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2019-09-01
Elsevier Ltd.
http://hdl.handle.net/10138/304490
D'amato, D, Droste, N, Winkler, K & Toppinen, A 2019, 'Thinking green, circular or bio: Eliciting researchers' perspectives on a sustainable economy with Q method', Journal of Cleaner Production, vol. 230, pp. 460-476. https://doi.org/10.1016/j.jclepro.2019.05.099

Journal of Cleaner Production 230 (2019) 460–476

Contents lists available at ScienceDirect

Journal of Cleaner Production

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

Thinking green, circular or bio: Eliciting researchers' perspectives on a sustainable economy with Q method

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A R T I C L E I N F O

Article history:
Received 31 October 2018
Received in revised form
25 April 2019
Accepted 10 May 2019
Available online 12 May 2019

Keywords:
Bioeconomy
Circular economy
De-growth
Green economy
Q-method
Sustainability

A B S T R A C T

The continuous emergence of new ideas and terms simultaneously enables and impedes the advancement of sustainability, because of an increasingly complex conceptual landscape. This study aims at highlighting combinations of sustainability concepts (circular, green and bioeconomy) and of development models (growth, steady-state, degrowth) which selected researchers have considered priorities for pursuing sustainability transformations. Leading scholars working on sustainability issues were asked to rank 36 statements describing activities related to either circular, green, bio, growth, steady-state or degrowth economy. Using Q methodology, an exploratory approach to the identification of shared or diverging opinions, three archetypical perspectives were identified across the respondents: 1. circular solutions towards economic-environmental decoupling in a degrowth perspective; 2. a mix of circular and green economy solutions; 3. a green economy perspective, with an emphasis on natural capital and ecosystem services, and critical towards growth. Economic growth was perceived negatively across all perspectives, in contrast to the current lack of political and societal support for degrowth ideas. Neither did bioeconomy-oriented activities have support among the participating researchers, even though half of the respondents were working with bioeconomy issues, which are currently high on the political agenda. The lack of support for pro-growth and bioeconomy solutions are unexpected results given the current political discourses. While the results are not to be generalised beyond the sample, they provide valuable orientation for emerging and under-investigated research and policy directions. If bioeconomy policies are to be implemented on a broader scale, it seems worthwhile evaluating the acceptability of the bioeconomy agenda among various societal actors. Furthermore, our results point to the (still under-explored) potential of formulating synergic circular, green and bioeconomy policies, possibly without a focus on economic growth.

1. Introduction

In the current international policy discourse, efforts towards sustainable development have been mainly rooted in the Agenda 2030 and the Sustainable Development Goals, adopted by the United Nations in 2015 (Smith et al., 2018). Concomitantly, three main sustainability concepts largely inform international and national policies globally: the circular economy, the green economy and the bioeconomy (CE, GE, BE). These concepts propose different solutions to reconcile economic, environmental and social goals.

CE draws on the ideas of industrial ecology and industrial metabolism, promotes reduction and efficiency in resource use, re-use and recycling of industrial outputs, and prolonging product lifetime. Engineering-driven innovation forms the foundation of such industrial changes, as identified in comprehensive literature reviews by Kirchherr et al., (2017); Prieto-Sandoval et al. (2018). Even though important components of GE include low carbon technology and resource efficiency (see definition by UNEP, 2011), its core elements consist of accounting, conservation and enhancement of multiple ecosystem services. The biosphere is thus seen as a fundamental matrix supporting human well-being (Gasparatos and Willis, 2015; ten Brink et al., 2012). Instead, the mainstream understanding of BE is that fossil-fuel-based industrial inputs should be replaced or complemented by renewable bio-

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https://doi.org/10.1016/j.jclepro.2019.05.099

based resources and materials. In this context, knowledge-based innovation and the use of biotechnology are key factors (Bugge et al., 2016; Pfau et al., 2014). Circularity is not explicitly embedded in BE, but a convergence between these concepts has been postulated and advocated for by, among others, Bezama (2016); Hetemäki (2017); Venkata Mohan et al., 2016.

All the three concepts are explicitly part of the policy debates and agenda setting processes at European Union (EU) level, with the action plan for the circular economy (EC, 2015), the green economy policy targets and objectives (EAA, 2013), and the bioeconomy strategy (renewed in 2018) (EC, 2012, 2018). The green economy, a concept driven by the United Nations (UNEP, 2011) is also reflected in the OECD green growth strategy (OECD, 2011). Bioeconomy policies are rather ubiquitous as well, despite different foci having been recorded across countries (Dietz et al., 2019). The circular economy has been particularly prominent in China, introduced through a national law (McDowall et al., 2017).

These three concepts are characterised by different assumptions and implementation strategies at various geographic and administrative levels, involving the co-participation of multiple actors, and more or less detailed guidelines. For instance, while in the BE strategy launched by the United States emphasis is placed on biofuels and biotechnology (USA, 2012), a greater breadth of sectors and industries is involved in the EU strategy, including, for instance, the food, chemical, pharmaceutical and textiles industries (EC, 2012, 2018). Even national strategies in the EU vary, especially in relation to domestic biomass self-sufficiency. For instance, Finland and Sweden focus strongly on the efficient use of their domestic forest resources (notably, a number of studies have recently focused on comparative analyses of national and regional bioeconomy policies, e.g. Bracco et al., 2018; De Besi et al., 2015; Kircher, 2012; Staffas et al., 2013). The Chinese strategy focuses on promoting waste reduction and recycling (Murray et al., 2015), while the latest EU CE strategy includes several elements, such as eco-design and product durability, waste management and recycling and sharing consumption models (McDowall et al., 2017). Instead, GE has attracted 'various contributions from developing and transitioning economies – which underlines its global development policy implications (D'Amato et al., 2017a, D'Amato et al.,b, p. 724), but it is operationalised with tailor-made solutions in each country (e.g., Jäppinen and Heliölä, 2015 in Finland).

National governments implement the above-mentioned policies through direct regulation, public procurement, use of economic instruments, and softer measures like capacity building and information-based approaches such as using nudges. Such policies can help spur corresponding innovations (Droste et al., 2016). Some policy instruments are typically associated with a particular sustainability concept. For instance, developing markets for ecosystem services by economic instruments are proposed under GE (Sandbrooks et al., 2013; Van Hecken and Bastiaensen, 2010), biotechnology innovations are associated with BE (Bugge et al., 2016), and regional industrial development policies are used for enhancing CE (Droste et al., 2016; Pitkänen et al., 2016).

As they gain political momentum, CE, GE and/or BE ideas are also increasingly object of scientific inquiry internationally, and are being absorbed in other societal context as well, such as industry and civil society. Simultaneously, multiple societal actors contribute to shaping the conceptualisations of CE, GE and BE, as often happens for emerging ideas, concepts and terms which become institutionalised through discourses and framing (Fischer and Hajer, 1999; Hajer, 1995).

Scientific literature exists addressing the internal diversity of the three individual concepts, also including the analysis of discourses. Various articles have pointed out that, due to their specific foci, each concept is limited in addressing all three sustainability dimensions comprehensively (economy, environment, society) and in questioning the adequacy of the proposed changes for achieving desired levels of sustainability, within either weak or strong sustainability visions. In this context, it also remains unclear whether these concepts align to development models of growth or of steady-state or degrowth (for critical perspectives on CE see Kirchherr et al., 2017; Martins, 2016; for GE see Bina, 2013; D'Amato et al., 2017a,b; for BE see Bugge et al., 2016; Pfau et al., 2014).

While the individual concepts are increasingly popular in scientific literature, there is surprising research void regarding the joint and comparative analysis of the three concepts. Recent exceptions include comprehensive literature reviews by D'Amato et al. (2017a,b) and Loiseau et al. (2016); an analysis by Bennich and Belyazid (2017); a content analysis of corporate sustainability reporting by D'Amato et al. (2019). This is despite the fact that some of the ideas advanced by these discourses can be considered overlapping, complementary and/or conflicting when outlining and pursuing sustainability goals and instruments. These three concepts are thus often treated separately, leading to very limited cross-fertilisation in their practical implementation (D'Amato et al., 2017a,b; Hetemäki, 2017).

Accordingly, there is a need to jointly evaluate CE, GE and BE concepts from a comparative perspective. Since they are popular concepts intended to realise sustainable development across the globe, it is worthwhile to investigate their relation to i) each other, and to ii) development pathways. The aim of this exploratory study is to analyse compatible and conflictual elements across CE, GE and BE concepts, as well as growth, steady-state and degrowth development models. Key researchers' opinions are elicited and condensed through Q-method into archetypical perspectives of shared and non-shared statements. The research question is framed as follows: *What combination of CE, GE and/or BE activities, and of development models (growth, steady-state, degrowth), do researchers consider priorities for policy-making in sustainability transformation?*

The contribution of this study is the reduction of some of the complexity surrounding key concepts and terms in sustainability science and policy. We acknowledge that the diversity and evolution of new perspectives are vital to advancing long-term sustainability transformations (definition by Elmqvist et al., 2019; Olsson et al., 2014), but the associated emerging complexity also represents an obstacle to implementation. Moreover, even though some of the process associated with shaping concepts and related discourses are realised within the scientific community, the opinions of scientists as such, are seldom subject to scientific enquiry. This study is thus an exercise striving to inform the operationalisation of sustainability strategies in the short term, and the shaping of pathways for sustainability transformations in the longer term.

The remainder of this article is structured as follows: Section 2 presents the conceptual underpinnings of CE, GE and BE. Section 3 clarifies data and method, with special focus on the characteristics and limits of Q methodology. Section 4 presents the results, while Sections 5 and 6 discuss the findings, draw conclusions and make recommendations.

1.1. Conceptualisation of CE, GE and BE

The conceptual background outlines the three concepts, CE, GE and BE; their relation to three dimensions of sustainability: the economy, the environment, and society; and their long-term development perspective in reference to sustainable growth, steady-state or degrowth.

1.2. The economic dimension

CE, GE and BE pursue inherently different strategies for improving economic sustainability. Under CE, new business opportunities arise from recycled and more efficient products and services. Improvements and innovation along the value and supply chains emerge from the reduction, reuse and recycling of raw and processed materials and energy. New customers and investors are attracted by means of circular or 'cleaner' approaches to industrial production. Recent literature in this context has analysed business model under a circular (Bocken et al., 2017; Manninen et al., 2018) and circular bioeconomy (CEBE) (Antikainen et al., 2017; Oghazi and Mostaghel, 2018; D'Amato et al., 2018a).

In BE, new products and services are based on biomass or hybrid materials, and advancements in production and innovation along the value and supply chains are achieved by either using biotechnology (Hansen, 2016; Reim et al., 2017) and/or improved agro-ecological land use techniques (Schmidt et al., 2012). New customers and investors are attracted via bio-based solutions in the industrial production-consumption system. In both CE and BE, cross-sectoral collaboration is required to enable additional value creation and firm-level competitiveness (Schütte, 2018; Korhonen et al., 2018).

Business opportunities from GE include not only the marketization of ecosystem services, but also the accounting of company dependence and impact on those services, leading to both business risks and a call for better accountability (D'Amato et al., 2018a,b). Initiatives such as the Natural Capital Coalition and The Economics of Ecosystems and Biodiversity suggests that customers and investors can be engaged by companies through investments in natural capital (NCC, 2015; TEEB, 2012). Environmental dependence and impact along the value and supply chains need to be governed through an integrated approach to ecosystem management.

1.3. The environmental dimension

Both BE and CE propose what resources should be used and how. BE mainly advocates the use of renewable bio-based resources for producing chemicals, materials and fuels, and thus concerns primary sectors such as forests, agriculture and fisheries (Asada and Stern, 2018). Cross-sectoral engagement, for instance, in innovation occurs in the energy and chemical sectors through opportunities for new bio-based (or hybrid) products (Guerrero and Hansen, 2018). By contrast, CE is mainly concerned with minimising inputs and outputs during the lifecycle of a product, regardless of the origin of the resource, with far-reaching implications for all sectors, especially in regard to resource efficiency, eco-design, recycling and reusing (Kirchherr et al., 2017). Nevertheless, CE and BE are not mutually exclusive, and several scholars advocate a circular bioeconomy (CEBE) where bio-based resources are utilised efficiently. For instance, D'Amato et al. (2018a,b) and Hetemäki (2017) a conceptual framework for CEBE.

The literature on BE shows diversity of perspectives in regard to environmental sustainability (reviews of BE in scientific and policy literature include Bugge et al., 2016; Hausknost et al., 2017; Priefer et al., 2017). While the main focus is on maximising the use of bio-based resources, some of the literature deals with enhancing the productivity and adaptation of agro-environmental systems by means of biosecurity and biotechnology.

GE as promoted by UNEP (2011) focuses greatly on promoting the conservation and restoration of natural capital and related ecosystem services deemed to contribute to human well-being (Bina, 2013; ten Brink et al., 2012). In this sense, GE is less material and resource-oriented than CE and BE, as it also addresses regulatory, cultural and supporting ecosystem services underpinned by biodiversity. It thus builds upon the natural and social science literature on ecosystem services research (Droste et al., 2018).

1.4. The social dimension

Overall, social sustainability does not form the core of any of the three concepts; however, GE appears to be the most inclusive, with its focus on human well-being, and BE addresses employment in rural areas, while CE considers social impact the least. Nevertheless, some CE researchers call for more social considerations and participation (e.g., Korhonen et al., 2018; Mustalahti, 2017).

The social implications of BE and CE strategies do not differ significantly, but are related to their corresponding value chains within primary production, manufacturing systems, and consumption. Closing the loop in CE would primarily occur in the context of secondary industries, while, generally, primary producers are seldom taken into account or incentivised. CE minimises and recovers waste and prolongs the life-span of a product through recycling, up-cycling, and reusing (Kirchherr et al., 2017). A part of CE is also dedicated to sustainability in urban systems, for instance, through water management, waste reduction and recycling, and improved energy efficiency. The demand side is important for both concepts: increasing attention is being directed to developing consumer or user-oriented products and services among business model scholars (e.g., Bocken et al., 2017; Pelli et al., 2017). Instead, the social dimension of BE addresses the economy of rural areas and the livelihoods in these locations, as it centres on primary production systems such as forestry, agriculture and fisheries (in the context of the forest sector: Kleinschmit et al., 2014; Roos and Stendahl, 2015). Both CE and BE include aspects of regional development and employment through triple helix university-industry-government arrangements for orchestrating new innovation (Bugge et al., 2016; Murray et al., 2015).

GE incorporates various social aspects and is the only concept to explicitly address inter- and intragenerational justice and public participation (D'Amato et al., 2017a,b). At a local level, GE addresses the issues of local and indigenous communities, education, nature-based recreation and eco-tourism. Tourism also has potential connections with BE and rural development. While CE and BE engage with civil society through users and consumers, GE involves dialogue with stakeholders and addresses the beneficiaries of ecosystem services.

1.5. Development models

Current economic systems, and thus job creation, are dependent on the premise of growth (Jackson, 2009). However, increasing production and consumption are causing depletion of natural resources and a crossing of planetary boundaries and ecological thresholds (Steffen et al., 2015). From the perspective of continuous economic growth, a solution envisioned to solve this conflict is absolute environmental-economic decoupling, which implies reducing material throughput. "Absolute decoupling theoretically occurs when environmental impacts are reduced while economic growth continues" (Ward et al., 2016, pp. 2–3).

However, some scholars (e.g., Asara et al., 2015; Jackson, 2009, 2011; Ward et al., 2016) argue that there is no evidence of absolute decoupling occurring and that the positive effects of relative decoupling are largely offset by increasing economic activity, thereby causing environmental impacts to continue increasing. Accordingly, a steady state or even a degrowth economy has been proposed as an alternative to the growth paradigm (Daly, 2007; Jackson, 2009).

A steady state economy is 'neither static nor eternal – it is a system in dynamic equilibrium within its containing, sustaining and entropic biosphere' (Daly, 2007, p. 117). In turn, '[d]egrowth is a voluntary, smoothly planned and equitable transition to a state of lower production and consumption' (Charonis, 2012, p. 6) or, in other words, 'a reduction (and eventually stabilisation) of society's throughput' (Kallis, 2011, p. 874). Therefore, both steady-state and degrowth aim to encompass and limit economic activity within the thresholds of life-supporting ecosystems by a 'selective downscaling of man-made capital and of the institutions needed' (Asara et al., 2015, p. 378). However, there is no consensus among scholars on how to achieve such degrowth (Schneider et al., 2010). However, a prosperous and labour-intensive economy without growth could be built, for instance, on education, health, care, the arts and environmental restoration (Asara et al., 2015; Jackson, 2009, 2011). While neither the CE, GE nor BE concepts explicitly address the growth dilemma, they generally tend to align with the conventional economic growth paradigm (D'Amato et al., 2017a,b).

2. Q methodology

Q methodology is a structured statistical approach in qualitative analysis (Brown, 1993; Watts and Stenner, 2005) that enables the investigation of subjective perspectives to determine existing archetypical perspectives on a controversial topic. It has extensively been used to elicit expert perspective on various issues in sustainability science. The method can be used on practical issues such as project management (Gilbert Silvius et al., 2016), rural innovation (Hermans et al., 2012) and local perceptions of cultural ecosystem services (Winkler and Nicholas, 2016). However, examples of particular relevance for this study include the use of Q methodology to unpack sustainability discourses (Barry and Proops, 1999), including those related to controversial issues in ecosystem services research and policy making (Hermelingmeier and Nicholas, 2017; Sandbrook et al. (2013). Q methodology is strong as an exploratory technique to 'bring a sense of coherence to research questions that have many, potentially complex and socially contested answers' (Watts and Stenner, 2005, p. 75), and is thus a particularly appropriate method for this study.

The method involves asking selected respondents (the P set) to rank a sample of statements (the Q set) about some topic (the concourse) from most agreement to most disagreement according to their individual preferences (Zabala, 2014). Based on the assumption of a quasi-normal distribution, the respondents must fill an approximately bell-shaped pyramid of fields with given statements. This generates a bulk of rankings around a rather neutral middle score and only a few more extreme rankings at the tails. Factor analysis is then employed to identify correlations among the individuals' rankings in order to synthesise shared and diverging perspectives as factors that represent the respondents' archetypical perspectives (see section 3.3). An appropriate study design is particularly crucial for the implementation of this method. Based on recommendations in the method-specific literature (Barry and Proops, 1999; Brown, 1993; Watts and Stenner, 2005), the following steps were adopted in this study. First, an initial list of statements was produced and further refined based on iterative consultations among the authors and with colleagues, to a final set of 36 statements. Second, the statements were ranked online by 13 experts, selected for their leading work in sustainability science. Third, an analysis of their answers was performed with a statistical software package.

2.1. Selection of statements – the Q set

In Q method, statements are put to the respondents who rank them according to their individual perspective. The statements represented sustainability activities linked to either a circular, green, bio, growth, steady-state or degrowth economy (Table 1 and Table 2).

The concourse and statements are usually identified through preliminary interviews and consultations with experts or by reviewing sources of information on the concourse (i.e., topic being considered) (Brown, 1993). The design of this study relied on an extensive review of the scientific literature published about CE, GE, and BE between 1990 and 2016 in English. In that review, more than 2000 articles were analysed using a machine-learning technique which uncovered the diversity among and within the three concepts (D'Amato et al., 2017a,b). That review was used together with more recently published material (identified with the help of a Web of Science search) to support the process of statement formulation.

Based on a discussion between the authors of the present study and exchange with other expert researchers, a list of 48 initial statements was reduced to a final list of 36. In Q methodology, between 30 and 40 statements are generally considered ideal to represent the concourse universe, while representing a manageable number of items for the respondents (see similar studies by Barry and Proops, 1999; Sandbrook et al., 2013). The statements initially collected were pre-structured into four categories, including the three dimensions of sustainability (the economy, the environment and society) and the development models (Table 1). This structure was meant for the authors' purposes and was not revealed to the respondents.

The statements were presented to the respondents in an online questionnaire. Before releasing it online, the questionnaire, along with the statements, was pre-tested with 12 researchers familiar with the research topic to ensure intuitive and smooth understanding and completion of the questionnaire and the clarity of the questions.

2.2. Selection of respondents – the P set

As Q methodology was the method chosen for investigating the diversity of perspectives on a given topic, the respondents needed to be information rich (Gilbert Silvius et al., 2016). To ensure this, the participants in the study were carefully selected using purposive snowball sampling. The selection process consisted of the following five steps (Fig. 1). First, six relevant articles were chosen from a literature list provided by D'Amato et al. (2017a,b). When selecting the articles, the following criteria were used: a. preference for articles dealing comprehensively with more than one concept (CE, GE and BE); b. preference for articles with a broad overview on sustainability (including pro/degrowth ideas) over specialised or technical topics; c. preference for pursuing a balance of articles dealing with all three concepts; d. preference for recent publications; e. avoiding selecting more than one article featuring the same first author. These criteria aimed for a balanced respondent sample with a broad overview regarding the three concepts. The same criteria were applied to the selection of articles in the following steps. Second, for each of these initial six publications, a further six articles cited in the reference list were selected. At this stage, the articles generally dealt with only one of the concepts (CE, GE or BE), and the sampling aimed for a balance between the three concepts. Third, the single most relevant article was selected for each of the 36 articles resulting from steps one and two. Fourth, nine further articles were selected from Web of Science to complement the set with the latest publications. The Web of Science search was integrated to provide the most recent relevant articles. Three searches were conducted on Web of Science in December 2017: "green economy, "circular economy" and "bioeconomy". The

Table 1
Structure behind the design of the statements: four categories are used, including the economic, environmental and societal dimensions of sustainability, and the development model.

Economic sustainability	
CE	Improvements in economic well-being at company & industry level from recycled and more efficient products and services, resulting in an increase in production efficiency.
GE	Improvements in economic well-being at company & industry level from ecosystem services-based markets and redirecting financial flows and achieving financial returns through investments in natural capital.
BE	Improvements in economic well-being at company & industry level from bio-based products and services and advancements in production through biotechnology and/or agro-ecological methods.
Environmental sustainability	
CE	Reducing resource dependence and environmental impacts through closing the loop of productive-consumptive material flows.
GE	Enhancing natural capital and related ecosystem services through conservation, restoration, and nature-based solutions.
BE	Re-directing resource dependence from non-renewables to renewables and reducing environmental impacts by developing bio-based industrial substitutes and complements through agro-ecological and technological approaches.
Societal sustainability	
CE	Regional development and transformations in urban systems through industrial clusters dedicated to efficiency, reduction of resources and waste, recycling and upcycling; consumer/user preferences and experience in the development of efficient, long-lived, recyclable products and services.
GE	Participatory and equitable distribution of costs and benefits from ecosystem management; development of eco-tourism and other biodiversity-based business; development and empowerment of local communities and indigenous groups.
BE	Regional development through primary producers and bio-based industrial clusters; consumer/user perspective and experience with bio-based products and services.
Development model	
Growth	Increasing production and consumption for the equitable provision of increasing human material needs.
Steady State	Equilibrium between production and population growth maintained at levels sufficient to guarantee equitable human improvement, especially in terms of moral, cultural and social progress.
Degrowth	Downscaling production and consumption, by emphasising dematerialization and servitization activities, especially in terms of equity, sufficiency and happiness.

Table 2
Set of statements (N = 36) proposed to the respondents.

Economic sustainability transformation is to be pursued through the following:		
CE	**GE**	**BE**
Create new business opportunities from recycled and more efficient products and services	Create new business opportunities from ecosystem services-based markets	Create new business opportunities from bio-based products and services
Improve and innovate along the value chain through closing the loop within and across industries	Implement a natural capital approach along the value chain	Advance and innovate along the value chain through biotechnology
Engage consumers and investors in cleaner production	Engage consumers and investors through nature-based solutions	Engage consumers and investors by adopting bio-based solutions
Environmental sustainability transformation is to be pursued through the following:		
CE	**GE**	**BE**
Maximize the efficient utilization of energy and material	Maximize synergies across a range of ecosystem services	Maximize the use of biological resources
Reuse, recycle and upcycle materials and energy	Protect biodiversity and enhance nature's benefits	Apply biotechnology and bioengineering solutions
Minimize harmful emissions and waste to the environment	Promote ecosystem resilience at landscape level	Promote productivity of agricultural, forestry and fisheries systems
Societal sustainability transformation is to be pursued through the following:		
CE	**GE**	**BE**
Adopt circular material flow strategies which meet social needs (e.g., water and waste management)	Redistribute costs and benefits of ecosystem service management fairly	Enhance primary production through adequate incentives to producers
Save energy and material in users' consumption	Implement participatory ecosystem management approaches	Support consumer and user-oriented bio-based products and services
Develop capacities for regional circular industrial clusters	Develop ecotourism and other nature-based solutions for regional development	Build capacities for bio-(technology)-based regional development
Development model: sustainability transformation is to be pursued through the following:		
Growth	**Steady state**	**Degrowth**
Expand the economy's productive potential	Stabilise the economy's productive potential	Limit and transform the economy's productive potential
Foster economic growth to facilitate satisfaction of material needs	Reach a steady state economy while redistributing access	Degrow the economy while reducing inequalities and exploitation
Decouple economic growth and material consumption through efficiency gains	Take rebound effects into account when decoupling economic growth and material consumption	Dematerialize society and economy through emphasising the role of sufficiency

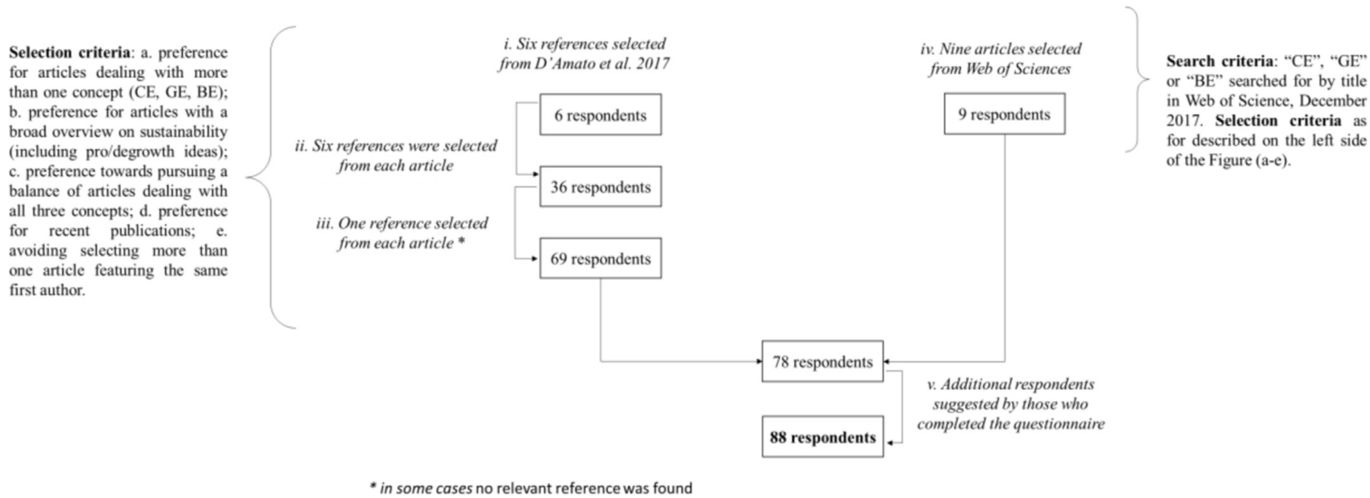

Fig. 1. The selection process for inviting respondents (population generation).

terms were searched for exclusively in the title, and the results were sorted by date. The three most relevant articles (see criteria a-e mentioned above) were selected for each search. This resulted in a total of 78 articles. Of these, the first authors were selected to be invited as respondents. Fifth, each respondent actually conducting the Q sort was asked to propose additional potential respondents, of whom 10 were suggested. The final list of respondents invited to participate comprised 88 researchers.

Potential respondents (N = 88) were invited via email to participate in compiling the online questionnaire, which they could access anonymously. The email and questionnaire explained the purpose of the study, i.e., to collect data on researchers' perspectives on the potential of CE, GE and BE strategies to facilitate sustainability transformations. The respondents were first asked to split the statements into three groups −agree least, neutral, agree most (Step 1, Fig. 3, Appendix). They were then asked to insert each statement into a score sheet (−5 to +5) shaped as an inverted pyramid and to double-check their ranking (Steps 2 and 3). To gain deeper insights on the ranking, the respondents were next asked to explain the reasons for their ranking in reference to the two statements posed at the extreme ends of the score sheet (−5; +5) (Step 4). The questionnaire also inquired into other demographic or potentially explanatory variables, such as the researchers' discipline/research field/area of work, current position/career stage, the country they mainly worked in, their main approach (CE, GE, BE, none), preferred strategy for prioritising for sustainability transformations and additional comments (Step 5 of 5). In total, 13 researchers responded to the questionnaire (response rate: 15%). All rankings were conducted between February and March 2018. Completing the questionnaire took between 14 and 91 min (average 23 min).

2.3. Analysis

In Q methodology, the Q sorts (i.e., the statement rankings by the respondents) are analysed to find similarities between the participants across the sample of statements (by contrast, multivariate statistics find correlations between variables). First, Q sorts are correlated. Next, a principal-component analysis is conducted to extract factors. The factors are then rotated using varimax. This procedure generates a number of weighted average Q-sorts that represent the shared perspectives of a group of respondents with similar rankings (Zabala and Pascual, 2016). Respondents who share similar views are thus extracted for one factor. The factors and the associated ranking of statements can be understood as how an archetypical respondent would have ranked the statements. The corresponding analysis was performed using the **R** software environment (R Core Development Theme, 2018) and the *qmethod* package (Zabala, 2014). The analytical source code can be found in a public github repository: https://github.com/NilsDroste/CEGEBE-QMethod.

To determine the most appropriate number of factors (i.e., perspectives), the following criteria were considered. First, the sum of squared loadings was calculated (called eigenvalues in the *qmethod* package) for each factor and those for which the value was >1 was selected. This resulted in a total of eight factors. Second, it was assumed that the higher the number of factors, 'the lower the number of participants [would be] who… significantly load on these factors' (Coogan and Herrington, 2011, p. 27). For the sake of shared perspectives, only those factors with at least two significant Q sort loadings were retained (i.e., at least two respondents correlating with each factor). This reduced the number of appropriate factors to three. Third, a scree test was performed. This is a graphical method of plotting the decreasing variance explained by each additional factor. The optimum number of factors is identified where the function levels off, which means that the greatest marginal gain in eigenvalues has been obtained. In this analysis, the scree test identified an optimum of two factors. However, since the variance explained by the two factors was less than 50% (Table 3), the authors decided to use three factors, which explained a variance of 58.8% and also contained at least two significant Q-sort loadings. This reasoning is in line with suggestions in the methodological literature (Watts and Stenner, 2005, 2012). For instance, Zabala (2014, p. 165) states that '[t]he usual criteria by which the number of components is selected include, inter alia, the total amount of variability explained, eigenvalues higher than a certain threshold… and a compromised solution between complexity and interpretability'.

Last, bootstrapping was applied to obtain 'additional and more detailed measures of variability' and standard errors for the study

Table 3
Number of factors, variance explained and associated Q-sorts (without bootstrapping).

No. of factors	Explained variance (%)	all eigenvalues > 1	Min 2 Q-sort per factor
2	48.4	yes	yes
3	**58.8**	**yes**	**yes**
4	67.5	yes	no
5	75.6	yes	no
6	81.6	yes	no
7	86.3	yes	no
8	90.2	yes	no
9	93.6	no	no

sample (Zabala and Pascual, 2016). The selected factors were then interpreted and named by the authors. The interpretation was supported by the examination of the statements ranked most similarly and most differently across factors.

2.4. Limitations

This study considered three concepts (CE, GE and BE), as they are greatly popularised in current policy-making. For example, recent European strategies (EAA, 2013; EC, 2012; EC, 2015) have been promoted involving all three of the concepts. Such political emphasis has also had an observable influence on the work of various societal actors, including researchers (see Sections 1 and 2). All three concepts explicitly include the aim of sustainability or sustainable development through a low carbon economy, even though in different ways. For example, some literature in CE refers to the sharing economy (Hobson and Lynch, 2016). In support of the authors' considerations, a review by Loiseau et al. (2016) identified the circular, green and bioeconomy concepts as key and interconnected in sustainability research in a large-scale review of sustainability concepts and terms, and suggested a hierarchical relation among them. A relation among the concepts was also mentioned by Ollikainen (2014), Hagemann et al. (2016) and Székács (2017). On these premises, the authors decided not to include other concepts of similar nature (e.g., low carbon economy, a sharing economy). In the final analysis, the choice of circular, green and bioeconomic concepts remains, in the authors' opinion, the best way to concisely frame the study.

For the purpose of this analysis, it was necessary to crystallize the internal diversity of CE, GE and BE in static definitions (i.e., activities). It is however acknowledged that CE, GE and BE concepts are dynamic, influenced and shaped by multiple societal actors such as scholars, practitioners, industry and policy-makers (see Section 1).

Several measures were taken to guarantee data validity and reliability. As mentioned in sections 3.2 and 3.3, the Q set (statements) and P set (respondents) were selected through systematic processes. The statements were based on and selected from a comprehensive body of scientific literature on the topic and were refined after several rounds of consultation with academic experts in the field. The respondents were selected through exponential discriminative snowball sampling, in which authors of articles were the potential respondents. Snowball sampling could have been limiting, as authors may cite scholars they are familiar with, thus excluding some bodies of literature. This eventuality was mitigated by the fact that there were several snowball sampling steps. Furthermore, the initial list was complemented by recent articles from Web of Science. Overall, any bias produced by the authors' selection, as well as any bias related to the method of snowball sampling should be limited by the multiple steps adopted in the selection. Moreover, the authors of this study had no influence over the willingness of the selected respondents to join the questionnaire.

The number of respondents in this study is relatively low but falls within accepted ranges. According to Watts and Stenner (2005, p.73), '[l]arge numbers of participants are not required for a Q methodological study'. Q methodology can be used to reveal main perspectives on a topic. It is recommended that the number of respondents should be smaller than the number of statements, because in Q method, the statements rather than the respondents are the variable of analysis and observations should exceed the number of variables (Webler et al., 2009, see also section 3.3). For instance, a study by Barry and Proops (1999) proposed 36 statements to 25 participants, while Sandbrook et al. (2013) included 34 statements and 12 respondents and Howard et al. (2016) used 40 statements and 26 respondents. With 36 statements and 13 respondents, this study thus falls well within established research criteria for Q method. Furthermore, the respondents represent the core target group, with high levels of expertise in the field, and provide a strategically selected sample of diverging perspectives with regard to different approaches – which can be considered of greater importance than the number of respondents (Watts and Stenner, 2005). In conclusion, the concourse is comprehensive and the Q sorts contain relevant viewpoints.

3. Results

The 13 respondents consisted mainly of academics based in Europe and North America. Their individual backgrounds included political science, geography, environmental sciences, chemical engineering, ecological economics, and technology. When asked, five respondents prioritised CE, four chose GE and one chose BE, while three chose none of them. One respondent explained that

> *None of the above strategies should be prioritized for sustainability transformations, or at least not in their academically dominant forms. A future steady state economy will necessarily have to be a circular bioeconomy, but under radically different institutional preconditions than what is usually understood by these terms today (a growth-based bioeconomy or circular economy won't last long).*

By contrast, another comment was

> *Circular, green, and bio- economies are all needed as part of a broader transition to a low-carbon future.*

The three factors were assigned the following names by the authors: ***CE degrowth***, endorsing circular solutions to the decoupling of economic development and environmental impacts, and pro-degrowth; ***CEGE***, including a mix of circular and green economy solutions, with no clear indication of preferred development

Table 4
Description and characteristics of the three factors identified.

Factor	CE degrowth	CEGE	GE no growth
Description	Decoupling/dematerialization through circular solutions	Resource reduction, efficiency and recycling along with biodiversity and ecosystem conservation	Ecological resilience towards decoupling/ dematerialization
Statement most agreed with	'Minimize harmful emissions and waste in the environment'	'Protect biodiversity and ecosystem services'	'Promote ecosystem resilience at landscape level'
Statement most disagreed with	'Foster economic growth to facilitate satisfaction of (basic) needs'	'Maximize the use of renewable resources'	'Foster economic growth to facilitate satisfaction of (basic) needs'
No. of flagged respondents	5	4	2

*Two of the respondents were not flagged for any particular factor.

models; and ***GE no growth***: a green economy perspective, representing a strong emphasis on natural capital and against growth (Table 4 and Fig. 2a; more detailed results in Table 5 in the appendix). Note that two respondents were not found to be associated with any of the three factors. Also, there was no particular tendency in any of these factors to score higher for a specific sustainability dimension (economic, environmental, social). In other words, factors are better characterised by solutions belonging to the circular, green, bio, growth, steady-state and/or degrowth economy, rather than by solutions aimed at improving a specific sustainability dimension (Fig. 2).

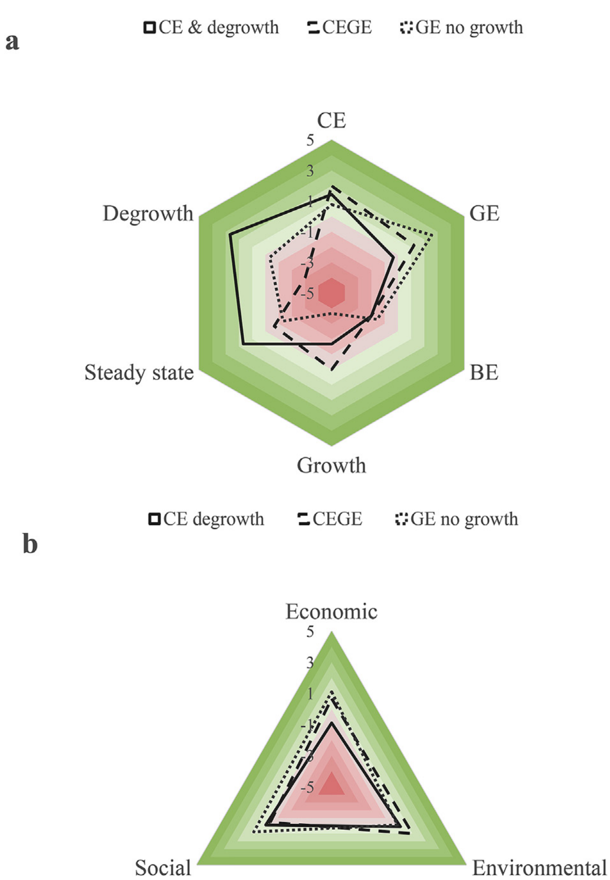

Fig. 2. Radar chart showing the average z-scored recorded for each of the three archetypical perspectives (CE degrowth; CEGE; GE no growth). The upper chart (a) displays how each archetypical perspective scores in regard to statements related to the three concepts (CE, GE, BE) and to the three development models (growth, steady state and growth economy). The bottom chart (b) displays the average z-scored recorded for the statements related to the three sustainability dimensions (economic, environmental, social). Note that scores are distributed differently for chart a, while chart b shows rather similar distributions of scores. CE = circular economy; GE = green economy; BE = bioeconomy. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

CE degrowth - Factor 1 was associated with positive scores for — or in other words agreement with — statements regarding CE and degrowth. The statement with the highest (positive) score concerned minimising negative environmental effects and adopting circular strategies (such as recycling) in combination with social needs. Statements regarding stable growth or degrowth also received highly positive rankings, including ideas for limiting or downscaling the economy via dematerializing and decoupling. In turn, the respondents agreed with some statements regarding GE, particularly ideas about biodiversity and ecosystem conservation. Respondents, however, disagreed with the idea of business solutions for ecosystem services management (such as ecotourism, nature-based solutions and ecosystem services markets). Ultimately, this factor concerned the adoption of circular solutions to decoupling economic development from environmental impacts, with an emphasis on a less material economy.

CEGE - Respondents in Factor 2 agreed with the CE statements and some GE statements. High scores were assigned to minimising negative environmental effects and efficiency, recycling, reusing, and upcycling materials and energy. The highest score in Factor 2 was assigned to a GE statement on protecting biodiversity and ecosystem services; other statements ranked positively regarded engaging business, customers and investors in ecosystem management. Concerning the long-term development perspective, the respondents in this factor agreed on the idea of decoupling growth from material consumption. In opposition to ***CE degrowth***, the ***CEGE*** factor advocated neither growth nor degrowth ideas, while still favouring decoupling. Overall, Factor 2 sought decoupling with a mix of circular solutions and some GE elements.

GE no growth - Respondents in Factor 3 mainly agreed with GE, with some CE statements and with the idea of dematerialization. High scores were assigned to statements about conserving and managing biodiversity and ecosystems, including by involving private actors, as business and consumer/user approaches were considered important (positive scores for economic statements in GE and CE). Factor 3 was explicitly characterised by a strong sentiment against economic growth (negative scores on all pro-growth statements).

Across the three factors, almost all statements regarding BE received the lowest (negative) scores, even though six respondents reported working with the concept of BE — note that only one respondent prioritised BE. In ***CEGE***, BE received the most negative value possible (−5) for the statement 'Maximize the use of renewable resources'. When asked to explain this choice, respondents expressed concern about the trade-off between the use of biological resources and nature conservation. Economic growth was negatively perceived in all factors. In ***CE degrowth*** and ***GE no***

growth, the most negative value was attributed to pro-growth statements. As expressed by one respondent (falling within the CE degrowth factor), '[t]he "Growth-Philosophy" must be somehow overcome. Degrowing strategies will make the western societies more resilient and the impact of consuming less is directly linked to lower emissions, waste and other harmful environmental impacts which affect the lower developed countries most'. The sustainability dimensions (economic, environmental and social) that characterised each CE, GE and BE statement did not seem to influence the respondents' choices (Fig. 2b).

4. Discussion

This study synthesised three archetypical perspectives on three mainstream concepts (CE, GE and BE) and three alternative development models (growth, stead-state and degrowth) for promoting sustainability transformations.

The first archetypical perspective, ***CE degrowth,*** prioritised circular solutions that would facilitate the decoupling of development from environmental impact. This perspective was extremely critical of economic growth (notably, it was also against the marketization of ecosystem services), while positively envisioning downscaling/stabilising the current economy. When considering the traditional understanding of CE (Kirchherr et al., 2017), the coupling of CE solutions and of steady-state or degrowth ideas, might represent a tension. Steady-state or degrowth literature advocate for radical, rather than adaptive, transformations towards sustainability, which are postulated to stem from a consortium of innovation types, and not limited to technology. However, this tension is reconciled in some of the recent literature suggesting that even though CE does not explicitly prohibit or restrict economic growth (Kirchherr et al., 2017), there is complementarity with the steady-state and degrowth discourses (Charonis, 2012; Hobson and Lynch, 2016). According to Ghisellini et al. (2016, p. 25), 'CE operates around the neoclassical economy framework [i.e., efficient allocation of resources] even if threatens some of its key pillars; e.g., CE proposes a rethinking of ownership (as also degrowth and steady state do) in favour of models where products are leased to consumers, who become only users of a service'. In this context, the traditional industrial and efficiency-oriented concept of CE begins to hint at a shared economy where users and consumers become key vectors of change (Hobson and Lynch, 2016). The question is whether a CE defined in more service-oriented, dematerialised terms is a sufficient condition to facilitate degrowth or a steady-state economy, and ultimately sustainability (as posed by Korhonen et al., 2018; Málovics et al., 2008).

The second perspective, ***CEGE***, was a mix of circular solutions with some GE elements. It also positively valued the idea of decoupling, while nevertheless advocating decoupling less firmly than did the ***CE degrowth*** perspective. This perspective was aligned with the traditional understanding of CE, according to which, '[t]he ultimate goal of promoting CE is the decoupling of environmental pressure from economic growth' (Ghisellini et al., 2016, p. 11). The elements of GE complement this approach, stressing ecological issues and businesses as key actors for the achievement of a green economy. To the knowledge of the authors, there is little in the literature explicitly linking CE and GE, but some literature exists providing examples of coupled CE and GE solutions, such as the ideas of techno-ecological synergy (Saladini et al., 2018) and eco-technology (Haddaway et al., 2018).

The third perspective, ***GE no growth***, resonates with the green economy in that it recognises the role of natural capital (Kasztelan, 2017). In other words, fostering ecological adaptation and resilience in addition to the techno-knowledge solutions is proposed by CE strategies alone, for instance. This is in keeping with the idea of developing more service-oriented activities to develop the economy (e.g., by ecosystem service approaches), thus departing from a materialistic approach to development. Overall, this perspective values the role of the private sector in fostering sustainability transformations, which corresponds with the UN-promoted idea of a GE characterised by investment in those economic sectors that can contribute to supporting natural capital. While GE is sometimes criticised for not aiming at a sufficiently deep socio-ecological transformation (D'Amato et al., 2017a,b), this study finds that experts see no fundamental contradiction in GE policies within a no-growth perspective.

Across all the three archetypical perspectives synthesised from the respondents' answers, CE always scored positively. CE is the most popular concept among the three, in terms of number of articles published scientific literature (D'Amato et al., 2017a,b). It is also a concept with a long and well-established research tradition, even though particularly centred on engineering and environmental sciences (Korhonen et al., 2018). The positive scores attributed to CE by all three archetypical perspectives signal that technological solutions are a widely accepted component for sustainability transformations. In this context, it is however important to remark the emergence of a body of literature pointing out the limits of CE as traditionally intended (i.e. strictly technology-oriented and failing to achieve net environmental benefit), and introducing more nuanced means of change, such as eco-effectiveness or sharing economy ideas (e.g. Pomponi and Moncaster, 2017; Bocken et al., 2017).

GE was endorsed in two of the archetypical perspectives, signalling that natural capital and ecosystem services accounting and nature-based solutions are considered ideas of interests, even though still subordinated to technology. Notably, the analysis revealed a general disagreement with BE solutions across all factors, even though half of the respondents declared to be working with BE as a concept. This finding can be interpreted in the light of two considerations. First, BE is a more recent concept than CE and GE and tt also has a considerably smaller body of scientific literature, which is more focused on technical and sector-specific topics (D'Amato et al., 2017a,b). The full potential and limits of BE for sustainability transformations remains without consensus. Second, the experts chosen may be concerned about the sustainability benefits claimed by BE strategies when these are solely based on replacing fossil resources with resources from living biomass. Sustainability issues are particularly critical if biomass originates from intensively managed ecosystems, which would conflict with other environmental and social goals (Pfau et al., 2014). Acceptability of bioeconomy-driven ecosystem management remains a topic of interest among scholars and professionals (e.g. Matthies et al., 2018).

As a result of a lack of support for BE activities, the data failed to reveal an archetypical perspective coupling circular bioeconomy activities. This was unexpected because CE and BE are increasingly conceptualised together in research, policy-making and business (Bezama, 2016; Carus and Dammer, 2018; Ciccarese et al., 2014; EC, 2018; Vis et al., 2016a,b), since both are resource-oriented concepts. The definition of CEBE is yet to mature. For instance, at business level, some actors interpret CE as a facilitator towards BE, while others find CE and BE more complementary (Leipold and Petit-Boix, 2018). The concept of CEBE is emerging in the literature not simply as a combination of the CE and BE. As Hetemäki (2017, p. 14) suggested: CEBE is ‘more than bioeconomy or circular economy alone’. For instance, CEBE could include the sustainable sourcing of biomass as well as practices from the sharing economy (D'Amato et al., 2018a,b).

Importantly, all the three archetypical perspectives all scored economic growth negatively. A possible reason is that the respondents were from OECD countries, where basic needs are mostly met and life-satisfaction is less strongly correlated with economic growth than with other factors, such as income inequality (Easterlin, 2015; Graafland and Lous, 2018). As some evidence shows that absolute decoupling of economic growth from environmental impact is unlikely (Ward et al., 2016), proposals for a degrowth or a steady state economy have been advanced, even though detailed plans remain undefined (e.g., by Jackson, 2009; Schneider et al., 2010; Kallis, 2011; Asara et al., 2015) and divide the scientific community (Drews and van den Bergh, 2017). Moreover, even though growth at all costs may not be necessarily appreciated by scholars nor by the general public (Drews and van den Bergh, 2017; Tomaselli et al., 2019), currently degrowth and steady state economy have little societal and political support (Buch-Hansen, 2018), and would likely need to be adjusted in light of the diverse needs of developed and emerging economies (Smith et al., 2018). Notably, the Sustainable Development Goals do not explicitly address development models other than growth (Bengtsson et al., 2018).

To the knowledge of the authors, only a handful of publications are dedicated to the potential relation between CE, GE or BE, and a steady state or degrowing economy (examples include Hobson and Lynch, 2016; Gainsborough, 2018). In light of resource constraints on a finite planet with a growing population, these interconnections represent potential avenues yet to be explored further.

5. Conclusions

This study used Q methodology to analyse researchers' perspectives on sustainability concepts (CE, GE and BE) and development models (growth, steady state, and degrowth). The aim was to identify compatible or conflictual elements of such ideas by eliciting researchers’ perspectives. The sample of respondents included experts from a range of sustainability science disciplines. CE received broad support and was considered a promising sustainability avenue, in combination with either GE approaches and/or economic downscaling. BE, unexpectedly, lacked support among the respondents. Consequently, CEBE ideas, even though emerging in scientific and policy literature, were not coupled by the respondents.

In the Q methodology, results are not easily generalizable beyond the sample. The value of the study lies mainly in identifying shared opinions regarding emerging or complex phenomena. Such exploratory results can thus provide valuable insights for further research and conceptual development. The findings of this study suggest three directions that are worth exploring further.

1) What are the effects of BE on natural capital and ecosystem services? Awareness and acceptability of various forms of BE could be investigated among researchers and other societal groups, such as decision-makers, industry experts, consumers/users and the general public in relevant contexts.
2) How can GE provide business opportunities in nature-based solutions in a perspective of steady state or no growth? The market focus of GE, contextualized in the form of markets for ecosystem services, remains a point of disagreement among researchers and also poses an interesting conundrum in light of the limited support for economic growth perspectives among the participants of this study.
3) How can CE and GE, and possibly BE policies, be combined with either steady-state or degrowth approaches in a synergistic way? This is a particularly underexplored direction which thus may hold potential for both policy and research.

Acknowledgements

This study was realised with funding from Jenny and Antti Wihurin Foundation and from the Academy of Finland (projects OPES and ORBIT, funding decisions 315912 and 307480). Nils Droste would like to express his gratitude for a scholarship from the Heinrich Böll Foundation, grant no. P118873. The authors wish to thank the study participants, the colleagues who helped us pre-test the questionnaire and four anonymous reviewers who guided the development of the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2019.05.099.

Appendix

This appendix contains Fig. 3 showing pictures of the five steps of the online questionnaire; and Table 5 displaying the results from the analysis.

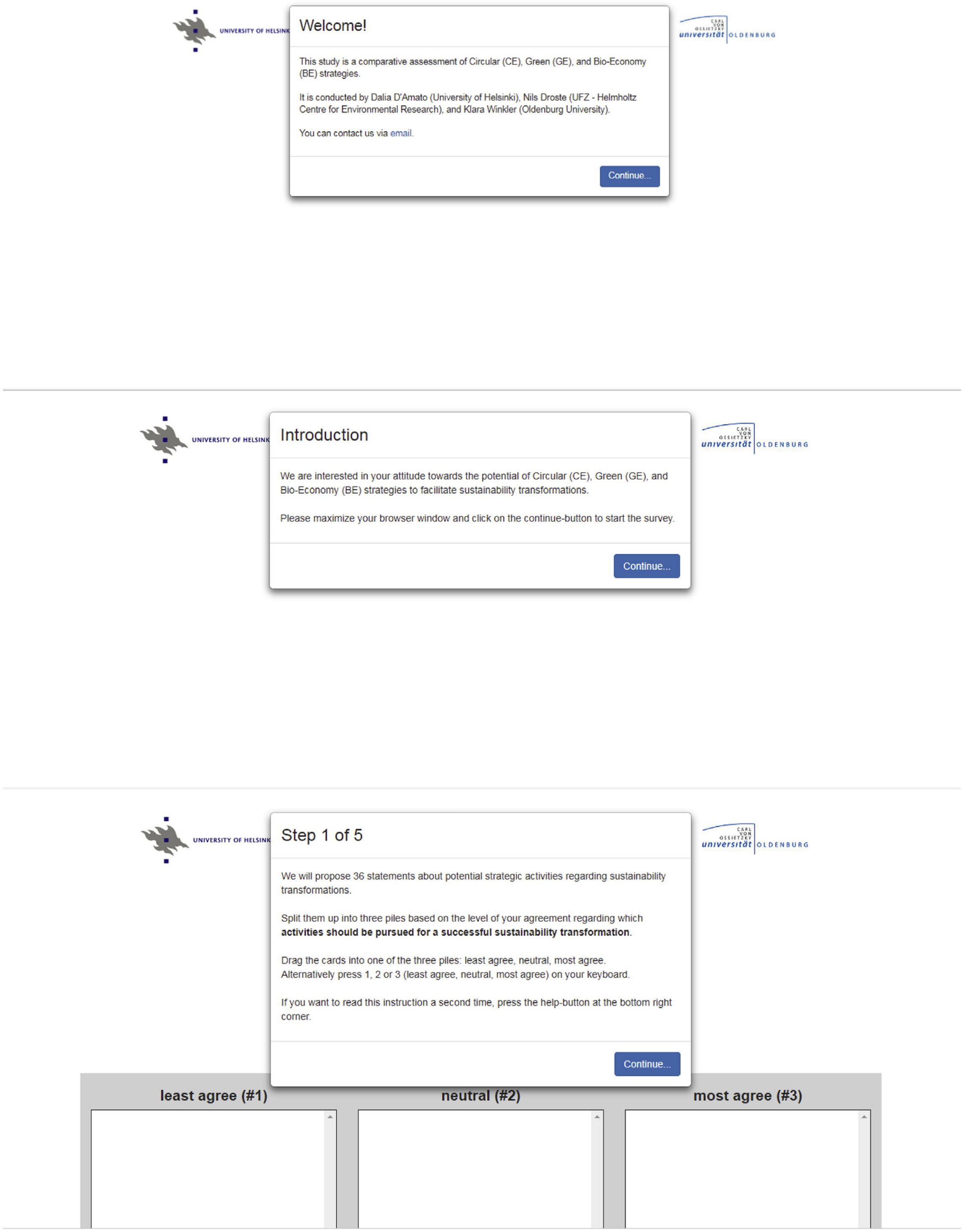

Fig. 3. The online questionnaire used for data collection.

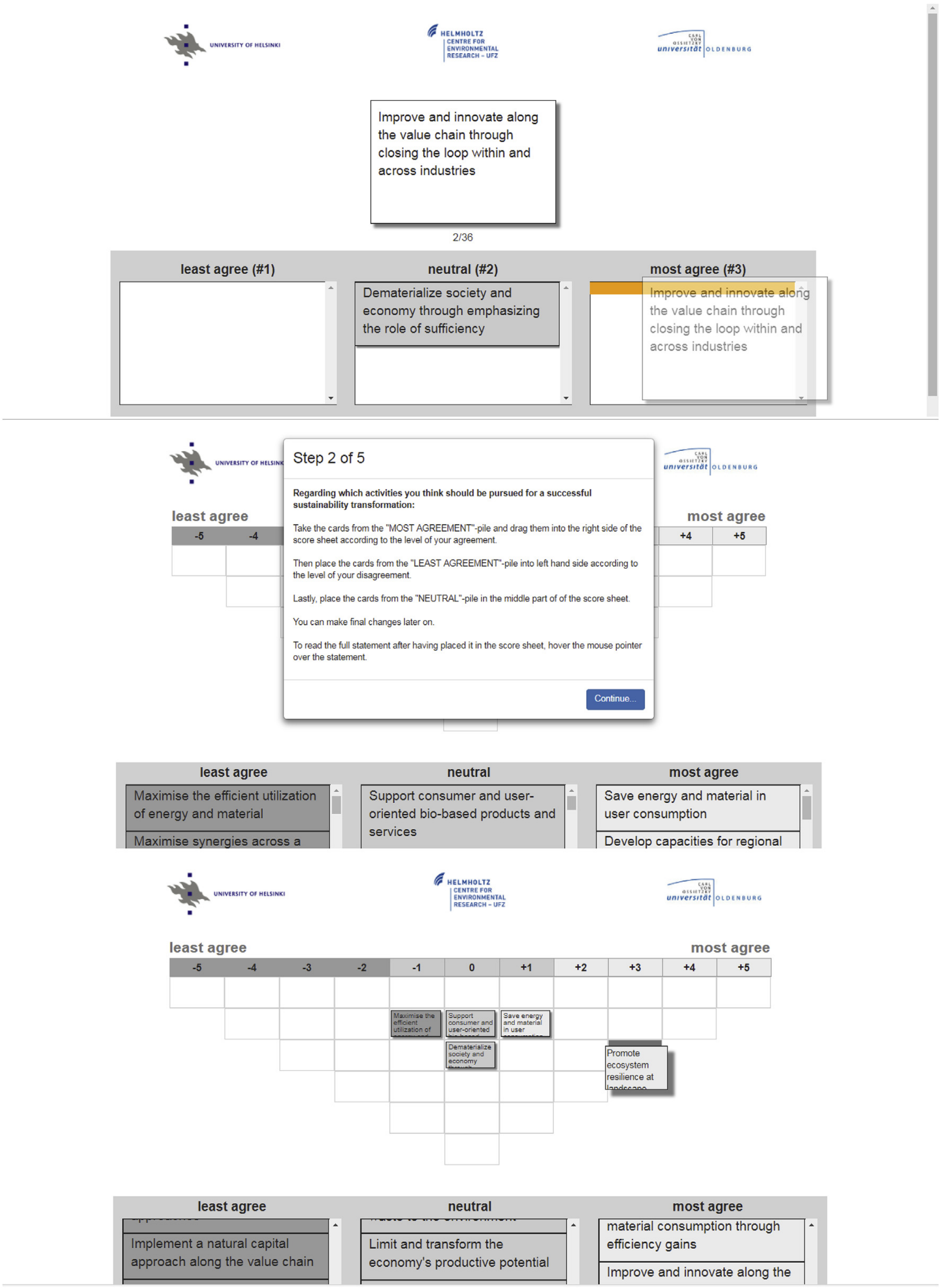

Fig. 3. (*continued*).

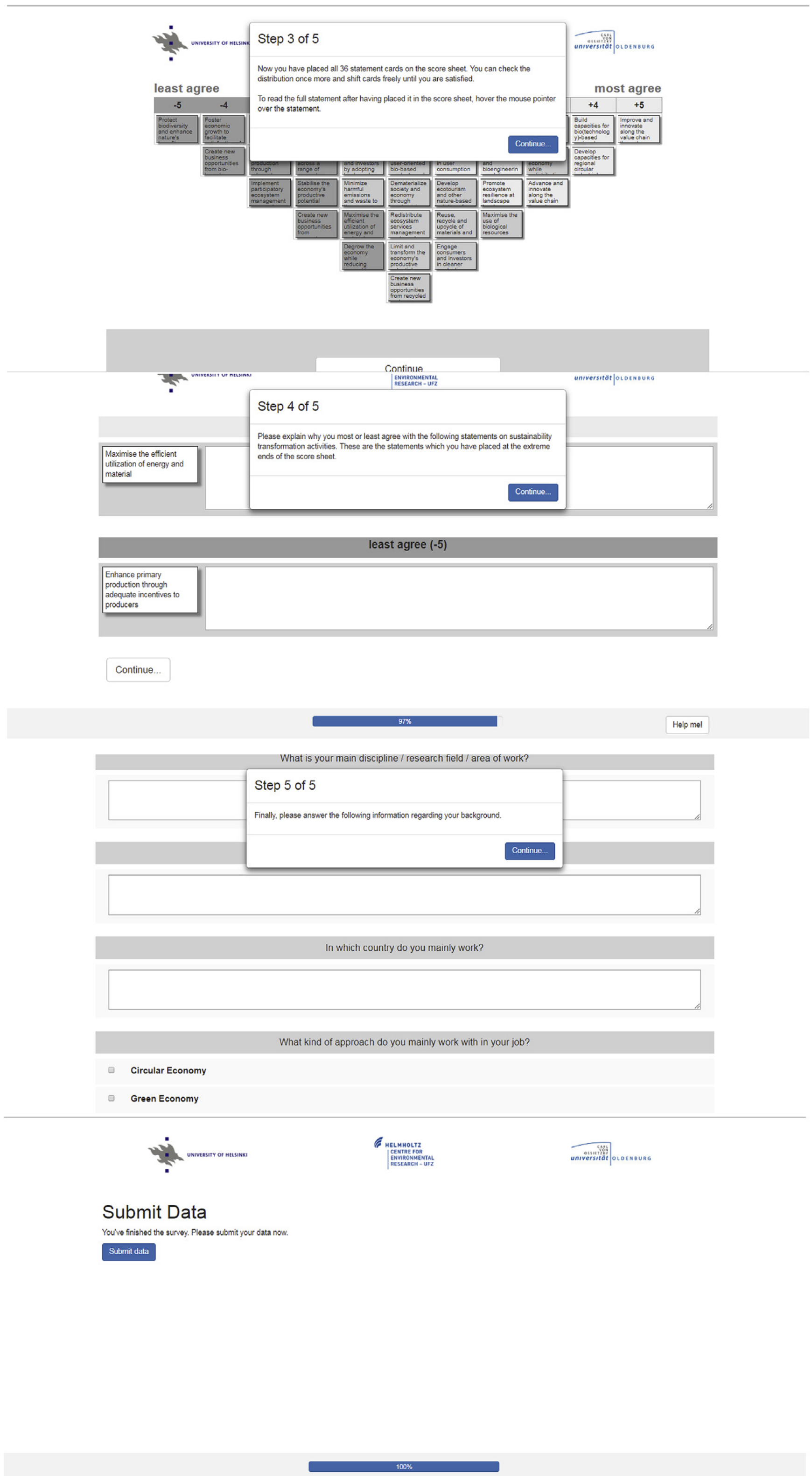

Fig. 3. (*continued*).

Table 5
Scores attributed to each factor (after bootstrapping).3

Statements	Factor z-scores			Dimensions
	CE degrowth	CEGE	GE no growth	
CE - Maximise the efficient utilization of energy and material	1	3	1	ENV
CE - Reuse, recycle and upcycle materials and energy	2	4	1	ENV
CE - Minimize harmful emissions and waste in the environment	5	4	0	ENV
CE - Adopt circular material flow strategies which also meet social needs (e.g., water, waste reduction, recycling)	2	2	1	SOC
CE - Save energy and material in user consumption	0	1	3	SOC
CE - Develop circular industrial clusters that promote regional development, employment, and capacity building	1	2	-2	SOC
CE - Create new business opportunities for recycled and more efficient products and services	1	2	2	ECON
CE - Improve and innovate along the value chain through efficiency, recycling, reusing, upcycling	1	-1	1	ECON
CE - Engage consumers and investors in cleaner production	0	1	0	ECON
GE - Maximise synergies between a range of ecosystem services	-1	1	2	ENV
GE - Protect biodiversity and ecosystem services	2	5	0	ENV
GE - Promote ecosystem resilience at landscape level	1	0	5	ENV
GE - Redistribute ecosystem services management costs and benefits fairly	2	0	3	SOC
GE - Implement participatory ecosystem management approaches	0	-1	3	SOC
GE - Develop ecotourism and other nature-based business that promote regional development, employment, and capacity building	-1	0	0	SOC
GE - Create new business opportunities from ecosystem services-based markets	-3	2	2	ECON
GE - Implement an integrated approach to ecosystem management along the value chain	-1	3	4	ECON
GE - Engage consumers and investors through nature based solutions	-2	1	4	ECON

BE - Maximise the use of renewable resources	-4	-5	-2	ENV
BE - Apply biotechnology and bioengineering solutions	-2	-3	-4	ENV
BE - Promote productivity of agricultural, forestry and fisheries systems	-3	0	-4	ENV
BE - Enhance primary production through adequate incentives to producers	-4	-4	-2	SOC
BE - Support consumer and user-oriented bio-based products and services	0	-2	2	SOC
BE - Develop bio-based and bio-technology businesses that promote regional development, employment, capacity building	-1	-2	-1	SOC
BE - Create new business opportunities from bio-based products and services	-2	0	0	ECON
BE - Advance and innovate along the value chain through biotechnology and/or agro-ecological methods	-2	-1	-3	ECON
BE - Engage consumers and investors by adopting bio-based solutions	0	-1	0	ECON
SUST - Expand the economy's productive potential	-3	0	-3	GRO
SUST - Foster economic growth to facilitate satisfaction of (basic) needs	-5	-3	-5	GRO
SUST - Decouple economic growth and material consumption	3	3	-3	GRO
SUST - Stabilise the economy's productive potential	-1	-1	-2	STEAD
SUST - Stabilise economic growth to safe-guard ecological thresholds while redistributing access	3	-2	-1	STEAD
SUST - Decouple economic growth and material consumption while taking rebound effects into account	3	1	-1	STEAD
SUST - Limit and transform the economy's productive potential	0	-3	-1	DEGRO
SUST - Downscale economic growth while reducing inequalities and exploitation	4	-4	-1	DEGRO
SUST - Dematerialize society and economy through emphasizing the role of sufficiency, happiness, and equity	4	-2	1	DEGRO

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