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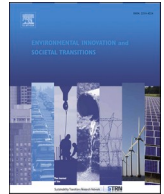
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Transition towards a bioeconomy: Comparison of conditions and institutional work in selected industries

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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

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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; Gümüşay 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 mechanisms 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 diverse, 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 inhabits 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

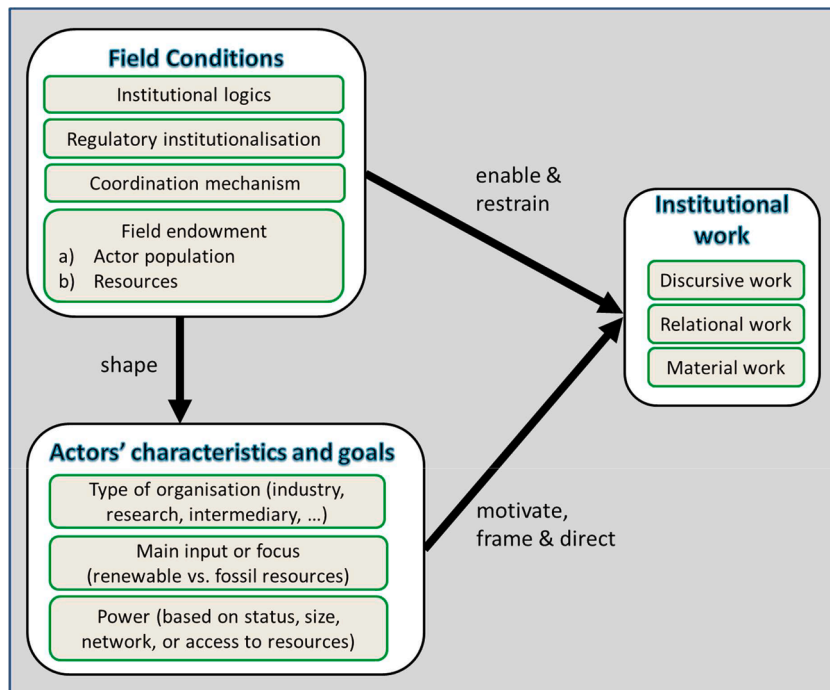


Fig. 1. Factors influencing the emergence, pattern and strength of institutional work.

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

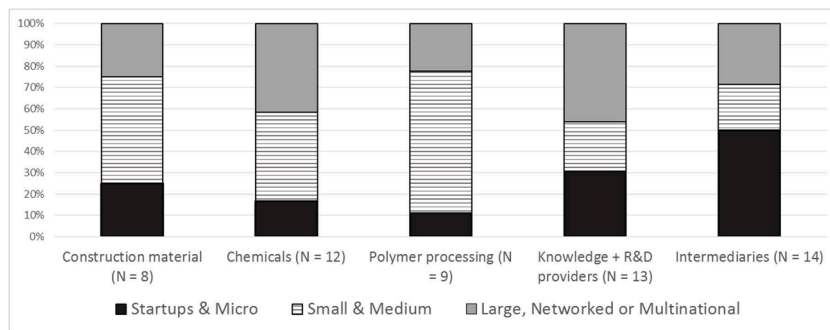


Fig. 2. Size distribution of interviewed actors by type ($N = 56$, percentages by subgroups)

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

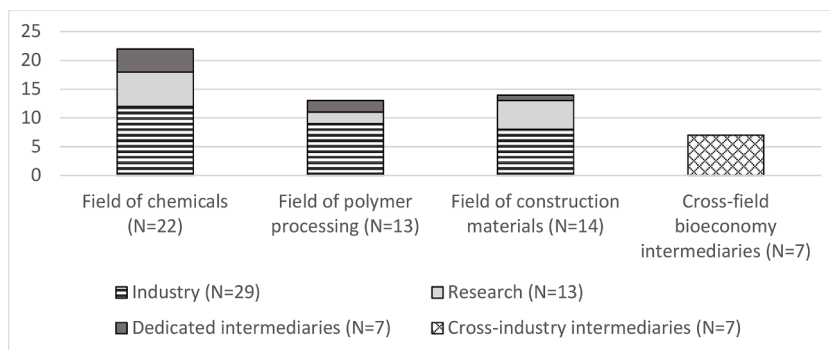


Fig. 3. Sample composition by exchange field and actor type ($N = 56$)

Note: N = Total number of interviews conducted.

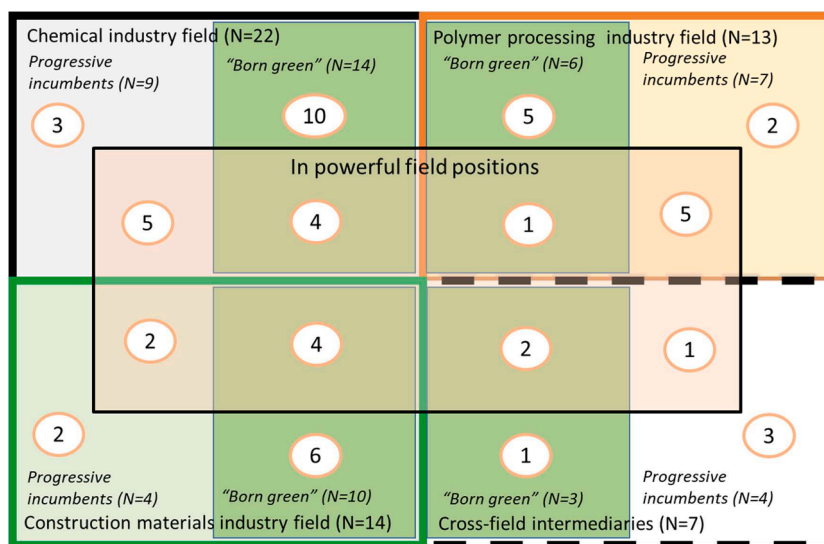


Fig. 4. Sample composition (number of interviewees) by industrial exchange field, use of / focus on renewable feedstocks and power positions ($N = 56$)

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 (DeVerno 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 <ul style="list-style-type: none"> 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
Discursive	Participation in high-level policy discourses	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Consulting European Commission officials on texts for biotechnology research calls 	R		PI
	Shaping norms	<ul style="list-style-type: none"> • Engagement in various committees with decision-making powers on STI policy and funds for biotechnology R&D 		R	PI
	Lobbying for	<ul style="list-style-type: none"> • Initiating a new norming committee for the standardisation of a specific substance (bio-based substitutes) 		I	BG
		<ul style="list-style-type: none"> • 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
		<ul style="list-style-type: none"> • Specific investment subsidies, regional level 	R	R	BG PI
		<ul style="list-style-type: none"> • Policy attention at the regional, national and European levels for a changed industrial policy, sustainable and resilient value chains 	I, X	X	BG PI
		<ul style="list-style-type: none"> • Biotechnology promotion, R&D funds 		I, R	BG PI
		<ul style="list-style-type: none"> • The use of food crops in industry 		I	PI
	Awareness raising	<ul style="list-style-type: none"> • ... among politicians on SME needs, suitable STI instruments and sequences of bioeconomy promotion 	R	R	BG PI
Relational	Reconfiguring value chains	<ul style="list-style-type: none"> • ... away from fossil feedstocks, establishing new co-operations 	I	I	BG
	Mobilising allies	<ul style="list-style-type: none"> • ... in the financial sector to get green innovation financed 	X		BG
		<ul style="list-style-type: none"> • ... from various industries to support regulatory change in favour of hydrogen production 		R	BG
	Establishing consortia, networks and clusters	<ul style="list-style-type: none"> • ... to advance the use of GMOs in industry 	R	I	BG PI
		<ul style="list-style-type: none"> • ... with SMEs and other industries to end the use of fossil feedstocks 	I		BG
Material	Joining consortia, networks and clusters	<ul style="list-style-type: none"> • ... to access information, build leverage to access R&D funds, or build power to counter large competitors 	I, R	I, R, N	BG PI
	Resource acquisition and investment in the implementation of R&D with the aim to change current practices and logics	<ul style="list-style-type: none"> • Application for R&D funding with the aim to build legitimacy via demonstration or pilot plants 	I, R, N	I, R	BG PI
		<ul style="list-style-type: none"> • 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
		<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 <ul style="list-style-type: none"> • 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	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
Relational		•... among customers and end users regarding necessary and desired functionalities of packaging	N	I	BG PI
	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
Material	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
	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	I	I, R	BG PI
		•Using renewable feedstocks			
		•Using waste			
		•Using recycled materials			

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 mechanisms 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 <ul style="list-style-type: none"> • 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 diverse 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 (Liefink et al., 2019), digitalisation (Papadonikolaki, 2018), servitisation (Pelli and Lähinen, 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; Mokhelesian 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 power	other	Operational base
Discursive	Consulting ministries & public authorities	<ul style="list-style-type: none"> •... 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	<ul style="list-style-type: none"> •Engaging in norming committees 	I, R		PI
	Lobbying for	<ul style="list-style-type: none"> •... 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 •... 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, R	BG PI
	Awareness raising	<ul style="list-style-type: none"> •... investment in a dedicated university chair for wood-based construction •... among politicians on STI policy specifics for a bioeconomy 	N		BG
			I	I, R, N, X	BG PI
		<ul style="list-style-type: none"> •... among politicians on agricultural and forest policies and the impact on the industry 	I, N		BG PI
		<ul style="list-style-type: none"> •... by the involvement of the general public in decision-making on infrastructure 		X	PI
		<ul style="list-style-type: none"> •... internationally in view of European agricultural and forest policies •... for strengthened bioeconomy innovation 	N	I	BG
	Mobilising allies		I		BG PI
	Aligning allies	<ul style="list-style-type: none"> •... in industry to get political attention for the benefits of bioeconomy promotion 	R		BG
	Establishing consortia, networks, clusters	<ul style="list-style-type: none"> •Cluster formation •Building networks for synergy creation 	N		BG
Relational	Joining consortia, networks, clusters	<ul style="list-style-type: none"> •Joining or supporting place-based cooperation networks in order to access more information and counter the “concrete-lobby” 	I, R	I, N	BG
	Strengthening collaboration	<ul style="list-style-type: none"> •Supporting information exchange, coordination of innovation endeavours 	I	I, R, N	BG PI
	R&D to change practices, norms and measurement protocols	<ul style="list-style-type: none"> •... for the development of bio-based construction materials and change of own practices 	N	N, X	BG
		<ul style="list-style-type: none"> •Experimentation with new materials and processing in order to achieve a proof of concept and change practices 	I, R	R	BG PI
	Producing evidence for the revision of regulation	<ul style="list-style-type: none"> •Investing in evidence production, new measurement procedures, certification, LCA calculation 	I	I	BG PI
		<ul style="list-style-type: none"> •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
	Building knowledge resources	<ul style="list-style-type: none"> •Facilitating other actors’ material and product testing in view of a wider use of new bio-based materials and transformed practices 		R	BG
	Facilitating innovation	<ul style="list-style-type: none"> •Reorienting research operations in view of bio-based materials and increased environmental sustainability 		R	BG
	Internal principles				

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

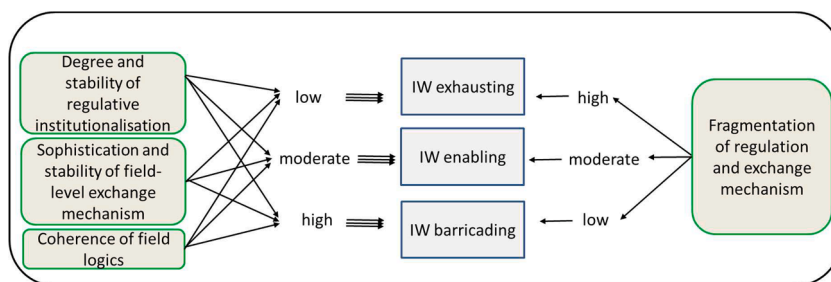


Fig. 5. Relations of relevant field conditions and institutional work. Note: IW = institutional work

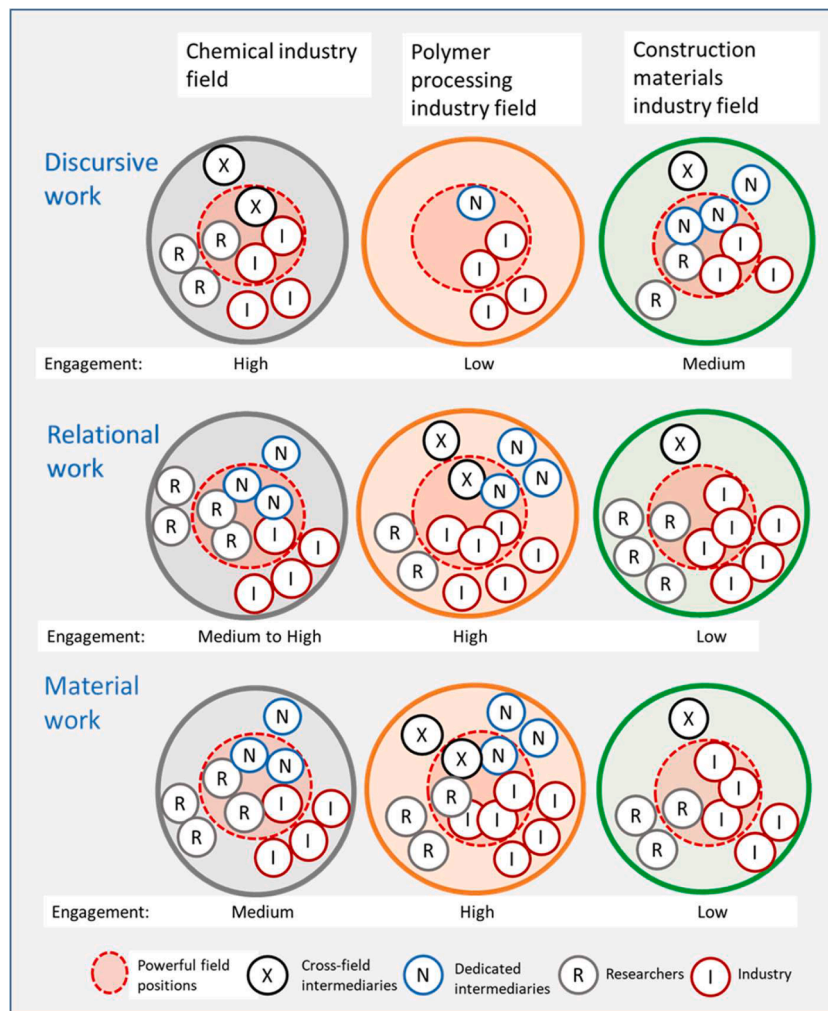
Source: Adapted from Dorado, 2005.

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 institutionalisation	Strong, stable, coherent	Medium, tightening, fragmented	Strong, fragmented
Field-level coordination mechanism	Highly sophisticated, stable, coherent	Sophisticated, stable, coherent	Fragmented, stable, incoherent
Field core population (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.

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Appendix

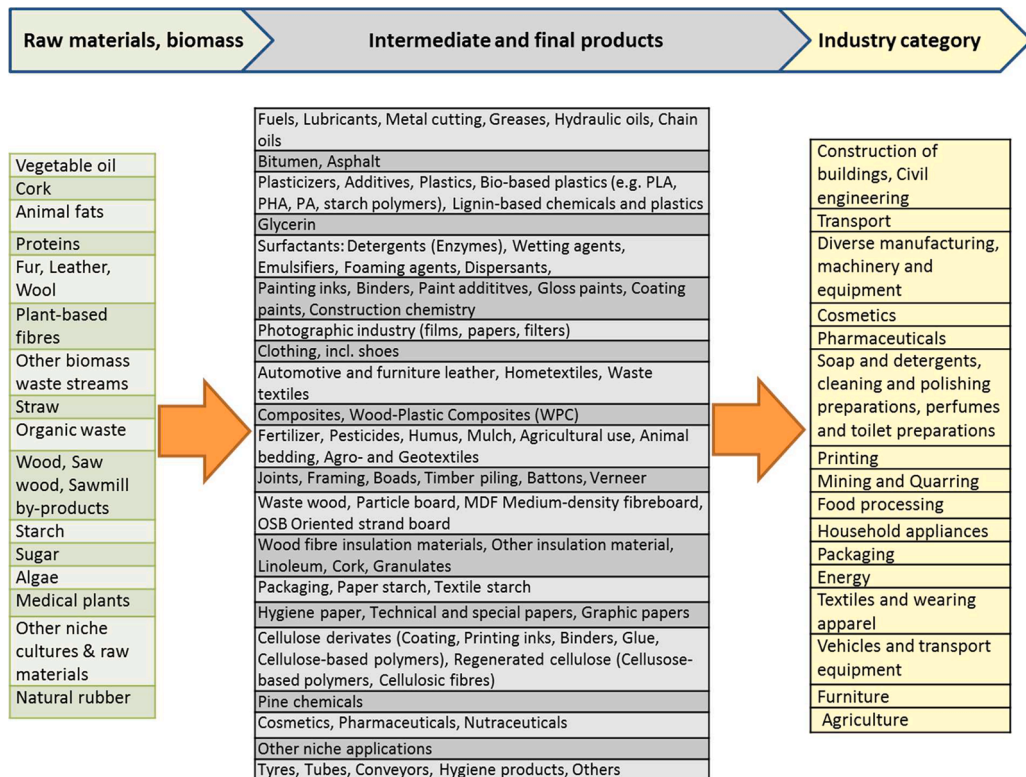


Fig. A.1. Use of renewable resources in European industries.

Source: Own visualisation based Raschka and Carus, 2014.

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