How to Use Crowdsourcing for Innovation?: A Comparative Case Study of Internal and External Idea Sourcing in the Chemical Industry

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Abstract--Successful social innovation rely strongly on open innovation and the impact of crowds to find alternative solutions in a more transparent way. Social media as web-based communication platform leverages practices of crowdsourcing for idea generation to become a prominent tool for open innovation. The extant literature mainly focuses on external crowds, such as users and end customers. Although conducting internal crowdsourcing with employees has entered the research agenda, detailed examination on how and when to use external or internal crowds for open innovation is still missing. Thus, the research aim of the present study is to identify success factors and challenges for internal and external crowdsourcing by determining their differences. An exploratory multi-case study research design is used to investigate crowdsourcing activities within a specialty chemicals company. We compare a case of external crowdsourcing, where academic researchers were invited to submit solutions to a specialized problem with a case of internal crowdsourcing, whereby employees generate ideas for new products in an idea competition. Based on three key components - task, crowd and outcome an their interrelationships in three dimensions – social, technical and innovation dimension, we thus present a framework on how to use internal and external crowds best to source new ideas and solution pathways.

I. INTRODUCTION

Companies are increasingly opening their boundaries to involve external expertise in their innovation process, a phenomenon called open innovation [21, 33]. Open innovation is defined by Chesbrough [13] as "a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology". Therefore, open innovation not only implies the integration of external knowledge into the organization's own innovation process (outside-in process), but also the use of special competencies from external partners during the commercialization of internally developed innovations (inside-out process) [13]. With the evolution of the "crowdsourcing" phenomenon, more and more companies broaden their own base of resources by using the pool of external knowledge, ideas, and labor for innovative tasks [53]. The involvement of the crowd for idea generation, which usually takes place in an online environment, has become a frequently used approach for the outside-in process of open innovation [16, 54]. Consequently, existing literature on innovation crowdsourcing and crowdsourced idea competitions mainly focuses on the engagement of the external crowd.

However, internally developed innovations could also use the mechanism of crowdsourcing, i.e. to tap into the collective intelligence and expertise of a heterogeneous group of actors instead of relying on a limited number of specified experts [42, 63], by involving employees [62]. Although researchers have started to investigate how to conduct intra-corporate crowdsourcing with employees [40], a direct comparison between the use of external and internal crowds for innovation is missing so far. Especially the question, "when should which kind of crowd be used" concerning their execution and innovation outcomes has not been answered yet. Work to date has been helpful in describing the phenomenon on a broad level. Nevertheless, a framework categorizing innovation crowdsourcing projects based on organizational needs would provide a roadmap from which researchers could build on for future research and practitioners could make more well-grounded decisions. Therefore, this study aims to find out when and how companies can use internal and external crowds for idea generation and idea sourcing.

The remainder of this article is structured as follows. First, crowdsourcing characteristics and process mechanisms are briefly presented. Then, data and methods, including the description of the chemical industry as the research setting, and the description of the two considered cases are presented. Afterwards, results are discussed intensively with particular focus on interrelations of the key components – task, crowd and outcomes, building propositions and decision paths for innovation crowdsourcing in three different dimensions, the social, technical and innovation dimension. Finally, a summary and an outlook on future research conclude this work.

II. CROWDSOURCING FOR INNOVATION

A. Definition and characteristics

The term "crowdsourcing" was originated by Howe [42] in the article "The rise of the crowd". It derives from two words: "crowd" and "outsourcing". The literal meaning of crowdsourcing is to outsource an activity to the crowd. Since there are different, sometimes widely varying definitions of crowdsourcing in the literature, Estellés-Arolas and González-Ladrón-de-Guevara [23] created a definition based on a systematic literature review of over 30 crowdsourcing definitions. As this definition combines the common elements of many perspectives on crowdsourcing, it will be used as an underlying definition of crowdsourcing in the following.

"*Crowdsourcing is a type of participative online activity in which an individual, an institution, a non-profit organization, or company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task. The undertaking of the task, of variable complexity and modularity, and in which the crowd should participate bringing their work, money, knowledge and/or experience, always entails mutual benefit. The user will receive the satisfaction of a given type of need, be it economic, social recognition, self-esteem, or the development of individual skills, while the crowdsourcer will obtain and utilize to their advantage what the user has brought to the venture, whose form will depend on the type of activity undertaken.*"

As the definition includes various types of crowdsourcing tasks that range from purely routine tasks to complicated tasks, crowdsourcing for innovation is only one type of task [22]. On the one hand, crowdsourcing tasks without any innovation characteristics are, for example micro jobs such as writing product descriptions on Amazon's Mechanical Turk. This crowdsourcing internet marketplace enables companies to obtain access to an enormous pool of users who perform tasks with less complexity in a shorter period of time and for lower costs than would be possible if the task was performed inside the company [10]. On the other hand, crowdsourcing with innovation characteristics, which is also the relevant task for this study, can be defined as "the public generation of innovation solutions to a complex problem posed by the company sponsoring the challenge call." [52] Thus, crowdsourcing for innovation is mostly sponsored and organized by a company and the tasks are mostly related to the early stage of the innovation process, the front end of innovation, where companies source ideas for new products, new services, new business models, or new processes [36, 53].

For the emergence of the crowdsourcing phenomenon, two essential conditions are observed: collective intelligence and the wisdom of crowds as well as use of modern information and communication technologies. Firstly, all crowdsourcing types rely on the notion of collective intelligence [10]. Collective intelligence refers to shared or group intelligence that emerges from the collaboration, collective efforts, and competition of many individuals that produces intelligent outcomes [73]. Surowiecki [63] states that 'under the right circumstances, groups are remarkably intelligent, and are often smarter than the smartest people in them'. This 'wisdom of crowds' is derived not from averaging solutions, but from aggregating them [9]. Secondly, crowdsourcing is necessarily dependent on new information and communication technologies (ICT). The speed, reach, anonymity, opportunity for asynchronous communication, and ability to perform many forms of media content makes the web a crucial precondition for

crowdsourcing [9, 63]. The internet is capable of increasing the degree of coordination, cooperation and generation of collective brainpower [10]. Especially web 2.0-enabled social interaction in online platforms or communities are common examples for crowdsourcing activities [36].

Furthermore, crowdsourcing initiatives can be of a collaborative or competitive nature. Competitive initiatives let individuals work alone on the solution and compete with each other, thereby aiming to provide the best solution [4, 45]. The collaborative nature of the crowdsourcing initiatives suggest the crowd working jointly to find the solution [10, 63]. In practice, the use of innovation crowdsourcing is often carried out in a mixed form consisting of both competitive and collaborative elements [12]. Here, the participants, with their individual proposed solutions, are indeed in a competitive situation with a limited number of incentives, but they have the opportunity to disclose interim solutions. This allows them to mutually provide feedback, assist in the search for solutions and combine existing partial solutions. Naturally, there is tension between these two elements [43].

Approaches available for innovation crowdsourcing can be categorized as internal or external [72]. The former category relies on a crowd made up by the company's own employees, while approaches in the latter category draw on the expertise of various external actors (i.e. individuals and organizations). External crowdsourcing can be subdivided into three different forms. Community crowdsourcing is organized by a company and is aimed at a broad network of external experts. These external experts must possess certain qualifications and experience to participate in such a project. The experts work on a specific issue in the community in a collaborative way. As a rule, community crowdsourcing can be observed in industrial enterprises and software vendors [61]. Open crowdsourcing describes an open call to the general public. Thus, no pre-selection of participants is carried out. The participants work on the issue individually without collaborative activities from other participants. Typically, this type of crowdsourcing can be observed in the consumer goods industry. Crowdsourcing via innovation intermediary relies on a particular type of company that connects potential ideators and problem solvers with organizations seeking new ideas or specific solutions to their problems [53]. These companies are specialized in the implementation of crowdsourcing projects, have formal relations with the two parties and are remunerated for their services. Examples of successful innovation brokers are InnoCentive, NineSigma and Yet2 [41].

The basic idea of internal crowdsourcing is to leverage the expertise and heterogeneous knowledge of a company's employees [62]. Afuah and Tucci [2] point out that "crowdsourcing can be internal to an organization", especially in the case of large multinational, multi-unit companies that have heterogeneous personnel outside R&D [6]. Employees possess rich and often tacit information on their company's customers, product and service offerings, production processes, and many other areas that are essential

for the competitiveness of the company. Hence, innovation should not only be evolved from R&D functions but from every employee, who comprises the whole internal knowledge base of a company [61]. Villarroel and Reis [69] define internal crowdsourcing as "... distributed organizational model used by the firm to extend problem-solving to a large and diverse pool of self-selected contributors beyond the formal internal boundaries of a multi-business firm: Across business divisions, bridging geographic locations, leveling hierarchical structures." Not only the employees from the R&D department, but also all the company's employees can be the initiators of innovation and have the opportunity to share their ideas and solutions for business and technical problems, typically on internal social enterprise platforms and in online communities. In this way, the probability of unexpected and hidden innovative ideas will be increased [50]. Internal crowdsourcing provides a number of advantages for the company. Some of these benefits include increasing innovation and improving the innovation culture of the company [20], or interactive integration of decentralized employees [6]. At the same time, a culture for innovation, working attitude, motivation for participation of the employees, and continuous, transparent communication are only some of the important challenges for internal crowdsourcing [62].

B. Process and project design elements

The process of a crowdsourcing project may vary depending on its objective and purpose. However, five general phases can be distinguished when conducting crowdsourcing projects: the deliberation phase, the preparation phase, the execution phase, the assessment phase and the implementation phase [32, 55]. In each of these phases there are organizational decisions and challenges [51]. Figure 1 illustrates the phases described below with their respective design elements.

1) The deliberation phase

In the deliberation phase, the fundamental decision is made as to whether crowdsourcing is at all an appropriate approach for the company and whether the task in particular is suitable. This phase is of great importance for the course of the entire process. The company should be clear about the objectives of the project. The expected outcome should be clarified at this stage. Results of innovation crowdsourcing can be very different: scientific driven searches are mostly highly specific, whereas the search for new design ideas in the consumer area could be rather broad and application oriented [32]. Examples include whether the generation of radical innovations or incremental product improvement is desired. Thus, the maturity of the expected outcome should be defined at the beginning. Furthermore, the right platform – whether a company-owned crowdsourcing platform or an intermediary platform – should be selected. Another important issue in this phase relates to the selection of the target crowd. The result of a crowdsourcing project depends

on the crowd it recruits. Therefore, it is essential to address the "right" audience depending on the project's objectives [22]. Additionally, internal resources and internal buy-in should be available for a successful crowdsourcing project [55]. The deliberation phase ends with the decision to start a crowdsourcing project.

2) The preparation phase

The principle objective of the preparation phase is to define and formulate the task of the crowdsourcing project as accurately as possible. It must be ensured that the question is not too narrow, but also not too general. It is about asking the right people the right question. After the precise definition of the issue, the target crowd selection can be reconsidered or re-specified. The selection of the target crowd should be based on the dimensions of size and heterogeneity of knowledge and not based on factors such as easy accessibility to enable the discovery of radically new and more effective solutions [45]. The next question to ask at this stage is how to mobilize the targeted audience. The motivation to participate and the incentives for the winner have to be clearly defined here, i.e. the decision of monetary and non-monetary rewards for the crowd has to be well considered [8]. Following the final approval of the crowdsourcing task and target crowd, the timing of the publication and the duration of the idea generation must be determined [55]. For elaborated ideas, such as a patentable principle or a functional prototype, the result is often the product of months of research, whereas for creative, interesting ideas or for catching a mood within the community, the result could be a statement in a few sentences after a flash of inspiration [32]. Furthermore, a set of evaluation criteria for idea rating needs to be defined and made visible for the community members. On the one hand, these criteria can facilitate the later selection process of the submitted ideas. On the other hand, they are used as guidelines for the participants to rely upon [55]. Finally, issues relating to intellectual property (IP) and confidentiality need to be resolved in this phase.

3) The execution phase

The execution phase is the actual online activity of the crowdsourcing project, where the crowd is asked to generate ideas or provide solutions to problems within a fixed period of time. Here, handling of incoming ideas and proposed solutions must be coordinated. Communication with community members could be possible with online community functionalities, e.g. to link or tag ideas into clusters, to comment on and to vote for ideas [12]. In addition, a decision must be made between silent observation and active facilitation. Active facilitation of the online community on the selected platform plays an important role, as it can help to resolve misinterpretation at an early stage.

4) The assessment phase

The assessment phase begins after the online crowdsourcing activities. This phase of the process is of great
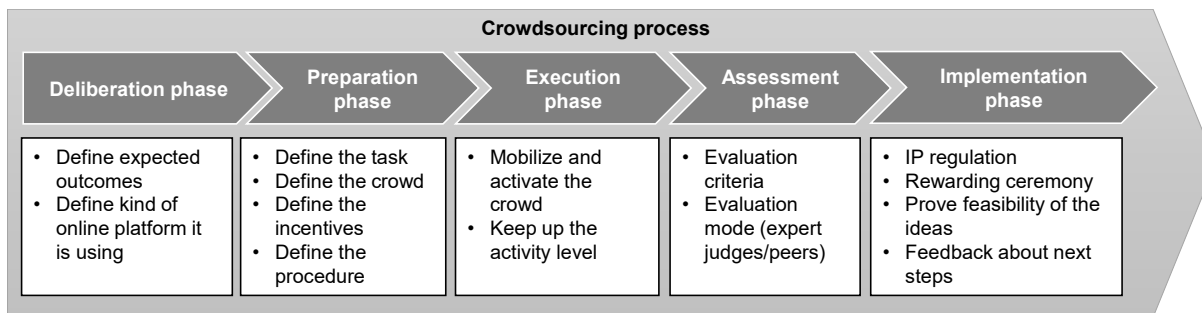
Figure 1: Crowdsourcing process phases with their respective design elements.

importance, because here the fate of the submitted ideas and solutions will be decided. The evaluating committee will be selected. Attention must be paid to the experience and expertise of the decision-makers in the field. However, it is also possible to incorporate a vote from the crowd in the overall jury evaluation [59]. Furthermore, the selection of the winner and awarding of reward take place in this phase. The rewards can be either given to one idea or distributed among several ideas. The rewarding system should be clearly defined and the decision should be communicated clearly and comprehensibly to the whole crowd.

5) The implementation phase

The last phase of the crowdsourcing process is the implementation phase. Implementation strategies for the winning ideas will be sought. At this stage, the decision is made as to what will happen with the results from the crowdsourcing project, when and how they will be implemented and who will be involved. It is important to communicate the next procedures of the ideas with their contributors. Transparency, clarity and feedback play a major role here [55]. Beside a fixed allowance as remuneration, many crowdsourcing projects also provide a profit-sharing approach or even cooperation or some responsibility for idea authors within the new product development project. Hence, the company can secure the feasibility of the ideas by keeping contact with the originators for continuous access to their knowledge [48].

III. DATA AND METHODS

An explorative multi-case study has been chosen as research design to answer the research question how the companies can use internal and external crowds to source ideas. Yin (1994) states that "In general, case studies are the preferred strategy when 'how' and 'why' questions are being posed". This research is of an explorative nature, since no previous investigation of comparing internal and external crowds for innovation exists. Aiming to enrich existing theory and to identify current internal and external crowdsourcing approaches with new and deeper insights from real-world cases, a qualitative research design seems purposeful to study the phenomenon in detail and

consequently explain the different approach companies have to choose regarding their innovation crowdsourcing projects [18]. Multiple case studies can prove valuable in order to illuminate contrasts and similarities between cases [37]. A comparative case study design in particular is used to identify common patterns and differences across cases, whereby two cases from a German specialty chemicals company concerning internal and external crowdsourcing are analyzed in detail.

The specialty chemicals industry is particularly suitable for case studies as it is complex and interlinked. In contrast to commodity chemicals that are sold based on their chemical composition, the products of specialty chemicals companies are sold because of their performance or function. While commodity chemicals are single-chemical entities that are generally readily interchangeable from any supplier, specialty chemicals can be single-chemical entities or formulations (combinations of several chemicals). The composition of the formulations significantly influences the performance and processing of their customer's product [49, 70]. Therefore, developing new products and services in the specialty chemicals industry requires intensive knowledge and ongoing innovation [30].

The overall profitability and growth of the specialty chemicals industry has been decreasing during the last ten years. The main reason is the increasing competitiveness of the business environment. To improve its margins, the specialty chemicals industry increases prices to compensate high R&D, energy, and raw material costs. In addition, specialty chemical companies are reducing costs and developing new products in faster-growing markets to reach their financial targets [44]. Due to the increasing competition from Asia and the Middle East, and the change of matured products into commodities, innovation seems to be one of the few opportunities for the Western specialty chemicals companies to gain competitive advantage [67]. Thus, innovation is the key to success and a success key factor of an entire industry. Especially the German chemical industry is investing increasing amounts in R&D of innovations [67]. Nevertheless, for some years the innovation portion of the total turnover in this industry has decreased [68]. Therefore, companies are increasingly seeking to promote innovation and are looking for alternative forms to generate innovations

and their successful performance. New forms such as crowdsourcing or open innovation communities are interesting topics for generating ideas [19]. A majority of companies in the chemical industry considers decentralized and highly creative brainstorming important. It is agreed that creative and systematic idea seeking activities must be coordinated within and between business areas [71]. Known are internal and external crowdsourcing contests from the largest chemical companies in Germany such as BASF, Evonik, or Bayer, which are aimed at customers, employees or the general public [74].

The present research was conducted within Evonik Industries AG, a specialty chemicals company headquartered in Germany. Evonik has a global R&D network with 35 locations and 2600 employees working in R&D departments on more than 500 innovation projects. R&D expenses in 2014 were around €413 million, from 2012 to 2014 €130 million was spent on building laboratory capacity and pilot plants. In 2014, Evonik had more than 25,000 patents and more than 7,000 trademarks with 250 new patents that year [26]. At group level, the company has the strategic innovation unit called "Creavis". Creavis works on disruptive innovations, which could evolve into new growth fields for Evonik, and develops new expertise. Creavis is organized into "innovation fields" and "project houses". Furthermore, the corporate foresight team of Creavis works on long term scenarios to identify new growth fields and strategic issues [27]. To participate in the latest research, Evonik cooperates with leading universities e.g. the University of Tokyo, the University of Minnesota, Shanghai Jiao Tong University and King Abdullah University of Science and Technology. In 2014, Evonik also supported 14 universities with 186 scholarships and integrates students into the internal talent programs. In addition, the company has cooperation agreements with key customers and also companies outside the chemical industry [29]. As a strategic addition, Evonik invests in promising start-ups to get an insight into innovative technologies and business activities and to acquire inspiration for its innovation work. In 2013, more than 300 potential candidates were examined and in the next few years up to €100 million will be invested [28]. Evonik has identified recognition as an important driver for creativity inside the company. To motivate creativity, for example an annual internal innovation award is conferred to acknowledge outstanding research achievements [25]. Since 2012, the department of Innovation Networks & Communication, which is responsible for corporate open innovation activities, started to gain experience with innovation crowdsourcing activities by involving external audiences and internal employees for idea generation and problem solving [57]. Two projects therefrom, one internal and one external crowdsourcing initiative within Evonik Industries AG, will be analyzed in the following sections.

Data collection took the form of participant observation involving "social interaction between the researcher and the informants in the milieu of the latter" [64]. It enables "insider" information to be obtained that would not be available through the use of interviews or other research techniques [65]. Besides observations, documentation, such as project plans, work documents and minutes from meetings, were collected in order to achieve triangulation for a higher validity of the findings. Data was analyzed for each case separately and summarized into case reports. Project managers were asked to review their cases, which enables the elimination of biases associated with subjective perception. Then, both cases were compared to distill category-specific characteristics and to identify important similarities and differences across the cases [18].

IV. WITHIN-CASE ANALYSIS

A. Case 1: ECRP – external crowd

The Evonik Call for Research Proposals (ECRP) is a new approach to open innovation at Evonik Industries AG that addresses scientists at universities and research institutes to find solutions relevant to the company's research needs. The topic of the first call in 2013 came from one business unit of Evonik who called for research proposals (ECRP) concerning new methionine synthesis without using the toxic hydrocyanic acid. The task was to find a synthesis approach for the "dream reaction" involving the efficient transformation of 3-methylsulfanylpropanal to methionine. Methionine is defined as an essential amino acid that cannot be synthesized by human and animal organisms and therefore needs to be externally conveyed [38]. Most produced methionine is therefore used in animal feed (2013: 600,000 t). In general, the methionine content of natural ingredients is relatively low. Therefore, many animal feeds primarily lack methionine or lysine. That is why additional methionine could improve growing conditions. Furthermore, the amino acid spectrum has to be tailored to individual requirements. If one amino acid is missing, the animal will be unable to use all the other amino acids for protein synthesis and growth.

However, the call for proposals is not limited to this approach, but is also open to other possible approaches or alternatives to the current synthesis or biochemical approaches to methionine are also welcome. The call description also determined very clearly what kinds of solutions were not of interest, such as investigating solutions modifying the existing production process or solutions that have been published previously or are under consideration for publication elsewhere. Attractive ideas could enter into research cooperation agreements financed by Evonik Industries AG. Additionally, the three best proposals will receive monetary awards.

Evonik explicitly invited academic researchers with expertise in the field of organic chemistry, biochemistry and catalysis to submit ideas. They contacted 62 universities and 162 chemistry professors from all German universities and

research centers such as Max Planck Institute and Leibniz Institute for Catalysis via e-mail and brochures on the Scientific Forum Chemistry of the German Chemical Society (GDCh). But the purpose was not only to target the professors, but also the students/PhD students, who might also have an idea to solve their problem. Therefore, the call also contained an appeal for students to contact their professors to discuss their ideas for submission. To address young researchers, the intention was to build a network with potential future employees. Furthermore, additional targets of the ECRP project was to gain visibility at the German universities, and especially to strengthen Evonik's reputation in chemical competencies. Another aim of the open call to all chemical professors was to identify experts and cooperation partners the company had never heard of before.

The call started on August 1, 2013 with e-mails sent out to all the predefined professors. The e-mail contained three documents: 1) request for proposal, 2) proposal submission template, and 3) rules of participation. The call was open for three and a half months until November 15, 2013, when proposals could be sent back to the e-mail account ECRP@evonik.com. One month later, September 1-4, additional brochures were distributed on the GDCh Scientific Forum Chemistry, where Evonik had a recruiting booth. The responsible manager for ECRP from the business unit was also at the booth to give further information about the call. Overall, 13 submissions and 15 ideas were received by the end of the call: 3 x one-pot synthesis; 2 x biocatalysis; 1 x enantioselective synthesis; 2 x photochemistry; 1 x heterogeneous catalysis; 4 x others. The evaluation meeting followed directly after the online submission on November 18. Seven experts from the research department of

methionine discussed all the ideas in a full-day workshop using four evaluation criteria:
1. Novelty and creativity, describing whether the proposed research concept was unknown so far and exhibits a high degree of creativity;
2. Probability of technical and commercial success, determining whether technical and commercial success is expected when implementing the proposed research concept;
3. Quality of project proposal, investigating whether the proposal was well explained and contained all the information necessary to describe the current research status with all references needed and time schedules of research progress and resources; and
4. Open innovation and collaborative research approach, identifying whether other research groups and experts would be involved besides their own research group and Evonik during the proposed research project.

Following the evaluation, three top ideas were nominated for possible research cooperation financed by Evonik Industries AG and these winners were also invited to the award ceremony on December 17 to receive their monetary rewards: 1st place: €10,000 + Evonik day; 2nd place: €5,000; 3rd place: €2,500. After six months of negotiation, Evonik decided to cooperate with all three universities for one year for proof of concept. Figure 2 illustrates the whole process of ECRP.

B. Case 2: Ideation jam – internal crowd
Evonik ideation jams are online idea competitions on the company's internal social media platform, which are available to the entire workforce of the company. Furthermore,
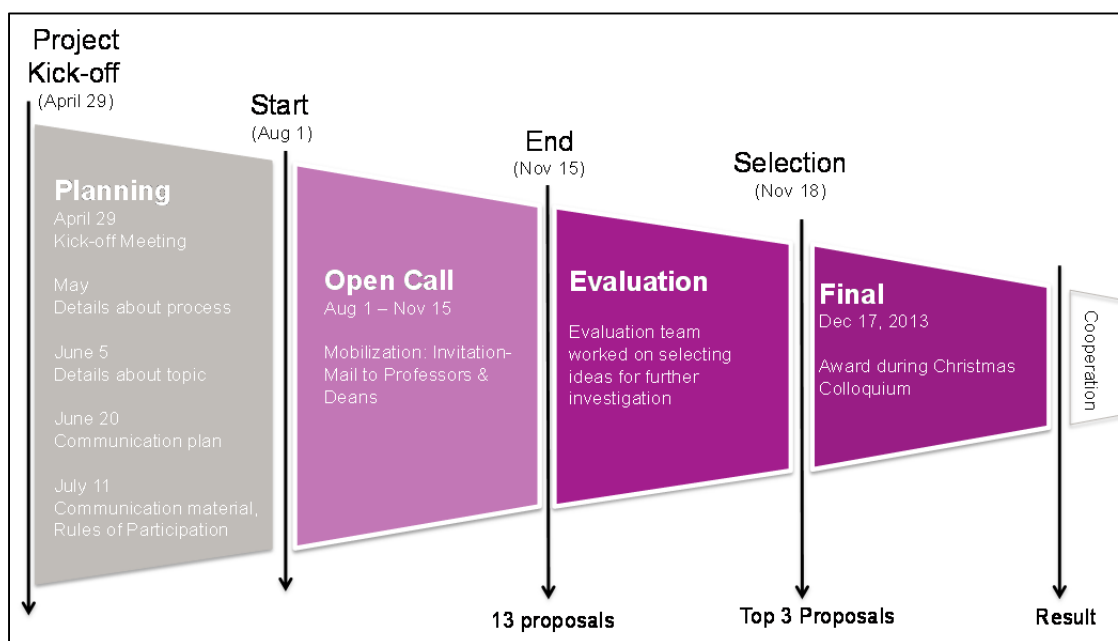

Figure 2: The ECRP process.

employees can create personal profiles of their work, background and expertise. Inspired by the jam sessions of modern jazz, where musicians play together by improvising without extensive preparation or predefined arrangements, IBM started their first innovation jam in 2006 to facilitate innovation among the masses, and also to include participants from external organizations and IBM employee family members in a web-based, facilitated brainstorming exercise [6]. Stimulated by IBM's success stories, Evonik started its first ideation jam in 2012, followed by several jams in the following years [24]. The jam is conducted in a community on the internal social media platform called Connections. The ideation blog as a function of the community enables all interested employees to publish ideas and comments and also to vote for them.

The specific ideation jam was organized in 2014 by one business unit of Evonik dealing with the topic of "unconventional, multifunctional surfaces". The main purpose was to generate five to six concrete and high quality ideas with significant business potential. These were subsequently to be transferred into real projects. The business unit is the solution provider for coating materials and additives with strong competences in the context of industrial coatings, tribology, surface protection and applying specific functions on to surfaces. With the ideation jam, it was looking for new functions, areas of application, new materials, new markets and also for specific technologies and competencies within and beyond the company's borders to implement them. The five most promising ideas entered a maturation phase with the management team acting as sponsors to install idea teams. The idea teams had the opportunity to present their current status six months later at a symposium. The concept of the symposium was tailored around the ideas that were presented.

The head of innovation management of the business unit explicitly invited all 2,600 employees of his business unit and particular groups of other business units to this idea competition, but the challenge was generally open to all employees on the IT platform. As an additional target, the openness of the idea competition was to be used as a tool to develop innovation capabilities across the organization, including team competences, as well as a constructive idea development culture. Furthermore, experts and topics of strategic interest were to be identified within the organization during the jam.

The online idea generation phase of the ideation jam was designed to last four working days. Idea submission was possible in the first three days and the fourth day was for discussion and refinement of the ideas and unsolved problems. The purpose of this project explicitly underlined the importance of refining and maturation of ideas in vivid online discussions on the platform to identify ideas with great potential, but also feasible approaches to implementation. Overall, 219 employees were involved in the ideation jam and 78 ideas were created that fitted the five predefined topic clusters: 1) energy; 2) bio-active; 3) switchable; 4) protective; and 5) others. In addition to the project team of three people, 11 facilitators helped during the online jam phase to facilitate idea maturation by giving feedback, sorting and subdividing the ideas into the clusters and giving participants a better overview of the submitted ideas. After the online phase, 11 screening team members (five of them were also facilitators) evaluated all the ideas using five criteria on a one to five scale: 1) strategic fit, 2) innovation level, 3) implementability, 4) level of detail / maturity, and 5) market and commercial potential.

During a one-day screening workshop, eight top ideas were identified to be presented during the business unit (BU) management team meeting, where the BU management team decided to launch five ideas with a committed project facilitator and a high-ranking sponsor. Finally, five months later, the state of development of these five ideas was presented at the Area of Competence Symposium (AOC) specifically organized around the topic "coating and bonding technologies" with external speakers and on-topic workshops. Figure 3 illustrates the whole process of the ideation jam.
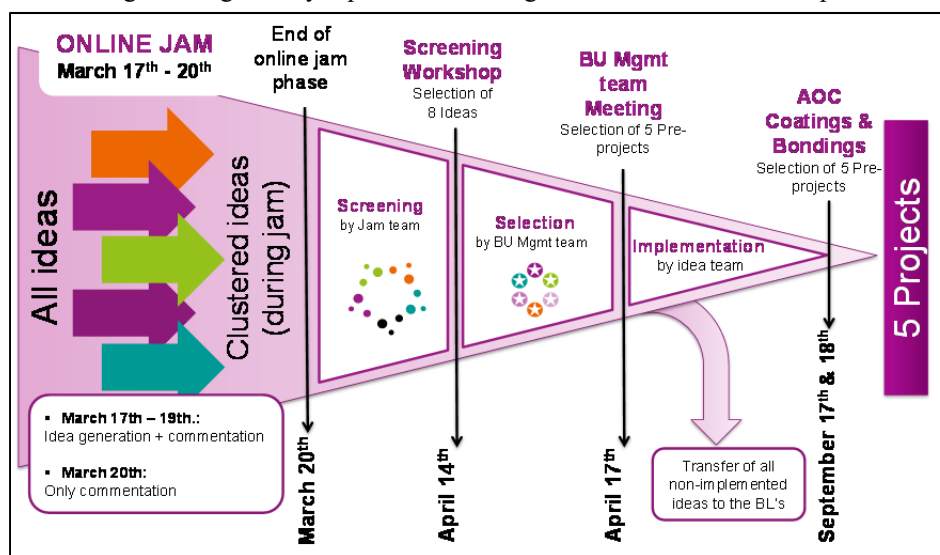

Figure 3: The ideation jam process.

V. CROSS-CASE ANALYSIS

Table 1 shows the design elements of the crowdsourcing process for the two cases and compares the performance of each element along the process phases. The ECRP project was conducted with a specified external crowd. In contrast, the ideation jam is characterized by involving an unspecified internal crowd. Interestingly, the only similarities between both cases are the evaluation criteria and evaluation mode in the assessment phase. Here, in both cases, an internal expert team was appointed in a full-day workshop to select the best ideas. The evaluation criteria were also basically the same, rating the four idea measurement dimensions that are commonly used in creativity research: novelty, feasibility, thoroughness and value addition [15]. Consequently, the rest of the design elements are case-specific and will be examined in detail based on three distinct components: task, crowd and outcome. As Figure 4 shows, this section will analyze and discuss the components in their interrelation, where each of them highlights one of three different dimensions of innovation crowdsourcing projects: the innovation, the social and the technical dimension. However, in the first instance, the most important factor for a successful innovation crowdsourcing project lies in the corporate-internal breeding grounds, which will be discussed first.

TABLE 1: COMPARISON BETWEEN BOTH CASES THROUGH THE CROWDSOURCING PROCESS.

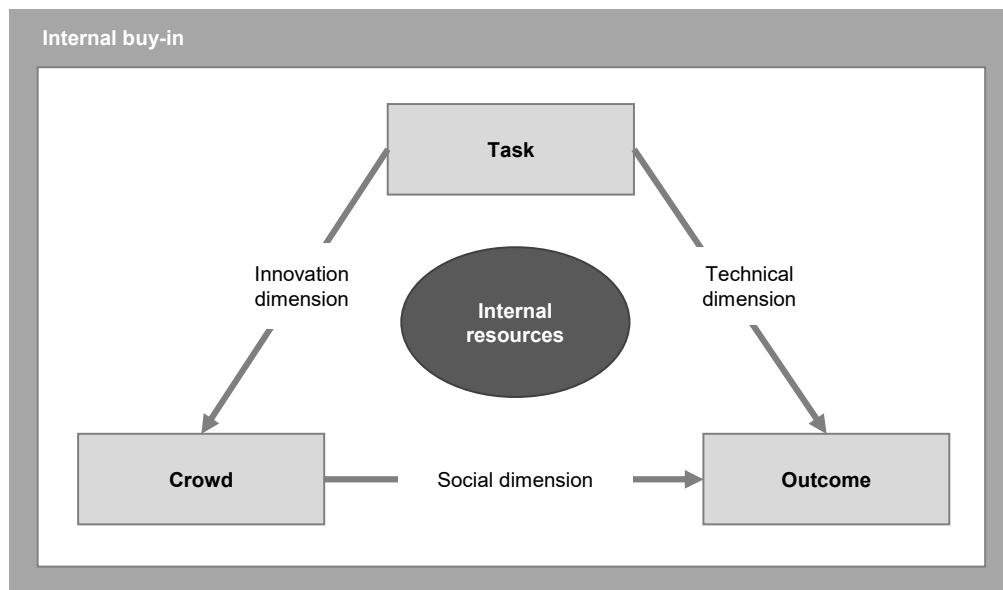| Phase	Criteria	External (ECRP)	Internal (Ideation Jam)
Deliberation and Preparation phase	Task	New methionine synthesis	Special properties, functions and areas of applications, markets and new materials for surfaces
	Crowd	External chemistry professors	Internal employees within the BU
	Main purpose	Research cooperation with universities or other research institutions for a new way to synthesize methionine	Concrete, high-quality project ideas with high business potential
	Additional targets	– Visibility at the university – Strengthen reputation of company's chemical competencies – Identify unknown experts and new cooperation partners – Building networks with students who could be future employees	– Further develop innovation capabilities across the organization, including team competences and an idea discussion and development culture – Identify experts within the organization
	Rewards / Incentives	Money prize and possible research cooperation	Non-monetary reward: Idea will turn into projects
	Online tool	E-mail account	Social enterprise platform
	IP right	Rules of participation: idea belongs to idea author unless it is chosen	Jam disclaimer: German Law on Employee Inventions and/or employment contract
	Internal buy-in	Responsible manager of the project was also responsible for the research cooperation, budget needed to be decided by the BL head	Responsible manager of the project will not be the sponsor of the ideas, budget needed to be decided by the BL heads
	Internal resources	5 project team members, 4 additional support (IP, branding), 7 evaluators	4 project team, 16 facilitators and evaluators, BU management team
Execution phase	Duration	3.5 months	4 days
	Submission mode	– Closed proposal submission – No online collaboration	– Open & transparent idea generation – Online collaboration
	Submission elaborateness	– Completed solutions – Detailed submission template	– Ideas / concepts – No idea template needed
Assessment phase	Evaluation criteria	1. Novelty and creativity 2. Probability of technical & commercial success 3. Quality of project proposal 4. Collaborative research approach	1. Strategic fit 2. Innovation level 3. Implementability 4. Level of detail / maturity 5. Market and commercial potential
	Evaluation mode	– Seven experts from the methionine research department – Full-day workshop	– 11 screening team members from all research departments of the BU – Full-day workshop
Implementa-tion phase	Rewarding ceremony	At the company's own annual innovation award	At company's AOC symposium with the BU as lead
	Achievements	– 15 ideas – 3 cooperations	– 78 ideas – 5 projects

Figure 4: The components and dimensions of innovation crowdsourcing and their interrelations.

A. Basic conditions of the organizing company

Prior to any deliberation for starting an innovation crowdsourcing project, the first and most important thing is to verify the readiness of the company for online innovation approaches, because it is important to achieve internal acceptance for a crowdsourcing project. There are two basic conditions for achieving internal commitment for a successful innovation crowdsourcing project: internal buy-in and involvement of internal resources. Internal buy-in implies not only that an executive manager agrees on the project plan and approves the budget for executing a crowdsourcing project, but it is more essential to gain general support from the business units, which should have the capacity and also the capability to adopt and absorb the results afterwards [58]. The managers, who have the power to decide on budget and activities within the R&D departments are here the crucial stakeholders [1]. If there was no buy-in or commitment from these management groups, the so-called "not-invented-here" syndrome would emerge [47] and implementation of the ideas and projects could be inhibited or even rejected. Another way to prevent the "not-invented-here" syndrome is to engage enough internal human resources as facilitators or evaluators to support the core project team. They should be inducted into the whole preparation process so that they can develop empathy for the crowdsourcing project from the beginning and promote internal acceptance [46, 54].

In the case of ECRP, one of the responsible managers for the project was the head of the R&D department and therefore he had the power to decide whether to enter research collaborations or not after the budget was approved by the head of his business line. Consequently, all three winning ideas entered into research cooperation projects. Although the project teams of the ideation jam did not involve business line managers, who have the power to

decide on budget and activities, each of them were committed to one winning idea as a project sponsor by providing the budget for further idea implementation within the company. This approach was also successful because the presentation of the five winning ideas at the symposium five months after the ideation jam showed great improvements and increasing maturity of the initial ideas that had been turned into real business projects.

Concerning internal human resources, besides the project team and evaluators, colleagues from the IP department and from employer branding were involved in the planning procedure for external crowdsourcing. Their support was not to promote internal, but external acceptance. Therefore, we can conclude that internal buy-in is needed to increase acceptance of ideas within the organization, whereas internal human resource involvement is needed to increase acceptance of the crowdsourcing project within the crowd.

Proposition 1:

If the ideas of innovation crowdsourcing projects are to be implemented successfully, then internal buy-in from managers who have the power to decide on research activities and budget is essential.

If the online ideation process of innovation crowdsourcing projects is to be executed successfully, then internal human resource is important to involve ab initio.

Proposition 2:

If external crowdsourcing is approached, then internal human resource should include IP and corporate branding departments to achieve a higher activity level of the external crowd.

If internal crowdsourcing is approached, then internal human resources should include managers and experts from

as many different functions and business areas as possible to achieve overall acceptance within the company, thus increasing the activity level of the internal crowd.

B. The task-crowd-interrelationship

In process industries such as the chemical industry, product and process innovation are two important innovation dimensions. Product innovations are new or better products being produced and sold. It refers to the question of WHAT is produced [39]. Focusing on the technological innovation field, product innovation means creating products that are entirely new to the company's product portfolio and are intended either to serve new customers or new applications for existing customers. Process innovations, on the other hand, are new methods that are used in the process of production. Utterback and Abernathy [66] defined a production process as "the system of process equipment, work force, task specifications, material inputs, work and information flows, etc. that are employed to produce a product or service". This definition explicitly excludes organizational process innovations. Thus, technological process innovation is the creation and subsequent adoption of an entirely new production process, which might radically change the company's existing production process [17]. Here, the question of consideration is HOW to produce.

The task of ECRP was to find a new way to synthesize an existing product. This task was asking for process innovation ideas because the product is already known and the question is HOW to produce it. The task of ECRP is highly complex and only people in a very specific knowledge field, namely the ones who have expertise in organic chemistry, biochemistry and catalysis, can even understand the task. Ideas about new synthesis or production processes can only be created by idea authors with a certain knowledge background. Thus, only a specified crowd can address tasks for process innovation in the chemical industry.

As opposed to ECRP, the ideation jam searched for new products, services, technologies or new business models. The ideas generated here contribute to product innovation. As product innovations do not necessarily need specific knowledge in research and development, but also information from other functions areas to identify opportunities and market needs, involving a heterogeneous crowd has been proven to increase creativity by cross-fertilizing their ideas and concepts [5, 7]. Hence, for product innovation, unspecified crowds with highly diverse backgrounds are required for creative and novel results.

Proposition 3:

If the task is to develop ideas for process innovation, then a specified crowd with deep inside knowledge is needed to solve the task.

If the task is to develop ideas for product innovation, then an unspecified crowd with diverse knowledge outside the familiar competencies is needed to respond to the task.

In addition, on the one hand, the company decided to approach an external crowd of experienced chemistry professors to solve the task of ECRP. Although methionine experts exist within the company, they are all in the R&D department of the business line and therefore their ideas for a possible new methionine production process are already known. An open call within the company to include all employees would not expect new path-breaking synthesis routes. Moreover, chemistry professors are rather close to the actual basic research and their proposals would create new synthesis approaches that are unknown to the company. However, if not all internal experts are identified yet, e.g. because the considered technological process is quite new to the company, then internal crowdsourcing could also create considerable added value by solving the process task internally.

Proposition 4:

If all internal experts for a specific task are already identified, then approaching an external crowd would create more new and innovative solutions.

If not all internal experts for a specific task are identified yet, then primarily approaching the internal crowd might be wise to benefit from a company's knowledge base.

On the other hand, the project team of the ideation jam decided to deploy the internal crowd for their product innovation task. This is understandable regarding the main purpose of this project. The expected outcome is to receive concrete, high-quality project ideas with high business potential. Therefore, only people who understand the coatings business are suitable for this job. Nevertheless, an open external crowd could also be used if the main purpose was to identify new markets or new trends for coatings with a social component, such as improving everyday life or reducing environmental pollution, which might touch everyone emotionally.

Proposition 5:

If the task is to create ideas for new applications or new business models, then an internal unspecified crowd should be approached to obtain useful project ideas.

If the task is to generate ideas for new markets or new trends, then an external unspecified crowd might be appropriate to provide stimulation for the company's future development.

Figure 5 summarizes the decision path to answer the question of the innovation dimension: What kind of crowd should be used for what kind of task?
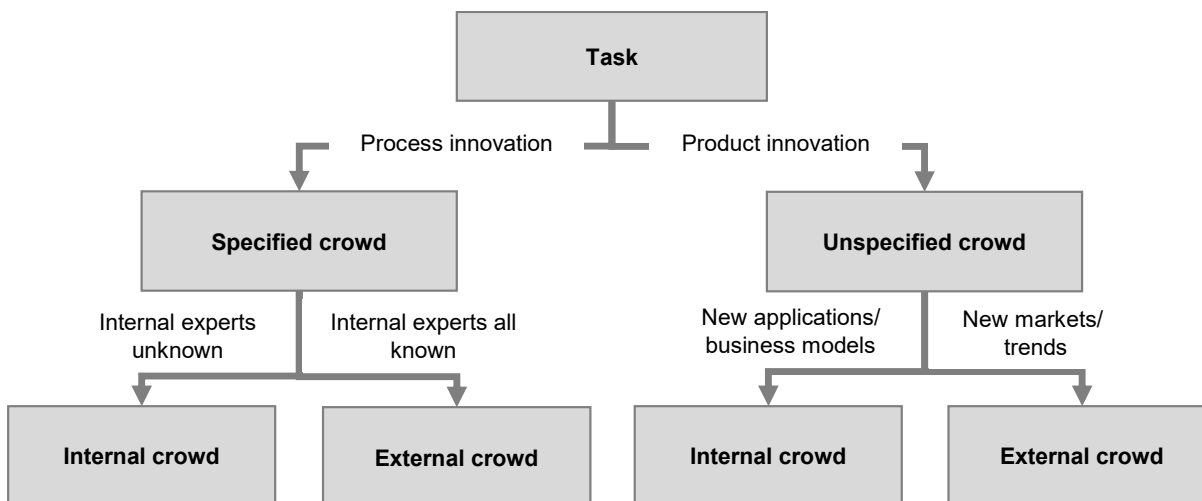
Figure 5: Innovation dimension of crowdsourcing for the task-crowd-interrelationship.

C. The crowd-outcome-interrelationship

When the crowd has been chosen, appropriate measures concerning intellectual property rights need to be determined. For an internal crowd, IP rights are normally regulated by the employment contract [72]. Due to the fact that all IP rights created during an internal crowdsourcing project will stay within the company, there are two consequences. Firstly, ideas can be discussed openly in the online communities of the enterprise social platform. Online community functionalities, such as commenting or voting on other participants' ideas, allow interaction between participants for further idea maturation and discussion. The online community enables open access for all employees and interactive collaboration between them. They could add their opinion and knowledge about the ideas transparently, develop and refine ideas together or be inspired by previous ideas for their own ideas [12]. Furthermore, as the ideation jam example shows, online collaboration between employees aims to develop a more open innovation culture, where people should learn to be less secretive, which is still widespread in the chemical industry [60]. Instead, team competencies and an open idea development culture should be introduced by using the crowdsourcing approach. Secondly, the employment contract incentives for the internal crowd were of a non-monetary kind to avoid conflict with the works council. Nevertheless, the possibility of establishing a reputation within the company or the opportunity to pursue one's own ideas into an internal business project are decisive factors that motivate employees to actively participate in crowdsourcing projects.

For an external crowd, IP rights management is a bigger concern that should be handled carefully a priori, especially issues of IP ownership and protection [31]. There is a tension between the crowd members who tend to protect their ideas and retain knowledge and the company that needs as much information as possible to understand the idea and then evaluate it properly [56]. In the case of ECRP, the participants were not allowed to share their project proposals or similar proposals with any third party until the company had evaluated the proposals and rewarded the winners. Upon conclusion of the ECRP, participants who have not been rewarded or to whom the company has not offered a joint research activity of any kind are free to pursue the project on their own – alone or together with third parties. They are free to file their own patents or to publish the scientific results. Due to these IP regulations, in the ECRP project one e-mail account was used to receive all the research proposals so that submissions from other participants were not even accessible for reading, not to mention for online collaboration. Also from the point of view of the participating professors, it was the right decision to chose a closed form of submission with no online collaboration, because they would refuse to openly present their solutions, which included sensitive research data. Since the desired additional targets of ECRP is to promote the company's brand within the chemical research society and to strengthen the reputation of its chemical competencies, this kind of one-way communication was sufficient. In addition, it is much easier for the company to choose the winners for the money prizes and possible cooperation, if there is no online collaboration between different institutions. In the case of ECRP, monetary rewards of up to €10,000 and the prospect of research cooperation between Evonik and the participants' university or other research institution worked well as motivation.

Proposition 6:

If internal crowdsourcing is approached, then IP rights should stay within the company. This fact enables 1) online collaboration on the enterprise social platform that supports the development of a more open innovation culture, and 2) non-monetary rewards as suitable incentives to spur internal innovation projects.

If external crowdsourcing is approached, the IP rights will stay with the crowd, if the idea is not rewarded. This fact
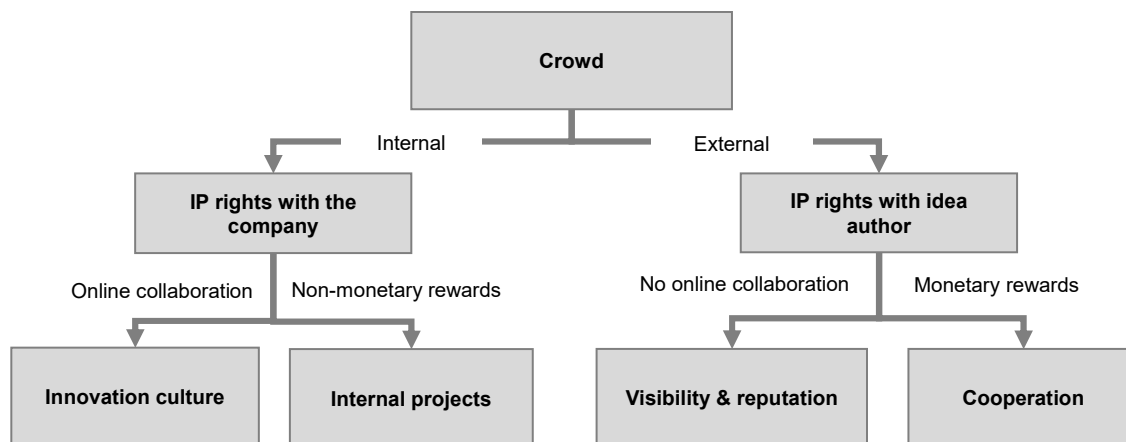
Figure 6: The social dimension of the crowd-outcome-interrelationship.

leads to 1) no online collaboration by using a one-way communication tool aimed at promoting the visibility and reputation of the company's research competences; and 2) monetary rewards that could include research cooperation with research institutions.

Motivational factors, such as rewards and incentives, and additional targets, such as the company's innovation culture and reputation, are social factors that always need to be considered in the relationship with the crowd, whereas their occurrences differ depending on the crowd type. Figure 6 shows the decision path to answer the question of the social dimension: what kind of crowd should be used for what kind of outcome?

D. The task-outcome-interrelationship

The specificity of the task in innovation crowdsourcing projects could be low if the task is quite open, or high if the task is highly specific. Depending on this characteristic, the submission elaborateness can also vary from low, such as raw ideas, to high, such as completed solutions [11]. In ECRP, the specified task for chemical experts outside the company was described very precisely and the desired outcome should be highly elaborated in the form of completed solutions. Therefore, a detailed submission template was provided, which comprises a short abstract of approximately 150 words that states briefly the purpose of the research proposal, gives a general description of the proposed solution, including theory and methodology adequate for the problem, significant chemical insights and substantial predictive value, and an optional field for further information for references or an implementation plan. Since participants are only allowed to send a finished proposal with all the information needed, they need more time to conceptualize their proposals before submission. It is a project that needs proper investigation with detailed descriptions of research facts. Therefore, the competition period for the external competition was 3.5 months, which is quite a long term for crowdsourcing [11].

On the other hand, the internal crowdsourcing project was searching for ideas or concepts for new applications and new materials for multifunctional surfaces, which is an unspecified, open task. The desired outcome could just contain a sentence, which should then be further discussed with other colleagues who may have more knowledge and experience regarding specific topics. In this case, no predefined idea template was required for idea submission. The online crowdsourcing phase took just four days. The event was kept so short to capture the first intuitions and inspirations of the people, which is highly valuable for creative, unconventional ideas [3]. Another reason is that the short time period prevents the generation of too many ideas, so that the participants still have some overview about the ideas posted for further online discussion. Especially for internal crowdsourcing, the participating employees have to handle their daily work beside the ideation jam. Therefore, short-term crowdsourcing is efficient to get as many ideas and discussions about the ideas as possible without neglecting the actual work.

Proposition 7:

If the task is highly specific, then the online crowdsourcing period should be long, so that participants have enough time to develop a complete solution and describe it in a detailed submission template.

If the task is formulated very openly, then the online crowdsourcing period should be short, so that participants can come up with creative, unconventional ideas that spontaneously cross their mind. No predefined idea template is needed to leave the solution space as open as possible.

The task-outcome-interrelation implicates important technical elements that are needed to set up an appropriate execution phase for an innovation crowdsourcing project to get the desired level of elaboration in the submissions. Figure 7 illustrates the decision path to answer the question of the technical dimension: what procedure should be use to get the desired outcomes?
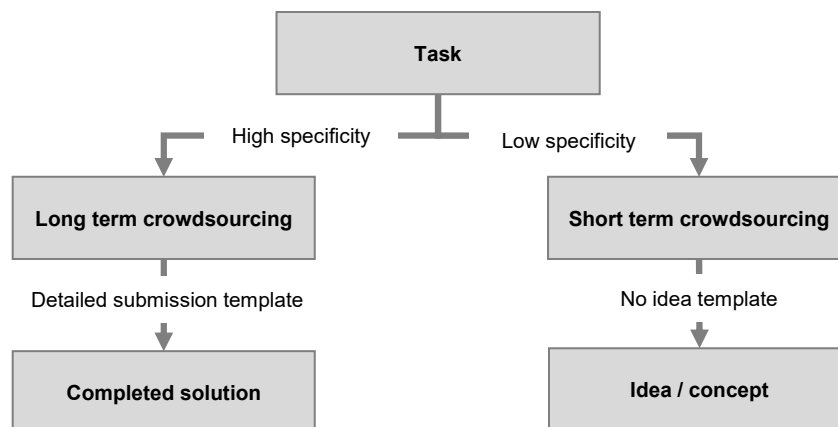
Figure 7: The technical dimension of the task-outcome-interrelationship.

VI. CONCLUSION AND OUTLOOK

Based on our analyses of internal and external crowdsourcing in the chemical industry, we find three key components (task, crowd, and outcome) and three dimensions (innovation, social, and technical) of innovation crowdsourcing in an integrated model. A detailed, comparative analysis of two cases, one of internal and one of external crowdsourcing, reveals four key findings:

1. Appropriate internal buy-in and also appropriate internal human resources are the two most important pre-conditions for performing a successful innovation crowdsourcing project.
2. The interrelation between task and crowd needs to be analyzed from an innovation aspect, i.e. innovation types and dimensions are the crucial factor as regards whether to use an internal or an external crowd.
3. The interrelation between crowd and outcome needs to be analyzed from a social angle, i.e. social factors such as innovation culture or reputation are the decisive reasons why the internal or external crowd should be used.
4. The interrelation between task and outcome needs to be analyzed from a technical perspective, i.e. practical elements of the crowdsourcing procedure are the critical success factor to get the desired outcomes.

From a theoretical point of view, the following implications can be derived. Firstly, the current scarce body of empirical literature about internal crowdsourcing [20, 40] and about crowdsourcing in B2B sectors [61, 62] could be enlarged. Second, the process [55] and the design elements [11, 34] of crowdsourcing could be merged into one integrated model (see Figure 4). Furthermore, we could show that creating interrelations between the three components – task, crowd and outcome – and their separate analysis in three different dimensions seems to be a more expedient way to manage innovation crowdsourcing projects than on an overall project level [11, 55] or when components are analyzed individually [14, 41].

Practical implications include that innovation managers in research-intensive companies can utilize the insights of these results to improve their understanding of crowdsourcing projects for innovation. In-depth comprehension of the relationships between task, crowd and outcome from different perspectives may help companies manage projects such as this more systematically. Finally, the elaborated decision paths could be used as a guideline when conceptualizing and implementing crowdsourcing projects in the early phase of innovation of the organizing company.

Nonetheless, beside these important theoretical and practical implications, this study also has some limitations. From a methodological point of view, a multiple case study of two cases within one company might draw some criticism due to a biased presentation of the general innovation crowdsourcing process. Future research could test the decision paths in a larger empirical study with differentiated industrial partners with more combinations between task, crowd and outcome. With regard to content, the evaluation issue was not included in the resulting models, because they were similar to each other in the considered cases. But more variation exists besides expert evaluations, such as peer review, self-assessment or a mixed method approach [12, 35]. Hence, a more differentiated analysis concerning the evaluation mode and its corresponding evaluation criteria should be included in future research. Moreover, this study only compared innovation crowdsourcing projects with external experts and internal non-professionals. Thus, it would be interesting to include the cases of external non-professionals and internal experts and how the interrelationships between task, crowd and outcome may be extended. Finally, the identified dimensions and perspectives of this study are likely to be useful as a foundational framework for further research in this area.

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