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ABSTRACT: Transition narratives are stories promoting particular pathways for development, promoting specific actions, strategies, and interventions to enable certain outcomes in socio-technical transitions. Narratives centered around biorefineries take a significant role in the growing bioeconomy discourse, yet they express remarkably different visions for the transition. The paper uses Q methodology to identify and analyse transition narratives related to biorefinery innovation, their domains of conflict and consensus, and implications for alternative pathways of development. The analysis shows that the narratives are divided on three aspects: the significance of different kinds of products, the importance of generating new or applying current knowledge, and the need for a comprehensive agenda of state interventions to support a transition towards a bioeconomy. Pathways to very different bioeconomies are indeed open, but policy should remain attentive to the existing conflicts and not presume consensus among actors who claim to support innovation for a bioeconomy.

KEYWORDS: bioeconomy; biorefineries; transition narratives; Q methodology

1. Introduction

The bioeconomy concept can be understood as an economy in which "the basic building blocks for materials, chemicals and energy are derived from renewable biological resources" (McCormick and Kautto, 2013, p. 2590) and has its origins in the policy sphere. The concept has however gained traction in different research fields (Bugge et al., 2016) and significant efforts have been made to unpack the bioeconomy as a political economic concept (Birch and Tyfield, 2013; Levidow et al., 2013) and analyse policy strategies for the bioeconomy (de Besi and McCormick, 2015; Meyer, 2017; Ollikainen, 2014; Priefer et al., 2017; Staffas et al., 2013). Although the bioeconomy discourse has emerged in the search for forms of sustainable economic development, researchers disagree on whether the bioeconomy is itself inherently sustainable or rather a threat to sustainability (Pfau et al., 2014) and the concept has been criticised for being a weak form of ecological modernisation aiming for increased exploitation of natural resources through (bio-)technological innovation (Kitchen and Marsden, 2011). Perspectives on innovation for the bioeconomy make up a complex fabric, woven of conflicts regarding the nature of technologies being promoted and different aspects of the utilisation of renewable resources, e.g. related to land use change, intensification of the use of natural resources, and the creation of new natural resource based industries. It becomes clear that the bioeconomy is a politically contested concept regarding the different possible futures and forms of development that are envisioned. Developing a bioeconomy is thus a challenge calling for both social and technological changes, the co-evolution of which has been described as a socio-technical transition towards sustainability (Geels, 2005; Markard et al., 2012). Such a transition requires changing behavior and expectations among consumers, institutional change regarding norms, standards and regulations, as well as technological and organisational innovation throughout supply and value chains.

Biorefineries are new types of technological configurations which could produce the basic building blocks which are necessary for the bioeconomy. Although the concept biorefinery is itself not unambiguously defined (Bauer et al., 2017), its core lies in the processing of biomass resources for the production of fuels, chemicals, and other value-added products (Cherubini and Strømman, 2011), even though the feedstocks and technologies used could be from a wide range of options (Cherubini et al., 2009). As well as biorefineries have the possibility to substitute for existing products based on fossil resources, they could also introduce new products, processes, and services to "pave the way" for the bioeconomy (de Besi and McCormick, 2015; Sillanpää and Ncibi, 2017). It is this central role in the bioeconomy that make biorefineries a suitable focal point for analysis as tensions and conflicts in the bioeconomy discourse are mirrored in its elements – biorefineries can support and drive the development of very different bioeconomy pathways. Tensions

between these pathways are however at risk of being neglected in narratives which argue that inherently biorefineries are "vehicles of sustainable innovation" (Wellisch et al., 2010, p. 277). Although not yet realised, visions for diverging pathways exist and are expressed by many actors. Narratives – stories told by different actors to describe and analyse complex and uncertain issues (Roe, 1994) – are expressions of the political contestation of pathways to a bioeconomy as certain innovations are being developed to fit within or as add-ons to specific industrial contexts that are consequently promoted directly or indirectly in the bioeconomy discourse. Key issues in these narratives are how the emerging bioeconomy balances the needs for economic development with a notion of sustainability, and how to deal with the challenge of a limited supply of resources – not only in terms of substituting biomass for a diminishing supply of petroleum, but also resources such as water, productive land, capital, and competence. However, regarding how to deal with these issues, there are very different expectations connected to the values being integrated into the narratives.

The paper focuses on Sweden where research on biorefinery technologies has been extensive, although their adoption and diffusion has been slow after reaching the pilot and demonstration stage. This has been explained with weaknesses in the innovation system related to fragmented and coordinated policies, especially regarding other biorefinery products than biofuels (Hellsmark et al., 2016; Hellsmark and Söderholm, 2017) and that significant challenges regarding capacity building and collaboration remain to be solved (Palgan and McCormick, 2016). The bioeconomy in the Swedish and Scandinavian context is in contrast to many other contexts, e.g. Europe and the US, more focused on the utilisation of forest resources (Kleinschmit et al., 2014), which has implications for the types of actors and technologies that are relevant for the bioeconomy compared to contexts which are more focused on agricultural resources. Strong industrial actors from the forest industry in Scandinavia have shown interest in biorefinery technologies mainly for fuels and energy production (Hämäläinen et al., 2011) although a few actors have made diverging choices (Karltorp and Sandén, 2012). Conservative organiational cultures and difficulties in collaborating across sectoral borders have however created barriers for strategic change and reorientation for many actors (Hansen and Coenen, 2017; Näyhä and Pesonen, 2014). Overcoming the valley of death in which biorefinery innovation currently finds itself requires both strong individual actors and supporting networks to provide complementary knowledge and resources (Mossberg et al., 2017). The Swedish context thus provides a setting with strong actors and policy support for the emerging bioeconomy, yet it can be questioned whether there is any real progress on the issue. As a concept gaining much attention in different arenas it is an interesting focal point for studying visions and expectations that have been formed, but not yet materialised.

The aim of this paper is to identify and characterise different narratives of innovation in the bioeconomy, their domains of conflict and consensus, and their implications for alternative pathways of development. The narratives are identified and interpreted using Q methodology, which is designed to study aspects of subjectivity such as social perspectives on contested issues. The paper contributes to the understanding of how actors engaged in technological innovation related to the bioeconomy understand their work and the implications it has in forming possible futures, engaging with their potentially very important political implications. In doing this, the study highlights diverging understandings of the role of knowledge and innovation in the contemporary debate about a socio-technical transition towards a low-carbon future. With its focus on actors the paper contributes to the literature on the bioeconomy as earlier contributions have mainly focused on the discourse as expressed in policies and governmental strategies. The paper firstly discusses the role of narratives for innovation and socio-technical transitions, the subsequent section presents the method employed to identify narratives that exist for biorefinery development as part of the transition to a bioeconomy. The fourth section presents and interprets the results obtained, thereafter follows a discussion about the areas of conflict and consensus that have been identified. Finally, the conclusions and implications of the study are outlined.

2. Framings and narratives in transitions

In ongoing socio-technical transitions multiple pathways are open, pathways that each one represents a different outcome and a different possible future. The pathways are envisioned by actors with individual values, goals and assumptions which build up a set of system framings and become part of the discourse related to the issue or problem in focus (Leach et al., 2010). Discourses are ensembles of ideas, concepts, and categories (Hajer and Versteeg, 2005), which include imaginaries, "representations of how things might or could or should be" that are enacted through practices, social relations and material artifacts (Chiapello and Fairclough, 2002), as well as narratives that are constituted of discursive elements which are organised and expressed in a certain manner (Urhammer and Røpke, 2013). Narratives are particularily relevant as a focal point for policy analysis for issues which are uncertain, complex and polarising, as in cases like these stories told by influential actors become forces in themselves and can define the policy outcomes if they gather enough support among policymakers and other actor groups (Roe, 1994; van Eeten, 2006). A narrative analysis can thus be seen as a focused and limited form of discourse analysis, restricted to the stories being told about what type of development is seen as likely and/or wanted by different actors active in the overarching discourse.

In transition studies it has been shown how established, powerful actors and social movements can use discursive strategies to set the agenda, as well as the framing of the issues constituting the agenda (Geels, 2014). This can be effectively used as a tool for counteracting emerging socio-technical niches and competing pathways which are potential threats to the interests of incumbent actors and regimes (Sengers et al., 2010) making narratives effective tools for power and dominance in transition processes. Promoting specific narratives of development and innovation are also important for building legitimacy for certain framings (Geels and Verhees, 2011), a key aspect in the early stage of an issue life cycle, when actors are having to accept certain issues as relevant to discuss and engage with (Penna and Geels, 2012). Transition narratives are thus suggesting particular pathways for development, intending to promote specific actions, interventions, strategies, and policies to ensure that an expected or ongoing socio-technical transition will unfold along the lines of a preferred transition pathway, be it one of radical realignment or more incremental reconfiguration (Geels and Schot, 2007). If successful the narratives gain support by a larger network of actors and institutions, creating boundaries for the possible and desirable – while there may at the same time exist conflicting, less visible narratives promoted by marginalised groups (Hermwille, 2016). Understanding narratives of transition pathways, and how actors view the roles of themselves and others in these, can therefore be a tool for identifying domains of conflict and consensus in emerging transitions. The narratives are thus not in themselves an outcome of a transition process but rather a beginning, and entities which can be analyzed to understand the politics of knowledge and technology that are being challenged in a transition. Although narratives include actors, objectives, and actions, technologies are often key elements in narratives around socio-technical transitions. The role of technologies is however not constrained to specific technological expectations (van Lente and Bakker, 2010) which Borup et al. define as "real-time representations of future technological situations and capabilities" (2006, p. 286), but technologies can also be used to order other aspects of narratives. Some transition narratives would thus be centered around specific technologies whereas others would see the technologies as more peripheral to the transition. Understanding what these narratives and expectations are and which conflicts their materialisation may cause are thus important tasks to provide directionality and governance for the transition.

The bioeconomy discourse has been the object of several previous contributions, many of which focus on the visions and expectations connected to biotechnology as a central technological field for the bioeconomy transition. However, the bioeconomy discourse has been shown to span more conflicts than the one regarding the potential dangers of advanced biotechnologies as the discourse is intricately connected to previous discourses on energy and environment. Pülzl et al. argue that rather than replacing previously important

meta-discourses, i.e. overarching discourses related to global developments such as ecological modernisation or sustainable development, the bioeconomy discourse bridges these meta-discourses as it "interweaves arguments of doom (limits to growth) with technological arguments (ecological modernisation) and economic arguments (neoliberalism), while being concerned mostly about the economy" (2014, p. 391). Ramcilovic-Suominen and Pülzl (2016) conclude that European bioeconomy policy narratives use sustainable development as a "selling point", while they are in fact focused on efficiency, productivity and industrial competitiveness for the production of food and biofuels. Kirkels (2012) also finds that although the bioeconomy can be seen as the most recent shift in the discourse on bioenergy, focusing on knowledge intensity and decentralisation, the focus on biorefineries creates a bridge to discourses on renewable energy which are more focused on visions of large scale industrial utilisation. These contradictions are in line with the findings of Birch and Tyfield (2013), Bugge et al. (2016), and Levidow et al. (2013) who identify biotechnology and life sciences as defining features of some bioeconomy visions which are centered around advanced, industrial bioengineering, whereas other visions are based more on ideas of using specific natural resources or socio-ecological processes. Trying to overcome the conflicts between different bioeconomy visions and imaginaries Birch provided a new definition of the bioeconomy, including it as part of a "broader societal transition to a low-carbon future" (2016, p. 15), i.e. seeing the bioeconomy as only part of a larger transition. Previous contributions on bioeconomy discourses have however mainly focused on the policy sphere, giving less attention to actors working with its realisation. As not only official policy narratives influence the development but also those of other individuals and groups, understanding the narratives told and enacted by different actors engaged in developing biorefineries as part of the transition to a bioeconomy becomes an important issue to unpack.

3. Methodology

The study uses Q methodology (see Dziopa and Ahern, 2011 for a review and introduction), which was developed in social psychology to study human subjectivity. With its potential to "open up" discourses (Leach et al., 2010), explore inherent contradictions and conflicts surrounding an issue without predefining categories and problem definitions, Q methodology is well suited as a tool for narrative analysis (Hermwille, 2016; van Eeten, 2006). Q methodology has been used for exploratory narrative analysis of an emerging transition to a collaborative economy (Gruszka, 2017), as well as for studies of social perspectives on environmental challenges and responses in studies of discourses on sustainability (Barry and Proops, 1999), perspectives on environmental policy (Addams and Proops, 2000), and framings of climate geoengineering (Cairns and Stirling, 2014). The

method is a quali-quantitative method which captures subjective positions in a specific discourse. This is done by (i) constructing a set of statements about the topic of interest (the Q sample), (ii) asking a number of participants to rank these statements according to their own perspective on the issue (perform a Q sort), and (iii) analyzing the Q sorts statistically using factor analysis to arrive at shared social perspectives on the studied topic. Among the advantages of Q compared to conventional discourse analysis methodologies is the transparency in presenting and interpreting data and the rigor in the approach due to its use of statistics for correlating different perspectives as expressed by the participants in their Q sorts.

3.1. The Q sample

The first step in the method is to develop the concourse, a large sample of statements about the topic of interest that capture different views on and aspects of the issue of interest. As the point is to study subjective perspectives on the issue it is important that the concourse is made up of statements about the topic that relate to values, opinions, and beliefs, but not statements that simply can be proven true of false. From the concourse a subset of statements is chosen, which constitute the Q sample that the participants sort.

Statements for the concourse were sourced from Swedish newsprint and industry press articles, governmental and industry sector innovation strategy documents, as well as descriptions of specific innovation projects conducted by academic institutions and firms from different industries. In the end the concourse consisted of 376 statements – a point at which new statements only seemed to repeat earlier ones – spanning a wide range of issues related to the topic. To develop the Q sample the statements in the concourse were inductively coded to identify important themes: economic development, energy, research, investments, environment and climate, competence, government and policy, products, feedstocks, and strategies. Although biorefineries have, especially in the European context, been argued to be important for the development of peripheral, agricultural regions, this aspect is absent in the Swedish discourse and the identified concourse, which is overwhelmingly centered around forest biorefineries. Statements were then selected from each of the themes, yielding a final Q sample of 45 statements. Some statements were used verbatim whereas others were edited for conciseness and clarity. The final Q sample is presented together with the resulting factor arrays in Table 3.

3.2. Participants and Q sorts

Q usually uses a small group of purposively sampled participants who receive the Q sample individually together with instructions on how to sort them, aiming to make participants carefully consider how the statements relate to each other (Brown, 1993). The aim is thus

to identify and characterise the diversity of important narratives within the discourse, although not claiming to present a fully exhaustive range of the perspectives that exist.

Participants were selected based on their working with issues relating to bioeconomy and biorefinery innovation in different professional roles, many from large industry firms that could be called regime actors. Participants were identified from organisations known to be active within the field of biorefinery development in different ways, e.g. from R&D or business development departments of companies, policy and strategy analysts of interest organisations and NGOs. These individuals were contacted via e-mail or telephone and asked to take part in the study. 20 individuals agreed to participate in the study, of whom 4 were women and 16 men. Participants had diverse backgrounds and were working in different sectors which all have engaged with the topic: academia (2), research institutes (2), agriculture (2), chemicals (3), energy and fuels (4), forest (3), public sector (2), NGO (1), and business consultancy (1). Participants were all assured that their participation would be anonymous. Q sorts were conducted in person, using printed cards with the statements, with the instruction to sort the statements with the instruction "What is your view of the development of biorefineries for a bioeconomy?" from "most unlike my view" (-4) to "most like my view" (+4) in a forced distribution pattern shown in Figure 1. The Q sorts were followed by an interview to enable a better understanding of the individual's perspective.

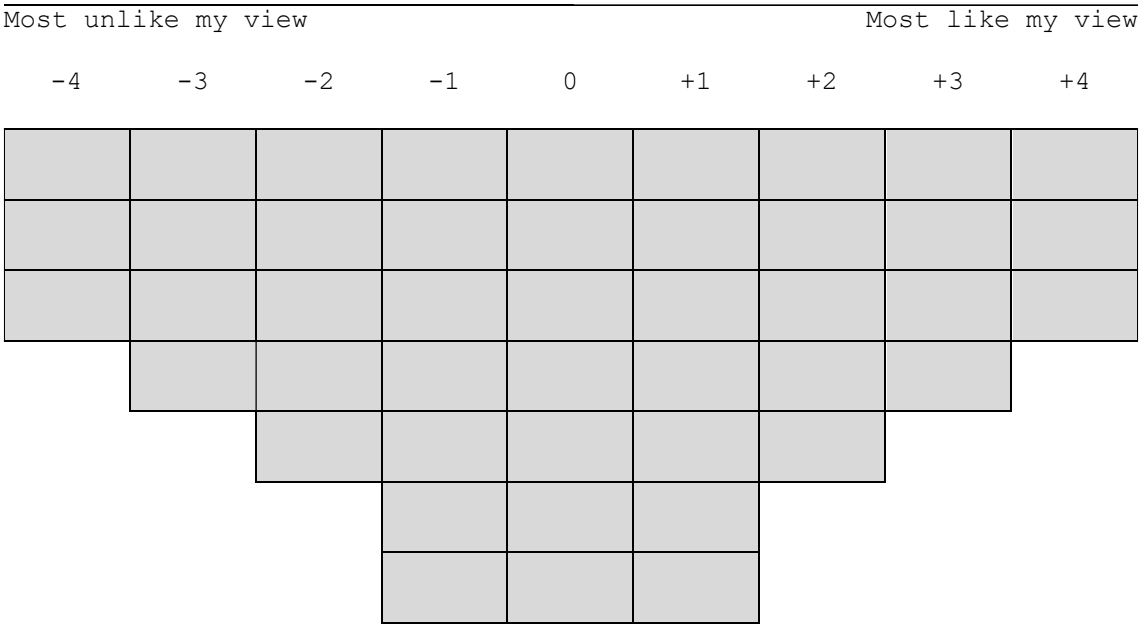

Figure 1. Forced distribution pattern for Q sorts.

3.3. Analysis

Unlike other methods that use factor or component analysis to find factors that explain a smaller number of characteristics or outcomes among a large sample of participants, Q uses a limited number of participants and instead finds correlations between the sorts made by the participants. The correlations between the individual Q sorts are then the basis for extracting factors, i.e. groups of shared perspectives. The number of factors to be extracted is determined by the researcher based on the empirical material as it cannot be deductively determined how many perspectives exist, although criteria such as the Kaiser-Guttman criterion (factor eigenvalues should be larger than 1) and a minimum number of two (Watts and Stenner, 2012, pp. 105-110) significantly loading Q sorts for each factor, i.e. having at least two participants correlate with statistical significance with a factor, can be employed for guidance. The extracted factors are subsequently rotated to explain the sorts in the best possible way, using judgmental or algorithmic rotation methods. The rotated factors are then used to create factor arrays, which are idealised Q sorts representing the identified narrative expressed through the factor. For this study principal component analysis (PCA) was used for factor extraction followed by varimax rotation using the `qmethod` package (Zabala, 2014) for the statistical computing software `R` (R Core Team, 2017), aiming to generate a simple but stable solution which explains as much of the variance as possible in the data.

4. Results and interpretation

The first part of the analysis is the statistical method explained above, which yields results in the form of factor characteristics, participants factor loadings, and the statements' factor and z-scores. Thereafter follows the interpretation, during which the factor arrays are used to create a narrative that holistically captures the perspective expressed through the factor and by the participants loading significantly on this factor.

4.1. Quantitative analysis

The quantitative analysis produced three factors, which together account for 45 % of the variance in the study. A summary of the factors is presented in Table 1. Eighteen of the participants loaded significantly ($p < .01$) on any of the factors, another participant (P13) is confounded, i.e. loaded significantly on two factors, and the final participant (P16) did not load significantly on any factor and can thus be seen as having a deviating perspective. The factor loadings of all participants are presented in Table 2. The significantly loading, non-confounded Q sorts were used to create factor arrays, which are idealised sorts for each of the factors. The factor arrays are presented in Table 3, which also indicates the statements that are significantly differently ranked by each of the factors ($p < .01$) as well as which

statements were similarly ranked by all factors (p >.05 for all factors), indicating consensus on the issue.

Table 1. Quantitative summary of factors.

	Factor 1	Factor 2	Factor 3
Defining Q sorts	8	5	5
Eigenvalue	4.15	2.46	2.31
Explained variance	21 %	12 %	12 %
S.E. of factor z-scores	0.17	0.22	0.22
Factor correlations (F1 / F2 / F3)	1 / 0.27 / 0.19	0.27 / 1 / 0.18	0.19 / 0.18 / 1

Table 2. Factor loadings of participants' Q sorts. Boldface indicate that the participant's sort load significantly on the factor.

ID	Professional sector	Factor loadings		
		Factor 1	Factor 2	Factor 3
P1	Academic research	0.1821	-0.7198	0.2352
P2	Forest	0.6023	0.2747	-0.1614
P3	Chemicals	0.6093	-0.0489	0.2244
P4	Chemicals	0.5939	0.1236	0.2769
P5	Government	-0.0899	-0.1338	0.7416
P6	Government	0.6482	0.0791	-0.2826
P7	Chemicals	0.2795	-0.0784	0.4027

P8	Institute research	0.1572	0.2952	0.4693
P9	Energy and fuels	0.3483	0.4841	0.1094
P10	Energy and fuels	0.1062	0.7199	0.1382
P11	Agriculture	0.7462	0.2146	0.0063
P12	NGO	-0.0762	0.3049	0.6552
P13	Academic research	0.5611	-0.4197	0.2640
P14	Forest	0.1365	0.5066	0.2455
P15	Institute research	0.6695	-0.0630	0.2451
P16	Energy and fuels	0.2744	0.3385	0.3168
P17	Forest	0.6326	0.1280	0.1868
P18	Agriculture	0.6039	0.2157	0.0840
P19	Business consultant	0.2380	0.1663	0.5004
P20	Energy	0.3577	0.4411	0.2213

The first factor (F1) represents a dominant narrative, with almost half of the participants loading significantly on this factor, while about a quarter of the participants load significantly on each of the two other factors. The second factor (F2) is a bipolar factor, i.e. it is defined by both significantly positively and negatively loading Q sorts, indicating that the participants loading on this factor have related but contradictory perspectives. Following Watts and Stenner (2012, p. 165) the factor will be split into two interpretations, representing two highly opposed narratives (F2+ and F2-), with the second interpretation being based on a complete negation of the factor array for factor F2.

Table 3. The statements from the Q sample with their z-score and Q-sort score for each factor. For statements that are distinguishing for the factors (p <.01) the score numbers are boldfaced. Italic numbers indicate statements on which the factors are in consensus (p >.05 for all factors being distinguishing).

Statement	Factor 1		Factor 2		Factor 3	
	Q-sort score	z-score	Q-sort score	z-score	Q-sort score	z-score
S1 Research must be governed more by industry to lead to the transformation to a bioeconomy.	-2	-1.049	4	1.423	4	1.447
S2 Everything that can be produced from petroleum could be produced from bioresources.	2	1.219	4	1.437	-1	-0.180
S3 Transportation costs for bioresources limit the possibilities for their utilisation	0	0.217	-2	-0.854	-2	-1.060
S4 The most difficult aspect of the transition to a bioeconomy is to find the ideas that match the challenges.	-3	-1.129	-4	-2.586	-2	-0.976
S5 New products from biorefineries have to be better and cheaper than existing products.	-1	-0.356	-3	-1.343	-3	-1.698
S6 A national bioeconomy strategy which influences all areas of policy is needed.	3	1.233	-2	-0.613	-3	-1.122
S7 Investments in research and development of new technologies must increase for the bioeconomy to grow.	1	0.316	-2	-0.846	0	0.206
S8 Bioenergy has an important role to play in the transition to a bioeconomy.	2	0.806	3	1.236	1	0.317
S9 Many claim to want a bioeconomy, but do not know what it is.	0	0.341	0	0.149	1	0.365
S10 Bioeconomy is primarily a buzz word.	-4	-2.241	2	0.561	-2	-0.964
S11 To little is invested to transform research to finished products.	0	-0.031	-2	-0.950	4	1.551
S12 Recycling of products and materials is an important part of the bioeconomy.	0	-0.047	-1	-0.254	2	0.776
S13 Sweden should not use its natural resources to meet the demand of others.	-4	-2.650	-1	-0.440	-4	-2.401
S14 There is a great interest for biobased products in the market.	-1	-0.456	2	0.748	-1	-0.123
S15 For firms to risk investing in development of biorefineries the state must show	1	0.148	3	1.286	1	0.530

leadership.						
S16 The forest is the foundation for the bioeconomy.	4	1.955	1	0.529	-3	-1.710
S17 Compared to energy production, other biobased products will be a larger driver in a transformation.	-1	-0.461	-4	-1.767	2	0.929
S18 Collaboration must be strengthened to facilitate the development of a biorefinery industry.	1	0.653	2	0.823	0	0.247
S19 Future biorefinery concepts will increase the demand for crossdisciplinary knowledge	2	0.692	0	0.145	0	0.161
S20 A condition for success in the bioeconomy is to be at the international knowledge frontier.	0	0.073	-3	-1.066	-1	-0.476
S21 The prefix bio is used for greenwashing of business-as-usual.	-4	-1.446	0	-0.017	-4	-1.895
S22 It is possible to manage forests sustainably and simultanesously increase the production of wood.	3	1.141	1	0.520	0	0.009
S23 The climate target is an important driver for the development of the bioeconomy.	1	0.385	4	2.579	1	0.726
S24 Ecosystem services and biodiversity must become integrated in business models.	-2	-0.703	3	1.306	2	0.954
S25 Increased production of bioresources will lead to conflicts with other interests.	-3	-1.339	-1	-0.130	1	0.610
S26 Industry investments are too small to develop the bioeconomy.	-2	-0.503	-1	-0.538	3	0.956
S27 A barrier to developing the bioeconomy is the costly technology shift it implies.	1	0.270	-1	-0.190	0	0.105
S28 The market functions best if it is left to develop on its own without involvement by the government.	-3	-1.376	-1	-0.575	-4	-1.747
S29 A biobased manufacturing industry will secure both long-term competetiveness and new jobs.	1	0.392	1	0.407	0	0.077
S30 Consumers' choices must create demand that can contribute to the transformation.	-2	-0.445	-2	-0.920	3	1.396

S31 Stable markets for biobased products must be created.	0	0.175	1	0.505	1	0.326
S32 A bioeconomy is a necessary shift to ensure both growth and a sustainable society.	4	1.848	0	-0.093	-1	-0.413
S33 To reach the biobased society is the chemical industry a key part.	3	0.850	-3	-0.966	3	1.207
S34 Firms do not themselves manage to develop the necessary new products and processes.	-3	-1.587	-3	-1.400	-1	-0.381
S35 Several different industry sectors must collaborate to develop new technologies for the bioeconomy.	2	0.542	1	0.513	3	1.305
S36 The bioeconomy will lead to a new industrialisation.	-1	-0.183	-1	-0.306	-1	-0.233
S37 Established industries will implement biorefineries in connection to existing production.	4	1.314	0	-0.027	-2	-0.619
S38 Boundaries between conventional industry sectors will break up when biorefineries become a new, growing sector.	-1	-0.001	2	0.687	1	0.543
S39 The public sector has a great responsibility to push the bioeconomy forward through procurement.	1	0.416	1	0.549	4	1.428
S40 Lobbying from strong interests leads to regulation that slow down the development of the bioeconomy.	-2	-0.402	2	0.559	0	0.277
S41 Public financial support will be needed for individual investments in biorefineries.	-1	-0.474	0	0.020	-2	-0.668
S42 Policy instruments to support the bioeconomy must be technology neutral.	0	0.091	1	0.286	-3	-1.150
S43 Policies for the bioeconomy is lacking a holistic approach.	2	0.943	0	0.163	2	0.932
S44 Policies are lacking the long-term perspective that is necessary for a transformation.	3	1.263	3	1.131	-1	-0.410
S45 Access to new venture financing is needed for the new investments.	-1	-0.406	-4	-1.679	2	0.846

4.2. Qualitative interpretation

Below follows the interpretation of the identified factors as coherent narratives, which have been assigned names aiming to reflect the core of their argument. The interpretation is based on the defining statements of the different factors but also extended to include other important statements from the respective factor arrays to allow for a holistic interpretation. Numbers within brackets in the interpretations refer to relevant statements and their rank in the factor arrays (see Table 3). Although the narratives are presented as distinct entities, the existence of confounded Q sorts – individuals loading significantly on more than one factor – point to the fact that these narratives can have soft boundaries and be partially overlapping.

4.2.1. F1: "Let firms innovate at their own pace"

The factor represents a narrative which puts a large degree of trust in that the bioeconomy is coming closer by the day, although they may have a sense that the speed of change is insufficient. Biorefineries are primarily seen as add-ons to existing forest industry facilities, and the forest industry – which is already a big part of the bioeconomy – is doing well in managing innovation for biorefineries. All in all, this is a narrative arguing that we are on the right track but need to be patient and let firms innovate at their own pace. Nine participants, of whom one is confounded, load significantly on this factor. The participants represent varying professional sectors, i.e. different industries as well as research and public sector.

The bioeconomy is far from a buzzword – rather it denotes a specific economic paradigm (S10: -4) as well as it is a necessity for ensuring economic growth and sustainability (S32: +4), although others using the word do not always understand the material base for the concept (S9: +1). The forest is the most important natural resource available in Sweden (S16: +4) and it should be used to produce products for global markets (S13: -4). The production of forest biomass can be increased sustainably (S22: +3) and without creating conflicts with other interests (S25: -3). Swedish firms are in a good position to develop the new products and processes for the bioeconomy (S34: -4) and are making the necessary investments (26: -2), although the scale of investments that are needed for new biorefinery technologies is a barrier to developing the bioeconomy (S27: +1). Investments in new facilities for biobased production will primarily be done by established industries as retrofits to existing facilities (S37: +4). Even though a biobased industry is unlikely to lead to a new wave of industrialisation across the country (S36: -1) it is an important contribution to ensuring competitiveness and new jobs (S29: +1). Although collaboration is needed to develop a biorefinery industry (S18: +2) it is not very likely to lead to a radical change in how industries are structured and divided (S38: 0). Policies aiming to support the

transition to a bioeconomy are lacking both a necessary long-term and holistic perspective (S43: +2; S44: +3) and a national strategy which influences all policy areas is therefore much needed (S6: +3) to support firms innovating for the bioeconomy in different ways.

4.2.2. F2+: "Energy is the key issue"

The factor represents a narrative which identifies the idea of a bioeconomy mainly as a way of dealing with global climate change. In this light the question of energy supply is the key problem to solve and different forms of bioenergy are the solutions to that problem, and thus also the main reasons to invest in biorefineries. Three of the four participants loading positively on factor F2 belong to the energy and fuels sector and the fourth represents a forest industry firm.

The global climate target is a very important driver for the development of the bioeconomy (S23: +4), although it has partially become a buzz word (S10: +2). Bioenergy is a key to this development (S8: +3; S17: -4) as energy and fuels constitutes a very large share of the possible product volumes from biorefineries, although the boundaries between the energy sector and others will partially disappear once the development takes off (S39: +2). There is however a significant risk that the bioeconomy will be hindered by lobbying from other strong interests (S40: +2), e.g. fossil resource based industries, especially internationally. Ideas are available in abundance (S4: -4) and investments in research and development of new technologies are by no means too small (S7: -2) but research should be governed more by industry to be able to generate the knowledge that is needed for a transformation (S1: +4). There is however no doubt that everything produced from petroleum could be substituted by biobased products (S2: +4) for which there is an emerging market interest (S14: +2), and significant investments are being made to transform research into new, finished products (S11: -2). The cost of technology shifts is not a significant barrier for a transformation (S27: -1) and there is plenty of capital available for new smart investments (S45:-4), but the state must show leadership for firms to risk investing in the development of biorefineries (S15: +3) especially when it comes to having a long-term perspective on policies that are implemented (S44: +3) and if possible they should aim for technology neutrality (S42: +1).

4.2.3. F2-: "The bioeconomy, an endless frontier"

The factor represents a narrative with a strong belief in scientific progress, but which also acknowledges that there is a misguided belief that science and technology alone will manage to solve the problems at hand. Biorefineries will mainly bring new types of products to the market, whereas other ways must be found to decrease the dependency on fossil resources for the products that are today seen as fundamental for society – simple substitution will

not suffice. The two participants loading negatively on factor F2, one of them confounded, are academic researchers.

The largest challenge to manage the transition to a bioeconomy is to find new ideas that match the challenges (S4: +4) as not everything that can be produced from petroleum could be produced from bioresources (S2: -4). The investments in R&D probably have to increase (S7: +2), but for scientific research to remain a strong driver of development (S1: -4) it should be left to guide itself. A precondition to be successful in the transformation to a bioeconomy is to be at the knowledge frontier (S20: +3) making firms unable to on their own develop the necessary new products and processes (S34: +3). It is mainly advanced non-energy products that will be important in the transformation (S8: -3; S17: +4) and thus the chemical industry has a very important role to play (S33: +3). As there is not really a very large interest for biobased products in the market (S14: -2) new products likely have to compete on both quality and price with conventional products (S5: +3). Firms should understand that investments are needed, and not wait for the government to be the leader or first mover (S15: -3; S39: -1) – long-term political targets have already been determined, but these are not the main drivers for a transformative change (S23: -4; S44: -3).

4.2.4. F3: "A green intervention agenda"

The factor represents a narrative expressing a strong belief in the capacity and necessity of public policy interventions to initiate transformative change in industrial and economic structures towards a bioeconomy with emerging biorefineries. There is a need for holistic and adaptive policymaking, supporting new technologies in different ways and finding new ways of financing innovation deployment and diffusion as industry actors are not doing enough to support the desired development, although they are important and needed allies. Five participants load significantly on this factor. The participants represent public sector, research institutes, chemical industry, an environmental NGO, and a business consultant.

Interventions by the government are crucial to developing a bioeconomy as markets are not well suited to develop in the right direction on their own (S28: -4). The public sector thus has a responsibility to develop demand through procurement (S39: +4) together with consumer groups that can articulate demand (S30: +3). Policy instruments need not aim for technology neutrality (S42: -3) but policy should have a more holistic approach to supporting the development of the bioeconomy (S43: +2) although this is most likely not managed with a national bioeconomy strategy (S6: -3). Sweden does however have a good position due to the availability of natural resources for the bioeconomy, which extend far beyond the forest (S16: -3), and these should be used to meet international demand (S13: -4). Industry actors are not investing enough to develop the bioeconomy (S26: +3) and when it comes to transforming research into finished products investments are definitely

too small (S11: +4). Although research shows a great transformative potential, industry must take a stronger role in guiding research to be useful (S1: +4). The new technologies will be boundary crossing and require different industry sectors to collaborate (S35: +3), and one of the important sectors to engage to reach a biobased society is the chemical industry (S33: +3). Although the bioeconomy is not very likely to lead to a new industrialisation (S36: -1) the prefix "bio" is far more than just greenwashing of business as usual (S21: -4). Biorefineries are not likely to be limited to being add-ons to existing industry (S37: -2) and thus the new investments need access to new venture finance (S45: +2).

5. Conflicting and contradicting narratives

This section outlines and discusses the areas of overlap and conflict found in the above presented narratives, which will be shown conceptually using a semiotic square to structure the comparison of the narratives (van Eeten, 2006).. A semiotic square is generically constructed by contrasting the narrative *A* with its contrary *not A*. Both of these narratives can be compared with the contradictory narrative *both A and not A* as well as its respective contrary narrative *neither A nor not A*. In terms of conflicts, the narratives are firstly clearly divided on what types of products are likely to be the most important for developing the bioeconomy. Secondly, the narratives diverge in their views on the importance of creating new or applying existing knowledge. Finally, the narratives express very different views on the role that the state and private enterprises should take in the transition to a bioeconomy. Some of the narratives take directly contrary positions on these issues, whereas others point to different ways of approaching them.

Starting with the contrary positions occupied by narratives *Energy is the key issue* and *The bioeconomy, an endless frontier*, which both focus on the importance of specific outputs from biorefineries, a semiotic square of the narratives can be drawn, Figure 2. While the narrative *Energy is the key issue* emphasises the role of bioenergy products, due to their possibility to directly substitute fossil fuels and thus reduce greenhouse gas emissions, the narrative *The bioeconomy, an endless frontier* underlines the importance of developing new advanced products with higher value than energy products, as they are more likely to lead to transformative industrial development. The narrative *Let firms innovate at their own pace* contradicts the two first ones in claiming that focusing on either product category is beside the point – both energy and other outputs are needed – as the focus should be on the raw material, biomass, which is the foundation for all products. This narrative supports all value chains based on forest raw materials, and expresses confidence in the capability of firms to eventually develop these new value chains. Finally, contrary to this narrative, and also contradicting the two first ones is the narrative *A green intervention agenda,* which argues

that mission-oriented state interventions are needed to initiate a transformation and to ensure that innovation for developing a bioeconomy happens at all.

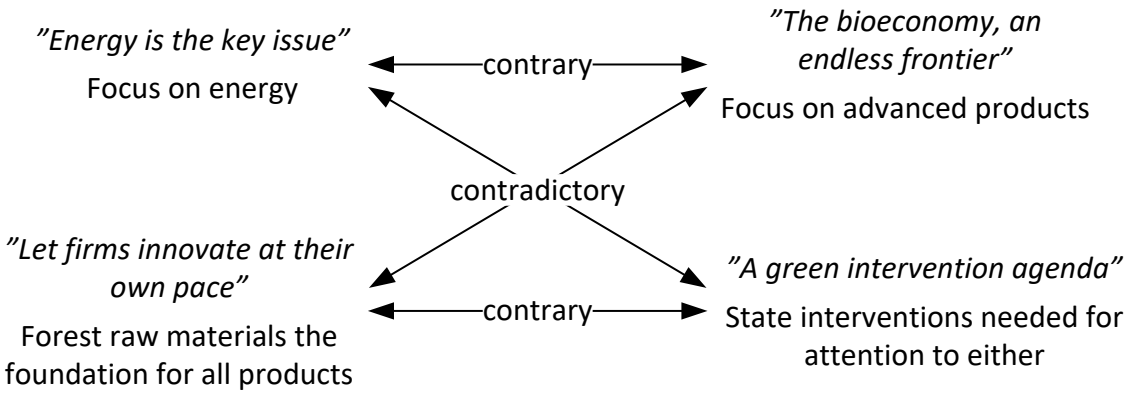

Figure 2. Semiotic square showing the relations between the identified narratives.

The conflict becomes apparent in some of the post-sorting interviews in which some participants state that there is in fact too much research – we should focus on doing what we already know works instead of looking for even better solutions and that it is important not to let the perfect become the enemy of the good. While the main conflict between the narratives *Energy is the key issue* and *The bioeconomy, an endless frontier* was above identified in terms of product categories, the conflict between the narratives is also intimately connected to the politics of knowledge as the narratives diverge on the importance of application of existing knowledge compared to the creation of new knowledge. The *Energy is the key issue* narrative argues that existing bioenergy and biofuel technologies are not perfect but important parts of the solution to the climate change problem, and even though innovation is needed for further improvements it is key to focus on application and diffusion of these technologies in known value chains, supporting the focus on renewable energy that is found also by Kirkels (2012). The *The bioeconomy, an endless frontier* narrative provides a contrary argument as it argues that major technology leaps will come and if resources are directed towards incremental innovation firms will not have a chance in the global competition and hence become irrelevant. According to this narratives biomass resources are too valuable to be used for simple applications such as energy and should instead be used for high value products such as cosmetics or advanced bio-composites which require firms to adopt new knowledge bases and direct their resources to new types of innovation activities. While this seems to be aligned with visions of a biotechnological bioeconomy – cf. the biotechnological visions identified by Bugge et al. (2016) and Kirkels

(2012) – it is in fact only partially so, as advanced biotechnology is only one of several types of technologies envisioned to be employed for producing these products, e.g. nanotechnologies and other processes of modifying molecular and structural properties of the raw materials will also be used. The narrative thus argues for a broad search for new opportunities rather than a vision defined by biotechnology as the main vehicle for developing the bioeconomy.

The *Let firms innovate at their own pace* narrative emphasises that firms from the forest and agricultural industry are what constitute the bioeconomy and are following a trajectory of transforming traditional production plants towards advanced biorefineries. Firms do this using their knowledge and competence about the available raw materials and the processing of the same, and although it takes time they are really the only ones who can and should take the entrepreneurial responsibility to do it. What is expected from the state and public sector is primarily long-term predictability and coherence – industry representatives many times referred to the need for stability regarding the "rules of the game". Underlining the role of firms to develop new bio-based processes and technologies to substitute fossil-based ones this is linked to the competitiveness narrative in EU policies identified by Ramcilovic-Suominen and Pülzl (2017). Shared between the three first narratives is also an understanding that the availability of bioresources is an important opportunity as well as a constraint for the development of a bioeconomy, and they can thus be seen as subscribing to an overarching category of bio-resource visions (Bugge et al., 2016), emphasising the physical materiality of bioeconomies and the need for efficiency in managing the available bioresources (Ramcilovic-Suominen and Pülzl, 2016). In contrast, *A green intervention agenda* emphasises that it is unlikely that firms will manage to innovate and push the development forward in a pace that matches the urgency of the issue, and thus the state and public sector really must take on a new role and embrace a larger responsibility for the needed experimentation. *A green intervention agenda* thus mirrors calls for the government and public sector to engage actively in supporting a new trajectory for industrial development towards a bioeconomy, a green entrepreneurial state in the words of Mazzucato (2015). This narrative thus emphasises the bioeconomy as a process of politics and policy, aiming to find a new way for economic growth and development.

The two lines of conflict identified above – the role of knowledge and entrepreneurial responsibility – can be seen as spanning a space onto which the positions expressed by the narratives can be mapped as seen in Figure 3. Based on the factor z-scores two indices were created to quantify the perspective of the different narratives on the role knowledge and entrepreneurial responsibility. The index for knowledge was constructed as the average of the z-score values of statements (-)S1,S 4, S7, S11, S19, and S20, which all relate to issues of research and competence, for each of the factors (F2- defined as the inverse of the z-score

values for factor F2). The index for entrepreneurial responsibility was created as the average z-score values of statements S15, S26, (-)S28, S34, (-)S37, S39, S41, (-)S42, and (-)S44, which all relate to issues of corporate and government strategy and risk-taking.

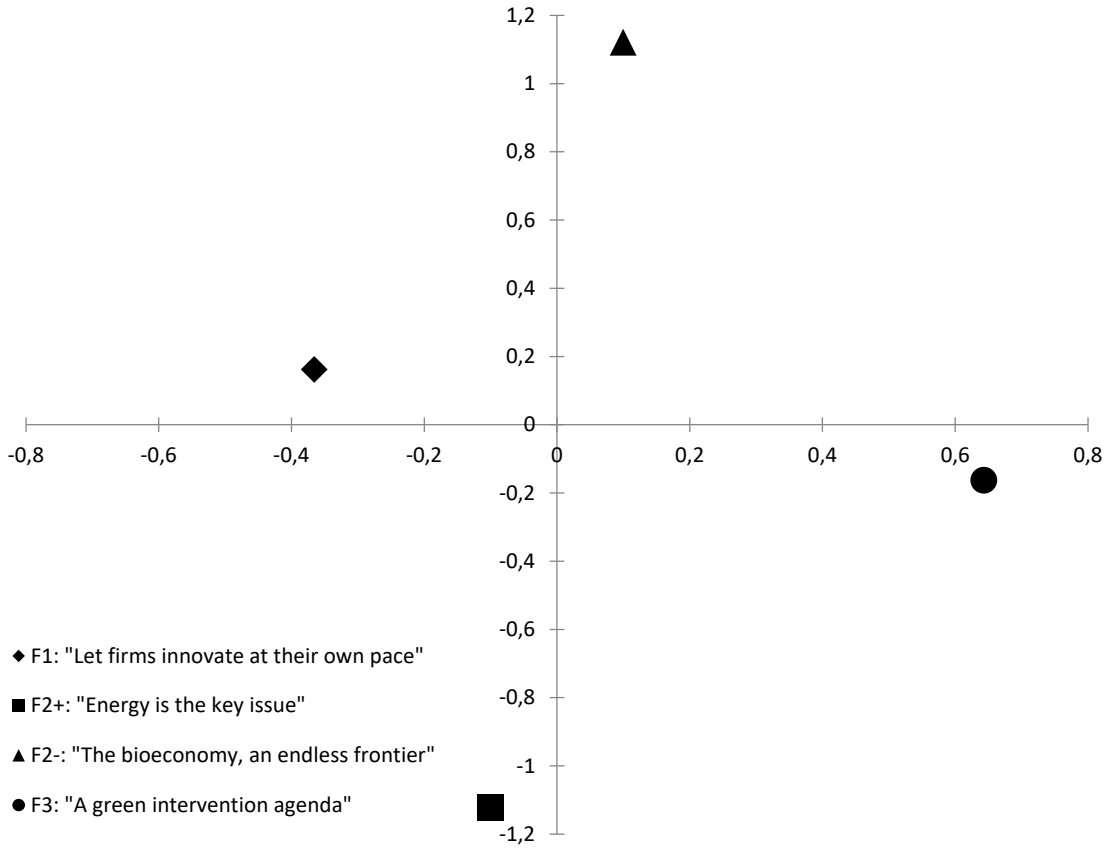

Figure 3. The identified narratives mapped onto the conceptual space spanned by the axes of entrepreneurial responsibility and the role of knowledge for innovation in the bioeconomy.

6. Conclusions and implications

The paper has explored narratives of different pathways for transformative change, and how such narratives come into play in the discourse on the transition to a bioeconomy. Using biorefinery innovation in Sweden as a focal point for this transition, contrary and contradictory narratives were identified and contrasted using Q methodology. This methodological approach has hitherto received little attention within transitions research, but has been shown to be an effective tool to identify and compare transition narratives and can be further used to investigate viewpoints of regime actors, which have many times been assumed to be a rather homogenous group. The analysis shows that the narratives are

divided on three aspects: the significance of different kinds of products, the importance of generating new or applying current knowledge, and the need for a comprehensive agenda of state interventions to support a transition towards a bioeconomy – showing that pathways to very different bioeconomies are indeed open. Research comparing the narratives identified in the paper with bioeconomy narratives from other regions and contexts could expand the understanding of how the idea of bioeconomy is understood in different types of political economy – and which conflicts are shared across biogeophysical and institutional contexts. Further, exploring the ways actors work to enable and institutionalise the pathways of these different narratives by gathering support and legitimacy in networks of different actor groups would also improve the understanding of the performativity of transition narratives.

As is evident from the use in this study of Q methodology and its limited size it cannot be claimed that the identified narratives are a comprehensive set of narratives in the bioeconomy transition discourse, yet they do point to lines of both conflict and consensus that can be found. It should thus not be understood as if all actors working with biorefinery innovation subscribe to either of these narratives, but that the narratives make explicit the interpretive flexibility in the bioeconomy concept. For policymakers, industrial actors and others who aim to support and further the transition to a bioeconomy it is important to understand why and how something they may perceive as the sustainable pathway of development can be met with resistance – not because a resistance would be inherently conservative or against a transition away from a fossil dependent world, but because they interpret the bioeconomy very differently. Thus, without making any statistical inference, i.e. generalising the narratives to represent a specific share of the population, the results of this Q study are valuable for understanding the nature of the conflicts in the emerging transition discourse.

While the conflicts between the different narratives largely follow the lines of conflict on the roles of bioenergy and more advanced products identified in earlier analyses of EU bioeconomy discourse (e.g. Kirkels, 2012), particular to the Swedish (and Scandinavian) context studied in this paper is the strong emphasis on forests being seen as the main source of resources and the forest industry as a key sector for innovation for a bioeconomy transition. Whereas most previous publications have focused on national and international policies and strategies (de Besi and McCormick, 2015; Levidow et al., 2012; Meyer, 2017; Ramcilovic-Suominen and Pülzl, 2016), the present study contributes with an actor-focused perspective on transition narratives and it also moves beyond dichotomising the bioeconomy as either a (bio-)technological or socio-ecological construct (Meyer, 2017; Priefer et al., 2017). The highly structured approach used in this paper thus complements and supports previous qualitative and discursive analyses. The identified conflicts show

diverging possible pathways for the bioeconomy and imply alternative forms of governance to support innovation and development. While strong mission-oriented governance through state interventions is argued to be crucial in one narrative, others instead argue that firms are better equipped to direct their resources and capabilities towards important needs and emphasise that predictability is the most important aspect of governance to support innovation for the bioeconomy. The apparent contradiction that large-scale transformative change is best supported by stability can be understood given that these narratives argue that applying current knowledge is enough to drive the transition and that radical innovation is not really necessary. An ambitious and aggressive interventionist policy agenda will thus most likely be met by significant resistance, although there is agreement on the point that a transformation is necessary.

The dominating narrative is one of incremental change and reconfiguration of the current regime, which may hinder renewal and deep structural change if it is left unchallenged in policy processes and governance. Counter-narratives are likely to need strong and effective advocates to stand up to incumbents, should they really employ their discursive power to take control over the issue. Engaging in stakeholder dialogues about governance structures to support innovation for the bioeconomy may be facilitated by acknowledging the conflicting perspectives identified and contrasted here, and a way to force different actors to reason about the different pathways presented, and not simply delegitimising them before achieving any traction in the discourse. Recent governance initiatives to create large strategic innovation partnerships between the public and private sectors may be hindered by these conflicts if it is assumed that it is possible to reach a consensus among groups of actors simply based on their all claiming to support innovation for the bioeconomy. Assuming consensus in a group of actors with such diverse and incommensurable expectations may leave it open for powerful actors to push a specific agenda through by "closing down" (Stirling, 2008) the discourse to a single narrative of incremental reconfiguration, hiding the nuances and conflicts that exist regarding the different bioeconomies that are in fact possible and thus excluding all pathways but one from the realm of the imaginable. To instead acknowledge and embrace the plurality of narratives of the bioeconomy could be part of moving towards a "governance on the inside" (Smith and Stirling, 2007) in which the politics of innovation for a bioeconomy is not limited to the reduction of technological uncertainty but retains its complexity.

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