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Societal Perspectives on a Bio-Economy in Germany: An Explorative Study Using Q Methodology

Corinna Hempel[1], Sabine Will[1], and Katrin Zander[1]

[1] *Johann Heinrich von Thuenen-Istitute, Thuenen Institute of Market Analysis (Germany)*

Corresponding author: Corinna Hempel, Bundesallee 63, 38116 Braunschweig

corinna.hempel@thuenen.de

ABSTRACT
Bio-economy describes an economy based on renewable instead of fossil resources. To ensure the success of this transformation it is necessary to involve society into the process. Q methodology was used to empirically assess people's perspectives on bio-economy in Germany. Using a Q-type factor analysis three perspectives were identified. "Sufficiency and close affinity to nature" focuses on natural/ecological relations, while "Technological Progress" favours technologies to become less dependent on fossil resources. The third perspective "Not at any price" is rather concerned about economic trade-offs. An online survey is planned to investigate the representation of these perspectives in the wider population.

Keywords: Bio-economy, bio-based, Q methodology, society, perspectives, innovation, sufficiency, living standard, Germany

Introduction

In 2005 the European Commissioner for Science and Research Janez Potocnik introduced the concept of a knowledge-based bio-economy. Two years later, the so-called "Cologne Paper" was published at the conference "En route to the Knowledge-Based Bio-Economy" (BMBF and BMEL, 2014). It summarized visions, forecasts, and recommendations to assist policy makers in identifying priorities and adopting measures. This publication pointed out that science needs the support of society, in that people have to be well-informed about opportunities and risks. The focus was especially on the acceptance of (green) biotechnology, which was expected to increase especially for the generation of non-food products (Cologne Paper, 2007). While the Cologne Paper mainly described bio-economy in the context of innovative/novel technologies, a joint publication by two German ministries (BMBF and BMEL, 2014) defined bio-economy in terms of using renewable resources and bio-based process solutions as well as developing circular economies and reusing resources and material flows many times. Likewise, other recent publications describe bio-economy as a holistic approach, in which sufficiency as well as sustainable consumption behaviour, and established practices and processes also play an important role (cf. Schmid et al., 2012; Priefer et al., 2017). It is aimed to harmonize sustainable economic growth with ecological and social demands. Although the relevance of involving the public into the transformation to a bio-based economy has been acknowledged, most people do not feel well-informed so far. A representative study in Germany shows that only 27% of the population feel sufficiently

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informed about the relationship between fossil resources and their industrial use for the production of everyday commodities, while 52% would like to know more about the composition of products. Every fourth person in Germany does not know that mineral oil is used in numerous everyday products, such as clothes, toys, packaging, and cosmetics (BMELV, 2012). The concept "bio-economy" is complex and a matter of social contestation and conflict, as can be seen for example in the "food or fuel"-debate. Since the importance of societal viewpoints on the development of a bio-economy in Germany has been recognized, people are the "experts" for tackling this research question. Hence, their understanding builds the core of this research and is captured through Q methodology to identify the societal perspectives on bio-economy in Germany.

Literature Review

Whereas Scherer et al. (2017), Rumm (2016) and Kurka (2012) focus on consumers' perceptions of specific bio-based products, to our knowledge, there is no study engaging with bio-economy as a holistic approach from the perspective of the public in Germany. One comparable study from the Netherlands identifies emotional viewpoints on a bio-based economy as a starting point for public engagement (Sleenhoff et al. 2015). This research does not reveal any single black or white feelings, but rather complex arrays of emotions among the general public. Different actions might appeal to different groups of people. In addition, Sleenhoff and Ossewijer (2016) present views on how people see themselves as being capable to engage in a bio-based economy (efficacy belief). The visual representations of a bio-based economy in this study influence people's perceptions of how they can engage. Thereby, the study shows how important the presentation of such a complex topic is for the engagement of the public. Results from an international study on green economy suggest that enhancing public knowledge and engaging with end users as well as image building and communication strategies can be important tools for the successful implementation of green concepts in practice (Pitkänen et al., 2016).

Results from a Dutch study by Lynch et al. (2016) show that participants generally favour bio-based technologies as a contribution to economic growth and sustainability. However, they also recognize downsides of a bio-economy, such as high costs, food shortages or deforestation. The weighing of pros and cons depends on the technology in hand. The acceptance increases when people feel more engaged with a technology and when they expect any personal benefit through that technology, as for example in the case of small-scale bio-refineries, but it decreases when they associate negative effects with a technology (Lynch et al., 2016). Wüste (2013), for example, shows that the acceptance of genetically modified energy plants is very low in Germany. Quite a few authors discover trade-offs/conflicts concerning the production and use of bio-based materials that people are aware of, namely monocultures, competition for land, loss of biodiversity, food or fuel debate, and the use of genetically-modified plants (Zander et al., 2013; Herbes et al., 2014; Kortsch et al., 2015; Rumm, 2016). Sijtsema et al. (2016) as well as Lynch et al. (2016) reveal that people are unfamiliar with the "bio-based" concept and that they feel a lack of reliable information to make their own judgements. Similarly, in a Swedish study the results show that information and knowledge on new technologies is very low among respondents (in this case: energy technologies). The authors reveal that the time between first discussions of new technologies and implementation will be shortened, if the public's knowledge is increased (Assefa and Frostell, 2007).

Associations with the bio-based concept in general as well as with specific bio-based products can be simultaneously positive as well as negative, causing mixed feelings and confusion (Sijtsema et al., 2016). The acceptance of bio-based products is positively influenced by health and environmental consciousness (Kurka, 2012; Scherer et al., 2017). According to Rumm (2016) environmental consciousness has got the greatest positive influence on willingness to purchase bio-based products. Onwezen et al. (2017) show that aversive feelings – due to subjective ambivalence – decrease the intention to buy bio-based products and strengthen

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the negative effect of risk perception on bio-based purchase decisions. Carus et al. (2014), Kurka (2012) and Scherer et al. (2017) show that consumers' willingness-to-pay values for different bio-based products vary depending on the product type.
In this context, Menrad et al. (2006) determine consumers' requirements for bio-based products: First of all, consumers will only accept higher prices if the quality of bio-based products is higher or there is any other additional benefit compared to conventional products. Secondly, the environmental benefits are important, but they do not justify higher prices from the consumer perspective. Thirdly, consumers associate positive health aspects with bio-based products and therefore might choose them. Finally, the production of the required biomass must not lead to environmental damage through monocultures (Menrad et al., 2006).
The above-mentioned findings highlight the complexity of the topic as well as the unfamiliarity with the topic in the public. Especially, discussions on the "bio-based" concept in general remain abstract (cf. Sijtsema et al., 2016).

Methodological approach

In the absence of a defined meaning or consensus on a concept, it is important to use empirical research with a focus on discovery and exploration to properly understand its subject matter. Q methodology is one approach, which can produce holistic data and capture relationships between themes instead of merely disaggregating them into subthemes. Thereby, it proves valuable as a means to gain access to subjective viewpoints (Stenner et al., 2003) and to answer questions about personal experience as well as matters of taste, values, and beliefs (Baker, 2006). A Q study was carried out to explore the viewpoints on bio-economy that exist among the general public in Germany. The subsequent chapter gives detailed information on the Q methodological approach.

Data collection

The basis of a Q study builds the selection of statements (i.e. Q set) about the topic under consideration. These statements should be a representative sample of all aspects and issues that are discussed around the topic bio-economy. They are compiled from various viewpoints and cover as many sub-issues of the topic as possible. An extensive literature search on bio-economy, including non-scientific sources such as internet platforms and newspaper articles as well as scientific publications, was carried out to create the Q set. The first selection of statements consisted of about 100 items. Statements with the same meaning were merged into one. The preliminary Q set was pretested with five colleagues, knowledgeable on consumer research and bio-economy; thereupon some statements were excluded or rephrased. The final Q set consisted of 56 statements covering the broad field of bio-economy (Table 13, Annex). The statements were originally used in German, but translated for this publication.
These 56 statements were printed on cards and presented to the participants during a face-to-face interview. Firstly, they were asked to sort the cards according to their agreement on three piles: one pile for statements about which they feel positive or which they definitely agree with, one pile for statements about which they feel negative or definitely disagree with, and one pile for statements about which they feel indifferent or which provoke both positive as well as negative feelings. After that, the participants are asked to distribute the cards from "totally agree" to "don't agree at all" on a predetermined grid (Figure 1), starting with the first pile and ending with the third pile, which is eventually distributed on the remaining fields in the middle of the grid. During the whole sorting process all cards can be reorganised as many times as necessary and desired. In a Q study each respondent's data is collected in form of an individual Q sort.

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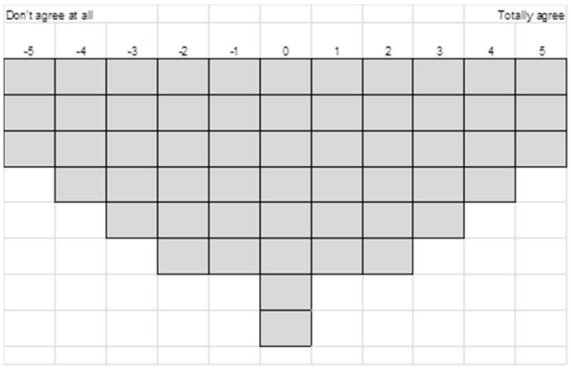

Figure 1: Predetermined grid from -5 (don't agree at all) to 5 (totally agree). All fields in one column represent the same level of agreement.

After the sorting, task participants were interviewed to reveal insights into their Q sorts. They were especially questioned about those statements with very high and very low agreement (±5 positions on the grid). Altogether each Q interview took about forty-five minutes. All forty-five interviews were conducted between June and July 2017.

Rather than a representative sample of the German population, the Q method requires that the respondents need to be diverse in their opinions as much as possible to reflect all existing perspectives about the topic. To ensure this diversity we applied non-random, qualitative sampling techniques. Firstly, the participants were recruited by a market research institute using quota sampling based on sociodemographic factors. Furthermore, snowball sampling was used by asking the participants to mention a person with a different, and with a similar viewpoint on bio-economy. A description of the sample (P-Set) is presented in Table 1.

Table 1: Sociodemographic information of the sample.

		P Set (%)
		n=45
Age	18-45	60
	46-65	40
Gender	Female	44
	Male	56
Place of residence	urban (248.500 inhab.)	78
	rural (21.500 inhab.)	22
Level of education	No university degree	58
	University degree	42
Employment	Students	18
	Part- or full-time occupation	67
	Retired	2
	Other	6
Environmental consciousness[1]	Neutral	36

[1] Based on two questions:

1. In comparison to an average person I know a lot about environmental impacts of products and services. Yes/No
2. People, who know me, perceive me as an environmentally conscious person. Yes/No

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Environmentally conscious	38
Environmentally unconscious	27

Data analysis

The free software package PQMethod (by Peter Schmolck) was used for analysis. The analytical process is based on correlations and by-person factor analysis; in other words: all Q sorts are compared and contrasted through factor analysis to discover any common forms of understanding. At first a Principal Component Analysis was conducted. Based on the eigenvalues, the scree plot, and the correlations between factors, a three-factor-solution (i.e. three societal perspectives on bio economy) was chosen. Subsequently, a Varimax rotation was applied. It was not additionally rotated by hand, since this procedure did not bring any further improvement of the statistics. Factor rotation was used to identify any Q sorts that closely approximate the viewpoint of a particular factor. The loading of a factor is a measure that tells us to which extent the Q sort is typical for a particular factor; it is expressed in the form of a correlation coefficient. All factor loadings higher than the significant factor loading (0.43) were flagged manually, when the loadings of the other two factors were below the significant factor loading. In case the loadings of more than one factor were higher than the significant factor loading, the respective Q sort was confounded, meaning that this respondent loaded on more than one factor. In case none of the factor loadings were higher than the significant factor loading, the respective Q sort was non-significant, meaning that this respondent did not load on any of the factors. Subsequently, so called factor estimates are prepared via a weighted averaging of all individual Q sorts that load significantly on a factor. However, the total weighted scores can only give a ranking of items for each factor, but do not allow for cross-factor comparisons. To solve this problem standardized z-scores are calculated. These z-scores are converted into single factor arrays, which represent an “average” Q sort for all respondents belonging to the respective viewpoint (i.e. factor). These “ideal-typical” Q sorts always correspond to the distribution used in the initial data collection and facilitate the interpretation.
Three different perspectives on bio-economy were identified. These three factors accounted for 38 of the 45 Q sorts; four Q sorts were confounded and three Q sorts were non-significant and hence, could not be allocated to any of the perspectives (Table 11, Annex). Altogether, the results explained 49% of the variance; values higher than 35-40% are regarded as sufficient (Watts and Stenner, 2012).

Data interpretation

For interpretation those statements were used, which were significantly distinguishing or similarly rated by the three factors. Especially the statements which were positioned at the extremes of the grid are interesting for interpretation. In addition, information from the accompanying interviews is used to more deeply describe the perspectives.
To put it in a nutshell, the analytical approach of Q methodology consists of three transitions. First of all there is the transition from Q sorts to factors via correlation and factor analysis, secondly the factor arrays are calculated from the factors through the weighted averaging of significantly loading Q sorts, and eventually the factor arrays are turned into factor interpretations. The factor interpretations will be presented in the following results section.

Results

Three different perspectives (factors) were identified by the Q study:

- “Sufficiency and close affinity to nature”
- “Technological progress”

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- "Not at any price"

The perspective 'Sufficiency and close affinity to nature' accounts for 23 Q sorts. The salient statements (placed in the ±4 and ±5 positions of the factor array) for the interpretation of this perspective are listed in Table 2. Those statements, which have been rated higher, respectively lower, by perspective 1 than by any other perspective, are presented in Tables 3 and 4, and are also included in the interpretation process. Consensus statements cannot be used for the differentiation of perspectives, but are valuable for the overall interpretation of the study.

The perspective 'Sufficiency and close affinity to nature' is characterised by the opinion that our society loses its relation to nature. Moreover, people belonging to this perspective believe that it is not nature that has to change but the people themselves. Therefore, working with nature or natural processes is preferred in contrast to the efficient and technological utilization of nature in form of biomass. This also means that a focus on technological applications in bio-economy is criticized, especially when it requires an increase of cultivated area for industrial and energy crops. People belonging to this perspective think that only waste and residual materials instead of extra grown resources should be used for a bio-economy. In addition, impairing nature through genetic engineering is refused.

> *"...The influence of genetically modified organisms in our nature has not been fully investigated for a long time yet. If you don't keep them down, they might mutate. I find that very, very scary." (BSF38_10)*

The focus in this perspective is on more traditional and established processes and methods. The exploration of natural processes and their implementation should be the basis of a bio-economy. Organic farming, for example, is supported as an alternative to conventional agricultural practices.

Since an increase in efficiency through purely technological innovations is criticized, sufficiency strategies are appreciated. Man is perceived as part of nature, thus, man has to change his behaviour, not nature. Against this background, the paradigm of economic growth is questioned.

> *"Way too many people do not think about natural interactions, because they worry too much about their own matters, their jobs etc. Everybody should think more about life on earth. If we continue like this, it won't be as good as it is right now." (BSM18_28)*

The perspective 'Sufficiency and close affinity to nature' is also characterized by the view that consumers are able to develop an effective countervailing buying power to the industry.

Table 2: Salient statements for perspective 'Sufficiency and close affinity to nature'. Consensus statements are not presented.

Statement	Factor score
Something important has been lost in many people, namely to view themselves as part of nature and to learn to understand natural interactions.	5
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
We cannot expect our children to endure, that our fossil resources will be extinct one day.	4
We will achieve more sustainability, if we use products (like e.g. furniture and clothes) longer or recycle them.	4
I believe that most of our future problems will be solved through technological progress.	-4
Fact is that genetically modified food becomes increasingly necessary to feed the world.	-4
I am not willing to pay a premium just because something is made of renewable resources.	-4
Modification of genes for industrial purposes is okay.	-5

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Table 3: Statements rated higher by perspective 'Sufficiency and close affinity to nature' than by any other perspective.[2]

Statement (factor score)
Something important has been lost in many people, namely to view themselves as part of nature and to learn to understand natural interactions.** (5)
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)
It is necessary that the government is not only consulted by scientists and industry representatives, but also from nongovernmental organisations. (3)
It is arrogant to believe that plants and animals should be optimised though genetic engineering.** (3)
As long as more and more forests are intensively used, a lot of mushrooms and insects are massively threatened.** (3)
Consumers can exert influence through their consumption on food retailers and thereby on producers and politicians.** (3)
Instead of developing something new all the time, one should use naturally occurring microorganisms to increase the efficiency of our agriculture.** (2)
We just need to save more energy instead of solely focussing on renewable resources in order to succeed in phasing out of fossil energies.** (2)
In a bio-economy we should only use waste and residual materials instead of extra grown resources.** (0)

** significant at p<0.01

Table 4: Statements rated lower by perspective 'Sufficiency and close affinity to nature' than by any other perspective.[3]

Statement (factor score)
Modification of genes for industrial purposes is okay.** (-5)
I believe that most of our future problems will be solved through technological progress.** (-4)
Fact is that genetically modified food becomes increasingly necessary to feed the world.** (-4)
It seems to be quite obvious, that all of us won't be able to live on organic agriculture.** (-3)
Bio-economy creates new jobs.** (-1)
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)
Bio-economy can reduce the enormous dependency on oil. But because of the growing demand for biomass, we have to focus on more and more efficient technologies.** (0)

** significant at p<0.01

The second perspective favours 'Technological progress' and comprises eight Q sorts. Salient statements for this perspective are shown in Table 5. Tables 6 and 7 comprise the statements, which have been rated higher, respectively lower, by the perspective 'Technological progress' than by any other perspective.

The perspective 'Technological progress' comprises people believing that bio-economy is an economic approach of the future in case technological innovations are explored and eventually introduced into the market and in society. Technological progress is considered as the key to solve global problems; this results

[2] Statements are listed, which are rated higher by at least two points on the scale.
[3] Statements are listed, which are rated lower by at least two points on the scale.

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from people's strong interest in and knowledge about technologies which is unfolded by three statements: People belonging to the perspective 'Technological progress' do not feel that it is frightening that 60% of our clothes are made from mineral oil. Likewise, they rather disagree that it is fascinating that clothes can for example be produced from coffee and tires from dandelion. Due to their apparently higher level of knowledge these innovations are not surprising to them. The opinion is that the increasing demand for biomass accompanied by the increasing importance of bio-economy should be met by the development of more efficient technologies, e.g. precision farming, circular economy, and recycling of products. Likewise, bio-based resources are suggested to be used for materials first, while only residual materials should be used for energy production to remain economically and ecologically sustainable. Thus, people belonging to the perspective 'Technological progress' totally disagree that heating with wood is climate-friendly.

> *"I oppose throwaway societies. I don't like when clothes are thrown away after they were worn only once. Clothing collections and recycling of cloths is something good…" (QM37_32)*

Whereas organic agricultural practices are rejected, the use of genetic engineering is regarded as necessary for the world's food security. Technological innovations should rather be perceived as opportunities than as potential risks and should be applied to utilise nature and its resources in an efficient way.

> *"…We won't get around genetically modifying our organisms, if we really want to have more efficient resource use." (QM29_43)*

Since genetic engineering is seen as one solution for feeding the world, the statement, that food production should always be the first priority, is rated comparably low by the perspective 'Technological progress'. Furthermore, people belonging to this perspective do not regard a consultation of governments through NGOs as necessary in the context of further developing our bio-economy. The confidence in industry and policy is relatively high.

Table 5: Salient statements for the perspective 'Technological progress'. Consensus statements are not presented.

Statement	Factor score
We will achieve more sustainability, if we use products (like e.g. furniture and clothes) longer or recycle them.	5
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.	5
Bio-economy is an economic approach of the future.	4
Precision farming should receive more attention in the context of a bio-economy, because it can help to save resources.	4
It is economically and ecologically reasonable to use resources for materials first (i.e. high-quality manufactured) and then for energy.	4
People, who use wood for heating, protect the climate.	-4
I am not willing to pay a premium just because something is made of renewable resources.	-4
It is arrogant to believe that plants and animals should be optimised though genetic engineering.	-5
Bio-economy is only means to an end to make genetic engineering socially acceptable.	-5

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Table 6: Statements rated higher by the perspective 'Technological progress' than by any other perspective[1].

Statement (factor score)
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.** (5)
It is economically and ecologically reasonable to use resources for materials first (i.e. high-quality manufactured) and then for energy.** (4)
Precision farming should receive more attention in the context of a bio-economy, because it can help to save resources.** (4)
Bio-economy is an economic approach of the future.* (4)
It seems to be quite obvious, that all of us won't be able to live on organic agriculture.** (3)
I believe that most of our future problems will be solved through technological progress.** (3)
Genetic engineering is an approach, which is very much criticized, but nonetheless it offers multiple options for the development of a sustainable agriculture in the future. Instead of dealing with it in a scientific way, large corporations like Monsanto/Bayer or BASF are insulted.** (3)
Fact is that genetically modified food becomes increasingly necessary to feed the world.** (3)
Modification of genes for industrial purposes is okay.** (1)
If you take a look at the whole lifecycle, bio-fuels do not save as much greenhouse gas emissions as has been hoped.** (1)
The cultivation of energy plants for the production of bio-fuels has led to the increase of food prices.** (0)

** significant at $p<0.01$; * significant at $p<0.05$

Table 7: Statements rated lower by perspective 'Technological progress' than by any other perspective[2].

Statement (factor score)
It is arrogant to believe that plants and animals should be optimised though genetic engineering.** (-5)
People, who use wood for heating, protect the climate.** (-4)
In light of the seemingly unlimited opportunities of biotechnology, we should care about the intrinsic value of nature.** (-3)
It is necessary that the government is not only consulted by scientists and industry representatives, but also from nongovernmental organisations.** (-3)
If you included the external costs of the environmental pollution through fossil fuels in the fuel price, nobody would buy them anymore.** (-2)
The industry tries to create new needs through the optimization of foods, instead of resolving nutrition and health problems.** (-2)
The focus of bio-economy should be the promotion of all natural interactions of life in the agricultural landscape.** (0)
It is frightening to imagine that 60% of our clothes are made from mineral oil.** (0)
It is fascinating that we can produce clothes from coffee and tires from dandelion.** (0)
It is important that in our bio-based economy, food production is always the first priority. No person in Africa should starve for this reason.* (2)

** significant at $p<0.01$; * significant at $p<0.05$

The third perspective is named 'Not at any price' and comprises seven Q sorts. Salient statements for this perspective are presented in Table 8. The statements, which were rated higher, respectively lower, by perspective 3 than by any other perspective, are listed in Tables 9 and 10.

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In the perspective 3 'Not at any price' the opinion prevails that a transition to a bio-economy can counteract climate change. It is fundamental, however, that people can keep their standard of living without losing any amenities. They are not willing to pay a premium for products made of renewable materials and sufficiency is definitely refused.

> *"I think that we need to find a solution in our days to protect our environment in the future. This solution needs to achieve that our living standard will not change. That is not only my opinion, but that of many other people. There is little point in me saying that I will cut down, that I will eat less meat, but if the other people from our society won't go with it, there is no point in it…" (BSM21_ 27)*

The lower prices of fossil-based products, due to low oil prices, are seen as barriers to act in a climate-friendly way. The internalisation of external effects would make fossil-based products less attractive and, thus, would be a chance for the economic development of the bio-based economy.

People belonging to the perspective 'Not at any price' do hardly have reservations about negative environmental effects of the utilisation of biomass for non-food purposes: They do not perceive maize monocultures and the decline of biodiversity to be a problem which might occur in a bio-based economy. Therefore, strategies to reduce the demand for biomass are less supported: People belonging to this perspective disagree that in a bio-economy only waste and residual materials instead of extra grown resources should be used. In addition, they rather oppose the statement that more sustainability will be achieved if products (like e.g. furniture and clothes) are recycled or used longer. They attach only little importance to consumers as a countervailing power against the industry.

Table 8: Salient statements for perspective 'Not at any price'. Consensus statements are not presented.

Statement	Factor score
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.	5
As long as the oil price is very low, the bio-economy will fail due to the high costs of its products.	5
The energy transition is necessary. It will help to leave the coal in the earth.	4
The further development of the bio-economy will help to curb climate change.	4
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
Bio-economy is only means to an end to make genetic engineering socially acceptable.	-4
We just need to save more energy instead of solely focussing on renewable resources in order to succeed in phasing out of fossil energies.	-4
Scientists dramatize, when they talk about the finite nature of fossil resources.	-5
In a bio-economy we should only use waste and residual materials instead of extra grown resources.	-5

Table 9: Statements rated higher by perspective 'Not at any price' than by any other perspective[1].

Statement
As long as the oil price is very low, the bio-economy will fail due to the high costs of its products.** (5)
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.** (5)

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The energy transition is necessary. It will help to leave the coal in the earth.** (4)
The further development of the bio-economy will help to curb climate change. (4)
If you included the external costs of the environmental pollution through fossil fuels, nobody would buy them anymore.** (3)
I am not willing to pay a premium just because something is made of renewable resources.** (3)
The solutions of bio-economy are growth-orientated and driven by economic interests. A true gold-rush atmosphere prevails – especially in the chemistry and agricultural industry. ** (0)

** significant at p<0.01

Table 10: Statements rated lower by perspective 'Not at any price' than by any other perspective[2].

Statement
Scientists dramatize, when they talk about the finite nature of fossil resources.** (-5)
In a bio-economy we should only use waste and residual materials instead of extra grown resources.* (-5)
We just need to save more energy instead of solely focussing on renewable resources in order to succeed in phasing out of fossil energies.** (-4)
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)
The promotion of bio-energy has contributed to the increase of maize monocultures.** (-3)
Bio-economy summarizes so many different technologies and aims, so that one can neither agree nor disagree with it.* (-3)
A plant-based economy has got great potential, but will entail a further decrease of biodiversity.** (-2)
Consumers can exert influence through their consumption on food retailers and thereby on producers and politicians.** (-1)
It is economically and ecologically reasonable to use resources for materials first (i.e. high-quality manufactured) and then for energy.** (-1)
We will achieve more sustainability, if we use products (like e.g. furniture and clothes) longer or recycle them.** (1)

** significant at p<0.01; * significant at p<0.05

Besides these statements that distinguish the three perspectives from each other, there are some statements at the extremes of the grid that are almost equally ranked by all participants. That means, all respondents strongly agree or disagree with these statements independent from the perspective on bio-economy that they represent. (1) All three perspectives comprise people who believe that we do need to care about global problems, because it is not supportable to just say that we cannot change anything anyways. They assume some responsibility for global problems and believe that it is about time to do something to curb them. (2) All respondents agree that society has to be better informed to successfully induce the development of a viable bio-economy. It remains open and requires further investigations on whether the kind of information needed differs between the three societal perspectives on bio-economy. (3) In general, the respondents disagree that the people won't be able to reduce their meat consumption and that it will be necessary to grow meat in the lab to save resources. Hence, at a first glance, respondents are sceptical about the necessity of meat production in the lab to solve this problem.

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Discussion and Conclusions

The Q-methodological approach applied in this study yielded three perspectives on bio-economy in Germany, namely "Sufficiency and close affinity to nature", "Technological progress" and "Not at any price". To the authors' knowledge, this is the first study that grouped people according to their perceptions on bio-economy in Germany and hence, contributes to the process of involving the public into the transformation from a fossil-based to a bio-based economy.

Bio-economy is a concept which has rapidly been gaining in importance in industry and policy, but which is not widely known to the public. The Q method turned out to be well suited to analyse and structure people's perceptions on bio-economy in its complexity, because it is able to capture all the different aspects of topic. Since the participants are largely aware of the individual aspects belonging to bio-economy, they can easily assign their personal relevance to these aspects. And, once the people are confronted with the different aspects of this concept, they become very interested and recognize interrelations. That is why, the ranking of the statements in a Q study is not perceived as being a difficult task by the participants despite its complexity. The Q study has proven to be a good task to start a dialogue with the public (cf. Sleenhoff et al., 2015).

The Q sorts as well as the forms of common understanding which could be drawn from these Q sorts help to understand which perspectives on bio-economy do exist in the German society.

The study in hand aimed at presenting general viewpoints on bio-economy, defined as a holistic concept to curb the demand for fossil resources. The three perspectives on bio-economy show that different processes or technologies combined under the concept bio-economy might appeal to different groups of people. Precision farming, genetic engineering, and circular economy, for example, are supported by the perspective "Technological progress", whereas organic farming and sufficiency strategies are favoured by the perspective "Sufficiency and close affinity to nature". The perspective "Not at any price", in contrast, rather focusses on cost-benefit relations and therefore supports all those activities that do not lead to increasing prices and that help to maintain the current standard of living.

In the current study, bio-economy is regarded in its entirety and therefore cannot be easily compared to earlier studies that had a focus on specific aspects of the bio-economy or on certain bio-based products. The results of this study show, that there is one perspective that rather agrees to technological progress in general and another perspective that is sceptical about new technologies and that there is one further perspective comprising people that primarily draw on costs and benefits in their considerations and are not willing to pay a premium for bio-based products. Hence, compared to the other studies, the findings from the current study point in the same direction, but can be allocated to different perspectives, i.e. groups of people with similar viewpoints, and thereby remain less vague and general.

The study in hand also shows that people believe that it is necessary to care about global problems, because it is not okay to deny one's own responsibility (cf. Sleenhoff and Ossewijer, 2016). However, quotes from the interviews following the sorting task show that especially people belonging to the perspective "Not at any price" think that it does not have any impact, if only individuals change their behaviour. Hence, these people are less motivated to change their own behaviour, e.g. save energy, reduce meat consumption or reuse/recycle materials. This indicates how different aspects of the broad concept of bio-economy are perceived rather negative by some people, while other people support these aspects. Thus, it is very important how such a complex topic is presented to foster engagement in the public (cf. Sleenhoff and Ossewijer, 2016).

Similar to all reviewed studies, this study also reveals a lack of knowledge and reliable information among participants to express their opinion on bio-economy. Therefore, it is very important to start information campaigns and to continue the dialogue with the public in order to enhance engagement and support for the transition to a bio-based economy. In doing so, the different perspectives on bio-economy and their specific

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characteristics need to be considered to create a successful communication strategy. While new and innovative technologies need to be explained carefully with an open debate on their risks and benefits, the potential of sufficiency, organic farming, cascade use, and circular economy, amongst others, has to be addressed as well. At the same time, the fear of higher prices and a descent of today's living standard needs to be considered in information campaigns to accommodate those people who are price-sensitive and sceptical about the impact of economic transformations on their future well-being.

Outlook

The Q study on societal perspectives on bio-economy in Germany was designed as an explorative study, building a basis for focus groups and a quantitative survey on people's perceptions on and expectations of the development of a bio-based economy in Germany. Focus groups, discussing specific aspects of the broad concept of bio-economy will explore the topic more deeply. Surveys will quantify the distribution of the three perspectives among the German population and investigate interdependencies between these viewpoints and personal characteristics of the respondents. The cumulative results will lead to policy recommendations for the development and communication of bio-economy in line with societal expectations in Germany.

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Short Vitae of all authors

The authors of this manuscript work in the area of consumer research at the Thuenen-Institute of Market Analysis in Germany. All three authors have got substantial experience in qualitative and quantitative methods of empirical social research, especially in the field of agricultural and food marketing. One important focus of their research activities is the exploration of the acceptance of innovative technologies in society.

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Annex

Table 11: Significant factor loadings of the 38 Q sorts that determine the three factors.

Number of Q sorts	Factor 1	Factor 2	Factor 3
1	**0.7186X**	0.0571	0.4200
2	**0.5993X**	0.2227	-0.0615
3	**0.7248X**	0.1282	0.1582
4	**0.5012X**	0.3468	0.3645
5	**0.4446X**	-0.0297	-0.0067
6	**0.6702X**	0.0290	0.1807
7	**0.4422X**	0.2797	0.2149
8	**0.5835X**	0.3652	0.2961
9	**0.6360X**	-0.0377	0.3963
10	**0.4497X**	0.3533	0.2703
11	**0.5298X**	0.3118	0.1931
12	**0.6259X**	0.2552	0.1916
13	**0.6991X**	0.1618	0.1084
14	**0.5940X**	0.2223	0.0511
15	**0.6111X**	0.2725	-0.1403
16	**0.5998X**	0.2201	0.2486
17	**0.5687X**	0.0184	0.3641
18	**0.7014X**	0.0059	0.1318
19	**0.6526X**	0.1102	0.3511
20	**0.5852X**	0.3809	0.4164
21	**0.6458X**	0.2514	0.2865
22	**0.7666X**	-0.1811	0.2065
23	**0.5114X**	0.1387	-0.1609
24	0.0120	**0.7466X**	0.1846
25	0.4061	**0.5932X**	0.2775
26	0.0066	**0.7695X**	0.1387
27	0.2908	**0.6836X**	-0.0298
28	0.0643	**0.7854X**	0.0061
29	0.1901	**0.5239X**	0.2817
30	0.0514	**0.7140X**	0.1844
31	0.2950	**0.6551X**	0.3322
32	0.0319	0.0869	**0.7172X**
33	0.2534	0.0179	**0.5180X**
34	-0.0751	0.2167	**0.6625X**
35	0.4068	0.3328	**0.6127X**
36	0.3515	0.2849	**0.5669X**
37	0.2795	0.2740	**0.4945X**
38	-0.1777	0.3685	**0.4820X**

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% expl. Var.	24	13	12

Table 12: Sociodemographic information of the three factors. Six Q sorts are not included, because they are either confounded or do not load on any of the three factors.

		P Set (%)	Factor 1 (%)	Factor 2 (%)	Factor 3 (%)
		n=45	n=24	n=8	n=7
Age	18-45	60	50	87	71
	46-65	40	50	13	29
Gender	female	44	58	13	29
	male	56	42	87	71
Level of education	No university degree	58	63	13	72
	University degree	42	37	68	28
Occupation	Students	18	13	25	0
	Part- or full-time occupation	67	67	76	43
	Retired	2	4	0	29
	Other	13	16	0	29
Environmental consciousness	Neutral	36	29	63	29
	Environmentally conscious	38	42	38	29
	Environmentally unconscious	27	29	0	43

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Table 13: Statements and the responding factor scores.

No.	Statement	Factor 1	Factor 2	Factor 3
1	Scientists dramatize, when they talk about the finite nature of fossil resources.	-3	-3	-5
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
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
4	Bio-plastics will only be ecological, if they are part of a return system.	-2	-2	-1
5	The cultivation of energy plants for the production of bio-fuels has led to the increase of food prices.	-3	0	-2
6	We won't be able to reduce our meat consumption. To save resources, we will need to grow meat in the lab.	-5	-4	-4
7	Bio-economy summarizes so many different technologies and aims, so that one can neither agree nor disagree with it.	-1	-1	-3
8	If you take a look at the whole lifecycle, bio-fuels do not save as much greenhouse gas emissions as has been hoped.	-1	1	-2
9	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
10	The energy transition is necessary. It will help to leave the coal in the earth.	1	0	4
11	It seems to be quite obvious, that all of us won't be able to live on organic agriculture.	-3	3	0
12	Bio-economy is an economic approach of the future.	1	4	2
13	I believe that most of our future problems will be solved through technological progress.	-4	3	-2
14	Instead of developing something new all the time, one should use naturally occurring microorganisms to increase the efficiency of our agriculture.	2	-1	0
15	People, who use wood for heating, protect the climate.	-2	-4	-1
16	Genetic engineering is an approach, which is very much criticized, but nonetheless it offers multiple options for the development of a sustainable agriculture in the future. Instead of dealing with it in a scientific way, large corporations like Monsanto/Bayer or BASF are insulted.	-3	3	-2
17	If you included the external costs of the environmental pollution through fossil fuels in the fuel price, nobody would buy them anymore.	0	-2	3
18	In a bio-economy we should only use waste and residual materials instead of extra grown resources.	0	-3	-5

DOI: http://dx.doi.org/10.18461/pfsd.2018.1818

19	Society needs to be better informed, in order for the bio-economy to become a success.	5	5	4
20	The production of microalgae does not compete with agricultural land. That is why microalgae are a resource of the future.	0	1	1
21	It is fascinating that we can produce clothes from coffee and tires from dandelion.	2	0	2
22	It is arrogant to believe that plants and animals should be optimised though genetic engineering.	3	-5	0
23	As long as more and more forests are intensively used, a lot of mushrooms and insects are massively threatened.	3	1	1
24	We cannot expect our children to endure, that our fossil resources are extinct one day.	4	2	3
25	Bio-economy creates new jobs.	-1	2	3
26	Fact is that genetically modified food becomes increasingly necessary to feed the world.	-4	3	0
27	Precision farming should receive more attention in the context of a bio-economy, because it can help to save resources.	-1	4	0
28	From the perspective of the poorest bio-economy is rather a threat than a blessing. It leads to increasing demand for agricultural land to grow plant-based resources, which is also needed for the production of food. Thereby, the bio-economy aggravates the competition between fuel tank and dinner plate.	-1	0	1
29	Under the concept bio-economy all life is turned into money.	-4	-4	-3
30	In light of the seemingly unlimited opportunities of biotechnology, we should care about the intrinsic value of nature.	1	-3	0
31	Vertical farming (farming in multi-storey buildings) is a great concept to produce food in a small space in cities.	1	2	0
32	It is frightening to imagine that 60% of our clothes are made from mineral oil.	2	0	2
33	Modification of genes for industrial purposes is okay.	-5	1	-3
34	Bio-economy is only means to an end to make genetic engineering socially acceptable.	-3	-5	-4
35	The biggest challenge for the bio-economy is the insecurity about the future supply of biomass (respectively biological resources).	-1	-1	-2
36	We will achieve more sustainability, if we use products (like e.g. furniture and clothes) longer or recycle them.	4	5	1
37	Some solutions from bio-economy (e.g. intensification of agriculture) to save the planet include exactly those methods, which have contributed to the environmental degradation.	-2	-1	-1
38	Consumers can exert influence through their consumption on food retailers and thereby on producers and politicians.	3	1	-1
39	The industry tries to create new needs through the optimization of foods, instead of resolving nutrition and health problems.	1	-2	1

DOI: http://dx.doi.org/10.18461/pfsd.2018.1818

40	I am not willing to pay a premium just because something is made of renewable resources.	-4	-4	3
41	A plant-based economy has got great potential, but will entail a further decrease of biodiversity.	0	0	-2
42	The promotion of bio-energy has contributed to the increase of maize monocultures.	0	0	-3
43	For our bio-economy rain forests should not be cleared.	5	4	5
44	The focus of bio-economy should be the promotion of all natural interactions of life in the agricultural landscape.	2	0	2
45	It is economically and ecologically reasonable to use resources for materials first (i.e. high-quality manufactured) and then for energy.	2	4	-1
46	The solutions of bio-economy are growth-orientated and driven by economic interests. A true gold-rush atmosphere prevails – especially in the chemistry and agricultural industry.	-2	-2	0
47	For the energy production in Germany more wind turbines and photovoltaic systems should be implemented instead of building on biomass.	0	-1	-1
48	It is important that in our bio-based economy, food production is always the first priority. No person in Africa should starve for this reason.	4	2	4
49	Bio-economy without circular economy does not work: All components of the biomass need to be used and, if applicable, reused, so that no waste is produced.	3	2	2
50	It is necessary that the government is not only consulted by scientists and industry representatives, but also from nongovernmental organisations.	3	-3	1
51	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
52	We don’t need to care about global problems, because we won’t be able to solve them anyways.	-5	-5	-5
53	The use of waste materials needs to be critically viewed, because it might lead to a situation, in which the production of waste is not avoided anymore.	-2	-3	-3
54	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
55	We just need to save more energy instead of solely focussing on renewable resources in order to succeed in phasing out of fossil energies.	2	-1	-4
56	The further development of the bio-economy will help to curb climate change.	1	2	4

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