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Creating a Circular Economy in the Automotive Industry: The Contribution of Combining Crowdsourcing and Delphi Research

Simone Wurster

Department of Innovation Economics, Technische Universität Berlin (TU Berlin), 10623 Berlin, Germany; simone.wurster@tu-berlin.de

Abstract: The circular economy (CE) is an essential societal topic of the 21st century. Although various scientific disciplines address it, many research gaps exist. The Delphi is a proven instrument for managerial decisions, which also gained importance in sustainability-oriented innovation research. Likewise, innovation processes using the input of crowds are emerging phenomena. Nevertheless, the Web of Science publication record includes a few articles applying crowdsourcing or the Delphi method to support CE-oriented management decisions only, and their further application has limitations. Addressing these gaps, this article presents an advanced concept integrating both methods to support the development of CE products and software responding to the worldwide need for more sustainable automotive products and CE solutions for tyres specifically. A combination of two-stage crowdsourcing and Delphi approaches was used, involving 509 participants from the EU member state Germany in total. This article provides, in particular, five contributions: First, it identified specific benefits of combining crowdsourcing and the Delphi method. Second, the attractiveness of a CE software system with product configuration tools is shown. Third, the interest in a quality label for sustainable tyres is unveiled. As the fourth contribution, the analyses show the importance of the CE software's and labels' consideration of social aspects in the tyre value chain and certain substances influencing appropriate recycling. Fifth, it represents consumers' suggestions for products made of tyre recyclates and their interest in additional CE automotive products. The article finishes with recommendations for developing a tyre CE and applying the method combination in research and management.

Keywords: management; sustainable; circular economy; crowdsourcing; Delphi; automotive industry; tyres; recycling; labelling; PAH

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1. Introduction

1.1. Supporting the Development of a Circular Economy by Crowdsourcing and Delphi Research

The circular economy (CE) is an essential societal topic of the 21st century. A CE is an economic system in which 'the value of products and materials is maintained for as long as possible; waste and resource use are minimized, and resources are kept within the economy when a product has reached the end of its life, to be used again and again to create further value' [1].

This article uses crowdsourcing and Delphi methodologies in an advanced concept that addresses the pressing needs to stimulate the global transition to a CE. Although various scientific disciplines address the CE, many research gaps exist. The Delphi is a proven instrument for managerial decisions, which also gained importance in sustainability-oriented innovation research [2–4]. Likewise, innovation processes using the input of crowds are emerging phenomena. Nevertheless, the Web of Science (WoS) publication record includes very few articles based on the Delphi method or crowdsourcing to support CE-oriented management decisions, and their further application has limitations.

The whole WoS record of 14 May 2021 contains only two contributions on 'crowdsourcing'/'crowd sourcing' to support CE-oriented management decisions, which, however, do not come from the management field. Likewise, it provides 23 articles based on the Delphi method whose keywords also include 'CE,' although the CE topic's importance in these articles is mixed. In addition, none of these articles is focused on CE aspects in the automotive industry, where suppliers' and consumers' views together are of high importance. This article is dedicated to the application of both methods to CE research in a specific automotive area. It aims to enrich CE management research with new insights, also focussed on suitable policy recommendations.

The Delphi method is a popular instrument for identifying and prioritizing issues for managerial decisions [2]. Nevertheless, its attractiveness also has limitations. Flostrand [5] highlights, for example, that 'in some contexts, a very large group of laypeople without recognised expertise is collectively as adept as many experts at coming up with insightful answers.' Experts regard crowd involvement as a complementary strategy to better respond to today's society's important sustainability issues [5]. The same author [5] states, however, that crowdsourcing is of limited value for messy problems that require expertise.

The present research is embedded in the German ConCirMy (Configurator for the Circular Economy) project, which addresses the need to respond to the global problem of sustainable automotive products and waste tyres. Waste tyres are 'becoming a significant environmental, economic, and technological challenge due to their high contents of combustible composition and potential for valuable materials and energy resources' [6]. Around 17 million tonnes of used tyres have to be managed globally every year [7], and by the end of 2030, the number of discarded tyres is expected to be approximately 5 billion [8]. Various regulatory changes of the last years intensify the need for appropriate solutions, for example, the End-of-Life Vehicles Directive in Germany. Therefore, proper knowledge to stimulate the demand for tyres made of sustainable CE materials is needed. All target groups are important in this context. This not only refers to buying decisions on the side of the consumers and the fact that the supply side has to respond to consumers' needs, but also various target groups on the supply side must agree on using and providing common integrated solutions. Furthermore, the realization of the CE requires accepted software tools and appropriate business models. In this context, Konietzko et al. [9] highlight the 'inform' function as a critical contribution of software to the CE.

In ConCirMy, a CE software system is being developed, with a product configurator being one of its primary interfaces with consumers. As a first use case of this software tool, the example of car tyres was chosen to make the environmental impact of a product's life cycle transparent to the consumer and facilitate sustainable buying decisions. Specifically, ConCirMys aims to develop software that makes the environmental effects/impacts transparent in a tyre's life cycle. The configurator addresses different players in the circular supply chain, such as designers, consumers, and recyclers, who can use the information in decision-making alongside other important factors such as functionality and cost. The aim is to support the production and purchase of more sustainable products, promote more environmentally friendly designs, and stimulate the recycling and reuse of tyres. Technically, the integrated environmental assessment of products and components in a product configurator and the comparative implementation of different calculation approaches are new. With the help of socio-economic analyses, ConCirMy investigates stakeholder's preferences and demand potentials for CE software, sustainable automotive components, and related sustainability aspects. This article provides answers to the following questions:

1. Which input (information on preferences and recommendations) can sustainability-oriented consumers and value system participants such as manufacturers and recyclers provide for specifying sustainable tyres, promoting their acceptance, and creating software for their configuration?

2. Which specific input for creating tyre-based CE products can be gained by crowdsourcing?
3. Which benefit can be gained by combining crowdsourcing and the Delphi methodology in this context?

Question 1 and 2 will be answered by a combination of crowdsourcing and Delphi research. Specific emphasis regarding question 1 is put on labelling and specific product information for consumers. Question 2 refers to a ranking of predefined product characteristics and additional CE ideas of consumers. In response to the final question, a reflection on the benefits of the chosen research method will be provided.

The most important contribution of this study is the specific insight gained by its research approach. Initially, a two-stage, two-part research approach to get appropriate information on two target groups was used. However, combining the two methods unveiled unique synergies, leading to significant new knowledge that would not have been created otherwise. This article is structured as follows: after this first section, Section 2 presents the study's materials and methods. Section 3 presents the results, followed by a discussion in Section 4. The article finishes with a conclusion and an outlook in Section 5.

1.2. The Intended CE

ConCirMy's CE goal is pictured in Figure 1. Inspired by Dyckhoff et al. [10], the figure shows the CE stages and all the system's relevant participants. In line with [10], the material flow level visualizes the material flow and transformation in the circular system and distinguishes six phases.

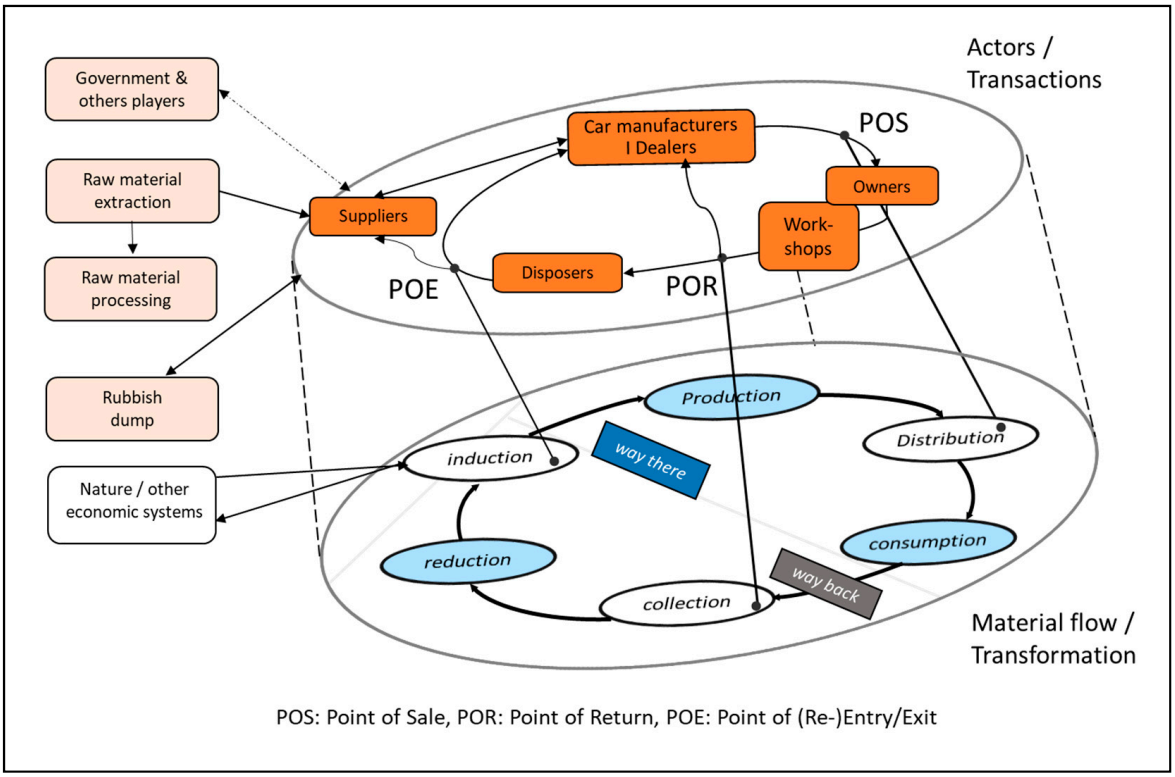

Figure 1. The CE model of this study.

A product is manufactured based on material transformation processes using raw materials from nature and raw materials from other economic systems in the production phase. Since most products' place of manufacture differs from the place of use, they are distributed in the subsequent **distribution** phase. During the **consumption** phase, the product or its usage potential is then consumed. The project's residues are collected and transported to their further processing through spatial transformations (transports) within the collection framework. The decisive process in the subsequent **reduction** phase is the conversion to useful secondary materials. During the **induction** phase, the secondary materials are finally returned to the production facilities to close the cycle. The induction phase also includes the transport of non-recycled waste materials out of the cycle and the transport of primary materials into the cycle. A tyre CE consists of four main stakeholder groups: suppliers (manufacturers/dealers) (1), consumers (end-consumers and organisations with car fleets) (2), and (public or private) recyclers (3) as well as parties, which influence the CE's material flow indirectly (e.g., the state and associations) (4).

ConCirMy aims to support the intended CE and purposeful entrepreneurial activities by customized software solutions. In this article's context, entrepreneurs are understood as innovators who implement change within markets by carrying out new combinations. These can take several forms: the introduction of a new good or quality thereof, the introduction of a new method of production, the opening of a new market, the conquest of a new source of supply of new materials or parts, and the carrying out of the new organisation of any industry (see [11] and its foundation: [12]). Besides the core system supporting the processes above, there are opportunities for various additional technical solutions such as Software plugins, mobile apps, etc.

1.3. Technical and Societal Framework Conditions of the Intended CE Products in the EU

1.3.1. Tyre Characteristics

Important requirements for the production of tyres, their life cycle, and a CE are defined by the European waste hierarchy of the Waste Framework Directive. According to this hierarchy, measures for waste prevention and waste management are ranked: 1. Prevention, 2. Reuse, 3. Recycle, 4. Recovery, and 5. Disposal [13]. Waste prevention requires appropriate measures already in the design phase. A further critical regulation for the European Economic Area, Regulation 1907/2006 of the European Commission concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH Regulation) [14], concerns the production of the raw materials and semi-finished products for tyre manufacture and, in particular, the plasticisers used for this purpose. Regarding the extender oils used for tyre production, it sets limit values for the 16 PAH (polycyclic aromatic hydrocarbons) species on the so-called EPA list (Art. 67 in conjunction with entry 50 of Annex XVII, see [7]). That document was issued by the U. S. Environmental Protection Agency, EPA, and lists 16 critical PAHs. A brief description of PAHs can be found in Box 1.

According to Box 2, PAHs are contained in extender oils for tyres and subsequent tyre recycling products. The carbon black in tyres as a (reinforcing) filler often also contains a high proportion of PAHs. This problem is not limited to the EU level.

Important framework conditions for dealing with PAHs in the production of certain tyre recycling products as opposed to tyre production are described in EU Regulations 1272/2008, 1272/2013 and 2018/1513 [15–17]. In these markets, the PAH content of the whole product is considered. Even if scrap tyres comply with the legal requirements applicable to new tyres, some contain high amounts of PAHs, so recycling them into secondary products becomes problematic in the context of the regulations and measurement methods applicable here.

Box 1. Polycyclic Aromatic Hydrocarbons (PAH) profile. Source: according to [18].

PAH Profile

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous in 21st-century society and are also concentrated in many consumer products. They are a harmful group of substances produced, for example, by combustion processes in fireplaces and stoves in households, traffic or industrial processes. PAHs are created by the incomplete combustion of organic material such as wood or oil. They are also a natural component of coal and oil.

Many PAHs have carcinogenic, mutagenic and/or reprotoxic properties. Some PAHs are persistent, toxic and accumulate in living organisms, such as the human body. 'Persistent' means that the substances remain in the environment for a very long time and are hardly degraded. PAHs with these three properties are of particular environmental concern.

PAHs bind to dust or soot particles and thus also enter the atmosphere. By rain, fog or snow, dust containing PAHs return to the earth's surface and are then deposited on the ground and plants or enter surface water.

In 1977, the U. S. Environmental Protection Agency (EPA) declared 16 PAHs as 'Priority Pollutants.' To determine a product's PAH content, these 16 compounds are often measured on a priority basis. Benzo[a]pyrene serves as a lead substance, i.e., it is considered representative of all other PAHs. The idea is that PAHs always occur in mixtures: if benzo[a]pyrene is present in a product, this applies in general also to all other PAHs of concern, which have very similar properties. Benzo[a]pyrene has been selected for consideration because it is also a particularly carcinogenic substance.

Box 2. PAH in tyres and tyre recycling products. Source: [19], expert discussion on PAH.

PAH in tyres

Since January 2010, an EU-wide limit value for plasticizers containing PAHs in tyres has been in force under Regulation (EC) 1907/2006 (REACH). It prohibits using extender oils to produce tyres or tyre parts if they contain more than 1 mg/kg benzo[a]pyrene or if the content of all eight listed PAH species together exceeds 10 mg/kg. If tyres exceed the specified limit values, they may no longer be placed on the market for retreading since the beginning of 2010. However, this restriction does not apply to tyres for bicycles and children's scooters.

PAHs in recycled products from used tyres, e.g., sports field surfaces

To affect human health, PAHs have to leak from the tyre, which hardly seems to occur to any relevant extent. There is scientific disagreement about the extent to which the PAHs' mere existence indicates health effects. Likewise, there is disagreement on how this PAH content should be measured. There are demands to introduce measurement methods, focusing better on the actual relevant health hazards, e.g., through migration measurements. Historically, the guiding principle regarding PAH limit values was primarily to reduce the PAH content as far as technically possible, following the ALARA principle ('As Low As Reasonably Achievable'). Although new tyres comply with all the limit values applicable to them, their PAH content is sometimes, depending on the measuring method used, higher than is permitted for some typical products of scrap tyre recycling. These higher values lead to problems and a lack of acceptance of such recycling products, although they do not appear to pose any relevant risk.

The European Regulation EU 1272/2008 on classification, labelling and packaging of substances and mixtures [15] amends the REACH Regulation and sets PAH limit values for products with repeated skin contact. Likewise, Regulation (EU) 2018/1513, which came into force in 2020, adopted an amendment to the REACH Regulation and regulated PAHs in clothing and shoes. Specific framework conditions also exist in other areas. The German Model Administrative Regulation for Technical Buildings (MVV-TB), for example, regulates PAH limit values for building products. The MVV-TB has to be applied, for example, for interior elements that may contain recycled tyre material.

1.3.2. Social Life Cycle Aspects

A specific aspect of accepting sustainable products is their social sustainability and social life cycle assessment (S-LCA). The use of social indicators can serve 'various decision-making functions.' They include, e.g., 'benchmarking performance, tracking progress over time, assessing alternative processes to manufacture a given product (. . .), monitoring supply-chain performance (. . .), and assessing product-related impacts on the well-being of stakeholders (. . .)' [20], based on a literature review. Summarising state of the art in research, [20] distinguish between five categories of social life cycle assessment: society, workers, consumers, value chain actors, and the local community. Workers are the most 'salient' [21] stakeholder group addressed in S-LCA research (104 papers; about 74% of [20]'s sample) with a particular focus on health and safety indicators when monitoring social performance. In Germany, for example, the creation of a value chain law is currently being discussed.

1.3.3. Labelling

The international standards organization ISO defines a label as a 'tag, brand, mark, pictorial or other descriptive matter, written, printed, stenciled, marked, embossed or impressed on, or attached to the packaging or container of a finished manufactured product' (ISO 21371:2018 (en), 3.1, [22]). Application fields of labels include, e.g., environmental and social sustainability, social and animal welfare, as well as safety and health.

Labelling is also a specific policy mix instrument [23] in transition contexts. Labels must be based on scientific methods that are reproducible and agreed standards of practice [24]. Regarding sustainability, labelling programs seek first to encourage a move towards more sustainable consumption patterns. Second, they aim to induce productive structures to increase the sustainability standards of the products and services (taken from [25], originally referring to environmental-friendliness as a specific aspect of sustainability).

Based on Regulation (EC) No 1222/2009, a mandatory EU tyre label for functional and energy-related tyre characteristics was established. The label, according to this regulation, provides classifications of tyres' performance for rolling resistance, braking on wet surfaces and external noise. A top-class tyre has less rolling resistance and therefore requires less energy to move the vehicle. This translates into lower energy costs (fossil fuels or electricity). Regulation (EC) No 1222/2009 is replaced by Regulation (EU) 2020/740 from 1 May 2021 onwards, with updated tyre classes. The updated energy efficiency class ranges from A (most efficient) to G (least efficient). The wet grip class ranges from A (shortest braking distance on wet asphalt) to E (longest). The external noise class ranges from A (less noise outside the vehicle) to B (more noise, with noise levels in the C class not allowed anymore). The new regulation also provides options for including an icon relating to grip in icy conditions and/or severe snow conditions in the label. In addition, a QR code for each tyre type identifier with a link to the EU product database EPREL is used [26].

The Ecolabel Index (http://www.ecolabelindex.com/, accessed on 5 May 2020) is the largest global directory of ecolabels. Currently, it provides information on 456 ecolabels in 199 countries and 25 industry sectors. The search term 'recycling' leads to 22 hits, including, for example, the Green Dot and the Cradle to Cradle Certified (CM) Products Program. Regarding appropriate recycling of tyres or related topics of a tyre CE, no international or European label exists.

2. Materials and Methods

2.1. Methods to Analyse Preferences Regarding This CE

2.1.1. Delphi Method

This article relies on a combined research approach using Delphi and crowdsourcing methodologies to address the tyre stakeholders' needs and interests. Linstone et al. [27] describe the Delphi method as 'a process of structuring a written, asynchronous communication process among a large problem-solving group so that it is tailored to the nature of the problem (. . .) and the objectives of the problem-solving exercise.' The Delphi method

was created in the 1950s and was initially used for forecasting by large groups of experts to contribute collectively to complex problem-solving processes [27]. In the subsequent years, its focus extended to various other purposes [28]. The authors of [29] and many others distinguish four types of Delphi studies: (1) Classical Delphi studies with a focus on 'facts to create a consensus'; (2) Decision Delphi studies with a focus on 'preparation and decision for future directions'; (3) Policy Delphi studies with a focus on 'ideas to define and differentiate views'; and (4) Ranking-type studies with a focus on the 'identification and ranking of key factors, items, or other types of issues' [30]. Currently, the ranking-type Delphi is a frequently used research method [2].

According to [31], Delphi analyses are beneficial when the problem solving or research process can benefit from collective, subjective input and when group dynamics do not allow for effective communication. Okoli and Pawlowski [2] highlight that a Delphi study does not depend on a statistical sample that attempts to represent any population. It is a group decision mechanism requiring qualified experts who have a deep understanding of the issues. Delphi studies consist of two or more rounds to validate and refine the initial communication activity results with the target group. The later rounds allow the respondents to modify their earlier input in response to the others' replies. On this basis, this methodology aims to synthesize the collective expertise of the participants (see [4] for further information). Regarding the implementation using a questionnaire, a web-based version of the questionnaire seems to be the most appropriate form for taking the survey [30]. For the feedback rounds, mean or median estimates of the panel should be provided [31]. According to [5], the Delphi technique is 'one of the best known and most widely used tools for polling the opinions of experts.' The consumers' opinion is, however, not addressed, while [5] highlights that big groups of laypeople are collectively as adept as many experts at coming up with insightful answers in some contexts.

2.1.2. Crowdsourcing

Using the wisdom of crowds [32] or crowdsourcing [33] has become an important research tool in the last decade. Crowdsourcing is defined as 'the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people rather than from traditional employees or suppliers' [5]. Similarly, [33] described crowdsourcing as 'the act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call.' The crowd is generally composed of heterogeneous individuals. It may be composed of scientists, experts in various fields, and novices [34].

The internet has facilitated the use of this methodology by providing the ability to access large crowds of people easily, rapidly, and at almost no cost [35]. Prpic et al. [36] distinguish between four types of crowdsourcing. Crowd voting means in its simplest form that an organization requests choices between alternatives from a crowd. Idea crowdsourcing implies that an organization invites opinions for specific questions and then evaluates the proposals. The third form is microtasking, in which large tasks are divided into small pieces, performed by individuals, and then combined into a completed task. The fourth variant is solution crowdsourcing, referring to contributions for particular problems from which the organizer of the activity adopts the best answer. In the given context, choices between different product features are necessary. For this reason, crowd voting is sought in particular, added by idea crowdsourcing on new tyre CE applications. Flostrand [5] states, however, that crowdsourcing is of limited value for messy problems that require expertise.

In the context of this research, the problem for which solutions are thought is complex. A common approach has to address the needs of all the different stakeholders. For this reason, analysing the needs of the consumers is not enough. Experts from the different life cycle stages of the intended tyre CE have to be involved as well. The Delphi methodology provides a tool for this task. Another limitation of crowdsourcing is that its activities coordinators usually have no opportunity to clarify the information given by the anonymous crowd via the web. The Delphi method provides a solution for this as well.

2.1.3. Combining Delphi Survey and Crowdsourcing Techniques

Summarising the benefits and limitations of (a) the Delphi method and (b) the crowdsourcing technique, a combined research strategy appears useful to support a tyre CE. Based on a framework of [5], Figure 2 describes each approach's contribution and limits by highlighting the benefits of a combined research methodology to specify the intended CE.

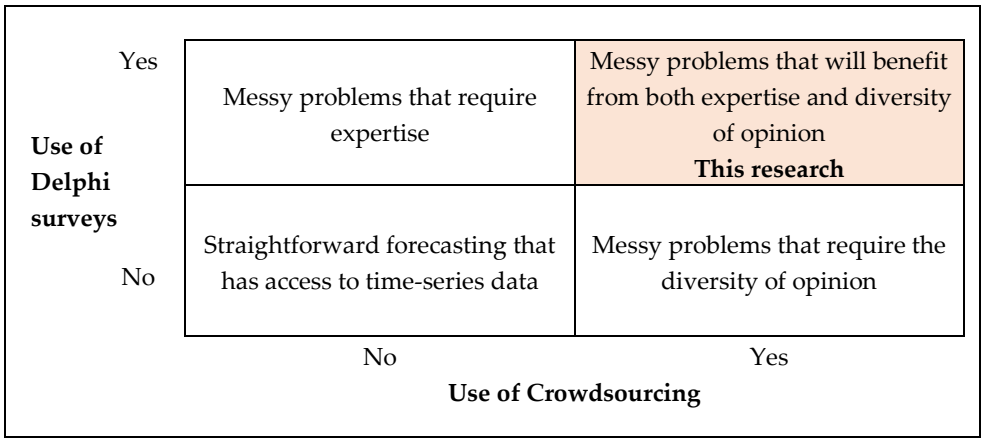

Figure 2. Advantages and limitations of Delphi surveys and crowdsourcing, showing the contribution of the present research.

The method applied for this research relies on the web-based interaction with two anonymous target groups by applying, in particular, features of ranking-type Delphi studies, crowd voting and idea crowdsourcing. Both groups, sustainability-oriented consumers and representatives of the value system, were contacted via a specific variant of an online survey with individual and group-specific questions. The contributions given anonymously were aggregated and analysed. Besides applying all standard features of crowdsourcing and the Delphi technique according to Table 1, specific crowdsourcing features of this research included the participation of experts AND laypeople and the high number of participants, comprising more than 500 persons.

Besides this, the research relied on an open, anonymous online survey. In line with the Delphi method, the research process included two rounds to facilitate feedback and validation. Since it addressed car and tyre industry representatives, the survey also involved people with a specific interest in the survey outcome. Specific characteristics advancing selected crowdsourcing features included working with a particular consumer group of sustainability-conscious consumers and the specific survey duration. Table 1 summarises both approaches' similarities and differences and describes the methodology applied in this article. Figure 3 shows the interrelation of both survey parts.

Table 1. Crowdsourcing and Delphi methods: similarities, differences, and application in this study.

Common Features of Crowdsourcing and Delphi Methods According to [5]		**Application in This Study**	**Explanation**
Participants are anonymous to one another		✓	Anonymous online survey
Incentive to participate is offered in some form		✓	Use of a raffle
Impartiality and objectivity		✓	Participants of member organisations could not participate
Neither have checks for reliability		Modified	Surveying different target groups provides certain reliability; an appropriate sampling was used
Differences between crowdsourcing and Delphi methods according to [5]		**Application in this study**	**Explanation**
Delphi (D)	**Crowdsourcing (C)**		
Relies on experts with explicit knowledge	Relies on non-expert laypeople	D + C	Experts and laypeople were involved
A smaller group of experts	Open to typically huge groups	C	A large group of >500 people participated
Multiple rounds of estimation, with feedback to the experts between rounds	Single round of estimation, no feedback	D	Two rounds
Results of the study are of interest to participants	Results might or might not be of interest to participants	D + C	Both scenarios are possible. The products shall, however, meet the participants' specific needs. Participants of the second round expressed their interest in this activity specifically in the first round
High-quality data	Highly variable data quality	D	The consumers are sustainability-conscious consumers and loyal to the activities of their platform. Several test questions were included for quality improvements
Low non-response rate	Self-selected	D + C	Mainly open survey, self-selection by consumers of a sustainability platform
Participants not anonymous to the researcher	Participants are generally anonymous to the researcher	C	Anonymous online survey
Participants cannot be competitors	Participants are the general public	Modified	Due to the anonymous process, value system players may also be competitors; volunteer sampling was used for consumers of a sustainability platform
Duration at least 3–5 days	Open-ended	Modified	Several weeks

2.2. The Survey in Detail

2.2.1. Consumer Survey

The survey's key topic included the importance of general and specific sustainable tyre characteristics for the users and various other stakeholders, CE software, and business models in the given context. In line with the focus of the ConCirMy project, the survey was conducted in EU member state Germany.

A clear privacy concept ensured the fulfilment of the participants' data protection rights. As part of the survey, all participants in both rounds were provided with the opportunity to win vouchers for shopping in sustainability-oriented online shops.

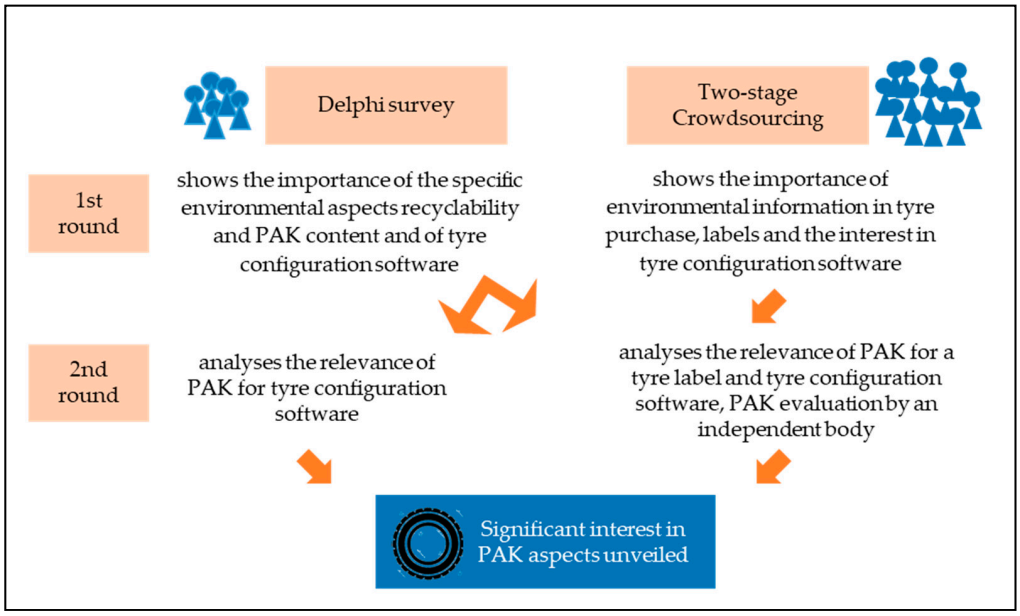

Figure 3. The interrelation of the survey parts.

The key survey element was a consumer survey whose topics are shown in the Appendix A, together with the survey topics of the value system participants. Specific topics included preferences for car tyres, the interest in sustainable tyres and innovative recycling management approaches, and the individuals' general green consumption behaviour. Concerning this survey's target group, [37] identified three possible consumer groups as target groups of CE business models: quality-oriented consumers, cost-oriented consumers, and, in particular, 'green' consumers, who are interested in environmental-friendly products.

Regarding sustainability in the automotive sector, [38] found a positive relationship between preferences for organic food and the interest in sustainable fuels (biofuels). Likewise, consumers of organic food appear to be an especially interesting target group for sustainable tyres. On this basis, the consumer survey relied on volunteer sampling among green consumers of high-quality organic food. The participants responded to a nationwide advert among all consumers of the platform MeineKleineFarm. MeinekleineFarm.org GmbH is an online food shop that markets food from regional, organic farms and focuses mainly on species-appropriate animal husbandry, conscious meat consumption, organic farming, and transparency along the entire value chain.

The two-stage survey was conducted from 16 January to 24 November 2020. In total, 5773 consumers were contacted via MeinekleineFarm. Of those contacted, 2084 consumers opened the e-mail with the study's invitation, and 567 clicked on the survey link. According to Table 2, the total number of participants is 451, of which 311 participated completely, and 140 completed the survey partly. On this basis, the response rate was 7.81%. Of the total participants, 261 consumers indicated that they had bought car tyres in the past, gave advice in such buying decisions, or informed themselves otherwise about car tyres. These consumers were asked detailed questions on their preferences in the following sections of the survey. 98 participants also participated in the second survey round, of which 51 indicated that they had bought car tyres in the past, gave advice in such buying decisions, or informed themselves otherwise about car tyres.

Regarding the distribution of age groups, the participants' profile (reference: data provided in the first round) was compared with the age of car owners in Germany, provided by [39]. Table 3 shows only minor differences, except for one: the group of 40–49-year-olds in the ConCirMy study, which is 11% lower than the vehicle users in Germany. In the groups 30–39 and 50–59, there is a higher percentage rate with the ConCirMy study. The share of the group '60–69' (20%) is even identical. On this basis, the age of the population is well reflected in the study. In terms of income, the level is slightly above the population average. This finding corresponds to the survey's specific focus on quality-oriented consumers prepared to pay more for sustainable products, if necessary.

Table 2. The selected characteristics of this study's participants.

Consumers	Value System Participants
451 persons, of which 261 have been involved in tyre purchases and were involved in the analysis. Age in years and share (linked by arrows): • 20–29 -> 3%; 30–39 -> 16%; • 40–49 -> 16%; 50–59 -> 29%; • 60–69 -> 18%; 70–79 -> 8%; • Not specified -> 11%	58 value system representatives coming from: • 12 organisations directly involved in the marketing of tyres: 2 tyre traders, 5 car manufacturers, 4 automotive suppliers, and 1 car trader • 1 raw material supplier, 1 workshop, 1 recycler of used tyres, 10 manufacturers of secondary products, and 7 others

Table 3. Age-related analysis of the consumer profile.

Age (Years)	Share ConCirMy Survey	Age (Years)	Share Car Owners Germany *
20–29	3%	21–29	7%
30–39	18%	30–39	14%
40–49	18%	40–49	29%
50–59	32%	50–59	29%
60–69	20%	60–69	20%
70–79	9%	70–79	11%

* based on modified data of [39], only on car owners between 20 and 79 years, the source provides also information on the groups 'up to 17', '18–20', and '80 and older'.

2.2.2. Survey among Value System Participants

The Delphi survey among supply-side participants of the tyre value system targeted stakeholders in nine areas in the tyre life cycle: car manufacturers, their suppliers, car dealers, raw material suppliers, tyre dealers, workshops, tyre recycler, manufacturers of secondary products, and other participants in tyre value creation. The sub-survey addressed four topic areas, starting with 1. the participants' perspective regarding tyres and 2. important environmental properties of car tyres and provision of information as well as the contribution of quality labels to the provision of product information. The next two topics were 3. innovative co-operations as part of a CE presented in Figure 1, and 4. Software for environmentally friendly car tyres to support such collaborations. Since the survey aimed to receive specific expert input, the participants were invited directly and by specific business social media channels. The sub-survey took place from 16 January 2020, to 24 November 2020. In total, 58 value system representatives took part, 14 also in the second round.

3. Results

3.1. Fundamental Stakeholder View: Benefits of a Software-Supported Tyre CE

In various countries, manufacturers are obliged to bear the costs of taking back end-of-life vehicles and their components. Concerning separate tyres, additional take-back options exist as well. Therefore, the potential CE's supply-side participants were asked whether they believe that CE co-operations with joint software solutions can lead to cost savings. Figure 4 shows the answers; 58% of the participants expect cost savings, and 42% do not. Asked to explain the causes of the cost savings, the participants referred to various items shown in Table 4.

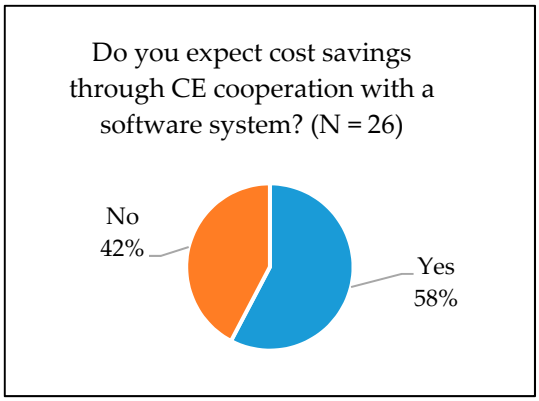

Figure 4. The expectation of cost savings by software supported CE cooperation.

Table 4. Specific economic benefits of a tyre CE with software system.

Faster coordination of the partners involved & uniform procedures	Savings in the disposal & recycling or storage of used tyres		Transparent information flow & quality without loss of details
Shorter transport routes & demand-oriented production control	Minimum mileage guarantee	Lower material costs	Probably improved coordination of withdrawal procedures
Better availability of information	Better recycling possibilities due to high return rates		Big Data & benefits of its use

Another question discussed the extent to which a CE would enable cost savings over the tyre life cycle. Twelve participants provided information on this; 66% expect cost savings of more than 10%; 42% even expect savings of more than 20%. When asked which vehicle components have a particular cost-saving potential through circular cooperation (multiple answers possible), the participants named batteries and tyres in particular.

3.2. Consumers' and Value System Participants' Input to Specify Sustainable CE Tyres and Tyre Configuration Software

The survey, summarised in Table 5, led to various general conclusions for the intended CE. In total, 66% of the responding consumers and 67% of the value system participants are interested in tyre CE software. The two top tyre sustainability characteristics for both consumers and the CE supply side were 'fair pay and working conditions along the supply chain' (93% and 76%) and 'recyclability of the tyre' (90% and 71%).

When asked whether a quality label for sustainable tyres could positively influence the willingness to purchase these tyres, 80% of the consumers and 75% of the value system participants who answered the question responded in the affirmative.

Table 5. Key results of the survey.

Topic	View of the Sustainability-Oriented Consumers	View of the Value System Participants
Top 10 sustainability characteristics of tyres (for a tyre configuration in the consumer study)	First round • Fair pay and working conditions along the supply chain (93%) • Recyclability of the tyre (90%) • Environmental pollution through the use of chemicals (89%) • Contribution to climate change (89%) • Exposure of human health to chemicals (87%) • Content of recycled material in the tyre (82%) • Energy consumption (80%) • Fine dust pollution (78%) • Fair land use (77%) • Origin of the raw materials used (77%)	First round • Fair pay and working conditions along the value chain (76%) • Recyclability of the tyre (71%) • Origin of the raw materials used (69%) • Noise pollution in city centres (64%) • Fine dust pollution (61%) • Exposure of human health to chemicals (57%) • Environmental pollution through the use of chemicals (57%) • Contribution to climate change (54%) • Fair land use (52%) • Content of recycled material in the tyre (50%) In addition, the relevance of the PAK topic was shown.
Interest in specific sustainable tyres and additional products (consumers only)	First round • Willingness to buy tyres with above-average content from renewable sources: 58%, tyres with an above-average share of recycled material: 73%, retreaded tyres: 27%, none of them: 3% (multiple choice) Second round • Trustworthiness of retreaded tyres identified a major problem • Interest in various other automotive CE products and products made of tyre recyclates unveiled	
Interest in a quality label for sustainable tyres	First round • 80% interest Second round • Favourite indicator: overall sustainability rating • Interest in PAH information	First round • 75% interest Second round • Favourite indicator: recyclability
Collaboration and configuration software	First round • 63% agreed that their willingness to purchase sustainable tyres can be increased by the opportunity to determine the tyre characteristics • 66% find software for this determination attractive Second round • Information on PAH content relevant • 84% would be willing to pay more for sustainable tyres	First round • 63% are interested in such a CE cooperation • 67% of them are interested in software to support the CE Second round • Information on PAH content relevant

(response rates vary).

This result suggests that a quality label can effectively respond to the currently low interest in buying tyres with sustainability features beyond those shown by the EU tyre label already. However, specifying the characteristics of the label will be of high importance. The CE software could provide information on the features of the various tyres communicated by the label. Figures 5–7 provide specific information on the preferences of the sustainability-oriented consumers and value system representatives. Persons who answered 'not important at all' on one or both questions of Figure 6 were not asked the relevant follow-up questions on environmental and social aspects of Figure 7.

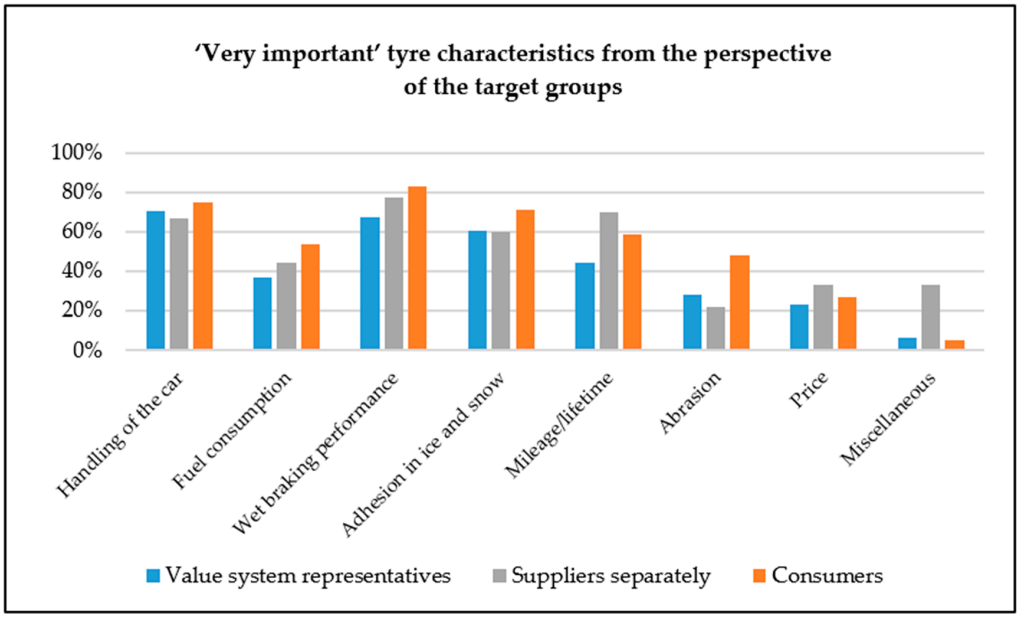

Figure 5. 'Very important' tyre characteristics from the perspective of the target groups. Note: For clarity reasons, the numbers of the producers are also shown separately; response rates vary.

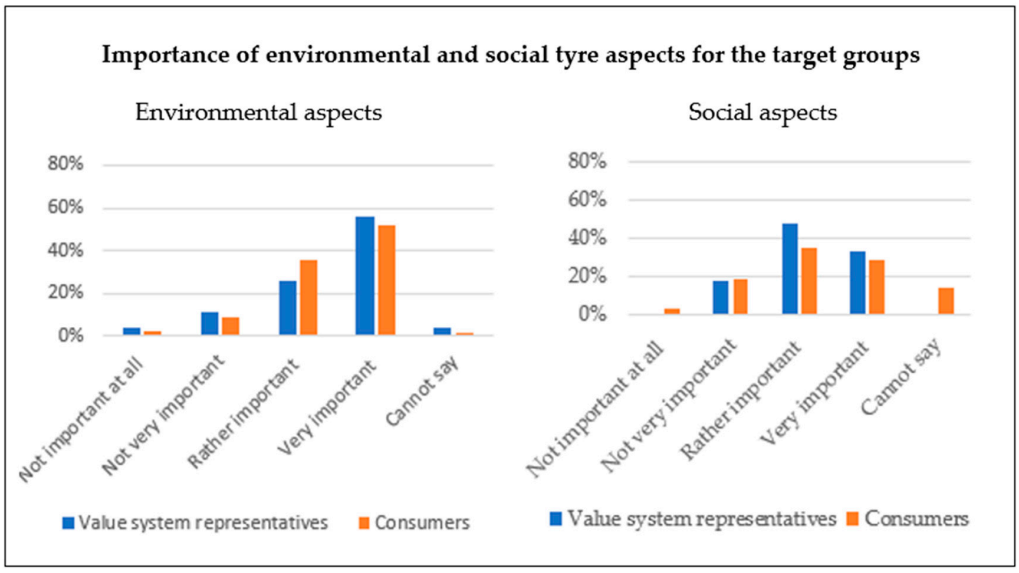

Figure 6. Importance of environmental and social tyre characteristics for consumers and suppliers. Note: response rates vary.

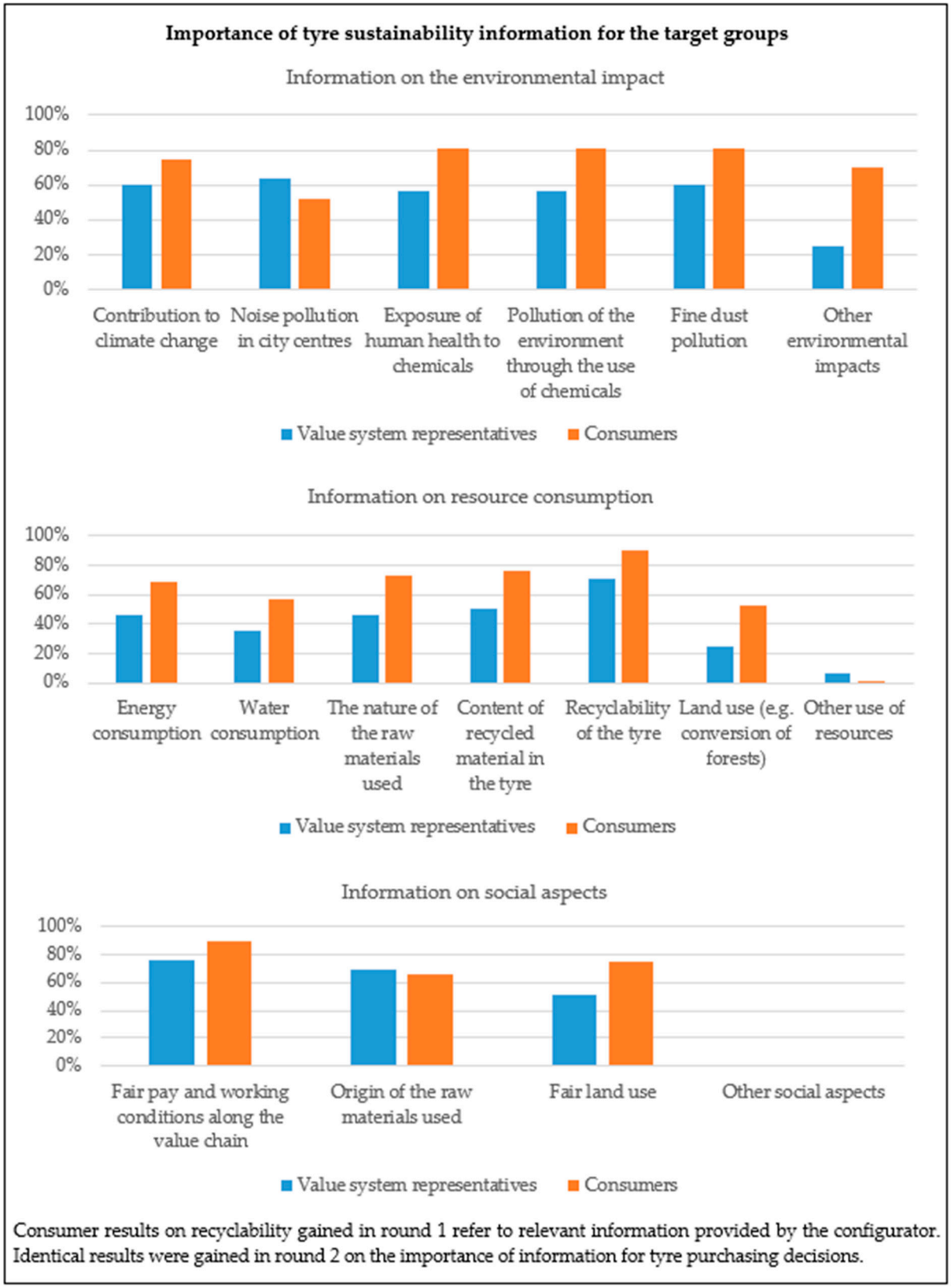

Figure 7. The importance of product information for the target groups. Note: response rates vary.

The figures show the importance of tyres' key functional characteristics such as wet brake performance and adhesion in ice and snow and various other functional tyre characteristics. As mentioned, they also visualize the specific importance of the item 'fair pay and working conditions along the value chain' as well as of the resource-related item recyclability. The second stage of the study also unveiled a specific interest in integrating these two aspects in a label for sustainable tyres. Based on the opportunity of providing additional comments, it was explicitly highlighted by a representative of the supply side that additional information is needed:

> *'PAH content (which is bound in [tyre] carbon black) [is important]. [It] prevents the marketing of new products made from old mature granules.'*

As described in Section 1, specific framework conditions exist with regard to PAH. According to Box 2, PAHs are contained in extender oils for tyres and subsequent tyre recycling products. The carbon black contained in tyres as a (reinforcing) filler also often contains a high proportion of PAHs, not limited at the EU level. On the other hand, in the markets for products made from recycled tyre materials, the PAH content of the whole product is considered. Even if scrap tyres comply with the legal requirements applicable to them, some of them contain high concentrations of PAHs, so that recycling into secondary products becomes problematic in the context of the regulations and measurement methods applicable here. Modified evidence on PAH content, and information for which secondary products a tyre would be suitable, may provide a solution.

3.3. Specific Information Gained by Crowdsourcing

Figures 5–7 provided specific information on the preferences of the sustainability-oriented consumers and participants involved in the production and marketing of tyres. Besides various similarities, many differences were visualized, stressing specific consumer preferences, the first being that consumers are demanding. If they have the possibility of determining a product attribute to be very important, they do this. On this basis, consumers' percentage rates on average are higher than those of the value system players in Figure 5. Second, according to Figure 7, the exposure of human health to chemicals, an aspect that the supply side may underestimate, is significant for consumers. The percentage rate of participants, which regards this item as important is 81% for consumers versus 57% for the supply side only. Third, recycled material seems to be another item relevant for sustainability-oriented consumers that has not been considered appropriately yet. It was selected by 77% of the consumers, but only by 50% of the supply side representatives.

Furthermore, the two-stage interaction with the consumers revealed the desired usage of the tyre software in the second survey round. Concerning the configurator's application fields, the consumers suggested extensions, also facilitating their own web-based use (see Figure 8). This response drove the further development of the software into new, additional directions.

The consumers' input regarding their interests in further CE-based car equipment and CE products made of tyre recyclates was of additional value. Depending on the product, between 75% and 88% of the consumers expressed interest in building protection products made from recycled tyres, floor mats made from recycled tyres, and products with wheels made of tyre recyclates. Similarly, more than 80% expressed interest in CE-based car interior trim, floor coverings, and seats, followed by 63% interested in car bodies made of recycled material. Besides recycling products with lower acceptance rates, the participants could suggest interesting automotive CE products and components themselves. The suggestions included, in particular, mirror surrounds, steering wheels, rims, as well as electronics and electrics. The consumers also had the opportunity to suggest additional products made of tyre recyclates they would be interested in. Their specific suggestions included bags, mats, gardening and building material, shoes with soles of recycled material, seat covers, tools, packing materials, and boxes. The interest in CE automotive products and products made of tyre recyclates is a specific stimulus for the CE's further development.

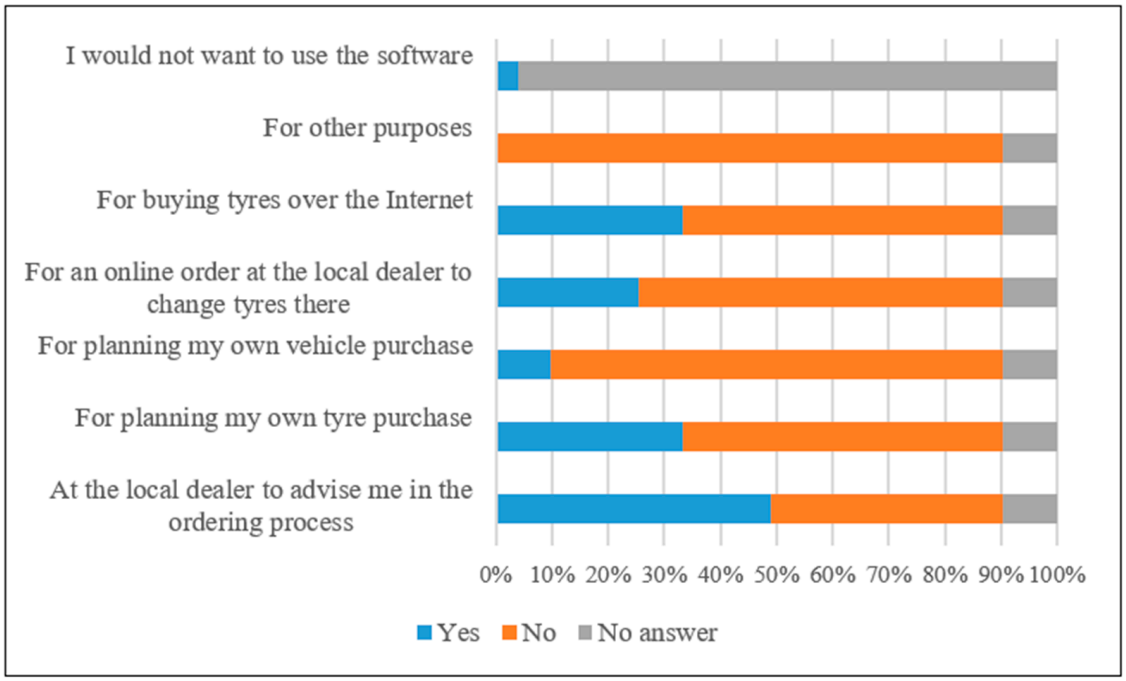

Figure 8. Consumers' preferred application fields of the CE software, N = 51.

3.4. Specific Information Gained by the Combination of Delphi and Crowdsourcing Techniques

The present research unveiled the specific benefits of combining the crowdsourcing and the Delphi methods. A first benefit was the receipt of input from different target groups on questions, which can be answered by neither professionals nor laypeople alone. When asked whether a quality label for sustainable tyres could positively influence the willingness to offer or purchase these tyres, 71% of the consumer responses indicated agreement. With an even higher percentage rate, 75% of the value system participants who answered the question responded in the affirmative. This twofold confirmation suggests that a quality label could usefully address the currently low interest in buying sustainable tyres. However, it is crucial to refine this opinion by interviewing a more significant number of participants. Additionally, it will be important to learn more about which characteristics could make such a label successful.

As a particular further contribution, the first round revealed fundamental topics, which facilitated specific knowledge on both target groups in the second round. The Delphi survey's first round unveiled the PAH content as a topic whose relevance requires further analysis. In the framework of the given project, these analyses appeared to be relevant for two areas: the relevance of PAH for environmental labels and the relevance of PAH for tyre configuration.

The labelling aspect is of particular value for buying decisions. For this reason, the consumers were asked a threefold question in the second round. First, they were asked whether they would be interested in receiving PAH information for their buying decision and, if so, whether a label should provide such information. If the second question was also answered with yes, they were then asked whether an independent body should conduct the PAH analysis. The results in Figures 9–11 show that the majority answered each question with yes.

Regarding ConCirMy, the importance of PAH for tyre configuration and a collaboration tool for value system players was relevant. As shown in Figures 12 and 13, both groups are interested. In total, 21% of the consumers could not answer this question, reflecting the topic's complex nature from consumers' point of view.

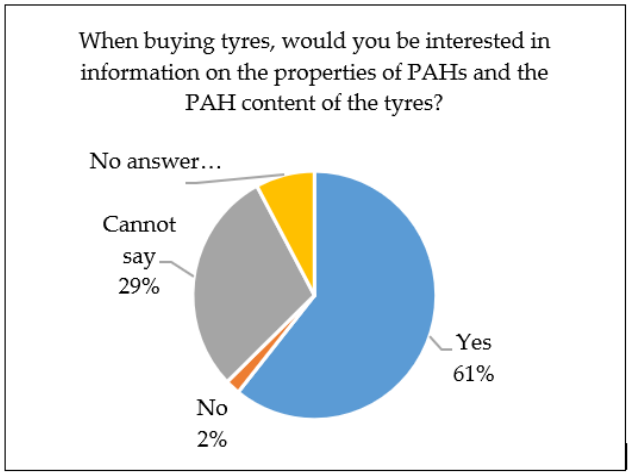

Figure 9. The interest of consumers in PAH information in tyre buying processes, N = 51.

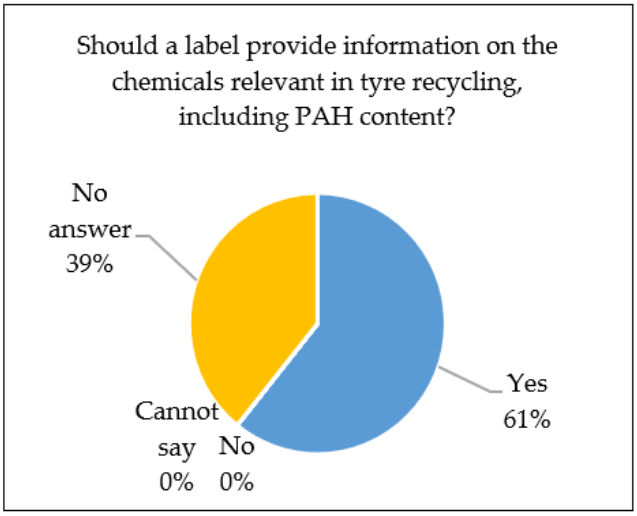

Figure 10. Consumers' interest in a tyre label with PAH information, N = 51. "no answer" includes mainly those who did not answer the previous question or answered "no" or "cannot say" there.

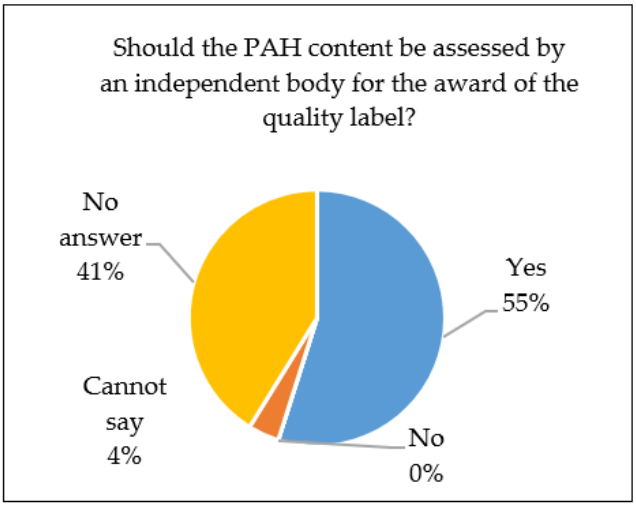

Figure 11. Consumers' interest in PAH assessments by an independent body, N = 51. "no answer" includes mainly those who did not answer the previous question or answered "no" or "cannot say" there.

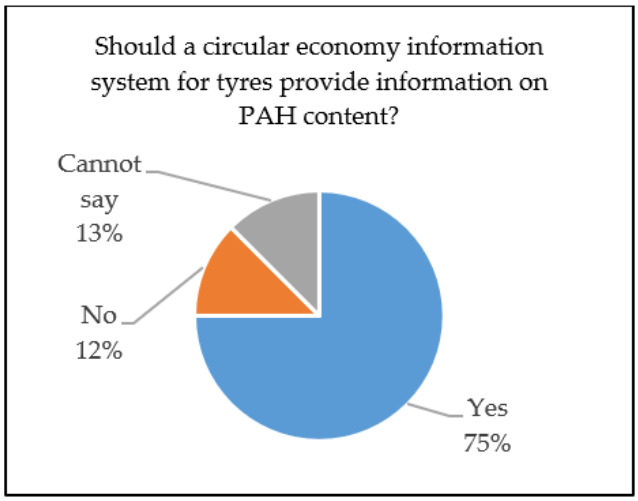

Figure 12. Interest in the Delphi survey in PAH information in a tyre CE information system (follow-up question on a previous question, N = 8).

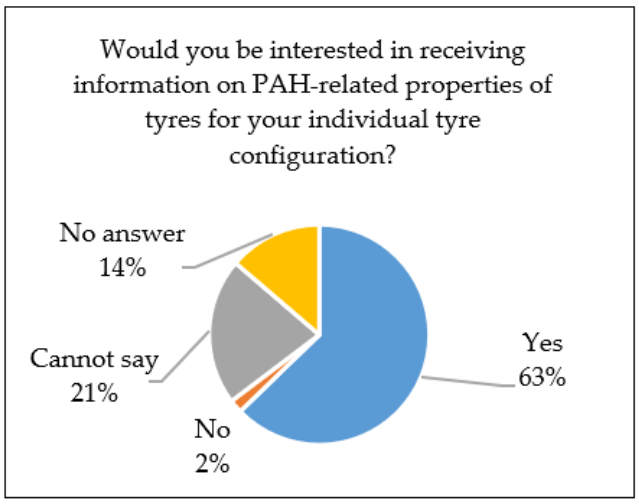

Figure 13. Interest in the consumer survey in PAH information in a consumer tyre CE information system, N = 51.

4. Discussion

4.1. Summary of Findings

This research aimed to provide answers to three questions:

1. Which input (information on preferences and recommendations) can sustainability-oriented consumers and value system participants such as manufacturers and recyclers provide for specifying sustainable tyres, promoting their acceptance, and creating software for their configuration?
2. Which specific input for creating tyre-based CE products can be gained by crowdsourcing?
3. Which benefit can be gained by combining crowdsourcing and the Delphi methodology in this context?

Question 1 referred to stakeholders' preferences regarding sustainable tyres' characteristics, specific software for a tyre CE, and sustainable tyres' acceptance.

Concerning functional characteristics, potential trade-offs are to be considered when specifying top priorities among rolling resistance, which influences fuel consumption, wet braking behaviour, and abrasion behaviour. Consumers and suppliers came to the following ranking: 1. wet braking performance, 2. fuel consumption/rolling resistance, and 3. abrasion behaviour. Regarding sustainability characteristics, fair pay and working conditions along the value chain and recyclability appear to be of particular importance.

Tyre CE software is welcomed by both the tyre supply and demand sides. Besides the sustainability aspect, the value system members also expect specific cost savings.

For reaching acceptance, the importance of labels was highlighted.

In response to question 2, consumers expressed not only their interest in products made of tyre recyclates suggested by the crowdsourcing managers, but they also provided various ideas for a tyre CE. They referred, in particular, to mats, building material, and products, whose production would first require appropriate PAH characteristics of the fabric. Besides this, they expressed interest in various further automotive CE products.

Concerning question 3, the presented research approach consisted of a two-stage survey with crowdsourcing and Delphi survey elements and addressed professionals and consumers alike. Based on this concept and its analyses in different target groups, 509 participants with their different views could be involved in the study.

CEs are systems comprising various target groups with complex and manifold interrelations. The specific case requires information on multi-node interactions. The acceptance and willingness of all target groups to participate in the CE are significant for its success: the supply side must be willing to create the CE, while the demand side must be ready to participate and use the CE's offerings. Therefore, an integrated CE implementation strategy will be necessary.

Crowdsourcing among consumers alone would have missed the value system players' backing, who stressed the intended CE's financial benefit. This perception of attractiveness is a crucial pre-condition for the suppliers' response to the consumers' wishes. Additionally, the crowdsourcing technique relies on a one-stage process. In contrast to this, the analysis unveiled various topics, which could only be addressed by the second survey round and its inclusion of major target groups. Using the crowdsourcing method alone would not have provided an opportunity to get the second round's answers.

For a comparison with a Delphi survey without consumers, on the other hand, specific consumer interests could be identified by the given method, e.g., concerning health issues of tyres and the use of recycled material.

4.2. Limitations

The analyses for this article provided beneficial insights to support a sustainable tyre CE. In addition to these results, several areas were identified, which require, on one hand, specific interpretation and, on the other hand, further analyses.

First, each research method has individual limitations, which have to be considered. As described in Section 2, a Delphi study does not depend on a statistical sample that attempts to represent any population but on high-quality input by experts. Volunteer sampling, applied for the consumer survey, is also linked with the impossibility of generalization. However, Table 3 shows that the participants' age-related profile is close to the age-related distribution of car owners in Germany. The participants' elevated income on average is in line with the intended CE's specific target group. In addition, the consumer survey was combined with the study among value system participants with the same core topics, which allowed for an appropriate evaluation and interpretation of the results.

Second, all research questions were answered by a study in Germany. Question 1, for example, aimed to analyse which information on preferences consumers and value system participants can provide regarding sustainable tyres and tyre configuration software. This study included 509 stakeholders only, while the targeted consumers had a specific sustain-

ability focus. To support the international adoption of sustainable tyres and configuration software, replicating the study in additional countries is highly recommended.

As mentioned earlier, this study's results shall be used for a software-based product configurator. Product configurators, in general, are widely discussed in the field of mass customisation, while the circularity-oriented configurator reflects a research gap. De Bellis et al. [40], for example, proposed a theory to match mass customisation interfaces to cultural information processing with an international perspective on these software products. In particular, they found that western and eastern consumers have different needs regarding configuration systems, the way information is presented, and the information processes there. Cultural aspects of sustainability preferences are not considered in this context so far. In the frame of this study, the influence of cultural elements, according to Hofstede and Hofstede et al. [41,42], as well as different sustainability considerations and environmental risk perceptions [43], require further research. Reflecting [41,42]'s findings on cultural aspects in the present research context shows the need for more research on the relationship between mass customisation and Hofstede's indices as a whole, and in particular, his cultural dimension individualism.

Potential research on sustainable tyres and configurators also depends on regional framework conditions and stakeholders' relations to the topic. As [40] stated for the U. S., the car manufacturer Ford already provides options for tyre configurations on its website there, although sustainability characteristics are not yet specified. A comparison with a study in the U. S. could extend the insights gained by the present research. In this context, it should be noted that the Hofstede scores even differ between western companies such as Germany and the U. S., and the perception of sustainability is an additional important factor, which requires consideration. Updates in the environmental policy of the U. S. make this perception a particularly interesting aspect. In addition, different national end-of-life tyre management schemes and related requirements exist, even among EU countries.

Tyre companies working internationally under the challenge of incorporating all the different cultural and sustainability-related specifics may also profit from the 'mindsponge concept' [44] and its contribution to corporate innovation capacity.

Another notable aspect is the situation of consumers with no specific sustainability preferences. We analysed this group as well, but the particular interest of sustainability-oriented consumers is more useful with regard to the specific research questions of this study.

Third, the interest in tyres with a substantial share of content from renewable sources is still low in Germany. Therefore, raising the awareness of these tyres and convincing consumers in buying decisions requires further analyses. Further work in the ConCirMy project analyses the potential contribution of different policy instruments in stimulating a tyre CE further and the role of public procurement in particular. Other limitations refer to the formulation of general conclusions on the combined use of crowdsourcing and Delphi methods. Suggestions for further research will be described in Section 5.

5. Conclusions

5.1. Implications for Stakeholder Analyses by Researchers and Managers

Implications of the present study include (a) implications on the further use of the chosen research methods and (b) implications for the research on sustainable tyres. Both dimensions are discussed in the following.

The Delphi method and crowdsourcing are proven research approaches. Nevertheless, they have limitations. For example, the focus of Delphi is mainly on experts and not consumers, although in some contexts working with big groups of laypeople may be beneficial, according to [5]. Likewise, [5] states that crowdsourcing is of limited value for messy problems that require expertise. This article has shown that a combination of crowdsourcing and the Delphi method can provide better insight into stakeholders' opinions on complex systems with multiple interest groups. It provided examples of possible benefits of combining both techniques to address the limitations on both sides.

The specific 'context' [5], which favours the work with laypeople was their consumption situation. The 'expertise' described by [5] referred in particular to specific recycling aspects, which helped the consumers in specifying their preferences. In addition, Delphi's multi-stage approach was of key value in specifying the crowd's input. However, the combination of both methods is only recommended if also beneficial under efficiency considerations. On this basis, our findings have several implications for scientists and companies with market research activities. They are advised to analyse the suitability of combining the crowdsourcing and the Delphi methods further. The combination is of particular interest when using knowledge of both business professionals and crowds is desired. Specifically, we suggest exploring further potential application fields, where a combination of the Delphi and the crowdsourcing method and/or a two-stage crowdsourcing approach is most suitable. To stimulate participation, using appropriate incentives is essential. Using a raffle to motivate consumers appeared to be helpful, while the value system members were most interested in receiving the common results.

Concerning research and management in the tyre context, an interest in PAH information and labelling was unveiled in both stakeholder groups of the study. Nevertheless, this aspect requires more research, for example, on:

- Which analytical methods shall be used to determine the PAH content?
- Which limit values shall be set?
- Who shall provide the label?
- How can the acceptance of a potential label and its usability also be ensured for public procurement?

As described, there is disagreement on how PAH content with leakage potential should be measured. The development of standards may provide solutions but would need time.

Concerning limit values, the ALARA principle was introduced. However, the specification of the limit values requires the agreement of all stakeholders involved, including, for example, environmental and health experts, the tyre industry, the users, and the producers of secondary products.

Regarding potential providers of a potential label for sustainable tyres, the author had the opportunity to discuss specific options in the German and European contexts. A possible solution may be a European approach, but the introduction of an EU Ecolabel would be a complex and time-intensive process. The author also received suggestions for extending the EU tyre label by CE aspects in additional discussions with public procurers. This option is another interesting aspect for further pursuit, which deserves more analysis. As part of further ConCirMy research, public procurers shared their view that a label alone would not be sufficient to procure sustainable tyre appropriately. Additional changes in law and procurement guides would be necessary.

As discussed as a limitation of this study in Section 4.2, the study's particular focus was on the EU member state Germany. More research will be necessary to understand stakeholder needs in additional regions and specify appropriate framework conditions for a tyre CE in other countries. Section 5.2 will provide additional implications with a specific focus on Germany and the EU. The formulation of recommendations for other regions would require further research.

5.2. Implications for the Further Development of a Tyre CE

The study provided deep insight into Germany's sustainability-oriented consumers' and value system participants' perspectives on a tyre CE and related configuration software. The findings resulted in three implications for the further development of a tyre CE in Germany. Due to Germany's active EU membership, they also address the promotion of a tyre CE in the EU as a whole:

1. Promote the development of test procedures for the wear and mileage of tyres
2. Stimulate CE tyre labelling and certification
3. Promote tyres with low PAH content

In line with the interests of the study's participants reflected by recommendation 1, EU regulation on the labelling of tyres was published. Regulation (EU) 2020/740 describes plans on including mileage and abrasion as performance parameters in the tyre label. Currently, no suitable test methods for these purposes exist [45]. An increase in mileage limits and a longer tyre life span are linked with waste prevention and specific CE criteria. To promote a tyre CE, pushing this development forward is important.

The general importance of labelling and certification (recommendation 2) is addressed several times in the European CE Action Plan [46]. This research also identified possible added value concerning car tyres, in particular regarding recyclability and PAHs. PAHs influence the potential applications of recyclates. A label can favour this use. Simultaneously, the new CE Action Plan describes the importance of high-quality recycling. In the present survey, there was a multifaceted appreciation of the PAH topic by both stakeholder groups: as a potential labelling item and also as a potential part of the product information provided by the tyre configurator. All stakeholder groups are asked to continue with common work to identify suitable solutions to the PAH issue. Specific items, which need to be addressed, were described in Section 5.1.

Item 3 requires targeted measures on a European level. In this context, the new CE Action Plan [46] recommends 'rewarding products based on their different sustainability performance, including by linking high-performance levels with incentives.' Similarly, promoting low-PAH tyres seems advisable.

Section 1.3.3 has shown the general importance of standards as a foundation of appropriate labels. Currently, it is not clear to what extent a label could be used for a future-oriented providing of PAH information. Challenges of the potential creation of a label bear the possibility that making this data available by the configurator will be the only remaining option to realise this information goal. A clear recommendation based on the present research, also regarding the assurance of high-quality, comparable data by the configurator, is to develop future-oriented standards for appropriate PAH measurements.

Labelling is often a specific aspect of policy mix considerations. This observation applies explicitly to sustainability issues and the CE in particular. Therefore, more research is also necessary to support broader CE-oriented policymaking appropriately.

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Institutional Review Board Statement: The study followed the proven procedures of our institute, developed with expert involvement, and also used for EU-level projects. In addition, the project's data protection approach was checked individually. An external ethical review was waived because of the absence of critical data in the study.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Without giving consent, interested parties could not participate in the study.

Data Availability Statement: Participants received the following information (in German, translated): 'The data collected is used exclusively for scientific purposes and scientifically analysed by the ConCirMy project. Your contact data will not be passed on to third parties outside of the project. Aggregated survey results are used for the preparation of scientific research papers and presentations.'

Conflicts of Interest: The author declares no conflict of interest.

Appendix A

Table A1. Summarised content of the two survey parts.

	Consumers	Value System Participants
	Round 1	
Questions on the participants	• Age, education, income • Sustainability attitudes in general • Driving habits • Use of information for purchasing tyres	• The function of the organisation in the value system • The expertise of the participant
Topics for both target groups	• Importance of general tyre characteristics • Familiarity with the EU tyre label • Importance of information on environmental and social aspects in the purchase of tyres • The possible benefit of a label for sustainable tyres • Interest in innovative recycling management approaches • Innovative cooperation and software for environmentally friendly tyres	
Individual topics for each target group	• Preferred tyre brand • Importance of the EU tyre label • Place of tyre purchase and disposal • Willingness to buy sustainable tyres and relevant information in this context • Relevant characteristics to configure tyres	• Detailed suggestions for a label for sustainable tyres • Specific CE features of the software • Potential cost savings by a CE for tyres and willingness to share CE profits with the partners • Interest in CE business models
	Round 2	
Questions on the participants	• Age, education, income • Green consumption and Corona pandemic	• The function of the organisation in the value system • Expertise of the participant
Individual topics for each target group	• Current mobility situation • In-depth questions on tyre preferences • In-depth questions on product information • In-depth questions on the willingness to buy sustainable tyres in the future • Interest in additional CE-based car equipment and products made of tyre recyclates • In-depth questions on software for environmentally friendly car tyres	• In-depth questions on sustainability characteristics of car tyres • In-depth questions on innovative co-operations and software for environmentally friendly car tyres: expected benefits • In-depth questions on innovative co-operations and software for environmentally friendly car tyres: specifications
Topics for both groups	• Information on the content of polycyclic aromatic hydrocarbons (PAH)	

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