of supply chains and energy security: bioenergy in the UK. Appl. Energ. 123, 307–315. https://doi.org/10.1016/j.apenergy.2014.01.084.

Georgescu-Roegen, N., 1978. De la science économique à la bioeconomie. Rev. D'écon. Polit. 88(3), 337–382. https:// doi.org/10.2307/1056148.

Germany Trade & Invest (GTAI), 2021. Plastics industry – industry and market numbers. Available at https://www.gtai.de/gtai-en/invest/industries/materials-processing/plastics#77334.
Geyer, R., 2020. Production, use, and fate of synthetic polymers. In: Letcher, T.M. (Ed.). Plastic Waste and Recycling, pp. 13–32. Cambridge: Academic Press.
Giampietro, M., 2019. On the circular bioeconomy and decoupling: implications for sustainable growth. Ecol. Econ. 162, 143–156. https://doi.org/10.1016/j. ecolecon.2019.05.001.
Giddens, A., 1979. Central problems in social theory. London: Macmillan.
Giddens, A., 1981. A contemporary critique of historical materialism. Vol. 1. Power, property and the state. London: Macmillan.
Giddens, A., 1984. The constitution of society: Outline of the theory of structuration. Univ. of California Press.
Gifford, E., McKelvey, M., 2019. Knowledge-intensive entrepreneurship and S3: conceptualizing strategies for sustainability. Sustainability 11(18), 4824. https:// doi.org/10.3390/su11184824.
Gill, P., Stewart, K., Treasure, E., Chadwick, B., 2008. Methods of data collection in qualitative research: interviews and focus groups. Br. Dent. J. 204(6), 291–295. https://doi.org/10.1038/bdj.2008.192.
Giuliani, E., Bell, M., 2005. The micro-determinants of meso-level learning and innovation: evidence from a Chilean wine cluster. Res. Pol. 34(1), 47–68. https:// doi.org/10.1016/j.respol.2004.10.008.
Giuntoli, J., Oliver, T., Kallis, G., Ramcilovic-Suominen, S., Monbiot, G., 2023. Exploring new visions for a sustainable bioeconomy. Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/79421, JRC132650.
Giurca, A., Späth, P., 2017. A forest-based bioeconomy for Germany? Strengths, weaknesses and policy options for lignocellulosic biorefineries. J. Clean. Prod. 153, 51–62. https://doi.org/10.1016/j.jclepro.2017.03.156.
Glaser, J., Laudel, G., 2010. Experteninterviews und qualitative Inhaltsanalyse als Instrumente rekonstruierender Untersuchungen. Wiesbaden: Verlag für Sozialwissenschaften.
Gliedt, T., Hoicka, C.E., Jackson, N., 2018. Innovation intermediaries accelerating environmental sustainability transitions. J. Clean. Prod. 174, 1247–1261. https://doi.org/10.1016/j.jclepro.2017.11.054.
Glynn, M.A., D'Aunno, T., 2023. An intellectual history of institutional theory: looking back to move forward. Acad. Manag. Ann. 17(1), 301–330. https://doi.org/10.5465/annals.2020.0341.
Goldstein, J.E., Neimark, B., Garvey, B., Phelps, J., 2023. Unlocking "lock-in" and path dependency: A review across disciplines and socio-environmental contexts. World Dev. 161, 106116. https://doi.org/10.1016/j.worlddev.2022.106116.
Golembiewski, B., Sick, N., Broring, ¨ S., 2015. The emerging research landscape on bioeconomy: what has been done so far and what is essential from a technology and innovation management perspective? Innov. Food Sci. Emerg. 29, 308–317. https://doi.org/10.1016/j.ifset.2015.03.006.
Gong, H., Andersen, A.D., 2024. The role of material resources for rapid technology diffusion in net-zero transitions: Insights from EV lithium-ion battery Technological Innovation System in China. Technol. Forecast. Soc. Change 200, 123141. https://doi.org/10.1016/j.techfore.2023.123141.
Gong, H., Binz, C., Hassink, R., Trippl, M., 2022. Emerging industries: institutions, legitimacy and system-level agency. Reg. Stud. 56(4), 523-535. https://doi.org/10.1080/00343404.2022.2033199.
Goswein, ¨ V., Reichmann, J., Habert, G., Pittau, F., 2021. Land availability in Europe for a radical shift toward bio-based construction. Sustain. Cities Soc. 70, 102929. https://doi.org/10.1016/j.scs.2021.102929.
Gothár, E., Schanz, H., 2024. Dynamics in the evolution of circular sourcing strategies: Evidence from German frontrunners sourcing for recycled plastics. J. Clean. Prod. 435, 140561. https://doi.org/10.1016/j.jclepro.2024.140561.
Granovetter, M., 1985. Economic action and social structure: the problem of embeddedness. Am. J. Sociol. 91(3), 481–510. https://doi.org/10.1086/228311.
Gray, B., Purdy, J.M., Ansari, S., 2015. From interactions to institutions: Microprocesses of framing and mechanisms for the structuring of institutional fields. Acad. Manag. Rev. 40(1), 115-143. https://doi.org/10.5465/amr.2013.0299.
Greenwood, R., Suddaby, R., 2006. Institutional entrepreneurship in mature fields: the big five accounting firms. Acad. Manage. J. 49(1), 27–48. https://doi.org/10.5465/amj.2006.20785498.
Gregg, J.S., Jürgens, J., Happel, M.K., Strøm-Andersen, N., Tanner, A.N., Bolwig, S., Klitkou, A., 2020. Valorization of bio-residuals in the food and forestry sectors in support of a circular bioeconomy: a review. J. Clean. Prod. 267, 122093. https://doi.org/ 10.1016/j.jclepro.2020.122093.
Grillitsch, M., Sotarauta, M., 2019. Trinity of change agency, regional development paths and opportunity spaces. Prog. Hum. Geogr. 0(0). https://doi.org/10.1177/0309132519853870.
Grillitsch, M., Trippl, M., 2016. Innovation policies and new regional growth paths: a place-based system failure framework. Pap. Innovat. Stud. 26, 1–23. https://EconPapers.repec.org/RePEc:hhs:lucirc:2016_026.

Grimm, A., Walz, R., 2024. Current and future roles of the automotive and ICT sectoral systems in autonomous driving-Using the innovation system approach to assess value chain transformation. Technol. Forecast. Soc. Change 198, 122990. https://doi.org/10.1016/j.techfore.2023.122990.
Grin, J., Rotmans, J., Schot, J., 2010. Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change. Routledge.
Grouiez, P., Debref, R., Vivien, F.D., Befort, N., 2023. The complex relationships between non-food agriculture and the sustainable bioeconomy: the French case. Ecol. Econ. 214, 107974. https://doi.org/10.1016/j.ecolecon.2023.107974.
Grundel, I., Dahlstrom, ¨ M., 2016. A quadruple and quintuple helix approach to regional innovation systems in the transformation to a forestry-based bioeconomy. J. Knowl. Econ. 7(4), 963–983. https://doi.org/10.1007/s13132-016-0411-7.
Gümüsay, A.A., Smets, M., Morris, T., 2020. God at work": engaging central and incompatible institutional logics through elastic hybridity. Acad. Manage J. 63(1), 124–154. https://doi.org/10.5465/amj.2016.0481.
Guest, G., MacQueen, K.M., Namey, E.E., 2011. Applied Thematic Analysis. London: Sage.
Haarich, S., Kirchmayr-Novak, S., Fontenl, A., Toptsidou, M., Hans, S., 2017. Bioeconomy Development in EU Regions. Mapping of EU Member States' Regions' Research and Innovation Plans & Strategies for Smart Specialisation (RIS3) on Bioeconomy for 2014- 2020. Study Commissioned by DG Research & Innovation. Brussels, Belgium: Publications Office of the European Union. Available at https://op.europa. eu/en/publication-detail/-/publication/15189f4a-2216-11e8-ac73-01aa75ed71a1.
Haberl, H., Wiedenhofer, D., Virág, D., Kalt, G., Plank, B., Brockway, P., ... Creutzig, F., 2020. A systematic review of the evidence on decoupling of GDP, resource use and GHG emissions, part II: synthesizing the insights. Environ. Res. Lett. 15(6), 065003. https://doi.org/10.1088/1748-9326/ab842a.
Haberl, H., Fischer-Kowalski, M., Krausmann, F., Schmid, M., 2023. Socio-metabolic transitions. In: Hensel, M.U., Sunguroğlu Hensel, D., Binder C.R., Ludwig, F. (Eds.). Introduction to Designing Environments: Paradigms & Approaches, pp. 71-92. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-34378-0_5.
Hair Jr., J.F., Page, M., Brunsveld, N., 2019. Essentials of Business Research Methods. Routledge.
Hajer, M.A., 1995. The politics of environmental discourse. Ecological modernization and the policy process. Oxford University Press.
Halberstadt, J., Schwab, A.K., Kraus, S., 2024. Cleaning the window of opportunity: Towards a typology of sustainability entrepreneurs. J. Bus. Res. 171, 114386. https://doi.org/10.1016/j.jbusres.2023.114386.
Haldar, S., 2019. Towards a conceptual understanding of sustainability-driven entrepreneurship. Corp. Soc. Resp. Env. Ma. 26(6), 1157-1170. https://doi.org/10.1002/csr.1763.
Hallett, T., Hawbaker, A., 2021. The case for an inhabited institutionalism in organizational research: interaction, coupling, and change reconsidered. Theory Soc. 50(1), 1–32. https://doi.org/10.1007/s11186-020-09412-2.
Hallett, T., Ventresca, M.J., 2006. Inhabited institutions: social interactions and organizational forms in Gouldner's Patterns of Industrial Bureaucracy. Theor. Soc. 35, 213–236. https://doi.org/10.1007/s11186-006-9003-z.
Hampel, C.E., Lawrence, T.B., Tracey, P., 2017. Institutional Work: Taking Stock and Making It Matter. In: Greenwood, R., Meyer, R.E., Lawrence, T.B., Oliver, C. (Eds.). The Sage handbook of organizational institutionalism, pp. 558-590, second edition. London: Thousand Oaks. http://digital.casalini.it/9781526415059.
Hardy, C., Maguire, S., 2017. Institutional Work and Change in Fields. In: Greenwood, R., Meyer, R.E., Lawrence, T.B., Oliver, C. (Eds.). The Sage Handbook of Organizational Institutionalism, pp. 261–280, second edition. London: Thousand Oaks. http://digital.casalini.it/9781526415059.
Hasselbladh, H., Kallinikos, J., 2000. The project of rationalization: a critique and reappraisal of neo-institutionalism in organization studies. Organ. Stud. 21(4), 697-720. https://doi.org/10.1177/0170840600214002.
Hassink, R., Gong, H., 2019. Six critical questions about smart specialization. Eur. Plan. Stud. 27(10), 2049–2065. https://doi.org/10.1080/09654313.2019.1650898.
Haynie, J.M., Shepherd, D.A., McMullen, J.S., 2009. An opportunity for me? The role of resources in opportunity evaluation decisions. J. Manag. Stud. 46(3), 337–361. https://doi.org/10.1111/j.1467-6486.2009.00824.x.
Heiberg, J., Truffer, B., 2022. Overcoming the harmony fallacy: How values shape the course of innovation systems. Environ. Innov. Soc. Trans. 42, 411-428. https://doi.org/10.1016/j.eist.2022.01.012.

Heiberg, J., Truffer, B., Binz, C., 2022. Assessing transitions through socio-technical configuration analysis–a methodological framework and a case study in the water sector. Res. Pol. 51(1), 104363. https://doi.org/10.1016/j.respol.2021.104363.
Hekkert, M.P., Suurs, R.A.A., Negro, S.O., Kuhlmann, S., Smit, R.E.H.M., 2007. Functions of innovation systems: a new approach for analysing technological change. Technol. Forecast. Soc. Change 74, 413–432. https://doi.org/10.1016/j. techfore.2006.03.002.
Helfen, M., Sydow, J., 2013. Negotiating as institutional work: the case of labour standards and international framework agreements. Organ. Stud. 34(8), 1073–1098. https://doi.org/10.1177/0170840613492072.
Helfferich, C., 2011. Die Qualität Qualitativer Daten, vol. 4. Wiesbaden: Verlag für Sozialwissenschaften.
Hellsmark, H., Mossberg, J., Soderholm, ¨ P., Frishammar, J., 2016. Innovation system strengths and weaknesses in progressing sustainable technology: the case of Swedish biorefinery development. J. Clean. Prod. 131, 702–715. https://doi.org/10.1016/j. jclepro.2016.04.109.
Hermans, F., 2018. The potential contribution of transition theory to the analysis of bioclusters and their role in the transition to a bioeconomy. Biofuel. Bioprod. Biorefin. 12(2), 265–276. https://doi.org/10.1002/bbb.1861.
Hermans, F.L., 2021. Bioclusters and sustainable regional development. in: Sedita, S.R., Blasi, S. (Eds.). Rethinking Clusters. Sustainable Development Goals Series, pp. 81–91. Cham: Springer. 10.1007/978-3-030-61923-7_6.
Hermans, F., Geerling-Eiff, F., Potters, J., Klerkx, L., 2019. Public-private partnerships as systemic agricultural innovation policy instruments–Assessing their contribution to innovation system function dynamics. NJAS-Wagen. J. Life Sci. 88, 76–95. https://doi.org/10.1016/j.njas.2018.10.001.
Herrfahrdt-Pähle, E., Schlüter, M., Olsson, P., Folke, C., Gelcich, S., Pahl-Wostl, C., 2020. Sustainability transformations: socio-political shocks as opportunities for governance transitions. Glob. Environ. Change 63, 102097. https://doi.org/10.1016/j.gloenvcha.2020.102097.
Hilgers, M., Mangez, E., 2014. Introduction to Pierre Bourdieu's theory of social fields. In: Hilgers, M., Mangez, E. (Eds.). Bourdieu's Theory of Social fields: Concepts and Applications, pp. 1–36. New York: Routledge.
Hinings, C.R., Logue, D.M., Zietsma, C., 2017. Fields, institutional infrastructure and governance. In: Greenwood, R., Meyer, R.E., Lawrence, T.B., Oliver, C. (Eds.). The Sage Handbook of Organizational Institutionalism, pp. 216–245, second edition. London: Thousand Oaks. http://digital.casalini.it/9781526415059.
Hipp, A., Binz, C., 2020. Firm survival in complex value chains and global innovation systems: evidence from solar photovoltaics. Res. Pol. 49(1), 103876. https://doi.org/10.1016/j.respol.2019.103876.
Hodgson, G.M., 2006. What are institutions? J. Econ. Issues 40(1), 1–25. https://doi.org/10.1080/00213624.2006.11506879.
Hojnik, J., Ruzzier, M., 2016. The driving forces of process eco-innovation and its impact on performance: insights from Slovenia. J. Clean. Prod. 133, 812–825. https://doi. org/10.1016/j.jclepro.2016.06.002.
Hoogstraaten, M.J., Frenken, K., Boon, W.P., 2020. The study of institutional work and its implications for transition studies. Environ. Innov. Soc. Transit. 36, 114–136. https://doi.org/10.1016/j.eist.2020.05.004.
Howells, J., 1999. Regional systems of innovation. In: Archibugi, D., Howells, J., Michie, J. (Eds). Innovation Policy in a Global Economy, pp. 67–93. Cambridge: Cambridge University Press.
Hsu, W.T., Domenech, T., McDowall, W., 2022. Closing the loop on plastics in Europe: the role of data, information and knowledge. Sustain. Prod. Consum. 33, 942–951. https://doi.org/10.1016/j.spc.2022.08.019.
Huttunen, S., Kaljonen, M., Lonkila, A., Rantala, S., Rekola, A., Paloniemi, R., 2021. Pluralising agency to understand behaviour change in sustainability transitions. Energy Res. Soc. Sci. 76, 102067. https://www.sciencedirect.com/science/article/pii/S2214629621001602.
Iddris, F., 2016. Innovation capability: a systematic review and research agenda. Interdiscipl. J. Inf. Knowl. Manag. 11, 235–260. URN: urn:nbn:se:hh:diva-32097.
Iles, A., Martin, A.N., 2013. Expanding bioplastics production: sustainable business innovation in the chemical industry. J. Clean. Prod. 45, 38–49. https://doi.org/ 10.1016/j.jclepro.2012.05.008.
Independent Commodity Intelligence Services (ICIS), 2019. Special report: top 100 chemical companies. Available at https://www.icis.com/explore/resources/icis-top-100- chemical-companies-of-2019/.
Ivanova, S., Treffers, T., Langerak, F., 2018. Emotional paths leading to opportunity desirability and feasibility beliefs through controllability. Int. Small Bus. J. 36(5), 546–573. https://doi.org/10.1177/0266242617751596.

Jasanoff, S., 2015. Future imperfect: Science, technology, and the imaginations of modernity. In: Jasanoff, S., Kim, S.-H. (Eds.). Dreamscapes of modernity: Sociotechnical imaginaries and the fabrication of power, pp. 1–33. Chicago: University of Chicago Press.
Jasanoff, S., Kim, S.-H., 2009. Containing the atom: Sociotechnical imaginaries and nuclear power in the United States and South Korea. Minerva 47(2), 119–146. https://doi.org/10.1007/s11024-009-9124-4.
Johannisson, B., Wigren, C., 2006. Extreme entrepreneurs: challenging the institutional framework. In: Christensen, P.R., Poulfelt, F. (Eds.). Managing Complexity and Change in SMEs: Frontiers in European Research, pp. 156-179. Cheltenham: Edward Elgar.
Johnstone, P., Stirling, A., Sovacool, B., 2017. Policy mixes for incumbency: Exploring the destructive recreation of renewable energy, shale gas 'fracking,'and nuclear power in the United Kingdom. Energy Res. Soc. Sci. 33, 147-162. https://doi.org/10.1016/j.erss.2017.09.005.
Jones, C., Lee, J.Y., Lee, T., Haack, P., Sieweke, J., Wessel, L., 2019. Institutionalizing place: materiality and meaning in Boston's north end. Microfoundations of Institutions, pp. 211–239. Bingley: Emerald Publishing Limited.
Jones, C., Meyer, R., Höllerer, M.A., Jancsary, D., Greenwood, R., Meyer, R.E., Lawrence, T.B., Oliver, C., 2017. The material and visual basis of institutions. In: Greenwood, R., Meyer, R.E., Lawrence, T.B., Oliver, C. (Eds.). The Sage Handbook of Organizational Institutionalism, pp. 621–646, second edition. London: Sage Publications.
Joxe, S., Bahers, J.B., 2024. Towards a Territorial and Political Ecology of "circular bioeconomy": a 30-year review of metabolism studies. Cambridge J. Reg. Econ. Soc. rsae020. https://doi.org/10.1093/cjres/rsae020.
Kabasci, S., 2020. Biobased plastics. In: Letcher, T.M. (Ed.). Plastic Waste and Recycling, pp. 67–96. London: Academic Press.
Kabongo, J.D., Boiral, O., 2017. Doing more with less: building dynamic capabilities for eco-efficiency. Bus. Strat. Environ. 26(7), 956–971. https://doi.org/10.1002/ bse.1958.
Kadura, B., Langbein, J., Wilde, K., 2011. Strengthening innovation systems – Foundation, concept and strategic approach. Hamburg: Dr. Kovač.
Käsbohrer, A., Hansen, T., Zademach, H.M., 2024. Multi-system interactions and institutional work: Actor interactions at the interface of residential storage systems and electric vehicles in Germany. Environ. Innov. Soc. Trans. 51, 100844. https://doi.org/10.1016/j.eist.2024.100844.
Kaiser, R., Prange, H., 2004. The reconfiguration of national innovation systems—the example of German biotechnology. Res. Pol. 33(3), 395-408. https://doi.org/10.1016/j.respol.2003.09.001.
Kanger, L., Schot, J., Sovacool, B.K., van der Vleuten, E., Ghosh, B., Keller, M., ... Steinmueller, W.E., 2021. Research frontiers for multi-system dynamics and deep transitions. Environ. Innov. Soc. Trans. 41, 52-56. https://doi.org/10.1016/j.eist.2021.10.025.
Kardung, M., Cingiz, K., Costenoble, O., Delahaye, R., Heijman, W., Lovrić, M., Zhu, B.X., 2021. Development of the circular bioeconomy: drivers and indicators. Sustain.-Basel 13(1), 413. https://doi.org/10.3390/su13010413.
Karali, N., Khanna, N., Shah, N., 2024. Climate Impact of Primary Plastic Production. Lawrence Berkeley National Laboratory. Available at https://escholarship.org/uc/item/6cc1g99q.
Ketels, C., Lindqvist, G., Sölvell, Ö., 2006. Cluster initiatives in developing and transition economies. Stockholm: Centre for Strategy and Competitiveness.
Ketels, C., Lindqvist, G., Sölvell, Ö., 2012. Strengthening clusters and competitiveness in Europe: The role of cluster organisations. The cluster Observatory 56, 56. Stockholm, Sweden: Stockholm School of Economics. Available at https://clustercollaboration.eu/sites/default/files/document-store/Strengthening_Clusters_and_Competitiviness_in_Europe.pdf.
Kedir, F., Hall, D.M., 2020. Resource efficiency in industrialized housing construction–A systematic review of current performance and future opportunities. J. Clean. Prod. 286, 125443. https://doi.org/10.1016/j.jclepro.2020.125443.
Kern, F., 2015. Engaging with the politics, agency and structures in the technological innovation systems approach. Environ. Innovat. Soc. Transitions (16), 67–69. https://doi.org/10.1016/j.eist.2015.07.001.
Kern, F., Rogge, K.S., 2018. Harnessing theories of the policy process for analysing the politics of sustainability transitions: a critical survey. Environ. Innov. Soc. Transit. 27, 102–117. https://doi.org/10.1016/j.eist.2017.11.001.
Kern, F., Rogge, K.S., Howlett, M., 2019. Policy mixes for sustainability transitions: New approaches and insights through bridging innovation and policy studies. Res. Pol. 48(10), 103832. https://doi.org/10.1016/j.respol.2019.103832.

Khan, O., Daddi, T., Iraldo, F., 2020. Microfoundations of dynamic capabilities: insights from circular economy business cases. Bus. Strat. Environ. 29(3), 1479–1493. https://doi.org/10.1002/bse.2447.
Kiefer, C.P., Del Rio Gonzalez, P., Carrillo-Hermosilla, J., 2019. Drivers and barriers of eco-innovation types for sustainable transitions: a quantitative perspective. Bus. Strat. Environ. 28 (1), 155–172. https://doi.org/10.1002/bse.2246.
Kivimaa, P., Boon, W., Hyysalo, S., Klerkx, L., 2019. Towards a typology of intermediaries in sustainability transitions: a systematic review and a research agenda. Res. Pol. 48(4), 1062–1075. https://doi.org/10.1016/j.respol.2018.10.006.
Kivimaa, P., Laakso, S., Lonkila, A., Kaljonen, M., 2021. Moving beyond disruptive innovation: a review of disruption in sustainability transitions. Environ. Innov. Soc. Transit. 38, 110–126. https://doi.org/10.1016/j.eist.2020.12.001.
Klein Woolthuis, R., Lankhuizen, M., Gilsing, V., 2005. A system failure framework for innovation policy design. Technovation 25 (6), 609–619. https://doi.org/10.1016/j. technovation.2003.11.002.
Kloo, Y., Nilsson, L.J., Palm, E., 2024. Reaching net-zero in the chemical industry—A study of roadmaps for industrial decarbonisation. Renew. Sustain. Energy Trans. 5, 100075. https://doi.org/10.1016/j.rset.2023.100075.
Köhler, J., Geels, F.W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Wells, P., 2019. An agenda for sustainability transitions research: state of the art and future directions. Environ. Innov. Soc. Transit. 31, 1–32. https://doi.org/10.1016/j.eist.2019.01.004.
Kok, K.P., Loeber, A.M., Grin, J., 2021. Politics of complexity: conceptualizing agency, power and powering in the transitional dynamics of complex adaptive systems. Res. Pol. 50(3), 104183 https://doi.org/10.1016/j.respol.2020.104183.
Kriesch, L., Losacker, S., 2024. Bioeconomy firms and where to find them. Region 11(1), 55-78. https://doi.org/10.18335/region.v11i1.523.
Kuhlmann, S., Edler, J., 2002. Governance of technology and innovation policies in Europe: investigating future scenarios. Fraunhofer-Institut für Systemtechnik und Innovationsforschung. Available at https://publica-rest.fraunhofer.de/server/api/core/bitstreams/9bc6679c-458e-40d0-8607-50215645980c/content.
Kuhlmann, S., Rip, A., 2018. Next-generation innovation policy and grand challenges. Sci. Publ. Pol. 45(4), 448–454. https://doi.org/10.1093/scipol/scy011.
Kuhlmann, S., Shapira, P., Smits, R., 2010. Introduction. A systemic perspective: The innovation policy danse. In: Smits, R.E., Kuhlmann, S., Shapira, P. (Eds). The theory and practice of innovation policy, pp. 1-22. Cheltenham: Edward Elgar.
Kukk, P., Moors, E.H., Hekkert, M.P., 2016. Institutional power play in innovation systems: The case of Herceptin®. Res. Pol. 45(8), 1558-1569. https://doi.org/10.1016/j.respol.2016.01.016.
Kump, B., 2023. Lewin's field theory as a lens for understanding incumbent actors' agency in sustainability transitions. Environ. Innov. Soc. Transit. 46, 100683. https://doi.org/10.1016/j.eist.2022.11.008.
Kuosmanen, T., Kuosmanen, N., El-Meligi, A., Ronzon, T., Gurria, P., Iost, S., M'Barek, R., 2020. How Big Is the Bioeconomy? Reflections from an Economic Perspective. (EUR 30167 EN). Publications Office of the European Union, Luxembourg. https://doi. org/10.2760/144526.
Kuzemko, C., Lockwood, M., Mitchell, C., Hoggett, R., 2016. Governing for sustainable energy system change: Politics, contexts and contingency. Energy Res. Soc. Sci. 12, 96-105. https://doi.org/10.1016/j.erss.2015.12.022.
Labanca, N., Pereira, Â.G., Watson, M., Krieger, K., Padovan, D., Watts, L., ... , Mehta, L., 2020. Transforming innovation for decarbonisation? Insights from combining complex systems and social practice perspectives. Energy Res. Soc. Sci. 65, 101452. https://doi.org/10.1016/j.erss.2020.101452.
Langeveld, J.W.A., 2015. Results of the JRC-SCAR Bioeconomy Survey. *Biomass Research Report* 1501. Biomass Research, Wageningen. Available at https://biobs.jrc.ec.europa.eu/.
Lau, A.K., Lo, W., 2015. Regional innovation system, absorptive capacity and innovation performance: an empirical study. Technol. Forecast. Soc. Change 92, 99–114. https://doi.org/10.1016/j.techfore.2014.11.005.
Lauber, V., Jacobsson, S., 2016. The politics and economics of constructing, contesting and restricting socio-political space for renewables–The German Renewable Energy Act. Environ. Innov. Soc. Trans. 18, 147-163. https://doi.org/10.1016/j.eist.2015.06.005.
Law, K.L., Narayan, R., 2022. Reducing environmental plastic pollution by designing polymer materials for managed end-of-life. Nat. Rev. Materials 7(2), 104-116. https://doi.org/10.1038/s41578-021-00382-0.

Lawrence, T.B., Suddaby, R., 2006. Institutions and institutional work, in: Clegg, S.R., Hardy, C., Lawrence, T.B., Nord, W.R. (Eds.), Handbook of Organization Studies, pp. 215–254, second edition. London, Sage Publications.
Lawrence, T., Suddaby, R., Leca, B., 2011. Institutional work: refocusing institutional studies of organization. J. Manage. Inquiry 20(1), 52–58. https://doi.org/10.1177/10564926103872.
Lawson, B., Samson, D., 2001. Developing innovation capability in organisations: a dynamic capabilities approach. Int. J. Innovat. Manag. 5, 377–400. https://doi.org/10.1142/S1363919601000427.
Lee, T.W., Mitchell, T.R., Sablynski, C.J., 1999. Qualitative research in organizational and vocational psychology, 1979–1999. J. Vocat. Behav. 55(2), 161–187. https://doi.org/10.1006/jvbe.1999.1707.
Leeuwis, C., Aarts, N., 2011. Rethinking communication in innovation processes: creating space for change in complex systems. J. Agric. Educ. Ext. 17(1), 21–36. https://doi.org/10.1080/1389224X.2011.536344.
Leipold, S., Petit-Boix, A., 2018. The circular economy and the bio-based sector-Perspectives of European and German stakeholders. J. Clean. Prod. 201, 1125–1137. https://doi.org/10.1016/j.jclepro.2018.08.019.
Lepoutre, J.M., Valente, M., 2012. Fools breaking out: The role of symbolic and material immunity in explaining institutional nonconformity.Acad. Manag. J. 55(2), 285-313. https://doi.org/10.5465/amj.2008.0340.
Levidow, L., Birch, K., Papaioannou, T., 2013. Divergent paradigms of European agro-food innovation. Sci. Technol. Human Values 38(1), 94–125. https://doi.org/10.1177/0162243912438143.
Levidow, L., Papaioannou, T., 2013. State imaginaries of the public good: Shaping UK innovation priorities for bioenergy. Environ. Sci. Policy 30, 36–49. https://doi.org/10.1016/j.envsci.2012.10.008.
Levy, D., Scully, M., 2007. The institutional entrepreneur as modern prince: the strategic face of power in contested fields. Organ. Stud. 28(7), 971–991. https://doi.org/10.1177/0170840607078109.
Lewandowski, I., 2018. Bioeconomy: Shaping the transition to a sustainable, Biobased economy. University of Hohenheim & Springer.
Lewin, K., 1951. Field theory in social science. Selected Theoretical Papers. DorwinCartwright (Ed.). Harpers.
Lieftink, B., Smits, A., Lauche, K., 2019. Dual dynamics: project-based institutional work and subfield differences in the Dutch construction industry. Int. J. Proj. Manag. 37(2), 269–282. https://doi.org/10.1016/j.ijproman.2018.03.005.
Lindberg, M.B., Markard, J., Andersen, A.D., 2019. Policies, actors and sustainability transition pathways: A study of the EU's energy policy mix. Res. Pol. 48(10), 103668. https://doi.org/10.1016/j.respol.2018.09.003.
Liobikiene, G., Balezentis, T., Streimikiene, D., Chen, X., 2019. Evaluation of bioeconomy in the context of strong sustainability. Sust. Dev. 27(5), 955-964. https://doi.org/10.1002/sd.1984.
Lizardo, O., Haack, P., Sieweke, J., Wessel, L., 2019. Specifying the "what" and separating the "how": doings, sayings, codes, and artifacts as the building blocks of institutions. In: Microfoundations of Institutions, 65, pp. 217–234. Bingley: Emerald Publishing Limited. https://doi.org/10.1108/S0733-558×2019000065A021.
Lo, J.Y., Nag, R., Xu, L., Agung, S.D., 2020. Organizational innovation efforts in multiple emerging market categories: exploring the interplay of opportunity, ambiguity, and socio-cognitive contexts. Res. Pol. 49(3), 103911. https://doi.org/10.1016/j.respol.2019.103911.
Löhr, M., Chlebna, C., Mattes, J., 2022. From institutional work to transition work: actors creating, maintaining and disrupting transition processes. Environ. Innov. Soc. Transit. 42, 251–267. https://doi.org/10.1016/j.eist.2021.12.005.
Loorbach, D., Frantzeskaki, N., Avelino, F., 2017. Sustainability transitions research: transforming science and practice for societal change. Annu. Rev. Env. Resour. 42, 599–626. https://doi.org/10.1146/annurev-environ-102014-021340.
Loorbach, D., Wittmayer, J., Avelino, F., von Wirth, T., Frantzeskaki, N., 2020. Transformative innovation and translocal diffusion. Environ. Innov. Soc. Transit. 35, 251–260. https://doi.org/10.1016/j.eist.2020.01.009.
Loste, N., Roldan, E., Giner, B., 2020. Is Green Chemistry a feasible tool for the implementation of a circular economy? Environ. Sci. Pollut. Res. 27(6), 6215–6227. https://doi.org/10.1007/s11356-019-07177-5.
Lounsbury, M., Crumley, E.T., 2007. New practice creation: An institutional perspective on innovation. Organ. Stud. 28(7), 993-1012. https://doi.org/10.1177/0170840607078111.
Lounsbury, M., Wang, M.S., 2020. Into the clearing: Back to the future of constitutive institutional analysis. Organ. Theory (1), 2631787719891173. https://doi.org/10.1177/2631787719891173.
Lovrić, N., Lovrić, M., Mavsar, R., 2020. Factors behind development of innovations in European forest-based bioeconomy. Forest Pol. Econ. 111, 102079. https://doi.org/10.1016/j.forpol.2019.102079.
Lühmann, M., Vogelpohl, T., 2023. The bioeconomy in Germany: a failing political project? Ecol. Econ. 207, 07783. https://doi.org/10.1016/j. ecolecon.2023.107783.

Lundvall, B.-Å., 1992. National systems of innovation: Towards a theory of innovation and interactive learning. London: Pinter.
Lundvall, B.-Å., 2007. Innovation system research and policy. Where it came from and where it might go. In: Paper presented at CAS Seminar, Oslo, December 4. Available at https://citeseerx.ist.psu.edu/viewdoc/dow nload?doi=10.1.1.502.1643&rep=rep1&type=pdf.
Lundvall, B-Å, Joseph, K.J., Chaminade, C., Vang, J., 2009. Handbook of innovation systems and developing countries. Building domestic capabilities in a global setting. Cheltenham: Edward Elgar.
Mäkitie, T., Hanson, J., Steen, M., Hansen, T., Andersen, A.D., 2022. Complementarity formation mechanisms in technology value chains. Res. Pol. 51(7), 104559. https://doi.org/10.1016/j.respol.2022.104559.
Magnusson, T., Berggren, C., 2018. Competing innovation systems and the need for redeployment in sustainability transitions. Technol. Forecast. Soc. Change 126, 217-230. https://doi.org/10.1016/j.techfore.2017.08.014.
Magnusson, T., Werner, V., 2023. Conceptualisations of incumbent firms in sustainability transitions: insights from organisation theory and a systematic literature review. Bus. Strateg. Environ. 32(2), 903–919. https://doi.org/10.1002/bse.3081.
Maguire, S., Hardy, C., Lawrence, T.B., 2004. Institutional work in emerging fields: HIV/AIDS treatment advocacy in Canada. Acad. Manage J. 47(5), 657–679. https://doi.org/10.5465/20159610.
Mahmud, M., Soetanto, D., Jack, S., 2020. Environmental management and product innovation: the moderating role of the dynamic capability of small manufacturing firms. J. Clean. Prod. 264, 121633. https://doi.org/10.1016/j.jclepro.2020.121633.
Malerba, F., 2004. Sectoral systems of innovation: basic concepts. In: Malerba, F. (Ed). Sectoral systems of innovation: concepts, issues and analyses of six major sectors, 9-41. Cambridge: Cambridge University Press.
Malerba, F., 2005. Sectoral Systems: how and why innovation differs across sectors. In: Fagerberg, J., Mowrey, D., Nelson, R. (Eds.). The Oxford Handbook of Innovation, pp. 380–406. Oxford: Oxford University Press.
Markard, J., 2020. The life cycle of technological innovation systems. Technol. Forecast. Soc. Change 153, 119407. https://doi.org/10.1016/j.techfore.2018.07.045.
Markard, J., Geels, F.W., Raven, R., 2020. Challenges in the acceleration of sustainability transitions. Environ. Res. Lett. 15(8), 081001. https://doi.org/10.1088/ 1748-9326/ab9468.
Markard, J., Hekkert, M., Jacobsson, S., 2015. The technological innovation systems framework: response to six criticisms. Environ. Innov. Soc. Trans. 16, 76–86. https://doi.org/10.1016/j.eist.2015.07.006.
Markard, J., Raven, R., Truffer, B., 2012. Sustainability transitions: An emerging field of research and its prospects. Res. Pol. 41(6), 955-967. https://doi.org/10.1016/j.respol.2012.02.013.
Markard, J., Suter, M., Ingold, K., 2016. Socio-technical transitions and policy change–Advocacy coalitions in Swiss energy policy. Environ. Innov. Soc. Trans. 18, 215-237. https://doi.org/10.1016/j.eist.2015.05.003.
Markard, J., Truffer, B., 2008. Actor-oriented analysis of innovation systems: exploring micro–meso level linkages in the case of stationary fuel cells. Technol. Anal. Strat. Manag. 20(4), 443–464. https://doi.org/10.1080/09537320802141429.
Markard, J., Wirth, S., Truffer, B., 2016. Institutional dynamics and technology legitimacy–A framework and a case study on biogas technology. Res. Pol. 45(1), 330-344. https://doi.org/10.1016/j.respol.2015.10.009.
Martin, L., Wilson, N., 2016. Opportunity, discovery and creativity: a critical realist perspective. Int. Small Bus. J. 34(3), 261–275. https://doi.org/10.1177/ 0266242614551185.
Material Economics, 2019. Industrial Transformation 2050: Pathways to Net-Zero Emissions from EU Heavy Industries. University of Cambridge, Institute for Sustainability Leadership (CISL), Cambridge. Available at https://materialeconomics.com/latest-updates/industrial-transformation-2050.
Matthews, C., Moran, F., Jaiswal, A.K., 2021. A review on European Union's strategy for plastics in a circular economy and its impact on food safety. J. Clean. Prod. 283, 125263 https://doi.org/10.1016/j.jclepro.2020.125263.
MAXQDA MAXQDA Software for Qualitative Data Analysis. VERBI Software—ConsultSozialforschung GmbH; Berlin, Germany. https://www.maxqda.com/.
Mazzucato, M., 2018. Mission-oriented innovation policies: challenges and opportunities. Ind. Corp. Change 27(5), 803–815. https://doi.org/10.1093/icc/ dty034.
McCauley, S.M., Stephens, J.C., 2012. Green energy clusters and socio-technical transitions: Analysis of a sustainable energy cluster for regional economic development in central Massachusetts, USA. Sustainability Science, 2012(7), 213–225. https://doi. org/10.1007/s11625-012-0164-6.

McCormick, K., Kautto, N., 2013. The bioeconomy in Europe: An overview. Sustainability 5(6), 2589–2608. https://doi.org/ 10.3390/su5062589.
McKelvey, M., 1997. Using evolutionary theory to define systems of innovation. In: Edquist, C. (Ed). Systems of innovation. Technologies, institutions and organizations, pp. 200–222. London: Pinter.
McKeown, B., Thomas, D., 1988. Q-Methodology (Vol. 07-066). Sage University Paper.
Mertens, A., Van Lancker, J., Buysse, J., Lauwers, L., Van Meensel, J., 2019. Overcoming non-technical challenges in bioeconomy value-chain development: learning from practice. J. Clean. Prod. 231, 10–20. https://doi.org/10.1016/j.jclepro.2019.05.147.
Metcalfe, J.S., 2005. Systems failure and the case for innovation policy. In: Llerena, P., Matt, M. (Eds.). Innovation Policy in a Knowledge-Based Economy, pp. 47–74. Berlin/Heidelberg: Springer.
Meyer, J.W., Scott, W.R., 1983. Organizational Environments. Beverly Hills: Sage Publications.
Micelotta, E., Lounsbury, M., Greenwood, R., 2017. Pathways of institutional change: an integrative review and research agenda. J. Manag. 43(6), 1885–1910. https://doi.org/10.1177/0149206317699522.
Minister van Economische Zaken (MEZ), 2013. Groene Groei: voor een sterke, duurzame economie. Brief van de minister van Economische Zaken, mede namens de staatssecretaris van Infrastructuur en Milieu, aan de Tweede Kamer van 28 maart 2013. Vergaderjaar 2012-2013, 33043, nr. 14. Available at https://www.rijk soverheid.nl/documenten/kamerstukken/2013/03/28/kamerbrief-groene-groeivoor-een-sterke-duurzame-economie.
Mokhlesian, S., Holmén, M., 2012. Business model changes and green construction processes. Constr. Manag. Econ. 30(9), 761–775. https://doi.org/10.1080/01446193.2012.694457.
Monteiro, P., Nicolini, D., 2015. Recovering materiality in institutional work: prizes as an assemblage of human and material entities. J. Manag. Inquiry 24(1), 61–81. https://doi.org/10.1177/1056492614546221.
Moss, S.E., Lawrence, K.G., 1997. The effects of priming on the self-reporting of perceived stressors and strains. J. Organ. Behav.: Int. J. Ind. Occup. Organ. Psychol. Behav. 18(4), 393–403. https://doi.org/10.1002/(SICI)1099-1379(199707)18:4% 3C393::AID-JOB809%3E3.0.CO;2-5.
Moulaert, F., Sekia, F., 2003. Territorial innovation models: A critical survey. Regional Studies, 37(3), 289–302. https://doi.org/ 10.1080/0034340032000065442.
Mubareka, S., Giuntoli, J., Sanchez Lopez, J., Lasarte Lopez, J., M'barek, R., Ronzon, T., Avraamides, M., 2023. Trends in the EU bioeconomy. JRC Science for Policy Report. Luxembourg: Publications Office of the European Union. https://data.europa.eu/doi/10.2760/835046.
Mueller, V., Rosenbusch, N., Bausch, A., 2013. Success patterns of exploratory and exploitative innovation: a meta-analysis of the influence of institutional factors. J. Manag. 39(6), 1606–1636. https://doi.org/10.1177/0149206313484516.
Muscat, A., de Olde, E.M., Kovacic, Z., de Boer, I.J.M., Ripoll-Bosch, R., 2021a. Food, energy or biomaterials? Policy coherence across agro-food and bioeconomy policy domains in the EU. Environ. Sci. Policy 123, 21-30. https://doi.org/10.1016/j.envsci.2021.05.001.
Muscat, A., de Olde, E.M., Ripoll-Bosch, R., Van Zanten, H.H., Metze, T.A., Termeer, C.J., ... de Boer, I.J., 2021b. Principles, drivers and opportunities of a circular bioeconomy. Nat. Food 2(8), 561-566. https://doi.org/10.1038/s43016-021-00340-7.
Navis, C., Glynn, M.A., 2010. How new market categories emerge: temporal dynamics of legitimacy, identity, and entrepreneurship in satellite radio, 1990–2005. Admin. Sci. Quart. 55(3), 439–471. https://doi.org/10.2189/asqu.2010.55.3.439.
Nelson, R.R., Rosenberg, N., 1993. Technical innovation and national systems. In: Nelson, R.R. (Ed.). National Innovation systems: a Comparative Analysis, pp. 3–23. New York, Oxford: Oxford University.
Nevzorova, T., Karakaya, E., 2020. Explaining the drivers of technological innovation systems: the case of biogas technologies in mature markets. J. Clean. Prod. 259, 120819. https://doi.org/10.1016/j.jclepro.2020.120819.
Nizamuddin, S., Baloch, A. J., Chen, C., Arif, M., Mubarak, N.M., 2024. Bio-based plastics, biodegradable plastics, and compostable plastics: biodegradation mechanism, biodegradability standards and environmental stratagem. Int. Biodeterior. Biodegrad. 195, 105887. https://doi.org/10.1016/j.ibiod.2024.105887.
Njøs, R., Jakobsen, S.-E., Wiig Aslesen, H., Fløysand, A., 2017. Encounters between cluster theory, policy and practice in Norway: Hubbing, blending and conceptual stretching. Eur. Urban Reg. Stud. 24(3), 274–289. https://doi. org/10.1177/0969776416655860.
Njøs, R, Sjøtun, S.G., Jakobsen, S.E., Fløysand, A., 2020. Expanding Analyses of Path Creation: Interconnections between Territory and Technology. Econ. Geogr. 96(3), 266–288. https://doi.org/10.1080/00130095.2020.1756768.

Nong, D., Escobar, N., Britz, W., Börner, J., 2020. Long-term impacts of bio-based innovation in the chemical sector: a dynamic global perspective. J. Clean. Prod. 272, 122738. https://doi.org/10.1016/j.jclepro.2020.122738.

Nooteboom, B., Van Haverbeke, W., Duysters, G., Gilsing, V., Van den Oord, A., 2007. Optimal cognitive distance and absorptive capacity. Res. Pol. 36(7), 1016–1034. https://doi.org/10.1016/j.respol.2007.04.003.

North, D.C., 1990. Institutions, Institutional Change, and Economic Performance. Cambridge: Cambridge University Press.

North, D.C., 1991. Institutions, ideology, and economic performance. Cato J. 11, 477.

Organisation for Economic Co-operation and Development (OECD), 2009. The bioeconomy in 2030: Designing a policy agenda. Paris: OECD.

Organisation for Economic Co-operation and Development (OECD), 2021. Policies to Reduce Microplastics Pollution in Water. Focus on Textiles and Tyres. Paris: OECD. https://doi.org/10.1787/7ec7e5ef-en.

Oliver, C., 1991. Strategic responses to institutional processes. Acad. Manage. Rev. 16(1), 145–179. https://doi.org/10.5465/amr.1991.4279002.

Oxford Economics, 2019. The global chemical industry: catalyzing growth and addressing our world's sustainability challenges. Report for the International Council of Chemical Associations (ICCA). Oxford Economics, Oxford. Available at https://www.oxfordeconomics.com/recent-releases/the-global-chemical-industry-catalyzinggrowth-and-addressing-our-world-sustainability-challenges.

Paletta, A., Leal Filho, W., Balogun, A.L., Foschi, E., Bonoli, A., 2019. Barriers and challenges to plastics valorisation in the context of a circular economy: case studies from Italy. J. Clean. Prod. 241, 118149 https://doi.org/10.1016/j.jclepro.2019.118149.

Papadonikolaki, E., 2018. Loosely coupled systems of innovation: aligning BIM adoption with implementation in Dutch construction. J. Manage. Eng. 34(6), 05018009. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000644.

Park, H., Grundmann, P., 2023. What does an inclusive bioeconomy mean for primary producers? An analysis of European bioeconomy strategies. J. Environ. Pol. Plan. 25(3), 225-241. https://doi.org/10.1080/1523908X.2022.2094353.

Parkins, J.R., Sherren, K., 2021. Identifying energy discourses across scales in Canada with Q methodology and survey research. In: Jacquet, J.B., Haggerty, J.H., Theodori, G.L. (Eds.). Energy Impacts: A Multidisciplinary Exploration of North American Energy Development, pp. 153-175. Louisville: University Press of Colorado.

Patani, S., Mubareka, S.B., Olsson, M., Girardi, J., Kilsedar, C., Zepharovich, E., Camia, A, 2023. EU Bioeconomy Monitoring System dashboards: extended with social indicators. Luxembourg: Publications Office of the European Union. https://doi.org/10.2760/827057, JRC136613.

Patterson, J., Schulz, K., Vervoort, J., Van Der Hel, S., Widerberg, O., Adler, C., ... , Barau, A., 2017. Exploring the governance and politics of transformations towards sustainability. Environ. Innov. Soc. Trans. 24, 1-16. https://doi.org/10.1016/j.eist.2016.09.001.

Pelli, P., LÄätinen, K., 2020. Servitization and bioeconomy transitions: insights on prefabricated wooden elements supply networks. J. Clean. Prod. 244, 118711. https://doi.org/10.1016/j.jclepro.2019.118711.

Perez-Aleman, P., 2005. Cluster formation, institutions and learning: The emergence of clusters and development in Chile. Ind. Corp. Chan. 14(4), 651–677. https://doi.org/10.1093/icc/dth063.

Pfau, S.F., Hagens, J.E., Dankbaar, B., Smits, A.J.M., 2014. Visions of sustainability in bioeconomy research. Sustainability 6 (3), 1222–1249. https://doi.org/10.3390/su6031222.

Pham, D.D.T., Paillé, P., Halilem, N., 2019. Systematic review on environmental innovativeness: a knowledge-based resource view. J. Clean. Prod. 211, 1088–1099. https://doi.org/10.1016/j.jclepro.2018.11.221.

Philp, J., Winickoff, D., 2019. Innovation Ecosystems in the Bioeconomy. Paris: OECD. https://doi.org/10.1787/23074957.

Pieroni, M.P., McAloone, T.C., Pigosso, D.C., 2020. Circular Economy business model innovation: sectorial patterns within manufacturing companies. J. Clean. Prod. 286, 124921. https://doi.org/10.1016/j.jclepro.2020.124921.

Piotrowski, S., Carus, M., Essel, R., 2016. Sustainable biomass supply and demand: a scenario analysis. Open Agric. 1. https://doi.org/10.1515/opag-2016-0003.

Planko, J., Cramer, J.M., Chappin, M.M., Hekkert, M.P., 2016. Strategic collective system building to commercialize sustainability innovations. J. Clean. Prod. 112, 2328-2341. https://doi.org/10.1016/j.jclepro.2015.09.108.

PlasticsEurope, 2019. Plastics – the facts 2019. An analysis of European plastics production, demand and waste data. Brussels: PlasticsEurope. Avalable at https://plasticseurope.org/wp-content/uploads/2021/10/2019-Plastics-the-facts.pdf.

PlasticsEurope, 2020. Plastics – the facts 2020. An analysis of European plastics production, demand and waste data. Brussels: PlasticsEurope AISBL and European Association of Plastic Recycling and Recovery Organisation (EPRO). Available at https://www.plasticseurope.org/en/resources/publications/4312-plastics-facts-2020/.

PlasticEurope Germany, 2020. Statusbericht der deutschen Kreislaufwirtschaft. Frankfurt am Main: PlasticsEurope Deutschland e. V.. Available at https://plasticseurope.org/de/ wp-ontent/uploads/sites/3/2021/11/Statusbericht_der_deutschen_Kreislaufwirtschaft_2020.pdf.

Ploum, L., Blok, V., Lans, T., Omta, O., 2018. Exploring the relation between individual moral antecedents and entrepreneurial opportunity recognition for sustainable development. J. Clean. Prod. 172, 1582–1591. https://doi.org/10.1016/j. jclepro.2017.10.296.

Porc, O., Hark, N., Carus, M., Dammer, L., Bic, D.C., Knapsack, C., 2020. European bioeconomy in figures. Available at https://biconsortium.eu/sites/biconsortium.eu/files/ documents/European/20Bioeconomy/20in/20Figures/202008/20-/202018.pdf.

Porter, M.E., 1990. The competitive advantage of nations. Harvard Bus. Rev. 68(2), 73–93.

Porter, M.E., 1998. On Competition. Harvard Business School Press.

Powell, W.W., Oberg, A., Korff, V., Oelberger, C., Kloos, K., 2017. Institutional analysis in a digital era: mechanisms and methods to understand emerging fields. In: Krücken, G., Mazza, C., Meyer, R.E., Walgenbach, P. (Eds.). New Themes in Institutional Analysis, pp. 305-344. Northampton: Edward Elgar.

Pruneddu, A., 2017. QSortWare [Computer software]. www.qsortware.net.

Purkus, A., Hagemann, N., Bedtke, N., Gawel, E., 2018. Towards a sustainable innovation system for the German wood-based bioeconomy: implications for policy design. J. Clean. Prod. 172, 3955–3968. https://doi.org/10.1016/j.jclepro.2017.04.146.

Pyka, A., Ari, E., Alva-Ferrari, A., Urmetzer, S., 2021. The bioeconomy transition process: Sailing through storms and doldrums in unknown waters. J. Innov. Econ. Manag. I110-27. https://doi.org/10.3917/jie.pr1.0110.

Raaijmakers, A.G., Vermeulen, P.A., Meeus, M.T., Zietsma, C., 2015. I need time! Exploring pathways to compliance under institutional complexity. Acad. Manage J. 58(1), 85–110. https://doi.org/10.5465/amj.2011.0276.

Ramcilovic-Suominen, S., Pülzl, H., 2018. Sustainable development – A 'selling point' of the emerging EU bioeconomy policy framework? J. Clean. Prod. 172, 4170–4180. https://doi.org/10.1016/j.jclepro.2016.12.157.

Raschka, A., Carus, M., 2014. Industrial Material Use of Biomass in Europe 2013. Available at https://renewable-carbon.eu/publications/product/industrial-material-use-ofbiomass-in-europe-2013-/e2/88/92-graphic/.

RDI2CluB, 2018. Benchmarking report: Triple-helix co-operation in biobased delta: RDI2CluB consortium benchmarking visit to biobased delta bioeconomy cluster in the Netherlands, April 18.–20.2018.

Rebolledo-Leiva, R., Moreira, M.T., González-García, S., 2023. Progress of social assessment in the framework of bioeconomy under a life cycle perspective. Renew. Sustain. Energy Rev. 175, 113162. https://doi.org/10.1016/j.rser.2023.113162.

Repolho, J.V., 2017. Local experiments in transition processes to increasing circularity in the building sector. Master Thesis at Aalburg University. Available at https://projekter. aau.dk/projekter/files/268197471/JVR_20171219_Msc_thesis_Sustainable_cities.pdf.

Richardson, C., Yamin, M., Sinkovics, R.R., 2012. Policy-driven clusters, interfirm interactions and firm internationalisation: Some insights from Malaysia's multimedia super corridor. Int. Bus. Rev. 21(5), 794–805. https://doi.org/10. 1016/j.ibusrev.2011.09.002.

Riedy, C., 2022. Discursive work: ethical meaning-making as a transformative practice for sustainable futures. Sustain. Sci. 17 (2), 541–554. https://doi.org/10.1007/s11625-021-00978-z.

Rijksdienst voor Ondernemend Nederland (RVO), 2015. Onderzoeksagenda Biobased Economy 2015 - 2027. 'B4B: biobased voor bedrijven, burgers en beleid'. Available at https://chemistrynl.com/wp-content/uploads/2019/01/ Onderzoeksagenda-BBE.pdf.

Robert, N., Giuntoli, J., Araujo, R., Avraamides, M., Balzi, E., Barredo, J.I., et al., 2020. Development of a bioeconomy monitoring framework for the European Union: an integrative and collaborative approach. N. Biotech. 59, 10–19. https://doi.org/ 10.1016/j.nbt.2020.06.001.

Roe, E., 1994. Narrative policy analysis: Theory and practice. Duke University Press.

Rogge, K.S., Reichardt, K., 2016. Policy mixes for sustainability transitions: An extended concept and framework for analysis. Res. Pol. 45(8), 1620-1635. https://doi.org/10.1016/j.respol.2016.04.004.
Rosenbloom, D., Rinscheid, A., 2020. Deliberate decline: an emerging frontier for the study and practice of decarbonization. Wiley Interdiscip. Rev. Clim. Change 11(6), e669. https://doi.org/10.1002/wcc.669.
Rosenbloom, D., 2020. Engaging with multi-system interactions in sustainability transitions: A comment on the transitions research agenda. Environ. Innov. Soc. Transit. 34, 336-340. https://doi.org/10.1016/j.eist.2019.10.003.
Rosenboom, J.G., Langer, R., Traverso, G., 2022. Bioplastics for a circular economy. Nat. Rev. Mater. 7(2), 117–137. https://doi.org/10.1038/s41578-021-00407-8.
Ruggiero, S., Kangas, H.L., Annala, S., Lazarevic, D., 2021. Business model innovation in demand response firms: beyond the niche-regime dichotomy. Environ. Innov. Soc. Transit. 39, 1–17. https://doi.org/10.1016/j.eist.2021.02.002.
Saldaña, J., 2015. The Coding Manual for Qualitative Researchers, second edition. London: Sage.
Salim, N., Ab Rahman, M.N., Abd Wahab, D., 2019. A systematic literature review of internal capabilities for enhancing eco-innovation performance of manufacturing firms. J. Clean. Prod. 209, 1445–1460. https://doi.org/10.1016/j. jclepro.2018.11.105.
Sanz-Hernández, A., Esteban, E., Garrido, P., 2019. Transition to a bioeconomy: Perspectives from social sciences. J. Clean. Prod. 224, 107-119. https://doi.org/10.1016/j.jclepro.2019.03.168.
Sarasvathy, S.D., Dew, N., Velamuri, S.R., Venkataraman, S., 2010. Three views of entrepreneurial opportunity. In: Acs, Z.J., Audretsch, D.B. (Eds.). Handbook of Entrepreneurship, pp. 77–96. New York: Springer.
Schirmeister, C.G., Mülhaupt, R., 2022. Closing the carbon loop in the circular plastics economy. Macromol. Rapid Commun. 43(13), 2200247. https://doi.org/ 10.1002/marc.202200247.
Schlaile, M.P., Friedrich, J., Zscheischler, J., 2024. Rethinking Regional Embeddedness and Innovation Systems for Transitions Towards Just, Responsible, and Circular Bioeconomies. Journal of Circular Economy 2(1). https://doi.org/10.55845/DTFI9420.
Schmid, O., Padel, S., Levidow, L., 2012. The bio-economy concept and knowledge base in a public goods and farmer perspective. Bio-Based Appl. Econ. 1(1), 47–63. https://doi.org/10.22004/ag.econ.125698.
Schmolck, P., 2014. PQMethod (Version 2.35). http://www.rz.unibw-muenchen.de/~p41bsmk/qmethod/.
Schot, J., Geels, F.W., 2007. Niches in evolutionary theories of technical change: a critical survey of the literature. J. Evol. Econ. 17, 605–622. https://doi.org/10.1007/s00191-007-0057-5.
Schot, J., Steinmueller, W.E., 2018. Three frames for innovation policy: R&D, systems of innovation and transformative change. Res. Pol. 47(9), 1554–1567. https://doi.org/ 10.1016/j.respol.2018.08.011.
Scott, W.R., 1995. Institutions and Organizations. Thousand Oaks: Sage.
Scott, W.R., 2003. Institutional carriers: reviewing modes of transporting ideas over time and space and considering their consequences. Ind. Corp. Change 12(4), 879–894. https://doi.org/10.1093/icc/12.4.879.
Scott, W.R., 2008. Institutions and Organizations: Ideas and Interests, 3rd edition. Thousand Oaks: Sage.
Scott, W.R., 2014. Institutions and Organizations, 4th edition. Thousand Oaks: Sage.
Seo, M.G., Creed, W.D., 2002. Institutional contradictions, praxis, and institutional change: A dialectical perspective. Acad. Manag. Rev. 27(2), 222-247. https://doi.org/10.5465/amr.2002.6588004.
Sewell Jr, W.H., 1992. A theory of structure: Duality, agency, and transformation. Am. J. Sociol. 98(1), 1-29. https://doi.org/10.1086/229967.
Shepherd, D.A., Williams, T.A., Patzelt, H., 2015. Thinking about entrepreneurial decision making: review and research agenda. J. Manag. 41(1), 11–46. https://doi. org/10.1177/0149206314541153.
Shi, C., Quinn, E.C., Diment, W.T., Chen, E.Y.-X., 2024. Recyclable and (Bio) degradable Polyesters in a Circular Plastics Economy. Chemical Reviews. https://doi.org/10.1021/acs.chemrev.3c00848.
Siebert, A., Bezama, A., O'Keeffe, S., Thrän, D., 2018. Social life cycle assessment: In pursuit of a framework for assessing wood-based products from bioeconomy regions in Germany. Int. J. Life Cycle Assess. 23(3), 651–662. https://doi.org/10.1007/s11367-016-1066-0.
Siracusa, V., Blanco, I., 2020. Bio-polyethylene (Bio-PE), Bio-polypropylene (Bio-PP) and Bio-poly (ethylene terephthalate) (Bio-PET): recent developments in biobased polymers analogous to petroleum-derived ones for packaging and engineering applications. Polymers (Basel) 12(8), 1641. https://doi.org/10.3390/ polym12081641.
Sjøtun, S.G., Njøs, R., 2019. Green reorientation of clusters and the role of policy: 'The normative' and 'the neutral' route. Eur. Plan. Stud. 1–20. https://doi.org/10.1080/09654313.2019.1630370.
Smink, M.M., Hekkert, M.P., Negro, S.O., 2015. Keeping sustainable innovation on a leash? Exploring incumbents' institutional strategies. Bus. Strategy Environ. 24(2), 86-101. https://doi.org/10.1002/bse.1808.

Smith, B.D., 2007. Niche construction and the behavioral context of plant and animal domestication. Evol. Anthropol. Issues News Rev. 16(5), 188–199. https://doi.org/10.1002/evan.20135.
Smith, A., Raven, R., 2012. What is protective space? Reconsidering niches in transitions to sustainability. Res. Pol. 41(6), 1025-1036. https://doi.org/10.1016/j.respol.2011.12.012.
Sölvell, Ö., 2008. Clusters: Balancing evolutionary and constructive forces. Ivory Tower Publishing.
Sotarauta, M., 2017. An Actor-Centric Bottom-Up View of Institutions: Combinatorial Knowledge Dynamics through the Eyes of Institutional Entrepreneurs and Institutional Navigators. Environment and Planning C: Government and Policy. https://doi.org/10.1177/0263774X16664906.
Sotarauta, M., Suvinen, N., Jolly, S., Hansen, T., 2021. The many roles of change agency in the game of green path development in the North. Eur. Urban Reg. Stud. 28(2), 92–110. https://doi.org/10.1177/0969776420944995.
Sovacool, B.K., Hess, D.J., Amir, S., Geels, F.W., Hirsh, R., Medina, L.R., ... Yearley, S., 2020. Sociotechnical agendas: Reviewing future directions for energy and climate research. Energy Res. Soc. Sci. 70, 101617. https://doi.org/10.1016/j.erss.2020.101617.
Sovacool, B.K., Iskandarova, M., Hall, J., 2023. Industrializing theories: a thematic analysis of conceptual frameworks and typologies for industrial sociotechnical change in a low-carbon future. Energy Res. Soc. Sci. 97, 102954. https://doi.org/10.1016/j.erss.2023.102954.
Spatan, S., Peter, D., Thiele, G., Wolfram, M., Ehnert, F., Scherbaum, S., ... Surrey, C., 2024. Epistemic outsiders: Unpacking and utilising the epistemic dimension of disruptive agency in sustainability transformations. PLOS Sustainability and Transformation 3(2), e0000097. https://doi.org/10.1371/journal.pstr.0000097.
Spekreijse, J., Lammens, T., Parisi, C., Ronzon, T., Vis, M., 2019. Insights into the European market for bio-based chemicals, EUR 29581 EN, Luxembourg: Publications Office of the European Union. Available at https://publications.jrc.ec.europa.eu/repository/handle/JRC112989.
Stark, S., Biber-Freudenberger, L., Dietz, T., Escobar, N., Förster, J.J., Henderson, J., Börner, J., 2022. Sustainability implications of transformation pathways for the bioeconomy. Sustain. Prod. Consum. 29, 215–227. https://doi.org/10.1016/j.spc.2021.10.011.
Starke, J.R., Metze, T.A., Candel, J.J., Dewulf, A.R., Termeer, K.J., 2023. 'Green future'versus 'Planetary boundaries'? Evolving online discourse coalitions in European bioeconomy conflicts. J. Clean. Prod. 425, 139058. https://doi.org/10.1016/j.jclepro.2023.139058.
Steen, M., 2016. Reconsidering path creation in economic geography: Aspects of agency, temporality and methods. Eur. Plan. Stud. 24(9), 1605–1622. https://doi.org/10.1080/09654313.2016.1204427.
Steen, M., Weaver, T., 2017. Incumbents' diversification and cross-sectorial energy industry dynamics. Res. Pol. 46(6), 1071-1086. https://doi.org/10.1016/j.respol.2017.04.001.
Stegmann, P., Londo, M., Junginger, M., 2020. The circular bioeconomy: its elements and role in European bioeconomy clusters. Resour. Conserv. Recy. X 6, 100029. https://doi.org/10.1016/j.rcrx.2019.100029.
Stephan, A., Schmidt, T.S., Bening, C.R., Hoffmann, V.H., 2017. The sectoral configuration of technological innovation systems: Patterns of knowledge development and diffusion in the lithium-ion battery technology in Japan. Res. Pol. 46(4), 709-723. https://doi.org/10.1016/j.respol.2017.01.009.
Stilgoe, J., Owen, R., Macnaghten, P., 2013. Developing a framework for responsible innovation. Res. Pol. 42(9), 1568–1580. https://doi.org/10.1016/j. respol.2013.05.008.
Stirling, A., 2019. How deep is incumbency? A 'configuring fields' approach to redistributing and reorienting power in socio-material change. Energy Res. Soc. Sci. 58, 101239. https://doi.org/10.1016/j.erss.2019.101239.
Sturm, V., van Leeuwen, M., Gonzalez-Martinez, A., Verhoog, D., Hark, N., de Beus, N., 2023. Providing Insights into the Markets for Bio-Based Materials with BioMAT. Sustainability 15(4), 3064. https://doi.org/10.3390/su15043064.
Suchman, M.C., 1995. Managing legitimacy: Strategic and institutional approaches. Acad. Manag. Rev. 20(3), 571-610. https://doi.org/10.5465/amr.1995.9508080331.
Sunio, V., Gaspay, S., Guillen, M.D., Mariano, P., Mora, R., 2019. Analysis of the public transport modernization via system reconfiguration: the ongoing case in the Philippines. Transp. Res. Policy Pract. 130, 1–19. https://doi.org/10.1016/j.tra.2019.09.004.
Susur, E., Hidalgo, A., Chiaroni, D., 2019. A strategic niche management perspective on transitions to eco-industrial park development: A systematic review of case studies. Resources, Conservation and Recycling, 140, 338–359. https://doi.org/10. 1016/j.resconrec.2018.06.002.
Suurs, R.A., 2009. Motors of sustainable innovation. Towards a theory on the dynamics of technological innovation systems. Utrecht. Available at http://igitur-archive.library.uu.nl/dissertations/2009-0318-201903/suurs.pdf.

Svensson, O., Nikoleris, A., 2018. Structure reconsidered: Towards new foundations of explanatory transitions theory. Res. Pol. 47(2), 462-473. https://doi.org/10.1016/j.respol.2017.12.007.
Thornton, P.H., Ocasio, W., 1999. Institutional logics and the historical contingency of power in organizations: executive succession in the higher education publishing industry, 1958–1990. Am. J. Sociol. 105(3), 801–843. https://doi.org/10.1086/210361.
Thornton, P.H., Ocasio, W., Lounsbury, M., 2012. The institutional logics perspective: A new approach to culture, structure and process. OUP Oxford.
Turnheim, B., Sovacool, B.K., 2020. Forever stuck in old ways? Pluralising incumbencies in sustainability transitions. Environ. Innov. Soc. Transit. 35, 180–184. https://doi.org/10.1016/j.eist.2019.10.012.
Uekert, T., Singh, A., DesVeaux, J. S., Ghosh, T., Bhatt, A., Yadav, G., ... , Carpenter, A.C., 2023. Technical, economic, and environmental comparison of closed-loop recycling technologies for common plastics. ACS Sustain. Chem. Eng. 11(3), 965-978. https://doi.org/10.1021/acssuschemeng.2c05497.
Upham, P., Dütschke, E., Schneider, U., Oltra, C., Sala, R., Lores, M., Klapper, R., Bögel, P., 2018. Agency and structure in a sociotechnical transition: hydrogen fuel cells, conjunctural knowledge and structuration in Europe. Energy Res. Soc. Sci. 37, 163–174. https://doi.org/10.1016/j.erss.2017.09.040.
Urmetzer, S., Schlaile, M.P., Bogner, K.B., Mueller, M., Pyka, A., 2018. Exploring the dedicated knowledge base of a transformation towards a sustainable bioeconomy. Sustainability 10(6), 1694. https://doi.org/10.3390/su10061694.
Van Assche, K., Beunen, R., Duineveld, M., 2014. The power of stories. In: Beunen, R., Van Assche, K., Duineveld, M. (Eds.). Evolutionary governance theory, pp. 45–54. Springer.
Van Assche, K., Duineveld, M., Beunen, R., Valentinov, V., Gruezmacher, M., 2022. Material dependencies: hidden underpinnings of sustainability transitions. J. Environ. Pol. Plan. 24(3), 281–296. https://doi.org/10.1080/1523908X.2022.2049715.
Van den Oever, M., Molenveld, K., van der Zee, M., Bos, H., 2017. Bio-based and Biodegradable Plastics: Facts and Figures: Focus on Food Packaging in the Netherlands 722. Wageningen Food & Biobased Research. https://doi.org/10.18174/408350.
Van de Poel, I., 2000. On the role of outsiders in technical development. Technol. Anal. Strateg. 12 (3), 383–397. https://doi.org/10.1080/09537320050130615.
Van Lancker, J., Wauters, E., Van Huylenbroeck, G., 2016. Managing innovation in the bioeconomy: an open innovation perspective. Biomass Bioenerg. 90, 60–69. https://doi.org/10.1016/j.biombioe.2016.03.017.
van Mossel, A., van Rijnsoever, F.J., Hekkert, M.P., 2018. Navigators through the storm: a review of organization theories and the behavior of incumbent firms during transitions. Environ. Innov. Soc. Transit. 26, 44–63. https://doi.org/10.1016/j.eist.2017.07.001.
van Oers, L., Feola, G., Moors, E., Runhaar, H., 2021. The politics of deliberate destabilisation for sustainability transitions. Environ. Innov. Soc. Transit. 40, 159–171. https://doi.org/10.1016/j.eist.2021.06.003.
Vandermeulen, V., Van der Steen, M., Stevens, C.V., Van Huylenbroeck, G., 2012. Industry expectations regarding the transition toward a biobased economy. Biofuel. Bioprod. Biorefin. 6(4), 453-464. https://doi.org/10.1002/bbb.1333.
Verband der Chemischen Industrie (VCI), 2019. Auf einen blick - chemische industrie 2018. VCI, Frankfurt am Main. Available at https://www.vci.de/vci/downloads-vci/ publikation/chemische-industrie-auf-einen-blick.pdf.
Vereniging van de Nederlandse Chemische Industrie (VNCI), 2020. Over de chemie. Availabel at https://www.vnci.nl/over-de-chemie.
Vitale, D.C., Armenakis, A.A., Feild, H.S., 2008. Integrating qualitative and quantitative methods for organizational diagnosis: possible priming effects? J. Mix. Methods Res. 2(1), 87–105. https://doi.org/10.1177/1558689807309968.
Vivien, F.D., Nieddu, M., Befort, N., Debref, R., Giampietro, M., 2019. The hijacking of the bioeconomy. Ecological Economics, 159, 189–197. https://doi.org/10.1016/j.ecolecon.2019.01.027.
Vivien, F.D., Altukhova-Nys, Y., Bascourret, J.M., Befort, N., Benoit, S., Debref, R., ... Petitjean, J.L., 2022. PSDR4 BIOCA-La bioéconomie en Champagne Ardenne: une variété de modèles de développement et d'agriculture. Innovations agronomiques 86, 307-318. https://hal.inrae.fr/ARINRAE-INNOVAGRO/hal-03645225.
Vogel, P., 2017. From venture idea to venture opportunity. Enterpren. Theor. Pract. 41(6), 943–971. https://doi.org/10.1111/etap.12234.
von Wirth, T., Fuenfschilling, L., Frantzeskaki, N., Coenen, L., 2019. Impacts of urban living labs on sustainability transitions: Mechanisms and strategies for systemic change through experimentation. Eur. Plan. Stud. 27(2), 229–257. https:// doi.org/10.1080/09654313.2018.1504895.

Vormedal, I., Bjander, J., Larsen, M.L., Lindberg, M.B., 2023. Technological change and the politics of decarbonization: a *re*-making of vested interests? Environ. Innov. Soc. Transit. 47, 100725 https://doi.org/10.1016/j.eist.2023.100725.
Wackerbauer, J., 2020. Sektoren der Bioökonomie. In: Thrän, D., Moesenfechtel, U. (Eds) Das System Bioökonomie, pp. 23-33. Springer Spektrum, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-60730-5_2.
Walrave, B., Raven, R., 2016. Modelling the dynamics of technological innovation systems. Res. Pol. 45(9), 1833-1844. https://doi.org/10.1016/j.respol.2016.05.011.
Warner, M., 2015. What makes scale-up of industrial biotechnology so difficult? Available at http://www.biofuelsdigest.com/bdigest/2015/12/02/what-makes-scale-up-ofindustrial-biotechnology-sodi_cult/.
Watts, S., Stenner, P., 2012. Doing Q methodological research: Theory, method & interpretation. Sage.
Webb, J.W., Khoury, T.A., Hitt, M.A., 2020. The influence of formal and informal institutional voids on entrepreneurship. Entrepr. Theory Pract. 44(3), 504-526. https://doi.org/10.1177/104225871983031.
Weber, K.M., Hoogma, R., Elzen, B., 2004. Integrated long-term strategies to induce regime shifts to sustainability: The approach of Strategic niche Management. In: Weber, M., Hemmelskamp, J. (Eds.). Towards Environmental Innovation Systems*,* 205-232. Springer.
Weber, K.M., Kubeczko, K., Rohracher, H., 2006. System innovations in innovation systems. In: Andersen, M.M., Tukker, A. (Eds). Perspectives on radical changes to sustainable consumption and production. Proceedings of the Workshop of the Sustainable Consumption Research Exchange Network, pp. 407-429. 20-21 April 2006, Copenhagen, Denmark.
Weber, K.M., Schaper-Rinkel, P., 2017. European sectoral innovation foresight: identifying emerging cross-sectoral patterns and policy issues. Technol. Forecast. Soc. Change 115, 240–250. https://doi.org/10.1016/j.techfore.2016.09.007.
Weber, K.M., Truffer, B., 2017. Moving innovation systems research to the next level: Towards an integrative agenda. Oxford Rev. Econ. Policy 33(1), 101-121. https://doi.org/10.1093/oxrep/grx002.
Wesseling, J.H., Lechtenböhmer, S., Åhman, M., Nilsson, L.J., Worrell, E., Coenen, L., 2017. The transition of energy intensive processing industries towards deep decarbonization: Characteristics and implications for future research. Renew. Sustain. Energy Rev. 79, 1303-1313. https://doi.org/10.1016/j.rser.2017.05.156.
Wieczorek, A.J., Hekkert, M.P., 2012. Systemic instruments for systemic innovation problems: a framework for policy makers and innovation scholars. Sci. Publ. Pol. 39(1), 74–87. https://doi.org/10.1093/scipol/scr008.
Wiesinger, H., Wang, Z., Hellweg, S., 2021. Deep dive into plastic monomers, additives, and processing aids. Environ. Sci. Technol. 55(13), 9339-9351. https://doi.org/10.1021/acs.est.1c00976.
Wijen, F., Ansari, S., 2007. Overcoming inaction through collective institutional work: insights from regime theory. Organ. Stud. 28(7), 1079–1100. https://doi.org/10.1177/0170840607078115.
Wilde, K., Hermans, F., 2021a. Deconstructing the attractiveness of biocluster imaginaries. J. Environ. Pol. Plan. 23(2). https://doi.org/10.1080/ 1523908X.2021.1891872.
Wilde, K., Hermans, F., 2021b. Innovation in the bioeconomy: perspectives of entrepreneurs on relevant framework conditions. J. Clean. Prod. 314, 127979. https://doi.org/10.1016/j.jclepro.2021.127979.
Wilden, R., Gudergan, S.P., 2015. The impact of dynamic capabilities on operational marketing and technological capabilities: investigating the role of environmental turbulence. J. Acad. Market. Sci. 43(2), 181–199. https://doi.org/10.1007/s11747- 014-0380-y.
Wittmayer, J.M., Avelino, F., van Steenbergen, F., Loorbach, D., 2017. Actor roles in transition: insights from sociological perspectives. Environ. Innov. Soc. Transit. 24, 45–56. https://doi.org/10.1016/j.eist.2016.10.003.
Wohlfahrt, J., Frechaud, F., Gabrielle, B., Godard, C., Kurek, B., Loyce, C., Therond, O., 2019. Characteristics of bioeconomy systems and sustainability issues at the territorial scale. A review. J. Clean. Prod. 232, 898–909. https://doi.org/10.1016/j. jclepro.2019.05.385.
Wohlgemuth, R., Twardowski, T., Aguilar, A., 2021. Bioeconomy moving forward step by step–A global journey. N. Biotech. 61, 22–28. https://doi.org/10.1016/j. nbt.2020.11.006.
Wohlin, C., 2014. Guidelines for snowballing in systematic literature studies and a replication in software engineering. In: Proceedings of the 18th International Conference on Evaluation and Assessment in Software Engineering - EASE, 14, pp. 1–10. https://doi.org/10.1145/2601248.2601268.
Wolff, F., 2022. The German Bioeconomy Discourse. In: Thrän, D., Moesenfechtel, U. (Eds.). The bioeconomy system, 259-267. Berlin, Heidelberg: Springer.

Woolthuis, R.K., Lankhuizen, M., Gilsing, V., 2005. A system failure framework for innovation policy design. Technovation 25(6), 609-619. https://doi.org/10.1016/j.technovation.2003.11.002.
Wooten, M., Hoffman, A.J., 2008. Organizational fields: Past, present and future. In: Greenwood, R., Oliver, C., Sahlin-Andersson, K., Suddaby, R. (Eds). The Sage handbook of organizational institutionalism, 130-147. London: Sage.
Wooten, M., Hoffman, A.J., 2017. Organizational fields past, present and future. In: Greenwood, R., Oliver, C., Sahlin, K., Suddaby, R. (Eds.). The Sage Handbook of Organizational Institutionalism, pp. 55–74. London: Sage Publications. http://digital.casalini.it/9781526415059.
Wydra, S., 2019. Value chains for industrial biotechnology in the bioeconomy-innovation system Analysis. Sustainability 11(8), 2435. https://doi.org/10.3390/su11082435.
Wydra, S., 2020. Measuring innovation in the bioeconomy – conceptual discussion and empirical experiences. Technol. Soc. 61, 101242. https://doi.org/10.1016/j. techsoc.2020.101242.
Wydra, S., Hüsing, B., Köhler, J., Schwarz, A., Schirrmeister, E., Voglhuber-Slavinsky, A., 2021. Transition to the bioeconomy–Analysis and scenarios for selected niches. J. Clean. Prod. 294, 126092. https://doi.org/10.1016/j.jclepro.2021.126092.
Wydra, S., Hüsing, B., Köhler, J., Schwarz, A., Schirrmeister, E., Voglhuber-Slavinsky, A., 2021. Transition to the bioeconomy–analysis and scenarios for selected niches. J. Clean. Prod. 294, 126092. https://doi.org/10.1016/j.jclepro.2021.126092.
Yitshaki, R., Kropp, F., 2016. Motivations and opportunity recognition of social entrepreneurs. J. Small Bus. Manag. 54(2), 546–565. https://doi.org/10.1111/ jsbm.12157.
Zabala, A., 2014. Qmethod: A package to analyse human perspectives using Q methodology. R Journal 6(2), 163–173. https://journal.r-project.org/archive/2014-2/zabala.pdf https://doi.org/10.32614/RJ-2014-032.
Zahra, S.A., Sapienza, H.J., Davidsson, P., 2006. Entrepreneurship and dynamic capabilities: a review, model and research agenda. J. Manag. Stud. 43(4), 917–955. https://doi.org/10.1111/j.1467-6486.2006.00616.x.
Zeug, W., Bezama, A., Thrän, D., 2020. Towards a Holistic and Integrated Life Cycle Sustainability Assessment of the Bioeconomy: background on Concepts, Visions and Measurements (No. 7/2020). UFZ Discussion Paper. http://hdl.handle.net/104 19/224078.
Zhao, E.Y., Fisher, G., Lounsbury, M., Miller, D., 2017. Optimal distinctiveness: broadening the interface between institutional theory and strategic management. Strateg. Manag. J. 38(1), 93–113. https://doi.org/10.1002/smj.2589.
Zietsma, C., Lawrence, T.B., 2010. Institutional work in the transformation of an organizational field: the interplay of boundary work and practice work. Admin. Sci. Quart. 55(2), 189–221. https://doi.org/10.2189/asqu.2010.55.2.189.
Zietsma, C., Groenewegen, P., Logue, D.M., Hinings, C.R., 2017. Field or fields? Building the scaffolding for cumulation of research on institutional fields. Acad. Manag. Ann. 11(1), 391–450. https://doi.org/10.5465/annals.2014.0052.
Zukauskaite, E., Trippl, M., Plechero, M., 2017. Institutional thickness revisited. Econ. Geogr. 93(4), 325–345. https://doi.org/10.1080/00130095.2017.1331703.

7 Acknowledgment

The elaboration of this thesis enjoyed the privilege of support by the continuous encouragement, creativity, and constructive feedback of Dr. Ir. Frans Hermans. His wide and deep knowledge of the transition science field was of immeasurable value – especially during research concept development and the article review processes. Unrestricted appreciation is hereby expressed for his unique competence to balance space for student's independent sense-making and guidance for goal achievement.
Moreover, the wider work context at the Department Structural Change at the Leibniz Institute of Agricultural Development in Transition Economies (IAMO) provided a unique and extremely supportive environment. Not only was BMBF-funding for the research group (The role and functions of bioclusters in the transition to a bioeconomy) successfully and flexibly managed. The institute was also decisive for contact establishment to bioeconomy stakeholders and access to a wide array of internal and external learning opportunities.

My gratitude also goes to those entrepreneurs, researchers, regional polititians, and professionals in intermediaries, NGOs and industry associations who trustfully shared their perspectives, voiced their views and/or completed surveys without any compensation. Their engagement and – in many cases – full-harted dedication to progress towards sustainability provided much more than data and unique insights. The resulting inspiration guided my efforts to systematically explore innovation and transition hurdles. In addition, I can't miss to express sincere gratitude to a number of anonymeous reviewers of individual articles: constructive comments and pin-point questioning led the way to the improvement of original drafts.

Lastly, my very personal thanks go to friends and family - most importantly Bernd and Dorothee, Dietrich, Hans, Norbert, Christoph, Ingrid und Maria, Rüdiger und Maritta, Michael and Frauke, Bärbel, Gesa, Stephan and Franz - for their sympathy, patience, encouragement and support.

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Torgauer Straße 116
04347 Leipzig
Phone: +49 (0)341 2434-112
E-Mail: info@dbfz.de

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