Crowdsourcing Properties and Mechanisms of Mega Hackathons: The Case of Junction

Alireza Jaribion, Siavash H. Khajavi, Ulriikka Järvihaavisto, Iiro Nurmi, Robin Gustafsson, and Jan Holmström

***Abstract*—Hackathons are time-bounded crowdsourcing events, which have recently prospered in many technology and science domains across the globe. We study Europe's largest hackathon, Junction, to better understand the distinct crowdsourcing properties and mechanisms of this type of hackathon as a form of tournament-based crowdsourcing. Moreover, we determined how they add value to attending companies and participants. In this regard, six qualitative and quantitative datasets from participants, companies, and the organizer were collected and analyzed. Our findings revealed five distinct crowdsourcing properties and mechanisms of mega hackathons, including intricate crowd selection, strong crowd vibe, instant crowd feedback, versatile crowd potential, and pervasive information technology. Based on our findings, we argue that these properties and mechanisms increase the possibility of finding innovative solutions to companies' problems in Junction-like mega hackathons. This article concludes with managerial implications for companies to consciously plan and prepare while knowing what to expect during the hackathon.**

***Index Terms*—Crowds, crowdsourcing, hackathon, open innovation.**

I. Introduction

ORGANIZATIONS are seeking more effective and efficient ways to expedite their innovation outcomes by transitioning from a secretive and silo-mentality style of innovating to open innovation [1], [2], where collaboration with outsiders is privileged [3]. As when extracting anything precious from its source, distilling wisdom from a crowd requires specific methods and tools. For harnessing external resources as sources of innovation, the use of open competitions by companies is rapidly increasing [4]. In this regard, various forms of tournament-based crowdsourcing are flourishing [5]–[7]. In tournament-based crowdsourcing, each individual or group from the crowd selects a problem, then presents a solution to that problem, and the winner is awarded based on the evaluation of the presented solutions [6], [7]. Emerging within the space of various forms of tournament-based crowdsourcing are hackathons, which have been spreading in several fields of technology and science [8]–[10].

In hackathons, the participants compete in teams for prizes while solving problems formulated by companies in a time-bounded setting [8], [9]. Today, hackathons are accepted as a source of innovation in cutting-edge disciplines [9], [10]. This is evident in efforts such as the CERN-organized hackathon related to quantum technologies in late 2019 [11]. Well-known entrepreneur and technologist Elon Musk also organizes hackathons for Tesla, Inc., in the field of artificial intelligence (AI), as stated in the following quote [12]: *"Tesla will hold a super fun AI party/hackathon at my house with the Tesla AI/autopilot team in about four weeks,"* posted on Twitter Feb 2, 2020.

In recent years, the body of knowledge surrounding the hackathon phenomenon is developing and research on hackathons has grown considerably [10]. Current streams of research exploring hackathons are focused on their evolution and design aspects [8]–[10], [13], [14], classification [8], [10], [15]–[17], and innovation acceleration [8]–[10], [16], [18], [19]. Although many researchers have also investigated the value proposition of hackathons [10], [14], [15], [20]–[22], most studies are generic and do not cover specific types of hackathons. Moreover, while hackathons are inherently a form of tournament-based crowdsourcing [3], [6], [15], [16], [20], [23], the literature has failed to explore the crowdsourcing aspects of hackathons considering the differences in types of hackathons. In our case study, we explore an emerging type of hackathon–the mega hackathon (MH)—which is on-site, international, multi-field, organizer-centric, and multicompany. Despite the surging amount of research on hackathons, there is surprisingly little research nor summarizing research on the key differences of the various types of hackathons and the unique properties and crowdsourcing mechanisms of the MHs. In that regards, the understanding of the unique value proposition of the MHs remains scattered and incomplete [24]. Furthermore, the implications for practitioners (e.g., companies) regarding why and how to engage are disregarded in the current body of knowledge. In this article, we make strides to fill these gaps in understanding by 1) providing clarity on the specific characteristics of MHs in relation to the several other types of hackathons, 2) proving novel

Manuscript received March 7, 2020; revised October 23, 2020 and February 3, 2021; accepted April 8, 2021. This work was supported by the Academy of Finland projects "ValueBioMat" under Grant 327248 and "Direct Operations" under Grant 323831. Review of this manuscript was arranged by Department Editor T. Brown *(Corresponding author: Alireza Jaribion.)*

Alireza Jaribion, Siavash H. Khajavi, Ulriikka Järvihaavisto, Robin Gustafsson, and Jan Holmström are with the Department of Industrial Engineering and Management, Aalto University, 02150 Espoo, Finland (e-mail: alireza.jaribion@aalto.fi; siavash.khajavi@aalto.fi; ulriikka.jarvihaavisto@aalto.fi; robin.gustafsson@aalto.fi; jan.holmstrom@aalto.fi).

Iiro Nurmi is with Smartly.io, 00100 Helsinki, Finland (e-mail: iiro.nurmi@hackjunction.co).

Color versions of one or more figures in this article are available at https://doi.org/10.1109/TEM.2021.3079107.

Digital Object Identifier 10.1109/TEM.2021.3079107

detailed understandings on the unique crowdsourcing properties, mechanisms, and value proposition of MHs, and 3) pointing out the benefits of attending and valuable ways to engage in MHs for the stakeholders. Our guiding research question is, *what are the distinct crowdsourcing properties, mechanisms, and value proposition of mega hackathons?*

Rest of this article is organized as follows. The introduction is followed by the theoretical background, which explores the research conducted to date on crowdsourcing and hackathons. The research methodology of this article is subsequently explained. Then, the findings are presented to elucidate the crowdsourcing properties and mechanisms of MHs. The theoretical and managerial implications follow, and finally, the article concludes with a discussion of the limitations and recommendations for future research.

II. Theoretical Background

A. Crowd and Crowdsourcing

1) Crowd: A "crowd" is a large group of people who self-organize around a common purpose, emotion, or experience [25]. In a 2009 report by U.K. Cabinet Office, crowd is defined as

> "a sizeable gathering of people in a given location, with a sufficient density distribution, who have come together for a specific purpose over a measurable period of time and who, despite being predominantly strangers or in an unfamiliar situation, feel united by a common identity and are, therefore, able to act in a socially coherent manner."

[26], [27].

Crowds have been viewed as both positive and negative entities. When they gather for political rallies or to support sports teams, crowds are considered positive, while riots and looting are seen as negative. According to Prpić *et al.* [28], companies often refer to crowds as collections of individuals engaged for organizational purposes.

2) Crowdsourcing: The term "crowdsourcing" derives from two words: crowd and sourcing. The former, again, refers to the people who self-organize around a common purpose to participate in an initiative [25], [26], while the latter refers to "a number of procurement practices aimed at finding, evaluating, and engaging suppliers of goods and services" [29]. Recent centuries have seen several instances related to the act of outsourcing a task to the crowd, such as the Longitude contest of the British government [5], [30], sheriffs distributing wanted posters in the Wild West, and architecture design contests for the most notable buildings, including the Sydney Opera House and the White House. Crowdsourcing is a rising trend in academic research that has significant use in practice and, with the emergence of digital technologies, is significantly enhanced. In 2006, Howe coined "crowdsourcing" as "a business practice that literally means to outsource an activity to the crowd" [31]. More explicitly, crowdsourcing "represents the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call" [31], [32]. Indeed, in some cases, firms are inclined to crowdsource problem solving rather than solving the problem internally or outsourcing it to a designated supplier [5], [33]. An advantage of this approach is that it improves the efficiency and effectiveness of problem solving [5]. More specifically, crowdsourcing also transforms distant search into local search under certain circumstances, which depends on problem specification, knowledge required for the solution, the crowd, and evaluating the solutions [5].

3) Crowdsourcing Process: To explore interesting crowdsourcing questions [6], a profound realization of the crowdsourcing process is necessary. The crowdsourcing process can be summarized and presented in four major steps [5], [6]. The first step is the problem formulation, delineation, and transmission to a crowd by the company's managers [6], [34]. The second step is the crowd's self-selection (without any assignment) to solve the problem [6]; notably, there is no guarantee about what happens if the crowd cannot satisfy the solution seeker. The third step varies based on the crowdsourcing type and can be solution evaluation [35], [6] or component solution aggregation [6]. The final step is solution assimilation and implementation by the company [6], [36].

4) Types of Crowdsourcing: While crowdsourcing encompasses broad areas, making it an effective and potent practice, this also makes it difficult to narrow and categorize [29]. Researchers describe crowdsourcing as a broad group of activities that take on different forms, and several studies have contributed to the development of crowdsourcing [6], [7], [37], [38], [39]. Vukovic presents an overview of various properties of crowdsourcing [37], and, in his renowned work, Brabham defines crowdsourcing and creates a typology on the basis of various cases such as Threadless, iStockphoto, and InnoCentive [35]. However, a more comprehensive categorization of crowdsourcing types is presented in [6], [7], [38], and [39].

Afuah [6] explains that tournament based, collaboration based, or a hybrid of both are three types of crowdsourcing. In tournament-based crowdsourcing, each individual or group from the crowd selects a problem and presents a solution to that problem [3], [6], [20], [23]. Afterward, the winner is awarded based on an evaluation of the presented solutions. Meanwhile, in collaboration-based crowdsourcing [5], [6], [40], [41], each actor presents only a part of the solution, and all of the presented parts comprise the solution to the problem. Notably, crowdfunding and open-source projects fall under the collaboration-based category [42]. As another category, a hybrid of tournament-based and collaboration-based crowdsourcing can be seen in using prediction markets for problem solving [43]. Further differences between each type can be observed when the solutions are ready: in the case of tournament-based crowdsourcing [6], the solutions are evaluated by the company's decision-making team or even the crowd itself [6], [35], while, in collaboration-based or hybrid crowdsourcing, there is component solution aggregation [6].

In another taxonomy on the basis of distinct web-based platforms [7], [39], crowdsourcing is likened to an umbrella, with four segments on its canopy: microtasks, macrotasks, crowdfunding, and contests. Microtask platforms assist project owners by breaking a large project into small tasks for a crowd

of actors to complete. Microtask platforms such as Amazon Mechanical Turk (MTurk) [44], Clickworker, and Lingotek are excellent for research, data validation, translation, and image tagging. In macrotask platforms, the crowd gets involved in a presented project to contribute based on their knowledge. Macrotask platforms such as Quinky, InnoCentive, and Chaordix are suitable for research and development as well as product innovation. Any combination of money, passion, and glory can be a source of inspiration for crowdsourcing in both macro- and microtask crowdsourcing [7], [45]. Crowdfunding [42] is yet another form of crowdsourcing, in which the crowd donates money for a project or a specified cause within a predetermined timeframe. Crowdfunding platforms are typically used for project fundraising, artistic support, startups, market research, and disaster relief. Platforms such as Kickstarter, Crowdrise, and SeedUps are paramount in crowdfunding. Contests, as another form of crowdsourcing, ask a crowd to work on a certain topic or provide solutions and ideas, while the seeker only offers rewards for the best entries. For crowdsourcing logo design and business names, contest platforms are ideal, and platforms such as 99designs, Crowdspring, and Squadhelp are popular for this purpose [7], [39].

B. Hackathon

The word "hackathon," which first appeared in 1999 [8], is a combination of two words: "hack" and "marathon." In this context, while "hack" concerns problem solving, "marathon" refers to an intense situation of time-bounded events, including a lack of sleep and an abundance of fast-paced tasks, often over the course of 24 to 48 h. However, some weeklong events have been held by Lappeenranta University of Technology, the first in cooperation with Nokia in the spring of 2005 [46]. Indeed, a hackathon is "a time-bounded and competitive event, where participants work in teams to ideate, collaborate, design, rapidly prototype, test, iterate, and pitch their solutions to a determined challenge" [8], [9], [10]. Furthermore, in the case that the appropriate means are provided, hackathons are also referred to as innovation accelerators [10].

1) Types of Hackathons: Since hackathons have not yet been standardized as a business practice [10], many researchers have investigated the evolution of hackathons and, based on the different criteria, have presented numerous classifications, as depicted in Table I.

Geographically, hackathons can be categorized as local [47] and global (international) [48], depending on from where the participants take part in the hackathon. Furthermore, a hackathon can be hosted online or on-site (traditional offline) [13], [50]. Online hosting allows a significant number of participants to take part globally [13], [50]. Moreover, participants can be employees of the solution seeker (company or organization) or completely independent; in this regard, hackathons are classified as internal [8], [18], foreign [48], or both internal and foreign [10]. In terms of field, tech-centric hackathons [8] focus on computer sciences [46], [17], programming, and software development with a specific technology or of a specific application, while focus-centric hackathons (applied hackathons) aim for software solutions that contribute to a business objective or a social issue such as social psychology [16], civics [15], [19], [52], [20], health [49], and economics [8]. In this regard, hackathons can also be multifield by involving several different fields. Regarding data accessibility, hackathons can enhance the use of open data that will benefit companies, governments, and citizens [9], [15], [48], [19], [51]. However, in some hackathons, the provided data are restricted by copyright, patents, or other control mechanisms [21], [22].

TABLE I
DIFFERENT CRITERIA AND CLASSIFICATIONS FOR HACKATHONS

Criteria	Classification
Geographical	Local [47] / International (global) [48], [49]
Hosting	Online [13], [50] / On-site (traditional) [13], [50]
Type of participants	Internal [8], [18] / Foreign [48] / Both internal and foreign [10]
Field	Tech-centric [8]: Computer science [46] [17] / Focus-centric [8]: Social psychology [16]; Health [49]; Economic; Business [9], [10]
Data accessibility	Open data [9], [15], [48], [19], [51] / Restricted [21], [22]
Administration	Company-centric [8] / Organizer-centric [10] / Government-centric (civic) [15], [20], [47], [19], [52]
Number of companies	Single- [8], [18] / Multi-company [14]

In terms of administration, a hackathon can be organized in three different ways: a) company-centric [8], [18], in which a company is the organizer and the solution seeker, b) government-centric, in which the government is the organizer and solutions will benefit the government and citizens [15], [19], [52], [20], [8], [47], or c) organizer-centric, in which an independent organization is the organizer [10]. Organizer-centric hackathons have two types of organizers: nonprofit [53] and for-profit [50]. In the case of nonprofit organizers, the value gained is related to the experience gained by the members of the team, as well as the development of their professional network, which can help them attain better career prospects. Moreover, members of a nonprofit organizing team earn a fixed income in return for their work [53]. In the case of for-profit organizers, the earned value is financial in the form of profits [50]. Moreover, depending on the number of companies participating in the hackathon as solution seekers, a hackathon can be single company [8], [18] or multicompany [14].

2) Benefits of Hackathons: All of the stakeholders, whether they are participants, organizers, companies, or the government, can gain benefits from hackathons. From the perspective of large enterprises, the benefits are outlined in four categories: strategy and performance, skilled people and collaboration, efficient process and knowledge-based environment, and continuous improvement and change [10]. Moreover, hackathons accelerate innovation, facilitate organizational changes, provide a creative environment, and enable the rapid development of ideas [10]. On the other hand, some articles have discussed that hackathons do not offer any economic gain to the companies, limiting the goals of entrepreneurs. Weak posthackathon activities and other limitations are topics that have been less frequently addressed. Although Flores *et al.* [10] present a comprehensive methodology for organizing hackathons to create value, the procedure for capturing this value has not been studied.

From the perspective of the organizers, which can also be solution seekers, Kitsios and Kamariotou [15] identify the factors that affect the success of open-data hackathons [9], [15], [19], [51], [48] and digital innovation contests. In their research [15], they define "success" as the accomplishment of an aim or purpose specified by the organizers of each hackathon that is aligned with participants' expectations [15], [19].

From the perspective of the participants, motivations are classified into two general groups: intrinsic and extrinsic [20]. Moreover, a wide range of studies have explored participants' motivations [8], [15], [52], [16], which include learning, networking, changing the world, winning prizes, and future job opportunities. Notably, the literature indicates some controversy regarding motivations, but in most of the studies over several hackathons, the rewards were the least important trigger [15]. For example, the access to open data given by the governmental organizers to the participants in civic hackathons [15], [19] may be a mutually beneficial situation in which the participants are able to engage with urban issues while the government can find effective solutions in a short period.

III. Research Methodology

We conducted an in-depth qualitative case study [54] of Europe's largest MH, Junction. Our objective was to explore the distinct crowdsourcing properties and mechanisms of MH that incentivize companies to utilize it as a form of tournament-based crowdsourcing. Due to the limited existing research on MHs, our study was exploratory in nature. Using a qualitative research approach, we examined the research question with open-ended survey and interview questions and were sensitive to the uniqueness of the social setting [55]. Abductive reasoning–going back and forth between our inductive study and the existing research on crowdsourcing and hackathons–guided the analysis of our empirical findings and the development of the theoretical framework that best explains the empirical observations [56].

A. Case Description: Junction

Junction is a nonprofit organization in which volunteer-led teams organize hackathons throughout the year and around the world. Junction acquires its funding from partnership contracts with both public and privately owned companies seeking solutions in the hackathon. By the end of 2019, Junction had organized 19 hackathons across the globe. The hackathon-filled year peaks with a flagship hackathon organized in the greater Helsinki region, Europe's leading hackathon, annually gathering approximately 1500 participants for a weekend-long experience. Junction's flagship hackathon is a meeting place for students, developers, designers, and other techies to team up and create new tech solutions (also referred to as projects) in 48 h. The solution seekers (which are the companies or partners) present their predefined problems (or "challenges") to the participants (referred to as hackers). The dynamic scene of Junction is illustrated in Fig. 1.

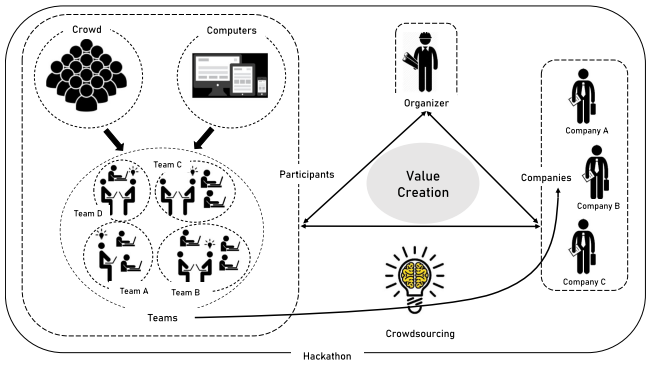


Fig. 1. Dynamic scene of Junction as an organizer-centric hackathon.

Since Junction's flagship hackathon is a multifield hackathon, the problems are related to several different fields such as computer sciences, business, social psychology, education, civics, healthcare, and economics. Thus, participants have a multitude of options from which to focus on and are not limited to one problem. Depending on the variety of fields, the Junction team clusters the problems into different "tracks," each track being related to problems within the same field. Moreover, in Junction, each company can offer participants working on its presented problems technology, such as hardware or software, and data from which to build their solutions. Each company also provides the winning prizes for the winning solutions to their presented problems.

This article focuses on Junction's flagship hackathon, with 1495 participants and 21 companies, which was held in Helsinki in November 2019. Based on the number of created projects (357), this was the largest hackathon ever held, as well as the most international, comprising over 100 nationalities. Moreover, this hackathon contained eight different tracks including cybersecurity, data economics, gaming, healthcare, smart building, sustainability, retail, and smart cities. To eliminate potential confusion caused by the similarity between the name of the organizing body and the title of the hackathon, hereafter, we refer to the organizing body of the studied hackathon as "the Junction team" and the studied flagship 2019 hackathon of this organization as "Junction."

Junction Planning Process: As Junction is financially dependent on partnership contracts with companies, the sales process plays a key role in enabling Junction to operate. The process typically starts with the Junction team prospecting various companies suitable for a hackathon. Suitable companies for a hackathon are generally those that have previously indicated an interest in innovation contests and hackathons, recruiting talent, or marketing their brand. Since Junction is a multifield hackathon, the partnerships are not limited to certain industries.

After the relationship between the Junction team and the company's key personnel has been initiated, the challenge-creation process begins. Here, the Junction team offers one or more workshops to the company. The workshops are managed by the Junction team and usually include the account manager and someone from the Junction team with a technical background

TABLE II
DATA COLLECTION METHODS, SATURATION LEVELS, AND SAMPLES OF SURVEY AND INTERVIEW QUESTIONS

Data set	Data type	Target	Collection method	N	n	Margin of error %	Confidence level %	Some examples of topics and questions related to the surveys and interviews
S1	Secondary qualitative and quantitative	Participants	Online questionnaire form	1495	1495	0	100	Demographic information (e.g., age, ethnicity, employment, gender, and education) and hackathon-related skills, such as programming, design, or business.
S2	Primary qualitative and quantitative	Participants	Informal interviews and survey	1495	127	7	90	Age? Gender? Where are you from? How many hackathons have you attended? What are your technical skills? What is your current work status? What are your reasons for participation in the hackathon? Which one is the main reason?
S3	Primary qualitative and quantitative	Companies	Semi-structured interviews and survey	21	19	7	95	Company name? Role in your company? How many hackathons has your company attended prior to this? Who in your organization decides on the hackathon participation? What are your company's reasons for participating in the hackathon? Which is the main reason?
S4	Secondary qualitative and quantitative	Participants	Online survey form	1495	213	6	95	What did you enjoy most about Junction? How did the hackathon match your expectations?
S5	Secondary qualitative and quantitative	Companies	Online survey form	21	11	18	90	What is your overall rating for Junction? How did the hackathon match your expectations? The best thing in Junction? What kinds of goals did you set for Junction? How well did you reach them? Did the quality of the projects match your expectations?
S6	Primary qualitative	Organizer	Informal interviews	-	-	-	-	Junction's organization process, the process of gaining companies' partnership, the organizer role, and the motivations and confronting challenges of attending companies.

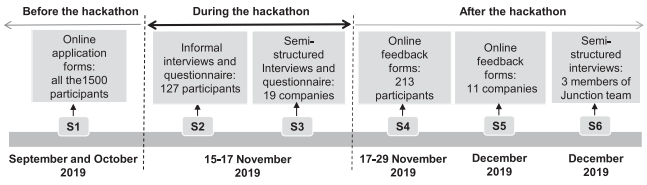


Fig. 2. Datasets and their collection timeline.

and experience in challenge creation. In the workshops, the Junction team assists the company in defining and modifying the challenge according to the company's goals regarding its participation in the hackathon. For instance, if a company aims to achieve innovative solutions for use in its current or future business, the challenge needs to be designed based on the company's real problems. In this regard, for a higher probability of crowdsourcing the problem, the company needs to consider the characteristics of the problem and the knowledge required for the solution. On the other hand, if a company aims to increase its brand awareness, it might focus on the approachability of the problem rather than the significance of the problem.

B. Data Collection, Validation, and Saturation

The datasets used in this article and the timeline for their collection are presented in Fig. 2.

To examine the Junction from all stakeholders' perspectives (participants, companies, and organizer), in total, six main sets of complementary data were collected and utilized for this analysis. These datasets are referred to by "S" followed by a number between 1 and 6; for instance, S1 refers to the first dataset used in this research. Regarding the participants' perspective, S1 and S4 complement S2. Regarding the companies' perspective, S5 complements S3. The organizer perspective is examined through S6. As described in Table II, all datasets include majorly qualitative data, however, some quantitative data regarding the age, number of participations, and rate of satisfaction were also collected. Indeed, the collected quantitative data enriched our qualitative analysis. For instance, one of the applications of quantitative data was to examine the representativeness of sample against the population.

Prior to Junction, we conducted five meetings with professors from the Industrial Engineering and Management Department at Aalto University. These professors are experts in relevant fields of entrepreneurial leadership, strategy, and venturing, psychology, and operations management. The findings from these initial expert meetings were then discussed among the research team in brainstorming sessions. In addition to the literature [10], [15], [19], [20], this assisted in selecting and tuning the research questions and subsequent interview and survey designs for S2 and S3. In the remainder of this section, we elaborate on each data set, the method of validation, and the assessment of its saturation.

1) S1: Dataset S1 was collected by the Junction team from all 1495 participants when they completed the online application forms. It consisted of quantitative and qualitative data and included demographic information (e.g., age, ethnicity, gender, education, and employment) about participants, which allowed us to understand where each person fit within the general population. Moreover, S1 included participants' hackathon-related skills, such as programming, design, or business. S1 was cross-verified against S2 and S4 in a methodological triangulation. Additionally, the S1 coverage of 100% of the participants created a confidence level of 100% and a margin of error of 0% (see Table II).

2) S2: Dataset S2 was collected during Junction in qualitative and quantitative forms using informal interviews and surveys. S2 involved the Junction participants. We utilized cloud-based Google Forms on two tablet devices and physically approached the participants for S2 data collection. During

Junction (48-h period), we employed random sampling [57]. According to the principles, every individual has an equal chance of being selected. To randomize the selection of the participants, we approached them in various locations throughout the Junction venue, including on different floors, rooms, and corridors, while they were on the move. We did not approach participants while they were busy working on their projects, and we selected high-traffic locations such as entrance stairs, the passage leading through the main hall, the snack stand, and the hall in front of the restrooms. To check our sample representativeness, we compared our sample characteristics with the population regarding gender, age, place of travel, and hackathon-related skills. In total, 127 interviews and surveys were performed; considering the statistical population of 1495 participants, this yielded a margin of error of 7% with a 90% confidence level (see Table II). The impact of the lower confidence level on the results was mitigated by verifying S2 with S1 and S4. The survey questions used for S2 were composed of multiple-choice and open-ended questions. It was designed to collect specific data regarding the value proposition of a hackathon from the perspective of the participants in addition to personal questions. To minimize response bias, we strived to keep questions simple and clear. Moreover, we solved participants' encountered issues during their responses. Additionally, we interviewed them informally, asked them to offer their opinions on Junction and whether there was anything interesting about it.

3) S3: Dataset S3 was collected by approaching the company's personnel at their stand during Junction. We performed a semi-structured interview followed by a survey. The responses to the interviews were recorded and later transcribed, and the survey was conducted using Google Forms on two tablets. In the S3 data collection, we were interested to know the motivations of participating companies, as well as their previous experiences with attending Junction and in other hackathons. S3 covers North American and European companies, which include small and medium-sized enterprises (SMEs) as well as large global corporations. Due to time constraints, 19 company representatives (see Appendix Table) participated in the data collection for S3. Since the total number of companies that were present at Junction was 21, our data saturation points at a margin of error of 7% with a 95% confidence level (see Table II). S3 was verified and methodologically triangulated by S5, which was collected after Junction.

4) S4: The Junction team collected S4 from the participants after the hackathon. Of the 1495 participants, 213 filled out the online feedback forms. This resulted in a margin of error of 6% with a 95% confidence level (see Table II). S4 was verified by the S2 and S1 datasets.

5) S5: Dataset S5 was also collected by the Junction team after the hackathon using an online survey form targeting the participating companies. The survey, which contained both quantitative and qualitative questions, was completed by 11 companies, which corresponds to a margin of error of 18% with a 90% confidence level (see Table II). S5 was used in conjunction with S3 for improved saturation and to cross-verify the datasets.

6) S6: Dataset S6 is a primary dataset that we collected while conducting informal interviews with the Junction team after the hackathon. These interviews involved meetings with the CEO, the chief strategy officer (CSO), and the head of marketing and communications of Junction. In the meeting with the CEO and CSO, we intended to gain insights about Junction's organization process, and we discussed the organizer role, as well as the motivations and confronting challenges of companies attending Junction. In the meeting with Junction's head of marketing and communications, we discussed general information related to the hackathon, such as the characteristics of the participants (e.g., age, nationality, and gender) and the process of gaining companies' partnership. In addition to these informal interviews with the Junction team, we utilized the insights of Junction's CEO, who is one of the coauthors of this article, as well as the experience of three other research team members who have each participated at Junction at least once.

TABLE III
RELATIONSHIP BETWEEN THE STUDIED SUBJECTS AND THE DATASETS USED FOR EACH

First-order concepts	Aggregate dimensions	Data sets
Broadcast advertising, skills, diversity, online application form, motivation, expert reviews, two-stage selection	Intricate crowd selection	S1, S3, S5, S6
People, venue, food, surprise moment, intensive and competitive environment, prize, volunteers, mentorship of experts	Strong crowd vibe	S1, S2, S3, S4
Companies' evaluation, transparency, participants' evaluation, reliability pre-defined criteria, pairwise comparisons	Instant crowd feedback	S6
Crowdsourcing innovative solutions, talent acquisition, employer branding, brand awareness, community building	Versatile crowd potential	S3, S5
Enhancing and facilitating various aspects, increasing efficiency and effectiveness, enabling and complementary role	Pervasive IT	S1, S6

C. Data Analysis

After we completed the data collection phase, we studied the survey results and analyzed the transcribed interviews using qualitative content analysis [58] to reach our findings. According to the abductive analysis approach [59], our understanding of the phenomena laid the foundation for the determination of the first-order concepts (see Table III). After the analysis of the interviews and the survey data, we utilized the evolving themes to aggregate the dimensions and determine the distinct crowdsourcing properties and mechanisms of Junction as an MH.

We relied on open coding in Excel spreadsheets and described the emerging concepts based on the actual language used by the interviewees and survey participants [60]. Two of the research team members collaboratively constructed the thematic coding structure. Afterward, one of the researchers reviewed and approved the coding structure. The first-order concepts are based on the thematic coding structure. Finally, the aggregate dimensions were extracted from the analysis of the first-order concepts on the basis of the literature. Table III presents the first-order concepts, aggregate dimensions, and datasets used for the thematic coding structure.

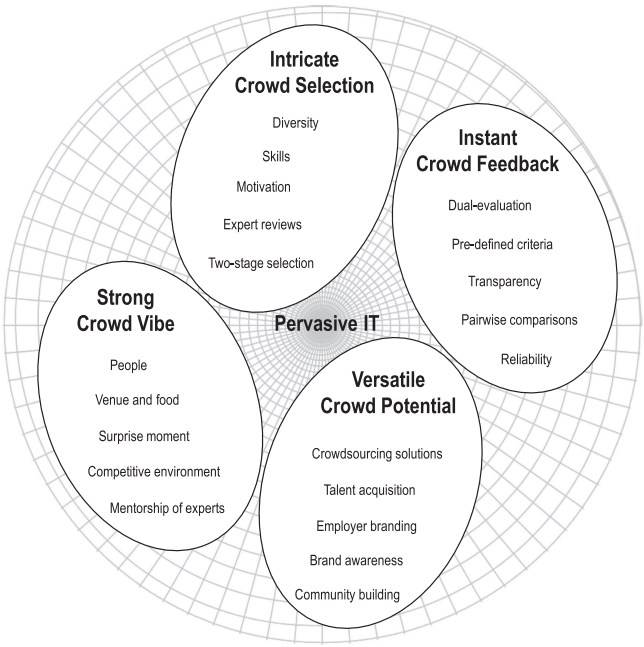


Fig. 3. Crowdsourcing properties and mechanisms of Junction as an MH.

IV. Findings

Based on our collected data and observations, we realized Junction, as an MH, has distinct crowdsourcing properties and mechanisms, which make it a prominent form of tournament-based crowdsourcing. As illustrated in Fig. 3, we categorize these distinct properties and mechanisms into five groups: intricate crowd selection, strong crowd vibe, instant crowd feedback, versatile crowd potential, and pervasive information technology (IT). In the following sections, these properties and mechanisms are described in detail.

A. Intricate Crowd Selection

As the first step, the Junction team officially broadcast the preliminary information on the hackathon through several platforms, including social media (i.e., Facebook, Instagram, Reddit, and cross promoting in other hackathons' social media), traditional media (i.e., newspapers), email campaigns, and webpages. Meanwhile, the registration links were opened. The applicants were directed to complete the application form individually, and, if they already had a team, they needed to mention that in their applications and connect their applications with a specified code. Since each submitted application was final, the selection process began during the registration period. The selection process considered the diversity, skills, and motivations of the applicants and took advantage of expert reviews and two-stage selection. We describe each as follows.

1) Diversity: Diversity refers to the existence of varying characteristics (e.g., age, gender, nationality, skill, etc.) among participants. The Junction team kept diversity top of mind while planning and advertising for the hackathon to ensure that they would attract interested applicants with varying nationalities and skills. They also reflected this during interviews:

"We welcome everyone—from outside Europe, a high school student, or a senior developer—interested to apply."—Junction team.

The Junction team also monitored the registration process; if they were not achieving their targets, they may have needed to reevaluate and modify their advertising approach. The application form included demographic information about applicants that allowed the Junction team to understand where each person fit into the general population. As a result, at Junction, the participants differed regarding their gender (76.8% male, 22.4% female, and 0.8% preferred not to answer), nationality (107 different nationalities), and skill (69.4% developer, 10% designer, 9.8% business, and 10.8% other).

2) Skills: The applicants needed to cover their hackathon-related skills on their application forms. Hackathon-related skills include three main fields: programming, design, and business. In addition, the applicants needed to specify their experience level; in other words, they needed to mention the number of hackathons they had previously attended. The skills and experience levels required for acceptance into Junction are typically a bit higher in comparison to smaller hackathons. As one of the informants explained us

"The skills are what matter, not the education."—Junction team.

3) Motivation: Notably, the applicants needed to add a motivation letter to their application form. The motivation letter is the most substantial part of the application form and showcases the applicant's desire and enthusiasm to attend the hackathon. Indeed, the motivation letter assists the Junction team with selecting goal-driven and energized applicants. Moreover, the participants' level of motivation is highly valuable for companies that bring their challenges to Junction. This was also reflected during interviews:

"Note that motivation is of great importance and counts in the applications."—Junction team.

"We had super-prepared and very enthusiastic participants that came up with a variety of crazy hacks during a short time."—Company F.

"The best thing in Junction was meeting devoted hackers and enthusiastic teams."—Company O.

4) Expert Reviews: The selection process consisted of the Junction team utilizing several experts and pundits in reviewing the applications. The selection requirements were not exceedingly strict, leaving some room for interpretation. Some applications were cross-referenced with other reviewers, and checks were made to ensure diversity in the skillset of the applicants.

5) Two-Stage Selection: Since Junction was an on-site hackathon and the participants needed to be physically present, the selection process occurred in two batches for taking into consideration a "no-show rate"—typically around 20–30% of the approved applicants. In the first batch, the selected applicants received an email asking them to confirm their attendance. The aim for Junction was to have 1500 participants; therefore, around 1800 applicants received the email to confirm their attendance.

Based on the results of the first batch, the number of final approved applicants was calculated. The second batch contained the remaining selected applicants. Ultimately, 1495 applicants attended Junction as "participants."

B. Strong Crowd Vibe

The first thing that stood out during the hackathon was the dynamic, jubilant, and excited crowd. A positive vibe can predict success even better than intelligence, ability, or prizes. Many of the participants conveyed a positive vibe even in the beginning, and adrenaline started to flow. When we asked them about their initial reactions when they arrived at the venue, we were confronted with the following answers. One of the participants, Julia, said she was *"feeling great and motivated to start working."* Another participant, Mikko, stated, *"Excitement! Thought it would be an exciting weekend!"*

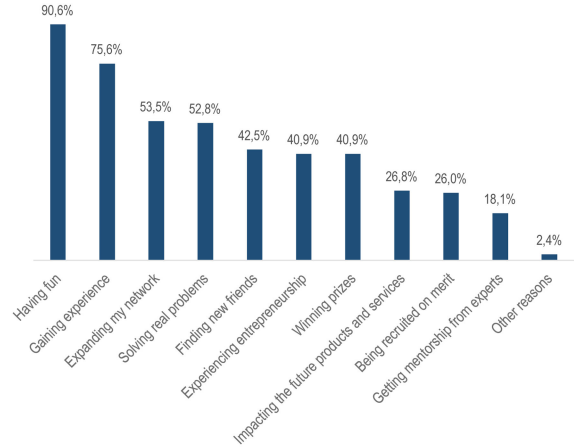
This strong crowd vibe was enabled by five drivers: people, venue and food, surprise moment, competitive environment, and mentorship of the experts. Each are described as follows.

1) People: According to 45% of the participants, people, and the positive atmosphere that they created, were the best part about Junction. "People" includes everyone present at Junction, the majority of whom being participants. As previously mentioned, the diversity of the participants was one important criterion in the intricate selection process; here, it played a significant role. As illustrated in Fig. 4, the participants had various goals for attending Junction. While, in tournaments, the prize is a key source of motivation, our study revealed that, at Junction, prize acted as a complementary target for participants. As depicted in Fig. 4, although winning the prize was among the goals of 40.9% of participants, only 3.1% mentioned it as their main goal. As illustrated in Fig. 4(a), 90.6% of participants attended Junction to have fun along with their other goals, while 75.6% of them were also keen to gain experience. This combination of having fun along with gaining experience created a happy crowd that wanted to engage with the challenges presented by companies. The Junction team also described Junction as *"a meeting place for people from all around the world: exploring, learning, creating, and having fun–with technology, with each other."*

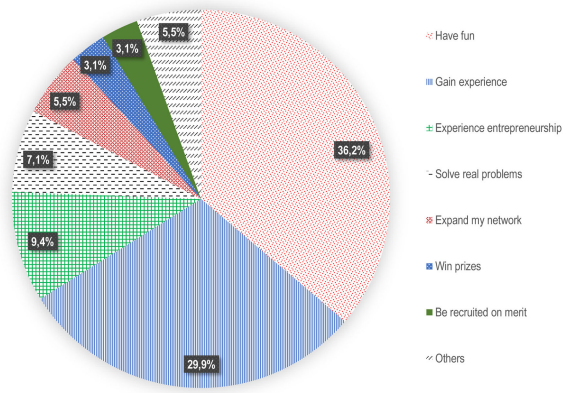
In addition to the participants, volunteers played a complementary role in creating this positive atmosphere. Junction had 344 volunteers involved in all parts of the production, from partnership and website teams to marketing and branding. Volunteers fueled the motivation at Junction and ran the operations like a powerful engine. They were eager to organize a world-class hackathon and to join an outstanding community of people from all over the world. The Junction team also reflected this during interviews:

"Ambitious and enthusiastic people are at the core of everything we do."—Junction team.

2) Venue and Food: Notably, 15% of the participants most enjoyed the venue's location and design. The Junction team radiated positive vibes at the venue by choosing a modern and large building, as well as adding furniture, lighting, and



(a) All goals



(b) The main goal

Fig. 4. Goals of participants for attending Junction.

decorations. Moreover, Junction provided free food and snacks for the participants at the venue. Accordingly, 19% of the participants pointed to the food as the most enjoyable aspect of the whole hackathon. This seemingly simple act had a substantial impact on participants' productivity and happiness, since they did not need to leave the area and pay for food. When we asked participants what they enjoyed most about Junction, we were confronted with the following answers. One of the participants, Vladimir, said *"the venue and lighting were great"* and another participant, Victor, stated, *"the location, free food service, and excellent access."*

3) Surprise Moment: The Junction team consciously introduced a moment of surprise, which was bringing a cute animal, called an alpaca, to the entrance of the venue. At that moment, a wave of happiness came over the participants. This fluffy and good-natured animal allowed participants to enjoy a different and exciting moment, as 3% of the participants specifically mentioned the alpaca to be the most enjoyable and memorable aspect of the whole hackathon.

4) Competitive Environment: During the 48 h period, everyone was working as a part of a team on the challenges, and this intensive and competitive environment created a strong vibe

and energy in the atmosphere. Some of the teams even stayed into the night to continue their work. When a team saw that the other teams were passionately working on the same or another project, they were impressed and, to some extent, motivated, and encouraged by the others. The positive energy that teams derived from each other and the whole atmosphere extended beyond just working together and kept the teams working overnight on the challenge.

5) Mentorship of the Experts: Another source of strong positive vibes for the crowd was the presence and mentorship of the experts at the companies' stands in the venue. As illustrated in Fig. 4(a), receiving mentorship from experts was among 18.1% of participants' goals. One of the participants, Jaakko, said *"I loved the talks with the experts! They were brilliant,"* and another participant, Emilia, stated, *"I enjoyed the mentorship at Company K's challenge."* The interaction between participants and experts had several benefits for both sides. The participants learned and gained insights from the experts, while the experts could guide the participants on the right trajectory regarding the company's challenge. This helped every person to feel more included and engaged. Moreover, due to this close interaction, the experts were able to identify the talents for later potential recruitment.

C. Instant Crowd Feedback

On the final day of Junction, for each company's challenge, the solutions presented by the participants were evaluated to determine whether they met the specified goals of the challenge and could be integrated into the company's current business. Since the number of projects was high (357), the effectiveness of the evaluation was of great importance. In this regard, Junction took advantage of dual-evaluation process and pairwise comparisons based on the predefined criteria, and the pace of this evaluation process was incredibly high—the whole process took place within four hours. We call this mechanism instant crowd feedback, which has high reliability and transparency. In the following, we describe the mechanisms and properties of this instant crowd feedback in detail.

1) Dual Evaluation: After the participants submitted their projects, there were two types of evaluations: *"companies' evaluation"* and *"participants' evaluation."* In companies' evaluation, a team of experts from the companies had the responsibility to review the projects that were submitted to their challenges. Based on this evaluation, the companies determined the winners of their own presented challenges and presented them the predetermined prizes. Meanwhile, participants' evaluation was done through peer reviewing. In consideration of the importance of companies' ability to influence customer feedback on their future products and services, the peer review helped companies become aware of participants' feedback as a sample of potential future customers.

2) Predefined Criteria: For both mentioned evaluations, the Junction team has highly recommended five evaluation criteria, including novelty, techiness, efficacy, wowness, and business value. "Novelty" can be described as the originality and uniqueness of the project. It must be considered that reinventing the wheel is not recommended; however, refining and reusing old material is good. "Techiness" refers to the completeness and technical aspects of the project. In this context, not only an attestation of future possibilities, but also the creation of something real is expected. "Efficacy" refers to the project's feasibility. The proposed solution should fit the highlighted problem and address the challenge. "Wowness" describes the level of "amazingness." More explicitly, it refers to how genuinely impressed companies are by the project. In this regard, the quality of pitch, demo, and prototype offers a high impact. "Business values" are the potential benefits that a company can gain from the project. These benefits enable the company to create revenue, investment returns, products, services, employment, and quality of life.

3) Transparency: Peer reviewing introduces transparency regarding the review process of the participants' projects. As the Junction team also reflected this during interviews:

"We have a lot of ambitious and curious teams coming to Junction. Naturally, they want to understand why a certain project has won. Peer reviewing gives them the possibility to discover other projects born at Junction and cast their vote for the winners."—Junction team.

The peer-review works in a way that participants are divided into pools and different teams go and review different projects. They go from table to table, review other's projects, and submit their evaluation in the Junction app.

4) Pairwise Comparisons: The peer review utilized a modified "Gavel model," which is based on pairwise comparisons and has been used in HackMIT since 2015. The method differs from traditional scoring methods by using fancy math to determine a ranking. Moreover, it outperforms having reviewers input scores from, for example, 1 to 10 and fully automates judging and reviewing logistics. The Junction app told participants which projects to look at. Then, the reviewer simply determined whether the project was better than the previous project, in their opinion, regarding the Junction team's five encouraged evaluation criteria. Each project was reviewed by at least five different teams; however, the math behind it allowed all projects to still compete even if they were reviewed less often than others [61]. The system collected all of the votes and generated a ranking of projects. The best rated projects proceeded to pitch in the final round on the Junction main stage. In this step, the participants voted to determine the winners of the first, second, and third prize according to the simple voting system, in which each person had one vote.

5) Reliability: The peer review improved the reliability of decision making and judgement in two ways. First, the more reviews and votes each project received, the more accurate and reliable the results of the judgement became. The Junction team also reflected this during interviews:

"We think participants are the experts of the challenges and therefore make the best judges. Peer reviewing also boosts reliability, because the more votes are cast, the more reliable the results become. In 2017, we recruited about 115 community judges, who gave a total of 2200 votes. With our 1495 participants reviewing, we're getting 13 times more judges."

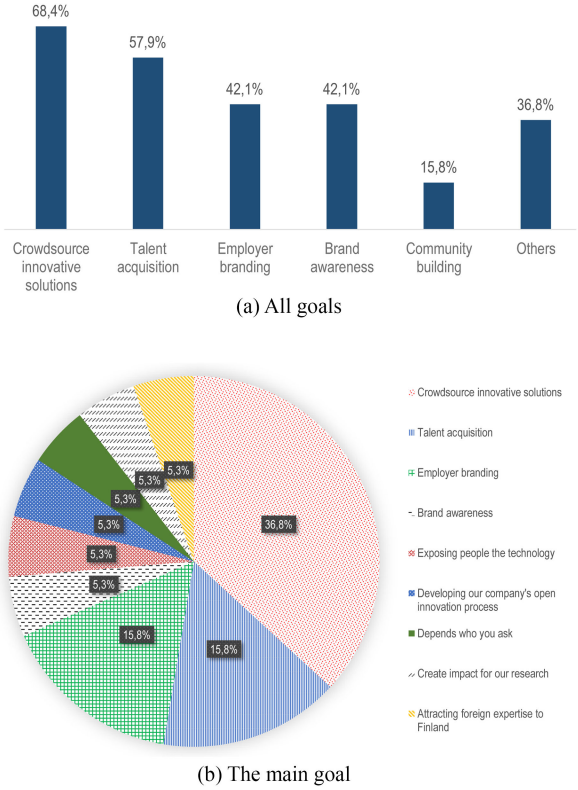


Fig. 5. Goals for companies attending Junction.

Second, the quality of entries was improved by using pairwise comparisons instead of having participants produce absolute scores [62].

D. Versatile Crowd Potential

Junction not only provided an opportunity for companies to crowdsource innovative solutions but also offered them multiple opportunities to gain value for their organization. In this regard, companies attending Junction intended to seize these opportunities and take advantage of the versatile crowd potential by gaining various values.

According to our collected data, the top five goals of companies that attended Junction were as follows [see Fig. 5(a)]: crowdsourcing innovative solutions (68.4%), talent acquisition (57.9%), employer branding (42.1%), brand awareness (42.1%), and community building (15.8%). Moreover, we asked the companies to elucidate their main goal of participation. As depicted in Fig. 5(b), the main goals for companies were crowdsourcing innovative solutions (36.8%), talent acquisition (15.8%), and employer branding (15.8%). We describe each of the top five goals as follows.

1) Crowdsourcing Innovative Solutions: As 36.8% of the companies stated in their interviews, crowdsourcing innovative solutions were the main motivation for most of the interviewed companies to attend the hackathon [see Fig. 5(b)]. Junction had collected some of the brightest young software talents, and companies were looking for a "fresh new perspective" to

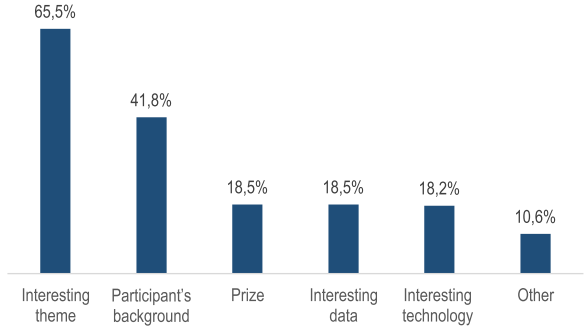


Fig. 6. Reasons for participants choosing companies' challenges.

their existing business, products, and processes. This was also reflected during interviews:

"It is about getting ideas, how people see our system through modern software design perspective"—Company B.

"We want to find solutions to improve our processes"—Company A.

"It is about getting large pool of ideas that could be very different than what we could come up with"—Company J.

Some of the companies had narrow challenges to seek a specific solution to a targeted problem. However, most of the companies wanted to keep their challenges relatively broad to nurture the imagination of the participants. Some of the interviewees mentioned that, in their experience, a narrow challenge leads to similar solutions from the different teams and that it is not as interesting for the teams to work on. As one company representative explained us:

"We didn't get many groups working for our challenge; we have a very traditional industrial challenge that does not seem to interest many people here..."—Company K.

Instead, a broader hackathon challenge invites participants to view the challenge from multiple perspectives and provide a wider range of innovative solutions to the same problem. As one company representative explained us

"Our challenge here in Junction is really broad, so we get lots of ideas. I don't really like this kind of very narrow challenge; it is not interesting for developers."—Company I.

Creating an interesting challenge for the teams was considered important to attract as many teams as possible so that the challenge could generate a large pool of new ideas. As illustrated in Fig. 6, interesting theme (65%) followed by participant's background (42%), prize (18%), interesting technology (18%), and interesting data (18%) were the participants' top criteria for choosing companies' challenges.

The challenge can also be "too open" if the goal is to find a functioning solution to a real-life challenge, as it might then be too different and far removed from the company's current business. Some of the interviewees also mentioned that it can be difficult to work with the hackathon teams to develop the idea into a functioning solution, as the teams consist of individual people, rather than real companies that have the resources to

work on the solution further. Notably, one company representative mentioned that the broader the challenge, the more difficult it might be to determine suitable solutions for implementation in the company. The company representative stated, *"the challenge was really broad—too broad, but we got a lot of great ideas. This year we wanted to make the challenge broad, but not as broad as last year. We could not implement ideas from last year's hackathon in our company."*—Company I.

Some of the companies also attended the hackathon for the first time to learn how they could use this kind of event in their open innovation process, so many of the companies did not have clear existing processes on how to implement the crowdsourced ideas. Among the companies with the main goal to crowdsource innovative solutions, 71.4% were completely successful and reached their goals, 14.3% attained mediocre results, and 14.3% failed in this regard. As one company representative stated, *"we have gotten good programs from here in the past few years. Not all have been fully implemented 100%, but we have gotten a lot of good ideas and money has been exchanged"*—Company A.

2) Talent Acquisition: Although crowdsourcing innovative solutions was the most common goal for most companies attending Junction, talent acquisition was among the goals of 57.9% and was the primary goal of 15.8% of the companies (see Fig. 5). As one company representative stated, *"we are here mainly to recruit more people"*—Company E.

Junction gathers some of the brightest young software talents from around the world in one place, which makes it a suitable place for companies to recruit new members to their teams. The Junction team has created an interview process for participating companies and potential candidates during the hackathon. The companies receive basic information about the participants (those who have agreed to share their information to the companies) from the Junction app. The app has a "comment" function in which companies can send invitations to meet up. The Junction venue has a dedicated meeting area in which companies and participants can meet. Additionally, some companies can post job listings to the Junction website. By using the Junction app as a matchmaking tool, 7.8% of the participants in this article established connections with companies regarding current and future recruiting opportunities.

Junction was held on the Aalto University campus in Otaniemi. Some of the interviewed companies mentioned that this location attracted them to participate in the hackathon. Companies B and D had many employees who came from Aalto University, which allowed them to see this hackathon as a great opportunity to meet potential candidates and hire more people from the university. This was also reflected during interviews:

"We have a lot of ex Aalto people working in our company... We need to get our name known here and understand what kind of talent is out there"—Company B.

"We have many employees from Aalto. We want to make our brand visible here."—Company D.

3) Employer Branding: Employer branding was among the goals of 42.1% and the main goal of 15.8% of the companies (see Fig. 5). While Junction has collected some of the brightest young software talents, it is a great opportunity for companies to describe their image as an innovative and tech-forward company, as well as a "great place to work," in the minds of participants and current employees. This was also reflected during interviews:

"We want to show developers that S [company name] is a cool company."—Company S.

"Our goal is to advertise our brand around the Aalto University campus regarding later recruiting opportunities."—Company D.

4) Brand Awareness: As illustrated in Fig. 5, 42.1% of the companies mentioned brand awareness as their motivation to participate in the hackathon, and 15.8% of them stated it as their main goal in joining Junction. Some of the smaller, less well-known software companies saw Junction as the ideal hackathon to promote their company brand and introduce their business in the developer community. As one of the company representatives stated, *"we want to raise awareness. People don't know about our company."*—Company G.

As a brand marketing strategy, the majority of companies gave participants promotional products such as hoodies or bags. This could truly help participants, as potential future customers, to recall and recognize the brand under different conditions in the future.

Some of the more established industrial companies saw Junction as the perfect opportunity to rebrand their organizational image. One of the company representatives stated, *"people experience us as a telecom company because of our history. They don't realize that we are a software company now."*—Company O.

These companies tend to be known as hardware companies, and they want to demonstrate to the community that they produce modern software products and services. This kind of branding activity helps companies attract and find talent for software development.

5) Community Building: 15.8% of the companies also mentioned community building as one of their reasons for participating in the hackathon. The companies saw the hackathon as a prime opportunity to network with engineers and build relationships in the developer community. As one company representative stated, *"there are a lot of people here from the Russian community. They have seen us somewhere before and here they come chatting to us. So, it is not only about the ideas, it is about building community—we want to network with engineers."*—Company I.

One company mentioned that Junction offered a suitable platform to connect with the European developer community. The company representative stated, *"our original idea was to organize a developer-focused meetup somewhere in the Nordic. However, inventing that kind of event from scratch is challenging... We thought, let's not invent the wheel, let's partner up... Junction has a big community of developers."*—Company S.

This came across several other informant interviews as well. It is clearly easier for companies to participate in hackathons like this than build their own community events from scratch.

E. Pervasive IT

IT refers to the computers, software, Internet, phones, tablets, communications networks, applications (e.g., Slack and Discord), cloud-based software repositories (e.g., GitHub), and any other devices that are used to send, receive, store, or process information. It plays a decisive role in facilitating and enhancing all of the aforementioned mechanisms and was vastly used in every aspect of Junction, including the planning and preparation (e.g., advertising, the application process, and selection), administration, evaluation during the hackathon (e.g., voting and data collection), and follow-ups after the hackathon (e.g., collecting feedbacks and any sort of communications among the organizing body, companies, and participants).

The Junction team utilized IT as a complementary tool for advertisements to increase visibility and to reach a more global audience. This resulted in high diversity in the nationality of the participants and companies, as well as enabled international participation, since the registration took place through a web-based application form that lowered the application barriers and widened the potential audience. This could be observed in the traveling origins of Junction participants, which were 87.2% from Europe, 5.2% from Africa, 3% from Asia, and 2.7% from North America. Moreover, the applicants could create and join their own teams through the registration platform—the Junction app.

The selection process of applicants by the Junction team-appointed committee also took advantage of IT through sharing the application materials for reviewing and cross-checking. Afterward, the announcement of the accepted applicants was performed through the Junction app, which happened during the period of selection. Additionally, the accepted applicants needed to confirm their participation—and apply for travel funding if necessary—using the Junction app. Later, the details related to the various aspects of the hackathon, including the food, location, program, attending companies, and challenges, were published on the Junction app and were shared with the participants.

During the hackathon, the IT tools played an essential role in creating an efficient and interactive environment among the Junction team, participants, and the companies. For instance, team formation for the teamless participants arriving at Junction was facilitated through announcements on Discord and Slack channels. As another example, IT was used for effective announcements from the Junction team regarding real-time events such as project submission deadlines, group photograph locations, and restaurant closing times. Moreover, teams utilized the Junction app for registration in challenges. Notably, 80% of the participants had heard about their selected challenge for the first time through the Junction website.

Each participating team utilized Discord to communicate with companies' experts (e.g., receiving information related to APIs and challenge specifics) and utilized IT tools of all sorts in the development, finalization, and presentation of their projects. Meanwhile, IT also facilitated the "matchmaking process" for companies regarding talent acquisition. In this regard, companies' experts could review participants' resumes on the Junction app and schedule interviews with individuals during the hackathon.

Furthermore, IT played an enabling role in the process of project judgment by participants (participants' evaluation), which allowed a rapid collection of the large inputs given by participants and facilitated the ranking of the projects to determine the winning teams. Without IT, the collection of feedback on such a scale would take much longer, while the use of the Gavel model for the ranking of the teams would be nearly impossible to perform.

Overall, IT played a foundational role in Junction through enabling and enhancing various aspects of this MH for all stakeholders. Therefore, we see IT as a pervasive fabric in the background that supported all aspects of Junction.

V. Discussion and Implications

A. Theoretical Implications

This article provides conceptual clarity on the different forms of hackathons and their unique properties and mechanisms. Further, this article presents a more detailed understanding of the unique crowdsourcing properties, mechanisms, and value-proposition of MHs. The MH is not only a prominent type of hackathon, but also a unique form of tournament-based crowdsourcing [7], [39], [63], [64]. In that regard, we contribute to the crowdsourcing stream of research by outlining five distinct crowdsourcing properties and mechanisms of MHs that distinguish them from other types of hackathons and forms of tournament-based crowdsourcing. These properties and mechanisms are intricate crowd selection, strong crowd vibe, instant crowd feedback, versatile crowd potential, and pervasive IT. Our contribution to the crowdsourcing theoretical body of knowledge [5], [6], [24] is the introduction of the MH as an emerging form of tournament-based crowdsourcing in which, due to its distinct properties and mechanisms, the probability of companies crowdsourcing a problem is high. According to [5], the more pervasive the problem-solving expertise is in the crowd, the more likely it is that someone in that crowd can solve the problem, and thus the probability is greater for companies to crowdsource it. We find that it is through intricate crowd selection that problem-solving expertise in the crowd can be successfully verified. Additionally, MHs' intricate crowd selection ensures diversity, motivation, and skills, while other forms of tournament-based crowdsourcing typically rely on skill-driven crowd selection. For instance, in Topcoder Open [64] and 99designs [39], the crowd selection is based on skill and community involvement, while diversity and motivation do not play a role.

Moreover, the literature suggests [5], [24] that the more motivated the members of a crowd are to solve a problem, the higher the probability is that the company will crowdsource it. We identify the strong crowd vibe as a central motivator. The literature indicates some controversy regarding motivations; however, our findings are in line with empirical studies from Kitsios and Kamariotou [15], [19]. In other forms of tournament-based crowdsourcing, while the prize is a key source of motivation [39], [63], [64], our study reveals that, in MHs,

the prize is not the main trigger [15], and it instead acts as a complementary incentive for participants.

Furthermore, according to the literature [5], [24], the more users who are available to evaluate a solution, the more likely it is that companies will crowdsource their problems, and the probability of crowdsourcing is higher. With regard to MHs specifically, the instant crowd feedback mechanism allows companies to rapidly take advantage of the large number of reviews for the solutions presented, whereas in other forms of tournament-based crowdsourcing, the company itself typically chooses the winning solution [39], [63], [64].

Finally, we find versatile crowd potential for the companies attending MHs. Hence, the value proposition of MH for companies, including talent acquisition, employer branding, creating brand awareness, and community building, is beyond crowdsourcing solutions alone. While our study focuses on MH, the contributing properties and mechanisms are also present with different emphases in other subforms of crowdsourcing. Hence, our article provides directions to further distinguish the various subforms of crowdsourcing and their unique crowdsourcing properties and mechanisms and show how these may differ with respect to the probability of a company crowdsourcing a problem.

B. Managerial Implications

Innovation managers use the MH as a new tool to venture beyond conventional ideation, as well as derive benefit from various prototypes and novel ideas for business innovation [9]. Using MHs allows managers to shorten the innovation cycle and access a diverse set of quality ideas. More explicitly, the managers can exploit hackathons to crowdsource innovative solutions for cases, in which they do not know who can solve the problem. The findings suggest that, in addition to crowdsourcing innovative solutions, managers can benefit from hackathons through talent acquisition, employer branding, creating brand awareness, and community building. However, some companies attend and derive limited benefits from hackathons while exerting the same amount of effort as the others. By realizing the properties and mechanisms of MHs, company managers can consciously plan and prepare for the hackathon while knowing what to expect during the hackathon. Furthermore, we argue that the versatile crowd potential offered in an MH makes this type of hackathon an attractive form of tournament-based crowdsourcing.

VI. Limitations and Future Research

The data used in this article were derived from an MH in Europe, which had participating multinational American and European companies. However, investigation of more MH cases is advised. Additionally, the dataset can be expanded to include Asian MHs and Asian companies. In this research, we specifically focused on MHs as a form of tournament-based crowdsourcing. However, other types of hackathons should also be studied with regard to their crowdsourcing properties and mechanisms. Another possible area for future research is to study how the design of the companies' presented problems in an MH can enhance their crowdsourcing potential. Since the most challenging part of crowdsourcing innovative solutions in MHs is the incorporation of the solutions into the company's established business, a study of the steps required to develop and incorporate the solutions is advised. Finally, the impact of versatile crowd potential on the probability of companies crowdsourcing a problem in the MH presents an interesting opportunity for future research.

Acknowledgment

The authors are very grateful to the insightful feedback and guidance of Department Editor Terrence Brown and three anonymous reviewers for their constructive comments. This article has greatly benefited from insights and comments of Kalle Lyytinen, Christopher Tucci, Risto Rajala, Peter Kelly, Pekka Töytäri, Natalia Vuori, Timo Vuori, Henri Heliö, as well as participants at the DBOSI'20 Workshop. They are grateful to Petrus Holm and the Junction organization for letting them study their inspiring hackathon. They want to thank Leila Abiedat for her assistance during the data collection. The authors also would like to thank Editor-in-Chief Tugrul U. Daim for his invaluable support.

Appendix
Overview of the Companies and Organizations Interviewed in Junction

Company	Business area	# of employees	Interviewee Position
A	Construction and logistics	∼1500	Metal engineer foreman
B	Digital healthcare	>7000	Research scientist
C	Research laboratory	∼50	Coordinator
D	Software	∼20	Software consultant
E	Digital sales consultancy	<50	Marketing lead
F	Technology vendor	>14500	Developer relations lead
G	Intelligent lighting	∼500	Engineering and research manager
H	Service organization	∼40	IT expert
I	Online social media	∼270	Machinery and research head
J	Video game developer	∼400	Game design lead
K	Technology vendor	>12000	Innovation manager
L	University	∼4000	Project leader
M	Public agency	∼60	Marketing manager
N	Forestry	>1400	Forest guide
O	Telecommunications	>95000	Business manager
P	IT consulting	∼77000	Marketing director
Q	Public funding agency	∼600	Internal R&D team
R	Investment management	∼15000	Software developer
S	Software	>1700	Developer relations team

References

[1] H. W. Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting From Technology*. Boston, MA, USA: Harvard Business Press, 2003.

[2] H. W. Chesbrough, "The era of open innovation," *Manag. Innov. Change*, vol. 127, no. 3, pp. 34–41, 2006.

[3] M. Flores, M. Golob, D. Maklin, and C. Tucci, "Speeding-up innovation with business hackathons: Insights into three case studies," in *Proc. Conf. Acad. Des. Innov. Manage.*, vol. 2, no. 1, 2019, pp. 656–677.

[4] E. Von *Hippel, Democratizing Innovation.* Cambridge, MA, USA: The MIT Press, 2006.

[5] A. Afuah and C. L. Tucci, "Crowdsourcing as a solution to distant search," *Acad. Manage. Rev.*, vol. 37, no. 3, pp. 355–375, 2012.

[6] A. Afuah, "Crowdsourcing: A primer and research framework," *Creating Capturing Value Through Crowdsourcing*, In CL Tucci, A. Afuah, and G. Viscusi (Eds.), *Creating and Capturing Value through Crowdsourcing*, Oxford, U.K.: Oxford Univ. Press, pp. 11–38, 2018.

[7] E. Simperl, "How to use crowdsourcing effectively: Guidelines and examples," *Liber Quart.*, vol. 25, no. 1, pp. 18–39, 2015.

[8] G. Briscoe and C. Mulligan, "Digital innovation: The hackathon phenomenon," Creativeworks London Working Paper, 2014.

[9] C. Tucci, G. Viscusi, and H. Gautschi, "Translating science into business innovation: The case of open food and nutrition data hackathons," *Front. Nutr.*, vol. 5, p. 96, 2018.

[10] M. Flores *et al.*, "How can hackathons accelerate corporate innovation?," in *Proc. IFIP Int. Conf. Adv. Prod. Manage. Syst.*, 2018, pp. 167–175.

[11] CERN, "Apply for the first quantum-computing hackathon at cern in October!," Sep. 2019. Accessed Feb. 3, 2020. [Online]. Available: https://home.cern/news/announcement/computing/apply-first-quantum-computing-hackathon-cern-october

[12] I. A. Hamilton, "Elon Musk announced he's hosting a super fun AI party Hackathon at his house next month," Feb. 2020, Accessed: Feb. 3, 2020. [Online]. Available: https://www.businessinsider.com/elon-musk-announces-tesla-hackathon-at-his-home-2020-2?r=US&IR=T

[13] E. H. Trainer, A. Kalyanasundaram, C. Chaihirunkarn, and J. D. Herbsleb, "How to hackathon: Socio-technical tradeoffs in brief, intensive collocation," in *Proc. 19th ACM Conf. Comput.-Supported Cooperative Work Social Comput.*, 2016, pp. 1118–1130.

[14] M. Komssi, D. Pichlis, M. Raatikainen, K. Kindström, and J. Järvinen, "What are hackathons for?," *IEEE Softw.*, vol. 32, no. 5, pp. 60–67, Sep./Oct. 2015.

[15] F. Kitsios and M. Kamariotou, "Open data hackathons: An innovative strategy to enhance entrepreneurial intention," *Int. J. Innov. Sci.*, vol. 10, 2018, pp. 519–538.

[16] Y. Maaravi, "Running a research marathon," *Innov. Educ. Teach. Int.*, vol. 55, no. 2, pp. 212–218, 2018.

[17] J. R. Byrne, K. O'Sullivan, and K. Sullivan, "An IoT and wearable technology hackathon for promoting careers in computer science," *IEEE Trans. Educ.*, vol. 60, no. 1, pp. 50–58, Feb. 2017.

[18] S. Halvari, I. Rainio, and A. H. Suominen, "Spilling hackathon methodology to industrial fuzzy front end innovation," in *Proc. ISPIM Innov. Symp. Int. Soc. Professional Innov. Manage.*, 2018, pp. 1–14.

[19] F. Kitsios and M. Kamariotou, "Beyond open data hackathons: Exploring digital innovation success," *Information*, vol. 10, no. 7, 2019, Art. no. 235.

[20] K. Gama, "Crowdsourced software development in civic apps-motivations of civic hackathons participants," in *Proc. Int. Conf. Enterprise Inf. Syst.*, vol. 2, 2017, pp. 550–555.

[21] S. Sousa, "Lessons learnt from a public-private big data hackathon," Report, Big Innovation Centre, 2013.

[22] G. Concilio, F. Molinari, and N. Morelli, "Empowering citizens with open data by urban hackathons," in *Proc. Conf. E-Democracy Open Government*, 2017, pp. 125–134.

[23] M. Flores, M. Golob, D. Maklin, C. L. Tucci, S. West, and O. Stoll, "Dare2hack: Crowdsourcing ideas through hackathons to codesign new human-centric services," in *Proc. 7th Swiss Conf. Data Sci.*, 2020, pp. 5–10.

[24] J. Bloodgood, "Crowdsourcing: Useful for problem solving, but what about value capture?," *Acad. Manage. Rev.*, vol. 38, no. 3, pp. 455–457, 2013.

[25] J. Surowiecki, *The Wisdom of Crowds*. New York, NY, USA: Anchor, 2005.

[26] G. Viscusi and C. Tucci, *Three's a crowd? In Creating and Capturing Value Through Crowdsourcing,* C. L. Tucci, A. Afuah, and G. Viscusi, Ed. Oxford, U.K.: Oxford Univ. Press, 2018, pp. 39–57.

[27] W. Challenger, W. Clegg, and A. Robinson, "Understanding crowd behaviours: Guidance and lessons identified," U.K. Cabinet Office, pp. 11–13, 2009.

[28] J. Prpić, P. P. Shukla, J. H. Kietzmann, and I. P. McCarthy, "How to work a crowd: Developing crowd capital through crowdsourcing," *Bus. Horiz.*, vol. 58, no. 1, pp. 77–85, 2015.

[29] E. Estellés-Arolas and F. González-Ladrón-de Guevara, "Towards an integrated crowdsourcing definition," *J. Inf. Sci.*, vol. 38, no. 2, pp. 189–200, 2012.

[30] T. Economist, "Following the Crowd," Sep. 2008. Accessed: Feb. 3, 2020. [Online]. Available: https://www.economist.com/technology-quarterly/2008/09/06/following-the-crowd

[31] J. Howe, "The rise of crowdsourcing," *Wired Mag.*, vol. 14, no. 6, pp. 1–4, 2006.

[32] J. Howe, *Crowdsourcing: How the Power of the Crowd is Driving the Future of Business*. New York, NY, USA: Random House, 2008.

[33] C. Horn, M. Bogers, and A. Brem, "Prediction markets for crowdsourcing," in *Creating Capturing Value Through Crowdsourcing*. London, U.K.: Oxford Univ. Press, 2018, pp. 292–309.

[34] N. J. Foss, L. Frederiksen, and F. Rullani, "Problem-formulation and problem-solving in self-organized communities: How modes of communication shape project behaviors in the free open-source software community," *Strategic Manage. J.*, vol. 37, no. 13, pp. 2589–2610, 2016.

[35] D. C. Brabham, "Crowdsourcing as a model for problem solving: An introduction and cases," *Convergence*, vol. 14, no. 1, pp. 75–90, 2008.

[36] C. L. Tucci, A. Afuah, and G. Viscusi, *Creating and Capturing Value Through Crowdsourcing*. London, U.K.: Oxford Univ. Press, 2018.

[37] M. Vukovic, "Crowdsourcing for enterprises," in *Proc. Congr. Serv.-I.*, 2009, pp. 686–692.

[38] D. Geiger, S. Seedorf, T. Schulze, R. C. Nickerson, and M. Schader, "Managing the crowd: Towards a taxonomy of crowdsourcing processes," in *Proc. Amer. Conf. Inf. Syst.*, 2011, pp. 1–11.

[39] U. Hassan and E. Curry, "A capability requirements approach for predicting worker performance in crowdsourcing," in *Proc. 9th IEEE Int. Conf. Collaborative Comput., Netw., Appl. Worksharing*, 2013, pp. 429–437.

[40] S. S. Levine and M. J. Prietula, "Open collaboration for innovation: Principles and performance," *Org. Sci.*, vol. 25, no. 5, pp. 1414–1433, 2014.

[41] C. Franzoni and H. Sauermann, "Crowd science: The organization of scientific research in open collaborative projects," *Res. Policy*, vol. 43, no. 1, pp. 1–20, 2014.

[42] E. Mollick, "The dynamics of crowdfunding: An exploratory study," *J. Bus. Venturing*, vol. 29, no. 1, pp. 1–16, 2014.

[43] C. Horn, M. Bogers, and A. Brem, "Prediction markets for crowdsourcing," in *Creating Capturing Value Through Crowdsourcing*. London, U.K.: Oxford Univ. Press, 2018, pp. 292–309.

[44] K. Fort, G. Adda, and K. B. Cohen, "Amazon mechanical turk: Gold mine or coal mine?," *Comput. Linguistics*, vol. 37, no. 2, pp. 413–420, 2011.

[45] T. W. Malone, R. Laubacher, and C. Dellarocas, "The collective intelligence genome," *MIT Sloan Manage. Rev.*, vol. 51, no. 3, 2010, Art. no. 21.

[46] J. Porras *et al.*, "Hackathons in software engineering education: Lessons learned from a decade of events," in *Proc. 2nd Int. Workshop Softw. Eng. Educ. Millennials*, 2018, pp. 40–47.

[47] T. Kigawa, "The movie hackathon an experimental event to produce community-based local movies," *J. Glob. Tourism Res.*, vol. 1, no. 2, pp. 97–100, 2016.

[48] A. Carruthers, "Open data day hackathon 2014 at Edmonton public library," *Partnership, Can. J. Library Inf. Pract. Res.*, vol. 9, no. 2, pp. 1–13, 2014.

[49] H. Kienzler and C. Fontanesi, "Learning through inquiry: A global health hackathon," *Teach. Higher Educ.*, vol. 22, no. 2, pp. 129–142, 2017.

[50] Yohan, "Physical or online? how to make your hackathons a success," Accessed: Feb. 3, 2020. [Online]. Available: https://get.agorize.com/physical-or-online-how-to-make-your-hackathons-a-success/

[51] A. I. Böhmer, A. Beckmann, and U. Lindemann, "Open innovation ecosystem—Makerspaces within an agile innovation process," in *ISPIM Innov. Summit*, Brisbane, Australia, pp. 1–11, 2015.

[52] K. Gama, "Preliminary findings on software engineering practices in civic hackathons," in *Proc. IEEE/ACM 4th Int. Workshop CrowdSourcing Softw. Eng.*, 2017, pp. 14–20.

[53] N. Linnell, S. Figueira, N. Chintala, L. Falzarano, and V. Ciancio, "Hack for the homeless: A humanitarian technology hackathon," in *Proc. IEEE Glob. Humanitarian Technol. Conf.*, 2014, pp. 577–584.

[54] R. K. Yin, "How to do better case studies," *SAGE Handbook of Applied Social Research Methods*. Thousand Oaks, CA, USA: Sage publications, vol. 2, pp. 254–282, 2009.

[55] J. W. Creswell and J. D. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Thousand Oaks, CA, USA: Sage publications, 2017.

[56] A. Dubois and L.-E. Gadde, "Systematic combining: An abductive approach to case research," *J. Bus. Res.*, vol. 55, no. 7, pp. 553–560, 2002.

[57] M. N. Marshall, "Sampling for qualitative research," *Fam. Pract.*, vol. 13, no. 6, pp. 522–526, 1996.

[58] P. Mayring, "Qualitative content analysis," *A Companion to Qualitative Research*. Thousand Oaks, CA, USA: Sage Publicatons, vol. 1, no. 2, pp. 159–176, 2004.
[59] K. Locke, K. Golden-Biddle, and M. S. Feldman, "Perspective-making doubt generative: Rethinking the role of doubt in the research process," *Org. Sci.*, vol. 19, no. 6, pp. 907–918, 2008.
[60] J. Corbin and A. Strauss, *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. Thousand Oaks, CA, USA: Sage Publications, 2014.
[61] J. I. Yellott Jr, "The relationship between Luce's choice axiom, thurstone's theory of comparative judgment, and the double exponential distribution," *J. Math. Psychol.*, vol. 15, no. 2, pp. 109–144, 1977.
[62] L. L. Thurstone, "A law of comparative judgment," *Psychol. Rev.*, vol. 34, no. 4, pp. 273–286, 1927.
[63] J. A. Villarroel, J. E. Taylor, and C. L. Tucci, "Innovation and learning performance implications of free revealing and knowledge brokering in competing communities: Insights from the Netflix prize challenge," *Comput. Math. Org. Theory*, vol. 19, no. 1, pp. 42–77, 2013.
[64] K. R. Lakhani, D. A. Garvin, and E. Lonstein, "Topcoder (a): Developing software through crowdsourcing," Harvard Bus. School Gen. Manage. Unit Case, no. 610032-PDF-ENG, 2010.

Alireza Jaribion is currently working toward the Ph.D. degree with the Department of Industrial Engineering and Management, Aalto University, Espoo, Finland.

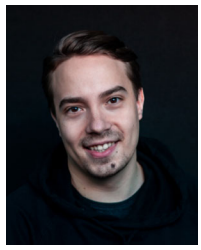
His research interests include the operations management, additive manufacturing, digital twins, fuzzy intelligent systems, data analytics, and open innovation.

Siavash H. Khajavi received the Ph.D. degree in industrial engineering and management from Aalto University, Espoo, Finland, in 2018.

He is currently a Postdoctoral Researcher and the Project Manager with the Department of Industrial Engineering and Management, Aalto University. His research interests include operations management, additive manufacturing, and digital twins.

Ulriikka Järvihaavisto is currently working toward the Ph.D. degree with the Department of Industrial Engineering and Management, Aalto University, Espoo, Finland.

Her research interests include ecosystem and platform strategy, decentralized ecosystem governance, and organizational identity change.



Iiro Nurmi received the M.Sc. degree in computer science from Aalto University, Espoo, Finland, in 2020.

He is a product Manager with Smartly.io and former CEO at Junction. His research interests include hackathons, leadership, people, creativity, processes, and technology.

Robin Gustafsson received the doctor of science degree in technology from Aalto University, Espoo, Finland, in 2010.

He is currently an Associate Professor of Strategic Management with the Department of Industrial Engineering and Management, Aalto University, Finland. His research focuses on strategy, organization and policy in technology-induced industry and market disruptions.

Jan Holmström received the Dr.Tech. degree from the Helsinki University of Technology, Espoo, Finland, in 1995.

He is currently a Professor of Operations Management with the Department of Industrial Engineering and Management at Aalto University, Finland. He is also an Expert in supply chain management and design science research. He has published extensively on the improvement of operations in industrial, project, and retail supply chain contexts.