R&D MANAGEMENT

Open innovation in the face of the COVID-19 grand challenge: insights from the Pan-European hackathon 'EUvsVirus'

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Being a grand challenge of global scale, the COVID-19 pandemic requires collective and collaborative efforts from a variety of actors to enable the expected scientific advancement and technological progress. To achieve such an open innovation approach, several initiatives have been launched in order to leverage potential distributed knowledge sources that go beyond those available to any single organization. A particular tool that has gained some momentum during COVID-19 times is hackathons, which have been used to unleash the innovation potential of individuals who voluntarily came together, for a relatively short period of time, with the aim to solve specific problems. In this paper, we describe and analyze the case of the hackathon EUvsVirus, led by the European Innovation Council. EUvs Virus was a 3-day online hackathon to connect civil society, innovators, partners, and investors across Europe and beyond in order to develop innovative solutions to coronavirus-related challenges. We have identified four dimensions to explore hackathons as a crowdsourcing tool for practicing effective open innovation in the face of COVID-19: broad scope, participatory architecture, online setting, and community creation. We discuss how these four elements can play a strategic role in the face of grand challenges, which require, as in the case of the COVID-19 pandemic, both urgent action and long-term thinking. Our case analysis also suggests the need to look beyond the 'usual suspects', through knowledge recombination with atypical resources (e.g., retired experts, graduate students, and the general public). On this basis, we call for a broader perspective on open innovation, to be extended beyond openness across organizational boundaries, and to explore the role of openness at societal level.

1. Introduction

Our society is currently going through the COVID-19 pandemic, as announced in March 2020 by the World Health Organization (2020). Public institutions have globally recognized that this pandemic not only represents a health emergency, but is also a human, economic, and social crisis, since it can lead to an increase of inequality, exclusion, discrimination, and global unemployment in the medium and long-term (United Nations, 2020a). According to the words of the Secretary-General of the United Nations António Guterres, COVID-19 pandemic is 'the most challenging crisis we have faced since the Second World War' (United Nations, 2020b).

COVID-19 actually represents what the management literature has previously labeled as 'wicked problem' (Head, 2008; Dorado and Ventresca, 2013) and, more recently, 'grand challenge' (Ferraro et al., 2015; George et al., 2016). COVID-19 presents all the three main aspects of a grand challenge individuated by Ferraro et al. (2015). It is in fact characterized by many interactions and nonlinear dynamics (i.e., complexity), its evolution is difficult to forecast for the actors (i.e., uncertainty), and it cuts across jurisdictional boundaries (i.e., evaluativity). As it happens with extensive and difficult to solve problems, the fight against COVID-19 pandemic requires a collective, coordinated, and sustained effort from numerous and different actors, to pursuit bold ideas and the adoption of less conventional approaches (Colquitt and George, 2011; George et al., 2016) in order to enable the required scientific advancement and technological progress.

Crises and large-scale disasters may become great stimulants of innovation, therefore, this could be seen as an important opportunity to investigate how coordinated and collective efforts can be achieved through open innovation, as a framework to develop new solutions to fight back (Chesbrough, 2020). Companies have often adopted open innovation, intended as a 'distributed innovation process based on purposively managed knowledge flows across organizational boundaries (Chesbrough and Bogers, 2014, p. 17), to speed up their innovation processes (Lazzarotti and Manzini, 2009; Dahlander and Gann, 2010; West and Bogers, 2014, 2017), and it has also been increasingly explored recently as a way to address grand challenges (Ahn et al., 2019; Sims et al., 2019; Bogers et al., 2020; McGahan et al., 2020).

The increasing demand for collectively supporting systemic grand challenges highlighted the role that open innovation can play, as the trigger to activate collaboration between traditional and eclectic sources, to enhance our collective ability to protect human life. For instance, we learn from crowdsourcing initiatives that the continued evolution of innovation models is creating a breeding ground for unsuspected supporters (Foege et al., 2019; Mack and Landau, 2020; Vermicelli et al., 2020). More specifically, over the last years, we have experienced the emergence of hackathons as an innovative practice based on participatory activity (Lifshitz-Assaf et al., 2020). The term 'hackathon' comprises the words 'hacking' and 'marathon'. While the former indicates the process of creative problem-solving, designing, prototyping, and tackling of the challenge, the latter refers to the intensity of the event, which is usually concentrated in 48–72 hr (Flores et al., 2019). Originally conceived as design, sprint-like, events with the primary goal to develop coding, hackathons have shifted over time away from being technology-oriented gatherings, toward becoming issue-oriented, and involving a much wider audience in a broader range of activities (Taylor and Clarke, 2018).

Since the beginning of the pandemic, we have witnessed a large diffusion of hackathons addressing coronavirus-related challenges (Vermicelli et al., 2020). In April 2020, the European Innovation Council led the EUvsVirus hackathon, an unprecedented initiative involving over 30,000 people from across Europe and beyond (innovators, partners, investors, and civil society), with a total of more than 2,000 projects submitted. We have taken inspiration from this initiative, which represents the first attempt to coordinate a Pan-European hackathon across communities and sectors, to conduct a case study aimed at answering the research question: 'How does a hackathon function as a tool for open innovation, to address the COVID-19 grand challenge?'.

This paper reflects on the dynamics of the event by investigating organizational challenges and enabling factors in the context of hackathons, in order to spur distributed innovation when facing complex challenges. Our discussion focuses on four elements, namely broad scope, participatory architecture, online setting, and community creation, starting from which we provide theoretical and practical insights in the domains of open innovation and R&D.

2. Conceptual background

Crowdsourcing has been broadly defined as the act of broadcasting tasks to a 'crowd' rather than to a designated 'agent', through an open, flexible

call (Howe, 2006; Jeppesen and Lakhani, 2010; Afuah and Tucci, 2012; Brunswicker et al., 2017; Tucci et al., 2018; Mack and Landau, 2020). It now represents an established open innovation tool to speed up innovation processes and consider alternative models to cross-disciplinary R&D teams, and/or R&D alliances, to explore knowledge across boundaries (Boudreau and Lakhani, 2013; Malhotra and Majchrzak, 2014).

The prevailing assumption behind crowdsourcing research was originally that crowds are able to provide novel solutions to well-defined problems, while the complex interdependencies of ill-defined problems can inhibit crowd's contribution to creative solutions. However, in recent years, the literature has recognized that ill-defined problems can be solved when combining knowledge across different perspectives (i.e., disciplines, experiences, and responsibilities), since it is not an easy task to determine in advance who the expert is (Malhotra and Majchrzak, 2014).

This approach has led to the emergence of a research stream aimed at exploring how to leverage crowds for solving complex problems. Majchrzak and Malhotra (2020), for instance, have developed a theory of corporate crowdsourcing in which the wicked problems are mainly framed as related to the development of new business models, new product lines, and new growth strategies. Other recent studies, on the contrary, have moved their focus onto government, not-profit organization, and community crowdsourcing, investigating social issues as complex problems that need to be addressed. The one by Almirall et al. (2014) investigates civic open innovation, providing evidence that crowdsourcing is an established practice within cities. Randhawa et al. (2019), instead, shed light on how government agencies engage with an external crowd of potential solvers to develop open innovation for social purposes, while Sims et al. (2019) develop a process model to understand how an open-source software community uses open innovation to address the societal challenge of providing affordable medical record-keeping software in developing countries. Schmidthuber et al. (2019) investigate open government for social innovation, by examining citizen involvement in an ideation platform initiated by a local government, and the motivations that affect participation intensity. Finally, Porter et al. (2020) present a case study of the environmental sustainability initiative Save Our Oceans, to understand how crowdsourcing can encourage diverse and heterogeneous stakeholders to interact constructively over time to generate novel ideas for developing sustainable solutions.

A crowdsourcing tool that is attracting increasing attention for leveraging crowds is the hackathon model. According to the definition provided by Lifshitz-Assaf et al. (2020, p. 1), hackathons can be intended as 'accelerated innovation processes that bring together individuals to voluntarily […] solve specific and ambitious challenges in an extremely limited and ad hoc time frame'. Literature on hackathons is still at an early stage, however, the practice shows that hackathons have shifted over time away from being primarily technology-oriented toward being more issue-oriented (Brabham, 2013; Taylor and Clarke, 2018; Patel, 2019), involving a much wider audience with the aim to address societal challenges (Porter et al., 2020). Since the coronavirus outbreak, dozens of COVID-19 hackathons have taken place to try to hack the virus. The social distancing imposed by governments has forced them to be moved online and their models rethought. The aim of our study is to shed light on how hackathons can be leveraged, in practice, to promptly address the COVID-19 crisis, gaining inductive insights on how they can work before grand challenges.

3. Methodology

3.1. Case description: the EUvsVirus hackathon

As COVID-19 reached pandemic proportions, pressures to take action rapidly increased. In this turbulent context, we have witnessed collective attempts to stimulate innovation efforts for disrupting solutions. An interesting phenomenon that captured our attention is the wave of hackathons that have taken place at local and/or national level to address the unprecedented challenges and negative effects brought by the COVID-19 pandemic. The European Commission, far from being indifferent to this turmoil, has organized the EUvsVirus hackathon, led by the European Innovation Council, which took place online on April 24th–26th. This event not only represented the first pan-European hackathon in the face of COVID-19, but it also attempted to institutionalize a new collaborative innovation model across countries. Civil society, innovators, partners, and investors across Europe invested their time and energy to develop innovative solutions for coronavirus-related challenges. Such a great engagement has been facilitated by the word of mouth generated on the web, and by the presence of national curators (who had already organized a national edition of a hackathon for

finding solutions for the COVID-19 crisis) that have agreed to collaborate with EUvsVirus. The event thus gathered more than 30,000 people from approximately 140 countries, to devise and plan over 2,000 solutions. For some participants it was not the first experience in a similar hackathon, and their solutions had been already developed in others, while other participants had to develop their projects from scratch.

Due to its ambitious and broad scope, the hackathon was articulated around six domains (i.e., Health & Life, Business Continuity, Social & Political Cohesion, Remote Working & Education, and Digital Finance, and Other). Each domain was then articulated in smaller challenges, for a total of 37 (see Table 1).

EUvsVirus rewarded more than 100 ideas with over 100,000 euros pledged by partnering organizations for the hackers' hard work and their novel solutions with the greatest potential to save lives and minimizing the effects in lifestyle during a global pandemic. To select the winners, ideas have been weighted according to impact potential (40%), technical complexity & novelty (20%), prototype completion (20%) and business plan (20%) (see Table 2).

Submissions have been evaluated by a panel of five jurors using the evaluation criteria mentioned above on a scale of 1–5 for each criterion, and the sum of the scores made the final submission score. They have then been evaluated in comparison with the submissions within the same challenge. Submissions ranked in the top 10% of each challenge were then presented in front of a panel of highly recognized, leading experts in the domain of that specific challenge. The panel held yet another voting with the same criteria, to select the winning project and two runner ups.

Table 1. List of domains and challenges

Domain	Challenges
Health & life	Protective equipment
	Ventilators/respirators
	Protection of medical personnel
	Real time communication & prevention
	Cheap rapid tests
	Lack of skilled caregivers
	Research
	Other
Business continuity	Efficient team work
	New and resilient business models
	Value chains & logistics
	Protecting employees
	Demonstrate purpose
	Stay close to your customers
	Other
Social & political cohesion	Protection of isolated & risk groups
	Mitigating fake news spreading
	Support arts & entertainment
	Fight against crime
	Protection of citizens & democracy
	Developing people-driven economies
	Other
Remote working & education	E-Learning methods & tools
	Efficient remote working
	Family life during remote working & education
	Primary and secondary school-specific challenges
	University-specific challenges
	Students' challenges
	Other
Digital finance	Support identification of financial shortfalls
	Speed-up access to financial support
	Speed-up distribution of financial support
	Availability of emergency health insurance
	Enable crowd to help financially
	Support for digitally excluded
	Other
Other	Any challenge not falling into the other categories

Source: https://www.euvsvirus.org/finalreport.pdf.

3.2. Data collection and analysis

Our research question: 'How does a hackathon function as a tool for open innovation to address the COVID-19 grand challenge?' answers to Eisenhardt et al.'s (2016) call to investigate grand challenges through inductive methods. We sought to provide a rich description of a single case, with the purpose of inspiring new ideas and developing practical and theoretical in-depth insights from a contextual empirical phenomenon (Dubois and Gadde, 2002; Eisenhardt and Graebner, 2007). EUvsVirus has been chosen because the event achieved impressive numbers compared to the other hackathons that have addressed COVID-19-related challenges. Furthermore, we were interested in this initiative due to its experimental nature and to the direct involvement of the European Commission and the European Innovation Council, that enabled relevant policy implications.

We have developed our findings by collecting and triangulating multiple primary data sources: observations, interviews, and document analysis (Table 3).

Table 2. Judging criteria

40% Impact potential	What is the impact to society if the idea is implemented at scale? Does this offer something that hasn't been solved already? If it has been solved, does this offer something different? Can it be scaled to meet thousands or even millions of people?
20% Technical complexity & novelty	Technical complexity does not necessarily mean code. This could be anything, hardware designs, specialized test kits or even a complex but clear business plan. Is this an innovative solution?
20% Prototype completion	Is there a ready technical prototype of the solution? If so, does it work well? Does the prototype present well the idea of the solution? How fast can the prototype be turned into a ready-to-use product?
20% Business plan	It is essential to consider the feasibility, economic and societal value, market knowledge and sustainability of the solution. What resources are needed to implement the solution?

Source: https://www.euvsvirus.org/finalreport.pdf.

Table 3. Overview of data sources

Data source	Detail	Use of data
Observation	One of the authors has joined the hackathon as team coordinator. Two of the authors have monitored in real-time the hackathon public activities/events on the social media Facebook and Twitter. Two other researchers collaborated to the observations by engaging as team participant and mentor, respectively	Observations and informal interactions within the hackathon provided us with a solid understanding of the context. These data helped to understand how the event was organized and which organizational choices were made in order to reassure the success of the event. Enabling factors and related challenges emerged. The participation in the hackathon in different roles allowed us to adopt a multifaceted perspective and to enrich the quantity of data captured
Interviews	We conducted twenty informal interviews with different actors during the hackathon. Eleven additional interviews and meetings with organizers were carried out after the event (interviewees: team participants, mentors, team coordinators, partners, organizers)	The informal interviews helped us to understand how the hackathon was progressing, combining authors' own opinions with other perspectives. The formal interviews at the end of the hackathon as well as the meetings with the organizers allowed for follow up, clarification and validation of emerging findings
Document analysis	"EUvsVirus" official website, press releases from European Commission, "EUvsVirus" public events on social media (e.g., interviews, coffee breaks, etc.), participants' posts on social media and personal blogs	The document analysis provided us with additional sources to identify statistics about the hackathon (no. of participants, partners, challenges, projects, etc.). Due to the dimension of the event, website and social media monitoring allowed us to obtain a comprehensive understanding of how the hackathon unfolded. The analysis of participants' online activity on blogs and social media further revealed their opinions about the event

As a first source of data, one of the authors along with another researcher with extensive experience as organizer and mentor in hackathons, participated in the event with the respective roles of team coordinator and mentor. The other two co-authors followed the online institutional activity of the hackathon through social media. Another colleague collaborated in this study by joining the event as a team participant. This made possible to capture data in real time and collect hour-by-hour field notes (Lifshitz-Assaf et al., 2020). All of the authors also engaged, after the event, in follow-up meetings with both participants and organizers.

As a second source of data, we investigated participants' perception and interpretations of the unfolding event, conducting twenty informal online interviews during the initiative (Hernes, 2014). These interviews were then integrated with eleven additional semi-structured interviews with organizers, conducted after the conclusion of the event. Although the protocol of interviews changed over time according to the role of the interviewee in the hackathon and the possible emergence of new queries (Gillham, 2005), all the interviewees were generally asked how familiar they were with hackathons, what were their motivations for participating, general comments and perceptions, benefits and challenges of the event, comparison with physical hackathons, and suggestions for improvements.

As a third source of data collection, we relied on archival documents. We have analyzed the

institutional documentation provided online before, during, and after the hackathon. We have also monitored social media and blogs in order to intercept information and opinions regarding the hackathon, from both the organizers and third parties.

These three sources of data generated our unit of analysis (field notes, interview transcripts, and archival data), and were coded using NVivo by one of the authors. A first analysis resulted in 350 empirically derived first-order nodes. In a second phase, the reference nodes have converged in 26 themes, following an iterative approach between empirical data and innovation management literature. As a last step, the three authors, have consolidated the 26 themes in four higher-order coding themes (i.e., broad scope, participatory architecture, online collaboration, and community creation) (see Table 4). At the end of the process, we have discussed the findings with the fourth researcher that participated in the hackathon as a mentor for further discussion and validation. The four elements that we have individuated are expected to activate effective crowdsourcing initiatives for practicing open innovation in the face of grand challenges, such as COVID-19. But they can also result as challenging. Some of the themes that were consolidated into higher-order categories refer, in fact, to possible bottlenecks (as in the case of *coordination* and *inexperienced participants* referring to the broader theme 'Participatory architecture' or *disengagement* referring to the broader theme 'Online collaboration'). In the next section, the four dimensions individuated during the coding analysis will be discussed to shed light on related positive outcomes, challenges, and management strategies.

4. Findings

4.1. Broad scope

In order to provide guidance for participants, EUvsVirus individuated six domains that have been subsequently split up in 37 challenges, as described in Section 3.1. Due to the complexity of COVID-19 phenomenon and its impact on society, the organizers did not provide a too detailed definition of any challenge. They only mentioned the topic. Under

Table 4. Data coding

First-order nodes	Themes	Generic themes
12	Problem complexity	Broad scope
9	Disruptive innovation	
21	Generating solutions	
6	Ambiguity	
23	Mass participation	
24	Unsuspecting supporters	Participatory architecture
8	Collective learning	
5	Absorptive capacity	
20	Coordination	
12	Inexperienced participants	
24	Self-management	
8	Permeable layers	
7	Small teams	
10	Media coverage	Online setting
19	Reduced innovation costs	
8	Real time feedback	
12	Disengagement	
19	Digital divide	
15	Online coordination	
6	Pre-event training	
7	Break activities	
17	Increased impact	Community creation
9	Sustaining novelty	
12	Generating engagement	
23	Matchathon	
14	Long-term collaboration	

the 'Business Continuity' domain, for instance, they individuated challenges such as 'Efficient Team Work', 'New and Resilient Business Models' and 'Value Chains & Logistics'. Then, under each challenge there was a list of possible relevant issues to be addressed. Examples of issues under the challenge 'Efficient Team Work', were, for instance, 'Improving Productivity Working at Home', 'Improve Communication', and 'Tracking Remote Work' (see Table 5).

The organizers' aim was at least twofold, as it emerged from the follow-up meetings. First, they wanted to incentivize mass participation. Proposing too specific definition of the challenges would have

Table 5. An example of how a specific domain was articulated

Challenges business continuity	Critical issues
Efficient team work	Improving productivity working at home
	Improve communication
	Tracking remote work
	Teambuilding during remote work
	How to enable more wide-spread teleworking?
New and resilient business models	Support in swiftly shifting production / service delivery to address the current needs (e.g., protective equipment)
	Tools and new business models too allow the service sector (e.g., tourism and ho-re-ca) to keep providing value to customers
	Easy tools to help start-ups and SMEs move online
	New business models or ideas which would consider other big crisis, while creating jobs to recover from the economic crisis created by COVID-19
	Quick and efficient job matching, to allow a match between rapidly changing jobs supply and demand, including for seasonal work and with priority for critical sectors (health, agriculture and food supply chain, etc.)
	Use of open source platform for e-commerce for click-and-collect online commerce services, free to any small and medium businesses
	To develop online platforms that enable customers to purchase solidarity vouchers to support their local SMEs
Value chains & logistics	Reconfiguring value chains – quickly adapt businesses to position themselves in changing value chains, find new suppliers and customers in a changing economy
	Logistics and value chains develop systems that allow users to better adapt their stock management and logistics to quickly adapt to changing demand and circumstances (e.g., border checks within the EU)
Protecting employees	Systems to allow companies to re-think the deployment of their workforce, to ensure their safety and minimize physical contact, while ensuring efficiency both during the transition period out of the crisis and in the medium term
	Quick and affordable disinfection systems for offices, shared spaces and public transport
	Easy decontamination of public spaces, offices, homes etc. (use of alternative methods; not only of classical disinfection liquids)
Demonstrate purpose	Shifting production to create medical equipment
	Match find & fit a solution & challenge – develop tools to match developed harvest the solutions that are immediately available and scalable to be provided urgently to hospitals, and other relevant players, such as businesses, clusters, public authorities etc.
	European Industrial value chains analysis, reinforcing, flexibilization, redesign
	Upskilling and reskilling plans for an exit strategy
	Collaborative ways to speed up production processes
	3D printing capabilities in Europe inventory
	How smart cities can fight COVID-19
Stay close to your customers	Under this challenge, we aim at figuring out how to help business to become digital. It should address also traditional (artisanal, local) and adjust its capabilities to stay in the market
Other	E.g., applications, methods, hardware relevant for this category. The above challenges are just suggestions. Feel empowered to get creative!

Source: Official website of the Hackathon EUvsVirus.

risked to attract mainly field experts. In that case, it would have been hard for them to envision an alternative framing to the problem, as it should be when facing grand challenges, that are complex by nature. Second, they wanted to play with ambiguity in order to stimulate different perspectives in the crowd and participants' creativity.

> We wanted to address COVID-19 from multiple perspectives. We wanted to give a 360-degree response and to do so we selected some domains and indicated some challenges, but then we gave the participants full freedom to interpret the challenge basing on their needs, skills, and innovative spirit.

Deciding to proceed this way, the organizers avoided at least two risks. First, stimulating the crowd to only come to incremental improvements, and not to disruptive innovation, because the problem proposed is too narrowed down. Second, encouraging the crowd to engage in problem definition with little efforts toward solution generation, as it happens sometimes when the problem is not defined at all.

4.2. Participatory architecture

EUvsVirus was built around a participatory architecture enabling collaborative innovation among experts, institutions, and unsuspecting supporters. The hackathon has involved younger and older citizens, workers from different fields (e.g., health, IoT, finance), prominent figures such as corporate CEOs, academics, investors, and representatives of nongovernmental organizations. Naturally, the organization had to deal with several challenges due to the high amount of participants.

> A lot of people that didn't work with each other before. So there was a lot of learning in terms of communication. And a lot of people that never worked with the European Commission before. So there was a specific language of communication there that you needed to understand and use.

Problems also emerged when teams had to be matched with mentors. An organizer explained:

> We did not make use of special softwares such as mentornity […] but we used Excel and Airtable. Of course, it's easier to manage the mentors on an Excel or Airtable platform when you have 40 mentors and 300 participants. But it's not so easy to manage the mentors manually when you have 2,000 mentors and 30,000 participants.

The hackathon established an organizational structure and specific roles (see Figure 1). However, in response to the need of coordinating people with those different roles (i.e., participants, mentors, team coordinators, mentor coordinators, volunteers, etc.), it has adopted a blurred multilayer structure, where people from the upper level left people from the lower level (e.g., mentor coordinators vs mentors as well as mentors vs teams, etc.) the freedom to take initiative. In this regard, during our participation in the event, we noticed how mentors self-managed to meet the needs of some teams that were still mentorless, late in the first day. In order to deal with this unexpected event, they communicated on their Slack channel to find a solution and to assign mentors to the teams that were still waiting for them. This is an example of how a technical issue has been solved with great flexibility through a bottom-up initiative.

Alongside coordination, another inevitable problem to be addressed was the skill gap among participants, coming from different backgrounds and competences. For example, a team mentor stated in its postevent reflections on social media that most of the participants lacked the design skills needed to apply human-centered design techniques to bring new ideas to the market.

However, this skill gap was mitigated partly by the matching mechanism of the hackathon, as evidenced by the case of a retired neurologist based in Northern Italy, who wanted to find ways to help self-isolating people overcome loneliness or depression during the crisis. His participation in the hackathon was motivated by the hope to match up with experts in the field of apps development.

Generally, the initiative increased citizen awareness about the active role they can play, alongside scientists and experts, in providing innovative solutions to face complex societal problems. As a team coordinator evidenced:

> In EUvsVirus we all felt equal, all on the same level, whether we were young, elderly, a CEO, or a university professor. We all found ourselves in the same context, and hierarchical roles faded away. This is what I would call collective effort for the common good […] The hackathon has helped individuals increase consciousness that each of their actions is reflected, positively or negatively, on the community. This awareness is fundamental for the fight against COVID-19 as well as other social challenges which affect us all.

People had the opportunity to engage in a process of collective learning. The strong presence of intrinsic motivations, and the opportunity to interact with people from different countries and backgrounds,

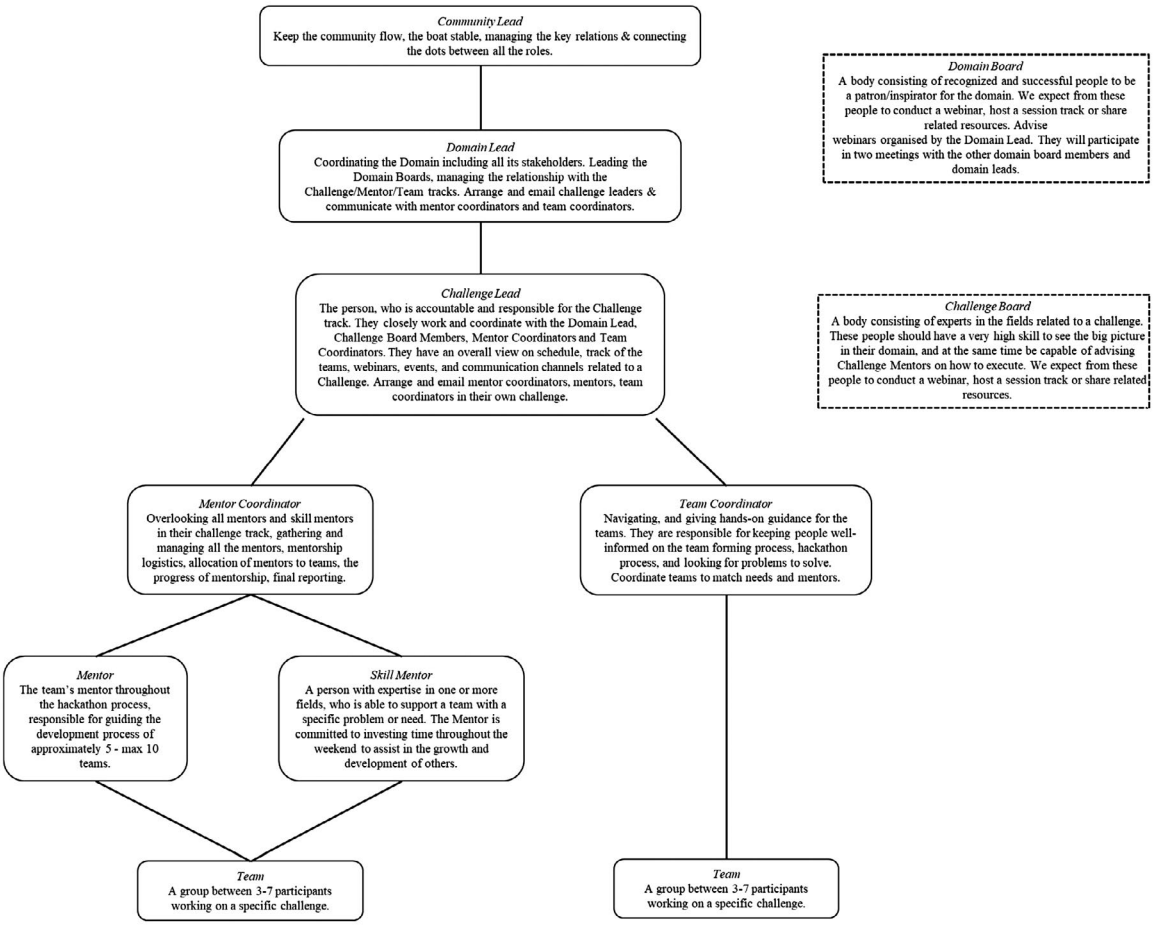

Figure 1. The organizational structure of the hackathon.*Source*: Elaborated from EUvsVirus documents.

contributed to increase the participants' capabilities to recognize, assimilate, and exploit new knowledge from the environment.

4.3. Online setting

EUvsVirus was built around virtual collaboration as a necessity imposed by social distancing. This made possible to mobilize collective intelligence at a relatively low cost, but, on the contrary, it also represented an organizational challenge.

The overall digital infrastructure of the event was created in order to make everything simple for the participants, reducing as much as possible the digital tools, renouncing as well to a specific project management or mentoring software that would have been needed. However, the participants had to necessarily manage multiple online platforms, and we realized, through our observations, how this experience has proved disorienting for some of them. To minimize this inconvenience, the organizers provided participants with a kit on how to navigate across the specific digital tools provided. More precisely, EUvsVirus hackathon made use of Slack as a coordination tool for teams (that could create their profile and get in touch with other participants, mentors, team coordinators, and partners), DevPost as a showcase for the various projects, and social media, such as Twitter and Facebook, to organize events (coffee-breaks, interviews, etc.), exchange comments on the initiative, and increase the media coverage. Participants made also use of other software (e.g., Miro) to share ideas in an open format.

Two team participants have discussed with us about the main challenges of conducting online hackathons, compared to their previous experiences in physical settings.

> *What we missed the most was a more immediate access to the advisors or mentors. […] We felt it difficult to access people that were relevant to us, the people we were assigned were jumping between thousands of calls, so that was a little hard.*

> It's hard to be creative in online sessions. The CMO of our company and myself live in the same city, so it is easier because we meet in person.

> Basically we do all the creative part, the slides etc. and we just give people work to execute. We believe that people who work from a distance can only execute, but the creative parts, the mission and the strategy is something that has to be done by a core team that meets physically. Because it's very easy to discuss functional things online, but discussing creative ideas it's very difficult. I feel one has to walk, draw on a white board, maybe even get a beer together.

On the contrary, the challenging aspects of online presence were counterbalanced by the enormous opportunity that the event gave to the various participants and partners to take advantage of a pool of ideas, knowledge, and relationships that would not have been possible in a physical context, as recognized by a team participant:

> We were not able to meet physically but the first benefit is obvious: *we were part of a hackathon with 30,000 people instead of 50 people in our own city, so it was bigger, it was more international, you were able to collaborate and connect with people from all over the world instead of just from your hometown.*

To make the event more dynamic for participants and to attract attention on social media, the organizers have also provided some events based on the model of physical hackathons, such as coffee breaks, but, above all, they have guaranteed a constant online presence on social media punctuated by interviews, live streaming and other forms of engagement.

4.4. Community creation

EUvsVirus took place with the purpose to engage people beyond the limits of the event. In the hackathon, we have witnessed the mobilization of a large community of volunteers who collaborated without monetary incentives, for the sole purpose of joining a challenge that spread across Europe and beyond. The findings from this sub-paragraph underline the importance of creating a community around a common goal for complex challenges such as COVID-19, but also the concrete needs that allow this community to have an impact. As an organizer pointed out:

> People had a common goal, this is essential, and the common goal was to fight COVID-19. This helps people build a community despite different backgrounds, different professions, and different perspectives. Maybe it wasn't so easy to manage such a big crowd but in the end you can build a community only when people can identify themselves around a specific problem. […] We know about many participants and partners that have built strong relationships during this event and we know we can count on them for future initiatives.

The numbers reached by this hackathon, favored both by the online conduct of the event and by the institutional presence of the European Innovation Council, have given rise to mechanisms that have positively surprised the adherents and have allowed the European Commission to lay the foundations of a future European innovation ecosystem ready to solve societal problems by using the power of innovation and technology.

However, the creation of a community needs to be incentivized by mechanisms that put the participants in the conditions to generate an impact. This means, above all, to implement two fundamental resources: time and money. Time to develop the project, despite the need to act promptly to fight the pandemic, and funds to allow aspiring innovators to scale up. This second aspect emerged from the opinion of a team participant, highlighting how intrinsic motivations should then be combined with extrinsic ones to strengthen long-term engagement.

> Yes, I feel part of a community and yes, I think this community is the right community to build the foundations to address challenges as well. I'm definitely sure that is true, but the community risk to feel kind of far apart, what you see now is a lot of people that contributed the whole time with the best intentions and in the end they invested 60/70/80 hr a week to work without any reward so far. Yes, we definitely need to have money to keep the spirit alive, otherwise we will be a part-time community that can address no problems at all because what we have it's only a hobby, next to our day job.

In order to strengthen the community and to speed up the process as much as possible, all the winners have been invited to an online matchathon held on May 22nd–25th. This event had the purpose to facilitate matchmaking with end-users, such as hospitals, and provide access to investors, corporates, foundations, and other funding opportunities from across the European Union.

5. Concluding discussion

Although researchers, practitioners, and policy makers are increasingly claiming that open innovation

might be the next way to tackle the world's most pressing societal challenges (European Commission, 2013; Chesbrough and Di Minin, 2014; Kohler and Chesbrough, 2019; Bogers et al., 2020), very little research, so far, has linked open innovation to societal impact before the coronavirus outbreak (Ahn et al., 2019). This study aims to move the research further, conceiving a broader perspective on open innovation which goes beyond the mere openness across organizational boundaries (Sims et al., 2019), and invites the scholars to extend the body of knowledge on open innovation by analyzing its impact not only at firm-level, but also at industry- and societal level (Bogers et al., 2017; Enkel et al., 2020; Forliano et al., 2020).

To do so, we have closely investigated the pan-European hackathon EUvsVirus in order to shed light on how it addressed the COVID-19-related challenges. We have inductively derived four elements that can enable open innovation before societal challenges, requiring urgent action and long-term thinking: broad scope, participatory architecture, online setting, and community creation. All of these aspects, however, also represent organizational challenges that can turn into benefits only through appropriate organizational design.

With regard to the first two dimensions, Majchrzak and Malhotra (2020) have introduced in their work a reflection on the scale (how many people innovating) and the scope (how big the problem, to what extent it is modular), highlighting how wicked problems and grand challenges require to unleash the crowd and to refer to broad issues that cannot be easily decomposed into neat narrow modularizable components. Our results proved to be in line with this argument, yet, partially in contrast with Majchrzak and Malhotra's reflection that digital technologies can promote knowledge sharing without necessarily requiring an interaction among the actors but only among the pieces of knowledge and ideas suggested. Our case, as a matter of fact, underlines the importance, even in online contexts, of the relational aspects of a collaboration to build a sense of community, which is relevant for complex challenges that require long-term thinking.

We also pointed out the importance of leveraging alternative framings of the problem, when complex challenges are at stake. This means that a larger scale should imply a participatory architecture, defined by Ferraro et al. (2015) as 'structure and rules of engagement that allow diverse and heterogeneous actors to interact constructively over prolonged timespans'. Although the hackathon took place for 3 days only, it was followed, 1 month later, by a matchmaking event. The analysis of this event is out of the scope of this study, however, it highlighted the efforts of the European Commission to extend the initiative over time and to strengthen the relationships within the EUvsVirus community. We have already suggested that participatory architecture in the face of grand challenges requires openness to atypical supporters (Schmidthuber et al., 2019; Sims et al., 2019). In this regard, we have found that citizens can benefit from these initiatives in several ways. For instance, they can enhance their individual ability to understand the languages of different disciplines and absorb new knowledge, fostering an individual absorptive capacity, as well as open science and innovation mentality, in the society (Ahn et al., 2019; Beck et al., 2020; Sauermann et al., 2020). Moreover, an effective governance model for responsible innovation (Scherer and Voegtlin, 2020), should balance the contribution of experts and citizens, minimizing the risk of an excessive focus on either technocratic rationality, that would leave aside the common good, or public concerns, that would downplay the role of scientific evidence.

5.1. Theoretical implications

This study contributes to the R&D literature by confirming that open R&D is more likely to lead to fitting solutions for societal grand challenges than projects undertaken within industrial or technological silos (Enkel et al., 2009). Moreover, the R&D literature has shown that there is not only one way to innovate across boundaries. For instance, at the intraorganizational level, innovation can happen by leveraging cross-functional teams or by occasionally engaging employees with suggestion boxes. At the interorganizational level, innovation can happen through R&D alliances along the supply chain, with competitors, or with other actors such as universities and governments (Bogers, 2011; Park et al., 2015; Sandulli et al., 2017). All these possible R&D practices have proven to be well established among practitioners, as well as richly studied in the literature. Their common characteristic is that they principally make use of known resources (Majchrzak and Malhotra, 2020). However, our society is increasingly called to face complex and unknown problems, that cut across fields of expertise and jurisdiction (Ferraro et al., 2015) and for which there is no way to know in advance how best to proceed (George et al., 2016). The content defined for the domain that needs to be shared is thus not known and, therefore, it is not possible to understand whoever owns domain-relevant knowledge (Majchrzak and Malhotra, 2020). In this regard, EUvsVirus enabled solution providers with

different and multifaceted knowledge backgrounds to freely respond to the challenge, giving life to a process of collective problem solving which is difficult to replicate.

This study also points out the limited academic knowledge on hackathons as increasingly relevant organizational forms in the domains of open and distributed innovation (Flores et al., 2019; Lifshitz-Assaf et al., 2020). Our study has shown that such events, with their purpose of dismantling knowledge boundaries, represent a valuable crowdsourcing model not only to provide novel solutions to well-defined problems, but also to ill-defined scientific, technological, and societal problems, as are those related to COVID-19 (Vermicelli et al., 2020). This study shows how combining the knowledge of skilled experts with that of atypical resources, such as retired experts, graduate students, and the general public (Wang et al., 2012; Chesbrough, Chesbrough; Ahn et al., 2019), can lead to unexpected innovative solutions for facing complex, uncertain, and evaluative problems (Etzion et al., 2017) like those caused by COVID-19. We also shed light on the pros and cons of conducting hackathons in an online-only modality.

5.2. *Practical implications*

Open innovation is an established innovation model in both academic research and industrial practice (Enkel et al., 2009; Gassmann et al., 2010) and it is now also becoming increasingly important in the public policy domain (Bogers et al., 2018; De Marco et al., 2020). For example, the European Commission launched the European Innovation Council with the purpose of breaking down the silos present in today's funding schemes, based on predefined calls for proposals. The aim is to embrace an open innovation philosophy to address complex problems, becoming aware that the most interesting disruptive innovations happen at the intersection of disciplines and sectors (Bogers et al., 2018). Despite these efforts, there is still high uncertainty with regard to which policies can best promote innovation. This initiative paves the way for conceiving a more inclusive model of responsible innovation, that includes also citizens in the search and development of innovative solutions, in which the European Commission is called to play the role of orchestrator of a wide innovation ecosystem that is ready for combining a broad set of knowledge, resources, capabilities, and perspectives. Moreover, collective actions can be governed through the coexistence of top-down and bottom-up efforts between institutions, central authorities, and ecosystem actors. As it is also evidenced by many interviewees, the ideas coming from corporate crowdsourcing tend to be less disruptive and more incremental, since they need to be integrated in corporate strategies and business models. Initiatives like EUvsVirus, instead, can really boost disruptive innovation. On the contrary, there is a real risk that these ideas do not scale up, because no corporates are willing to invest on them and because of lack of funds. These are the two main risks that need to be managed in order to allow innovative solutions to access the market and to provide societal impact. In other words, there is an urgent need to integrate these programs with corporate needs and strategies, to help innovators. This also means that incumbent firms and consulting companies should enter these initiatives, not just to legitimate themselves in front of the stakeholders, but to direct their behavior to integrating the ideas that come up into their business models, finding solutions for new products and services in a creative and cost-effective way, from a diverse crowd than what may be possible to gather within an organizational R&D unit. All this will facilitate the scaling up of ideas and their access to the market, in a win-win-win solution for innovators, larger firms, and society.

5.3. *Limitations and avenues for future research*

Despite the insights from the findings, this study is not free from limitations. We observed a contemporary and emerging phenomenon but we cannot capture the long-term impact of the EUvsVirus initiative in the face of COVID-19 crisis. This limit characterizes almost all the studies addressing the COVID-19 issue. But, it is also a recurrent problem in the literature on hackathons, since scholars have dedicated, so far, most of their efforts to analyze the single event, with limited attention to the potential outcomes of hackathons over time (Nolte et al., 2018). EUvsVirus, instead, contributed to the creation of a community. Next studies could then focus on scrutinizing how this community can be sustained and evolve over time, once the hackathon is over, and how it can turn into a transnational innovation ecosystem through the power of digital communication technologies. We have also mentioned that the European Innovation Council has invited all the hackathon winners to participate in an online matchathon as next step of EUvsVirus pan-European program to fight COVID-19. Further studies may analyze how the matchathon unfolded, which dynamics were established between the new actors, and how the projects evolved in this new context. This would help to understand how hackathon's energy might be funneled into winning projects. In fact, while in corporate crowdsourcing the main organization, as

solution seeker, has usually a clear strategy to incorporate the most valuable solutions, we still have less evidence on what happens in purpose-driven events such as EUvsVirus.

With regard to the methodological aspects, we based our findings on a single case study only (Eisenhardt et al., 2016). This raises some issues in terms of generalisability. However, we believe this case study represents a stepping stone to tackle the complex research gap on how open innovation and, more precisely, hackathons can contribute to tackle grand challenges in pressing times. Further research could extend the perspective and develop a more comprehensive study that considers the global wave of hackathons that have taken place in the wake of COVID-19.

Finally, research on grand challenges has overlooked so far how the Internet and new communication technologies can provide unlimited accessibility to knowledge and ideas, and incentivize collective innovation (Etzion et al., 2017). Hence, several questions remain unresolved, on how virtual spaces can stimulate multivocal coordination and fruitful interactions when different perspectives and different logics are at stake (Furnari, 2014; Ferraro et al., 2015).

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