1.5. Using Q Methodology for Identifying Societal Viewpoints on Bioeconomy

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Introduction

The bioeconomy describes the transition from a fossil-based economy to an economy based on renewable resources. Scientific and non-scientific publications alike have considered bioeconomy in the context of new and innovative technologies, rather than adopting a holistic approach, which has been used in more recent research (Hausknost et al. 2017). While the bioeconomy concept has not yet reached significant public awareness, both politicians and researchers have shown an increasing interest in this topic due to its potential to tackle some urgent global problems, such as the depletion of resources and climate change. The majority of citizens do not know that the bioeconomy combines a variety of measures and strategies, all based on the idea to sparingly use fossil resources and/or replace them with renewables (Schmid et al. 2012; Priefer et al. 2017). This is the case even though citizens show a growing concern about these challenges and are able to recall specific mitigation measures (e.g., a reduction of air travel or recycling activities). It is essential to involve society in the innovation process in order to ensure the success of a transition to a bioeconomy and to increase its acceptance (Albrecht et al. 2012; Barry/Proops 1999; Sleenhoff/Osseweijer 2015). Most studies have focused on society's acceptance of the bioeconomy's different individual aspects, due to the fact that the public knows about single measures by and large, instead of one holistic bioeconomy concept. We chose a Q methodological approach to shed more light on the acceptance of a bioeconomy as a whole and, in so doing, aim to close this research gap. The study was conducted as part of the joint research project »BEPASO – Bioeconomy 2050: Bio Economy PAthways and SOcietal transformation strategies)«, which was funded by the BMBF and was finalised at the beginning of 2020 (Banse et al. 2020).

This contribution has a methodological focus and, as such, takes a closer look at the Q methodology, describing its implementation in the context of citizens' beliefs and perceptions about the bioeconomy. It focusses much less on the results, instead revealing some conclusions and implications from a methodological standpoint. The remainder of this work is structured as follows: The first part gives a general introduc-

tion of the Q methodology and describes the methodological approach in a detailed way. The section that follows deals with the Q study's implementation in identifying citizens' viewpoints on a bioeconomy in Germany. This section covers both the data collection and the analysis and explains the approach that we chose to combine the Q study with a quantitative survey. In the end, results are briefly summarised and we provide some conclusions and implications regarding the methodology.

Q Methodology

An Overview

The Q methodology is an exploratory approach that uncovers relations between different aspects, attitudes, or beliefs that belong to one complex topic, instead of viewing them separately. It is specifically designed to capture subjectivity in a systematic and holistic manner (Stephenson 1975). The Q methodology allows for a detailed representation of existing viewpoints on a particular topic within a population (Watts/Stenner 2012) and answers questions about personal experiences, such as taste, values, attitudes, and beliefs (Baker 2006). This approach's specific strength lies in its standardised statistical data analysis procedure, especially in contrast to other qualitative methods. While the Q methodology was originally introduced in psychology, health, and social science research, it has increasingly been applied in the field of environmental and socio-economics more recently. Q studies work well to explore complex belief structures and can be helpful in designing (environmental) policies that are supported by society (Barry/Proops 1999): »The capacity to ›tap into‹ underlying preference systems that may not otherwise have been articulated by respondents is a particular strength of Q methodology« (Baker et al. 2010: 2).

Development of the Q Set

A Q study's starting point is the selection of statements relating to the topic being researched. A clearly formulated research question forms the frame for the selection of statements. The total set of all statements that come under consideration is called the concourse. For the purposes of a Q study, only a subset of the concourse is selected, the so-called Q set. These statements should be a close representation of all aspects and issues that are part of the public discourse on a given topic. Therefore, they should draw upon different scientific and non-scientific sources of information in order to guarantee a diversity of attitudes and beliefs (Watts/Stenner 2012). Since the generation of a Q set is critical to the success of a Q study, we recommend thoroughly discussing the choice of statements with experts and laypersons, focusing on comprehensiveness, overlap, and redundancy. Statements need to be reformulated or removed from the list in an iterative process. Moreover, a pretest should be carried out prior to the main study with people from diverse backgrounds. The total number of statements strongly depends on a given topic's complexity, but does not exceed 80 statements for the most part; participants should not be overburdened with the sorting task. In addition, the

number of statements should not be too small, because this might imply inadequate coverage. Watts and Stenner (2005) recommend using between 40 and 80 statements.

The Q Sorting Task

In a Q sorting task, the participants are asked to sort the set of statements depending on their level of (dis-)agreement. To begin with, they are supposed to sort the statements into three piles: one pile contains those statements with which participants spontaneously agree, another pile holds those with which they disagree, and a third pile contains those statement about which the participants are indecisive. In a second step, the statements have to be sorted on a predetermined grid based on a scale from ›totally disagree‹ to ›totally agree‹. The scale ranges from -6 to +6 or -5 to +5 for most Q studies. The Q grid is designed in such a way that the majority of statements can be placed in the middle part of the scale (i.e., following a bell-shaped curve). The use of a predetermined Q grid is known as a »forced Q sort«, given that participants can only place the statements along this Q grid's lines. Hence, they need to decide how they view the different statements in relation to each other. This approach helps participants to reveal the structure and hierarchy of their beliefs, even though they might not be actively conscious about their preferences for single items (Müller/Kals 2004). The alternative approach is the so-called »unforced Q sort«. It will not be described here because we have decided against using it in this study; readers who are interested can find more information in Bolland (1985).

The participants process one pile of statements after the other, usually starting at one of the extreme points of the scale. In the end, the participants sort the statements about which they were indecisive on the remaining fields of the grid. Participants are allowed to rearrange the order of the statements at any time during the sorting process (Watts/Stenner 2012). The resulting arrangement of statements on the grid is called a Q sort and represents the basic unit for subsequent analysis. The sorting task can take place either online, with the help of software which administers the sorting task, or offline where participants work with a pile of »real« cards with statements printed on them. The setting notwithstanding, the sorting task will be followed by an in-depth interview in which participants are asked some follow-up questions concerning the sorting task. This interview helps to uncover reasons why participants put particular statements at the extreme points of the grid, which statements they were indecisive about, or which aspects they missed in the context of the research question. Learning more about participants' reasoning is very important for the later interpretation of the viewpoints provided.

Selection of Participants (P Set)

Before describing the analysis of the Q sorts, some information ought to be given concerning the selection of participants, the so-called P set. It is especially important for a Q study to generate a sample that is as diverse as possible. The sampling can either be strategic (in case prior knowledge about the relation between opinions and certain characteristics is available) or opportunistic (where prior knowledge does not exist). Where

prior knowledge is available, it is important to develop recruitment questions that ensure the identification of participants with diverse opinions. The actual size of the P set plays a secondary role. Watts and Stenner (2005) recommend 40 to 60 participants as a rule of thumb, but state that pattern and consistency in the data can also be detected with a smaller number of participants. Danielson (2009) proposes between 10 and 50 participants. Moreover, the aim of a Q study is not to achieve representativeness, by considering the actual size of viewpoints and their composition, but to reveal salient viewpoints that exist in society or among a particular group of people.

By-Person (Inverted) Factor Analysis

The collected Q sorts form the basis for a by-person factor analysis. In contrast to a »standard« factor analysis, the aim is to compare Q sorts and to reveal shared meaning within the participant groups (Watts/Stenner 2012). Different statistic programmes can be used for the analysis, such as the free software environment R or the specifically developed free software PQMethod by Peter Schmolck (2014), amongst others. The type of factor analysis employed is a principal component analysis. The number of factors (i.e., viewpoints) is identified based on the eigenvalue, a scree plot, and the so-called Humphrey rule (Watts/Stenner 2012). The latter states that factors should be chosen for further analysis »if the cross-product of its two highest loadings (ignoring the sign) exceeds twice the standard error« (Brown 1980: 223).

Interpretation and Description of Viewpoints

The factor loading indicates how typical a Q sort is for a specific viewpoint (factor). A viewpoint stands for a group of participants with similar opinions on the topic under study. This is expressed as the correlation coefficient or factor loading. This coefficient needs to be significant in order to clearly allocate a Q sort to a viewpoint. If a Q sort significantly loads on more than one factor (i.e., it can be allocated to more than one viewpoint) then it is confounded. Likewise, a Q sort cannot be allocated to any of the viewpoints in cases where none of the factor loadings is significant. Q sorts are manually flagged, in case they exceed the significant factor loading for one of the factors, in order to determine those Q sorts that will be included in the calculation of an average Q sort for each factor (Watts/Stenner 2012). The factor arrays summarise the Q sorts of all individuals that belong to that viewpoint into one Q sort that approximates the viewpoint as closely as possible (Hempel et al. 2019). Together with the information from the follow-up interviews, the factor arrays serve as the basis for interpretation. Special attention is paid to those statements that have been placed at the extreme points (+5 and -5), as well as to other statements that are most salient for the viewpoint (Watts/Stenner 2012). Commonalities and connections between statements are uncovered and compared in the process of interpretation. The way in which the resulting viewpoints are described and presented to the public can either follow a narrative or a commentary style. Both styles help to draw holistic pictures of the viewpoints. While the authors tell a story around each viewpoint in the narrative style, the commentary style leads to the

provision of summaries of viewpoints, especially those that focus on the particularities of each viewpoint and the differences between viewpoints.

Combining Q Methodology and Survey

As explained previously, a Q study is a very straightforward approach to revealing viewpoints that exist about a topic, research question in specific, among a particular group of people or in society as a whole. However, information about the number and characteristics of people that share one viewpoint cannot be inferred from a Q study. It is necessary to include the results of a Q study in survey research to get more insights into how the viewpoints are composed and how they are distributed throughout the general population. Furthermore, the combination with a survey allows for the use of additional variables or scales, outside the Q set, to draw relations between viewpoints and other important information (e.g., correlating agreement with a particular viewpoint with personality). There are three different ways to combine Q and surveys: Talbott's Q block, Brown's standardised factor index score and self-categorisation to short factor descriptions (Baker et al. 2010). In this work, we will focus on the second approach (Brown's standardised factor index score, also referred to as the »scale creation« approach by Danielson [2009]).

The Scale Creation Approach

The scale creation approach uses results from the Q study to develop short scales for the measurement of each viewpoint. This approach's main advantage is the similarity to the psychometric scales that are typically used in survey research. Hence, it is easy to integrate these additional scales into surveys (Danielson 2009). However, it is necessary that the Q study yielded sufficient extreme-value distinguishing statements to apply the scale creation technique. The first step is the selection of extreme-value statements (i.e., those statements that were placed at the two ends of the Q grid) and distinguishing statements for each viewpoint (i.e., a statement that is salient for at least one viewpoint). Two to five statements can be chosen for each viewpoint in the scale creation process, depending on the size of the Q set and the structure of the resulting viewpoints. These are implemented on five-point Likert scales which ask for a respondents' level of agreement from »totally agree« to »totally disagree«.

The responses on the Likert scales (ranging from 1-5) are reverse scored following the survey, in case statements were strongly rejected by participants belonging to one viewpoint. All item scores were then multiplied with the rank score that this statement captures in the average Q sort for this particular viewpoint (Danielson 2009). If, for example, a respondent selected 4 on the Likert scale for statement A and statement A was then placed on rank 5 in the average Q sort for this particular viewpoint, then 4 has to be multiplied by 5. This process is repeated for all statements for all respondents and yields the so-called statement index scores (Baker et al. 2010). The scores of all statements belonging to one viewpoint's scale are summed up, so that there is one final score for each viewpoint and for each respondent; this score is called the factor

index score (Baker et al. 2010). These scores are then standardised by converting them into T-scores with a mean of 50 and a standard deviation of 10. The standardisation is carried out to account for the differences in the rankings of the statements that were selected to represent the different viewpoints (Danielson 2009). The comparison of the final standardised factor index scores indicates what viewpoint a respondent can be allocated. The higher the score, the higher the agreement with a viewpoint. It is possible that a person cannot be clearly allocated to one viewpoint (i.e., the difference between the most likely and the second-best factor is very small) (Baker et al. 2010). What this means in practice will be shown in the next section of this work.

Q Methodology in the Context of Bioeconomy

Identification of Societal Viewpoints on Bioeconomy

The BEPASO project's Q study was designed with the aim of eliciting the nature of attitudes and beliefs held by the German population about the bioeconomy. The reason for choosing the Q methodology lies in the research topic's complexity. Single aspects and measures comprising bioeconomy are well-known to the German population. However, while the term bioeconomy and its conceptualisation as one holistic approach are rather unknown, we assumed that Q methodology would help to gain insights into participants' preference systems that might otherwise have been difficult for them to articulate. Moreover, we decided to carry out the Q study at the beginning of our project, because of its explorative nature on the one hand and because the extensive literature and media search (required to develop an appropriate Q set) helped us to familiarize ourselves with Germany's public discourse on bioeconomy on the other.

The sources that we used to generate the Q set included scientific and non-scientific sources, such as posts in online forums and social media as well as newspaper articles. Our first list included around 100 statements that two of us worked on together. We deleted statements with very similar meanings and tested the preliminary Q set with five experts in the area of consumer research and bioeconomy and with two laypeople. After that, we deleted a few statements and reformulated others to ensure comprehensiveness. The final Q set consisted of 56 statements. Although we kept the statements as simple as possible, they included some technical terms that could not be avoided. Therefore, we also generated a glossary that we provided to our participants in case they were unfamiliar with the terms employed. The glossary included, for example, definitions of precision farming or bio-based resources. The reason to include a glossary, instead of giving verbal explanations, was to ensure that all participants received identical information.

The aim of survey research is to collect data from a sample that is a very close representation of the population. In a Q study, the aim is to have a representative set of statements, while the sample should include participants with very diverse opinions on a given topic. We recruited participants with heterogeneous sociodemographic backgrounds and different levels of environmental consciousness in order to ensure the best possible diversity (Table 1). A specialised market research agency recruited about half

of the 45 participants, based on a recruitment questionnaire. The remainders of the participants were recruited following a snowball procedure (i.e., we asked every participant to name one person with a very similar opinion to theirs and one person with a very different opinion on the topic, who might also be interested in participation). The interviews took place in June and July 2017. Participants received a monetary incentive after the interviews.

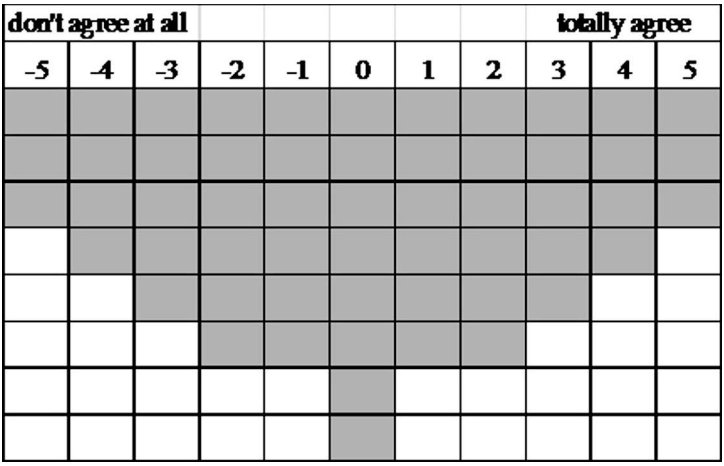
Table 1: Information on the sample (P set); n=45

in %		
Age	18-45 yrs	60
	46-65 yrs	40
Gender	female	44
	male	56
Place of residence	urban (Braunschweig ~248.500 inh.)	78
	rural (Quedlinburg ~21.500 inh.)	22
University degree	yes	42
	no	58
Employment	students	18
	part- or full-time occupation	67
	retired	2
	other	6
Environmental consciousness	neutral	36
	conscious	38
	unconscious	27

Both the interviews and the Q sorting task were carried out face-to-face. The 56 statements were printed on individual cards, which were first sorted into three piles, depending on participants' agreement, and then into the Q grid's 56 squares (Fig. 1). A short follow-up interview was carried out afterwards which aimed to acquire more information about the reasoning behind participants' Q sorts. The majority of participants said that they enjoyed the task more than they would have enjoyed either a »normal« interview or a survey. Most of the respondents perceived the topic to be very interesting and admitted in the follow-up interviews that they did not view these aspects in a holistic way previously; they perceived this learning effect to be a benefit of this type of study. None of the participants experienced the task as being either too complicated or tiring, which was one of our main concerns when preparing the Q interviews.

The 56 resulting Q sorts were analysed using the programme PQ Method by Peter Schmolck (2014), following the procedure described in the previous chapter. We identified three factors (i.e., viewpoints) based on the eigenvalue and consideration of the scree plot. These three factors comprised 38 of the 45 Q sorts that our data collection yielded. Four participants' Q sorts could be allocated to more than one factor (i.e., they were confounded) and three further Q sorts were not significant (i.e., they could not

Figure 1: Grid that was used for the sorting task in the Q study on bioeconomy. All squares in one column represent the same level of agreement.



be allocated to any factor). Altogether, the three factors explained 49 % of the variance, which is regarded as satisfactory according to Watts and Stenner (2012).

The factor arrays for these three factors were used for interpretation, alongside additional information from the interviews. We named the resulting viewpoints »sufficiency and close affinity to nature«, »technological progress«, and »not at any price« (Tab. 2). An extensive description of the results can be found in Hempel et al. (2019).

Table 2: Short overview on the results from the Q study on bioeconomy

	Viewpoint 1	Viewpoint 2	Viewpoint 3
Name	Sufficiency and close affinity to nature	Technological progress	Not at any price
Short description	Focus on nature and ecological interactions	Focus on technological opportunities	Focus on economic cost-benefit considerations
Charcateristic quote	»There is absolutely no reason for clearing our rainforests. This is one of the biggest crimes of humanity. This is the lung of our planet, its heart, its soul.«	»...We won't get around genetically modifying our organisms, if we really want to have more efficient resource use.«	»However, this solution has to achieve that our standard of living will not change...«

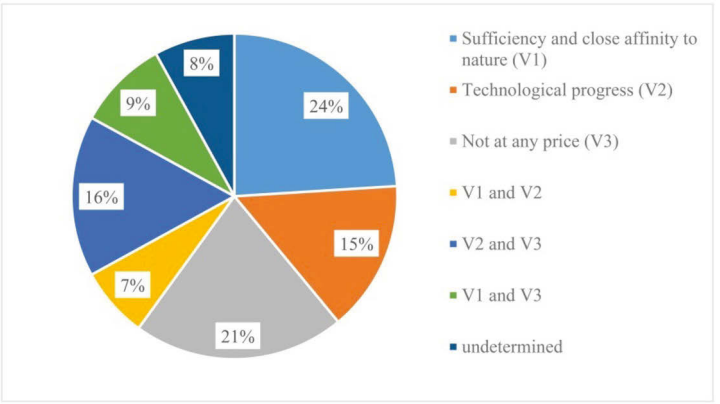
Combination of Q Study Results with Survey Research

The Q study itself yielded three societal viewpoints on the transition from a fossil-based to a bio-based economy. We applied the scale creation approach in a quantitative online

survey to gleam more insights into how the viewpoints are related to other sociodemographic and psychographic variables. The main reason why we chose to use the scale creation approach, rather than one of the other options mentioned previously, was the close resemblance to the scales with which survey respondents are familiar. In addition, the Q study's analysis yielded enough statements that were both distinguishing as well as salient and, as such, were suitable for the creation of scales. We used a five-point Likert scale to determine respondents' agreement with the statements that were selected (Tab. 3). In addition to the scales measuring respondents' agreement with the viewpoints on bioeconomy, the questionnaire also covered respondents' environmental awareness, meat consumption, and perception of various bioeconomy-related issues. The survey was carried out through an online access panel in Germany in July 2018. Socio-demographic quotas were set to achieve a representative sample (n=977) of the German population aged between 18 and 65.

The standardised factor index scores were calculated for all respondents, based on the data collected through the survey, and the three scores were compared to allocate the respondents to viewpoints. A clear allocation to one viewpoint was possible for 60 % of the respondents, while 32 % of the respondents could almost equally be allocated to two viewpoints. However, 8 % of the respondents could not be allocated to any of the three viewpoints. Figure 2 shows the percentages of respondents that are allocated to particular viewpoints and to combinations of viewpoints.

Figure 2: The distribution of viewpoints in the sample population; shares in %



At the first glance, it might appear unusual to have an allocation to more than one viewpoint. However, it might not be uncommon in real life to agree, at least partly, with more than one viewpoint. In this context, one recommendation for future research would be to apply more than one technique to »quantify« viewpoints, in order to have an opportunity to compare and validate the findings. Apart from the benefits of the scale creation technique (e.g., similarity to existing survey tools, straightforward analytical approaches), there is one major drawback; namely, the dissociation of the statements from the Q set's context. While the viewpoints are based on participants' sorting of the

Table 3: Statements that were selected for the scale creation process; the corresponding rank scores from the Q study are presented in the columns.

Scale	Statements	V1	V2	V3
Viewpoint 1	Something important has been lost in many people, namely to view themselves as part of nature and to learn to understand natural interactions.	5	1	2
	In light of climate change, resource scarcity, and environmental problems, we cannot continue as we have done so far. We need to say goodbye to economic growth and learn to live with less.	4	-2	-4
	Fact is that genetically modified food becomes increasingly necessary to feed the world.	-4	3	0
	Modification of genes for industrial purposes is okay.	-5	1	-3
Viewpoint 2	Precision farming should receive more attention in the context of a bio-economy, because it can help to save resources.	-1	4	0
	Bio-economy can reduce the enormous dependency on oil. But because of the growing demand for biomass, we have to focus on more efficient technologies.	0	5	3
	I believe that most of our future problems will be solved through technological progress.	-4	3	-2
	Modification of genes for industrial purposes is okay.	-5	1	-3
Viewpoint 3	It needs to be guaranteed that we will be able to keep our standard of living, for all changes in the light of bio-economy.	0	3	5
	We just need to save more energy instead of solely focusing on renewable resources in order to succeed in phasing out of fossil energies.	2	-1	-4
	It is economically and ecologically reasonable to use resources for materials first (i.e. high-quality manufactured) and then for energy.	2	4	-1
	As long as the oil price is very low, the bio-economy will fail due to the high costs of its products.	-2	-2	5
Note: The statement »modification of genes for industrial purposes is okay« was used both for viewpoints (V) 1 and 2.				

entire set of statements, the short scales might not correctly reflect these viewpoints. Hence, a validation through another technique, either Talbott's Q block or self-categorisation to short viewpoint descriptions, would be very valuable (cf. Baker et al. 2010).

Comparing the groups of citizens who share particular viewpoints yielded some interesting additional insights, which are summarised here. There was not much difference between the viewpoints regarding sociodemographic variables, except for gender. There is a significantly higher share of female respondents that focuses on nature and ecological interactions when it comes to assessing the bioeconomy. Conversely, a significantly higher share of male respondents focusses on the bioeconomy's technological opportunities. These personal beliefs are confirmed by respondents' evaluation of various issues within the bioeconomy. While respondents who prioritise technological progress, and the economic considerations associated with the bioeconomy, agree about the necessity of genetic modification to meet global challenges, the »sufficiency and close affinity to nature« view clearly opposes any kind of genetic modification. The »technological progress« view is also significantly more in favour of efficient technologies to meet the growing demand for biomass than the other two viewpoints. In addition, respondents who focus on ecological interactions are less convinced that technological progress will solve future environmental problems. The »not at any price« viewpoint is significantly more concerned with economic growth compared to the other two viewpoints: The current standard of living needs to be maintained. This factor is especially important for respondents who focus on economic considerations and technological opportunities when it comes to evaluating the bioeconomy.

Conclusions and Implications

The implications presented in this chapter focus on the insights gained through the implementation of a Q study and its combination with a survey in the context of societal acceptance of bioeconomy. The discussion of the Q study results is not part of this work, but is presented in Hempel et al. (2019).

The Q study turned out to be a good starting point through which to enter into a dialogue with the citizens on a relatively unknown topic. The development of the Q set implies a thorough review of the discourse, given that these views are presented through both scientific and non-scientific media. On the one hand, that task was a good preparation for the research team and helped to align our conception of a bioeconomy; on the other hand, the decomposition of this very complex topic into statements that represent single aspects helped participants to reveal their opinions through the sorting task. The special strength of this type of data collection is that the participants do not evaluate the statements independently, as they might in a traditional questionnaire procedure, but in relation to each other. This supports the individual evaluation process and results in the Q sorts' typical relational statement structure (Müller/Kals 2004). Hence, the Q study approach turned out to be a useful technique to explore citizens' viewpoints, despite the complexity of the topic as well as its varying definitions and conceptualizations. However, the importance of the Q set's development for the success of the Q study needs to be borne in mind. The selection of meaningful, comprehensive,

and representative statements is time-consuming and requires extensive discussions with colleagues and pretests with laypeople. The sorting task itself was perceived as very interesting and not too demanding or tiring by the participants. Hence, they were highly motivated to provide further information in the follow-up interviews and to suggest additional participants for the Q study.

The by-person factor analysis was carried out using Peter Schmolck's PQ Method (2014), following a straightforward procedure. The combination of a rather qualitative and exploratory approach with a standardised, statistical procedure to analyse the data is something that is unique to Q studies. The resulting factors are based on correlations between people and builds upon the core of the viewpoints, which are then described and interpreted using additional information gleamed from the interviews. The consideration of segments or viewpoints is a common and reasonable approach to the study of beliefs and perceptions, especially about rather complex or controversial issues. It is superior to the study of averages throughout the entire population, given that this might lead to a loss of meaningful information stemming from the heterogeneous opinions found in a society. In sum, the Q methodology is a fruitful and reliable technique to identify viewpoints regarding the transition to a bio-based economy in Germany. Like other (more) qualitative methodologies, it can be criticised for not being representative, and thereby not allowing for any generalisations concerning the extent and structure of the viewpoints encountered. Different techniques have been developed to combine a Q study with a quantitative survey in order to overcome this disadvantage. In this contribution, we have focused on the »scale creation« technique. While the »scale creation« technique was easy to implement in a survey, it was not possible to clearly allocate one third of our sample to a particular viewpoint. Therefore, we would recommend using at least one additional technique to compare and to validate findings.

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