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Crowdsourcing and COVID-19: How public administrations mobilize crowds to find solutions to problems posed by the pandemic

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Abstract: *We discuss how public administrations have used crowdsourcing to find solutions to specific problems posed by the COVID-19 pandemic, and to what extent crowdsourcing has been instrumental in promoting open innovation and service co-creation. We propose a conceptual typology of crowdsourcing challenges based on the degree of their openness and collaboration with the crowd that they establish. Using empirical evidence collected in 2020 and 2021, we examine the extent to which these types have been used in practice. We discuss each type of crowdsourcing challenge identified and draw implications for public policy.*

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Evidence for practice

- Public administrations have used crowdsourcing during the COVID-19 pandemic to respond to new and urgent needs of the population.

- We propose a conceptual distinction between four different types of crowdsourcing challenges, depending on the degree of co-creation between seekers and solvers and the degree of openness of the solution.

- Public administrations have used all four types of crowdsourcing; 'open co-creation' challenges constitute a small share of all public crowdsourcing challenges.

- There is scope for more extensive use of 'open co-creation' challenges in the context of policies responding to large-scale complex problems such as the COVID-19 pandemic.

Introduction

The scale and urgency of the COVID-19 pandemic have led governments to implement rapid and complex interventions in a variety of social and economic domains (Huang, 2020). A global wicked issue (Moon, 2020), the pandemic is characterized by complexity and uncertainty (Steen and Bradsen, 2020), affecting every aspect of life, disrupting social, organizational, and political processes (Dahlke et al., 2021; Shi et al., 2020) and highlighting the strong interdependency between social and political systems (Grizzle et al., 2020; Schomaker et al., 2021). The rapid spread of the pandemic has forced governments to implement multiple, and sometimes unprecedented, measures to prevent the collapse of healthcare systems and national economies worldwide (Bel et al., 2021; Capano and Lippi, 2021; Mei, 2020). These include making substantial investments in areas such as research and development (R&D) for vaccines and treatments, mechanisms to track the spread of infection, and the production of protection and risk reduction devices.

Crowdsourcing has played a role in this particular context. Public administrations' increasing adoption of new digital technologies – including, in particular, platform government practices, as well as open data and open-source practices – has facilitated the use of crowdsourcing to respond quickly and creatively to new and urgent needs of citizens (Bryson et al., 2013; Kim et al., 2021; O'Reilly, 2011). For example, Lim (2020, cited in Kim et al., 2021) recounts how the South Korean government, faced with a shortage of respiratory masks, published the Application Programming Interfaces (APIs) that managed the pharmacy administration system, allowing private developers to design apps to track the availability of masks in pharmacies in real time.

Crowdsourcing is the practice of obtaining solutions (services, ideas, or other contributions) from a crowd (an undefined, large group of people) by means of an internet-disseminated

open call, often via crowdsourcing platforms (Howe, 2006). The seeker and the solvers of the crowdsourced solution do not have a hierarchical relationship, and their collaboration takes place on equal terms (Schenk and Guittard, 2011).

Crowdsourcing has become a tool of public administrations, used to serve various purposes (Brabham, 2015; Bryson et al., 2013; Liu, 2017; Nam, 2012). For example, crowdsourcing serves as a distributed problem-solving model for public administrations, with the potential to involve citizens in policy design and implementation and in improving public services (Liu, 2021). It is also used to co-produce public services and improve their effectiveness, acceptance, and legitimacy (Dutil, 2015; Liu, 2017; Weng et al., 2020). Finally, it is an important tool of collaborative government (Hall, 2021; Hartley et al, 2013; Steen and Bradsen, 2020), e-government (Aldemir and Sen, 2021; Hardy and Williams, 2011; Linders, 2012), open government (Brabham, 2015), and platform government (Agarwal, 2018; Cordella and Paletti, 2019; Kim et al., 2021; Van Dijk et al., 2018). In particular, the concept of platform government is used to denote the government's use of new IT platforms in order to engage in extensive collaboration with users, going beyond the simple adoption of e-government practices, and moving towards service co-creation, whereby providers and users cooperate to recognize and exploit value co-creation opportunities (Alves, 2013; Uppström, 2014). Another important, related feature of platform government is the production and use of open data and open-source software and, more generally, the adoption of open innovation practices (Bonina and Eaton, 2020; Kim et al., 2021; Mergel and Desouza, 2013). In the public sector, governments engage in open innovation when they leverage the resources and knowledge contributed by a variety of constituents, such as government departments and agencies, citizens, and private sector organizations, in order to solve public problems. Open innovation practices can be instrumental both in increasing the value and innovativeness of existing public services, and in co-creating entirely new services with users (Bekkers and

Tummers, 2018; Liu, 2017; Mergel and Desouza, 2013; Mu and Wang, 2020). Yet, the use of crowdsourcing, as a tool of platform government to elicit solutions from the crowd, can imply different degrees of collaboration and co-creation between seekers and solvers, and different degrees of openness in the innovation process. Examining the extent to which governments effectively use crowdsourcing to support service co-creation and open innovation, particularly in the context of the urgent and systematic problems posed by the COVID-19 pandemic, can help us to better understand governments' ability to use this instrument to its full potential, and highlight areas in which its use could be improved.

In this article, therefore, we investigate the following question: *To what extent has crowdsourcing been used by governments to support co-creation and open innovation processes to tackle the issues associated with the COVID-19 pandemic?*

To respond to this question, we built an original dataset of crowdsourcing challenges (calls to participate in competitions, propose ideas, or perform specific tasks) related to COVID-19, based on a systematic search on the major crowdsourcing platforms for those challenges that had been launched and funded by organizations of a public nature in two distinct periods, in 2020 and 2021.

The paper is structured as follows. In the next section, building on the open innovation literature, we propose a framework for analyzing crowdsourcing as a tool to promote open innovation and service co-creation, by distinguishing what we call 'open co-creation' from other types of crowdsourcing, according to a typology spanning two dimensions: the degree of the openness of the challenge, and the level of collaboration with the crowd. We then describe our data and methodology and, in the following section, we present our analysis. Finally, in the last section we conclude with some implications for policy.

Crowdsourcing as an instrument of platform government: a framework for analysis

The theoretical literature and the discussion of empirical cases of platform government highlight three fundamental features of this phenomenon which, at least in theory, are fully consistent with the use of crowdsourcing. First, the extensive use of platforms, i.e., new digital technologies, in all the various stages of design and implementation of public services (Kim et al., 2021). Second, the presence of some degree of co-creation with the various types of users that the service is intended to benefit (such as the citizens directly interested in the service; Hartley et al, 2013) and/or other stakeholders interested in contributing to its existence (such as the providers of technology or expertise needed to deliver the service; Hartley et al., 2013; Kim et al., 2021; Linders, 2012). This co-creation is between equals: the public administration leads the process, but not in a hierarchical relationship with the relevant stakeholders, such that the former disposes and the latter benefits or responds. Third, services develop as a result of the availability of information, data, or software that are, to some extent, open. In addition, many of these services produce open data (Bonina and Eaton, 2020).

The first feature – the use of platforms – is certainly present in all types of crowdsourcing. This is not necessarily the case, however, for the other two features. Services that are defined or implemented through challenges launched on crowdsourcing platforms may not be fully co-created, and they may not involve the use and/or release of open data. As noted by Agrawal (2013), moving some services online does not, in itself, make them innovative. Similarly, the use of crowdsourcing may not automatically imply that the public administration is adopting open government practices, as the data used in the crowdsourcing challenge may not be publicly available. Furthermore, the extended and non-hierarchical collaboration that should, theoretically, take place through crowdsourcing, may not materialize in practice (Mergel and Desouza, 2013).

A wide range of crowdsourcing challenges can be identified, with various degrees of co-creation and openness (Eggers and Singh, 2009). In Figure 1, we depict some possibilities, considering the two characteristics defined above (the degree of co-creation and the degree of openness), which may be present to varying degrees; for simplicity, we consider the two extremes of high or low. While the quadrant shown in Figure 1 identifies four different types of crowdsourcing based on these extremes, in practice we expect wider range of possibilities to exist, in which the characteristics shown on the axes take on intermediate levels; in other words, we expect that specific crowdsourcing challenges found in practice will be more or less close to each type, rather than being neatly attributable to one of the four categories.

<<FIGURE 1 ABOUT HERE >>

In Figure 1, we identify four types of crowdsourcing challenges. If the degree of the crowd's autonomy in defining the service is low, the service is not co-created (Fu et al., 2017; Lember et al., 2019), but is essentially defined by the public administration, which chooses its features. For example, the public administration may require that the solutions offered by the crowd must fall within a certain category of eligible solutions, which has been specified in advance with a high level of detail. The public administration may also want to specify who is entitled to participate in the challenge, including some categories of individuals while excluding others. If the degree of openness of the challenge is low, this type of crowdsourcing is very similar to the traditional sourcing ('e-sourcing' or 'e-procurement', in this case). Instead, a challenge could combine a low degree of co-creation and a high degree of openness. This is the case of challenges aiming to release open data or open-source software, responding to the public administration's detailed specifications ('release of public data').

When the degree of co-creation is high, the crowdsourcing participants engage in a horizontal collaboration with the public administration to co-create the service (Alves, 2013; Lember et al., 2019). Here, the participants do not simply provide information and suggestions within a

well-defined framework of services specified by the public administration, they also propose ideas and content concerning the type of services that should be offered and define their characteristics. Depending on the level of openness, various types of crowdsourcing challenges with a high degree of co-creation can be identified. If the challenge involves neither the exchange of open data or software, nor the dissemination of information beyond the participants, this could be a situation where the public administration invites an unspecified crowd to provide ideas about services it could/should offer and their characteristics ('elicitation of ideas'). Finally, when the crowd is also supposed to use and deliver open data and open-source software, we have 'open co-creation'.

Co-creation and the presence of open data might be particularly important when providing rapid solutions to novel problems, as in the case of the recent COVID-19 pandemic. These two features are present in the examples discussed by Kim et al. (2021). Using the interpretative scheme in Figure 1 and a dataset of public or public-private challenges collected from the most widely used crowdsourcing platforms, we discuss the extent to which governments have used crowdsourcing to support co-creation and open innovation processes during the COVID-19 pandemic.

Data collection and analysis

We extracted data from 20 different internet platforms on which crowdsourcing challenges were posted (i.e., Battle of concepts, Challenge.com, Desafios, Ennomotive, Foldit Lab, GitHub, Hackster.io, HeroX, Inocrowd, IdeaScale Crowd, InnoCentive, Innoget, JOGL, Kaggle, MyGov, OpenIdeo, Starthubs, Synsapien, Crowdcity testing methods sourcing platform, #DATA4COVID19 Living Repository), identified through a keyword search online. Some of these platforms were created for the specific purpose of hosting COVID-related challenges, and some were closed down some time after the outbreak of the pandemic.[1]

The first data extraction took place between April and September 2020, thus covering the first few months after the pandemic outbreak. The second extraction took place between October and November 2021. Restricting our focus to challenges mentioning COVID-19, we identified 158 challenges, of which 83 were either fully public – issued and funded by a public administration – (n=41), or led by a public-private partnership (n=42). For each challenge we collected detailed information about the funders, the characteristics of the challenge (duration, reward, budget, geographical target), the details of the expected solution and its dissemination (IPR, licensing, data sharing), and the characteristics of the eligible solvers (nature, location).

The public administrations issuing these challenges included ministries and governments, defense forces, and health administrations. Almost all public administrations were at the national level (i.e., national governments or national research centers). On average, each challenge funded by public-private partnerships included seven different organizations, including governments, research centers, hospitals, leading multinational enterprises (e.g., Amazon or Microsoft), and NGOs. Some local municipalities also featured among the public administrations involved in public-private partnerships.

The challenges focused on a number of problems that arose during the pandemic. For example, many challenges relied on the crowd to create new masks or treatments for COVID-19 infections; others tried to develop systems for the home care of sick patients, for sharing real-time information on the spread of contagion and methods of prevention; others were intended to help citizens fact-check online discussions to counter disinformation. Given the specialized nature of the tasks involved, most were open to an expert crowd. Only 35% of the challenges involved a monetary prize. In the event a monetary prize was offered, the budget allocated by the seekers was rather high (48% of the challenges had a budget of more than one million USD) even though it was generally divided among several winners. Some of these

challenges had a specific geographical target, while others sought solutions that could potentially be applied anywhere. Table 1 shows some key features of the challenges.

<<TABLE 1 ABOUT HERE>>

To operationalize the concept of co-creation, we looked at the description of the challenge. By definition, all the challenges we considered involved collaboration with the public. However, in line with our previous characterization, we considered those challenges in which the public administration specified in advance, with a high level of detail, the type of service it expected to receive from the crowd, as having a relatively low level of co-creation between the seeker and the solvers. In fact, in these cases, the crowd's task was relatively limited and very clearly defined by the public administration. Moreover, very often, these challenges did not require the mobilization of an indistinct crowd, but of very specific categories of solvers. As a result, these challenges were very similar to external service sourcing, which is not a particularly new or necessarily typical mode of platform government. Conversely, we considered those challenges where the public administration defined a problem area very broadly and asked for ideas from the crowd, without specifying in advance the type of service it expected to receive, as having a high degree of co-creation. Here, the contribution of the crowd was indeed substantial, as the crowd was both contributing to identifying the problem, and to providing its solution.

In order to operationalize the concept of openness we looked at two fundamental aspects: i) how the intellectual property rights (IPR) and/or licensing was managed; ii) how the dissemination of solutions was governed. We deemed that challenges requiring participants to issue open-source licenses and disclose all information about their proposal (data used, codes) had a high level of openness. Conversely, we considered challenges where the participants did not have to share their solution and where they held the IPR with respect to the proposed solution, as having a relatively low level of openness.

Table 2 shows how each of the attributes we considered in order to operationalize the degree of co-creation and openness of the challenges were distributed among the 83 public and public-private challenges.

<<TABLE 2 ABOUT HERE>>

We then used a qualitative content analysis of the challenges to analyze how the attributes listed in Table 2 were combined within individual challenges. In this way, we identified challenges that are representative examples of the four ideal types of crowdsourcing identified in Figure 1. We describe them in what follows through some examples.

Types of crowdsourcing challenges

In this section, we describe some of the challenges most representative of the four different types of crowdsourcing challenges that public administrations can use in situations requiring a response to citizens' new and urgent needs. The COVID-19 pandemic, to which our analysis refers, is a good example of such a situation, although similar needs could also emerge in other circumstances.

E-procurement

This is the case where the crowd is called upon to respond to a precise, detailed need of the public administration, with a number of participant constraints, and without the requirement to use open practices. It could be assumed that this type of challenge aims to achieve goals not necessarily related to gathering inputs from a wide variety of constituents (i.e., the crowd), but rather to facilitate innovation in the public sector (like ordinary procurement, although in a somewhat modified form; Demircioglu and Vivona, 2021; Lenderink et al., 2019) or support economic recovery (Pircher, 2020). While it is not always possible to clearly attribute challenges to a specific type, we found 11 challenges which could be considered very close to this type, based on their degree of co-creation and openness (using the attributes listed in

Table 2). An example is a challenge launched by the National Research Council (NRC) Canada at the end of May 2020. The challenge, posted on the HeroX platform and relaunched on many Canadian government sites, was "*seeking a solution for reagents required for nucleic acid sample preparation and rapid and efficient SARS-CoV-2 Ribonucleic Acid (RNA) extraction in order to perform downstream molecular diagnostics of COVID-19 with capability to integrate within existing and/or potential microfluidic platforms for sample-to-answer solutions that can be deployed on the frontline for rapid testing*".[2] The NRC specified 17 mandatory features that an acceptable solution would have to display. The challenge described in great detail the time frame in which the solution was to be delivered, including a series of intermediate milestones that the solver had to respect, as well as a set of conditions that the solver must meet. Only for-profit small businesses (with up to 499 employees) located in Canada were eligible to participate. Such companies had to have an R&D department located in Canada, 50% of the employees' salaries had to be paid to Canadian residents, and at least 50% of the senior executives had to be Canadian residents. The challenge participants were not required to disseminate the proposed solution to third parties, but only to communicate it to the seeker. The winners received a grant from the NRC to produce the solution. They held all intellectual property rights attached to the solution.

This challenge does not seem particularly different from a standard procurement scenario, except for the fact that the medium through which the request for services is disseminated is a crowdsourcing platform. While this allows for a much wider range of potential contributors, the presence of a set of constraints imposed by the NRC also on this aspect makes this example closer to e-procurement than to more open forms of collaboration.

Release of open data

The second case, more consistent with open practices than the previous one, is where the seeker specifies many aspects of the expected solution in advance, but allows for open

dissemination of information about the solutions submitted. Based on an analysis of the attributes of the challenges (as listed in Table 2), we found that seven challenges could be considered close to this type. An example is a challenge launched in May 2020 by the European Commission. The challenge required the participants to provide solutions to a number of COVID-19-related problems, such as the design of portable devices for COVID-19 at the clinical point of care, or the production of digital tools for real-time surveillance of COVID-19 patients. Solutions had to be close to market and have already received the Conformité européenne (CE) marking to *"proceed to large scale testing, piloting and deployment operations in critical healthcare areas"* or should have been "*innovative solutions that have already been validated in lab environments (TRL 6-7 or higher) with the aim to help accelerate developments and achieve conformity assessment (CE marking)*".[3] In a series of calls published on the European Commission's website and relaunched throughout various networks, challenge requirements were specified in great detail. Participants could only be organizations, and in particular consortia among innovative firms (including SMEs) and/or other organizations. Although constraining the types of participants, the challenge met a number of open innovation criteria. Participants were required to issue open source licenses, where applicable. The challenge contained rapid data-sharing clauses, such that all solutions had to be disseminated to everyone. Data had to be accessible and re-usable by anyone who might want to use the data or the proposed solutions and develop them in some way (even those not allowed to participate in the challenge).

It is precisely the presence of all these clauses that differentiates this type of challenge from e-procurement. Besides funding some consortia with grants to produce a public service, the European Commission was also funding the production of open-source solutions and freely available data with this challenge. In this sense, the challenge is compatible with an open government logic.

Elicitation of ideas

The third case refers to challenges that aim to elicit contributions from the crowd, leaving the crowd a large degree of freedom. All possible types of participants are allowed. However, participants are not required to disseminate their solution to third parties and they do not adhere to open practices. We found that a small subset of challenges (four) could be considered very close to this type, based on their attributes as listed in Table 2. An example is a challenge launched by the Korean government and the Seoul Institute of Technology, asking solvers to come up with new ideas for masks and other personal protective equipment (PPE) to prevent the transmission of respiratory viruses. The challenge was published on the InnoCentive platform in June 2020. To respond to the challenge, all solvers had to do was to send a written idea to the seekers. The challenge was aimed at eliciting ideas from the crowd, with no particular constraints on the characteristics of the participants or the type of solution expected. It did not ask participants to disseminate the solution found or to make the data available. This can be considered a typical example of a challenge aimed at eliciting ideas that will eventually be transformed into services for citizens.

Open co-creation

The fourth and final example is that of open co-creation, with a high degree of collaboration between the seeker and the solvers, and open dissemination of information. We found seven challenges that fitted well with this model of open co-creation, again based on their attributes as listed in Table 2. The OpenCovid19 Initiative, a challenge posted on the JOGL platform, is an example of this type of crowdsourcing. The challenge was aimed at developing "*open-source and low-cost tools and methodologies that are safe and easy to use to fight the COVID-19 pandemic. All projects are open source and are ready to welcome volunteering contributors from all around the world*".[4] The challenge was proposed as an act of horizontal governance, in which the crowd (of any kind) was called upon to contribute not only to the

solution, but also to the identification of the problem. Moreover, the challenge, posted on the HeroX platform and launched by a network of public organizations (including the Agence Française de Développement, NESTA, and Open Source Pharma), did not foresee any restriction on the type of participants, operating on the belief that different people could provide their different perspectives on identifying the most pressing problems and proposing how to solve them. This challenge is an example of open co-creation.

Key drivers of the choice to use different types of challenges

Under the same label of crowdsourcing, we found four different types of uses of the crowd on the part of public administrations or public-private partnerships. These uses can be more or less in line with the idea of collaboration between equals and open innovation. We might then ask which factors drive the government's choice to use each type of challenge. To address this question, we further analyzed the content of the challenges, comparing those that were more representative of each of the four types. This qualitative analysis suggests that there are two main drivers that differ across the four types.

The first driver is the object of the challenge. Many of the challenges related to goods or services close to being commercialized on the market, and/or that concerned goods requiring standard approval procedures (e.g., medical devices), tended to be positioned in the 'low' end of the co-creation spectrum. That is, they took the form of public procurement (or pre-commercial procurement)[5] or, in some cases, procurement with open data production. For example, among the challenges we classified as e-procurement we included a challenge issued by the Canadian National Research Council, which sought a "*low cost system (unit cost <$25) that can continuously measure temperature, peripheral capillary oxygen saturation (SpO2), blood pressure (BP), pulse and respiration rates, and transmit this information wirelessly to a base station for COVID-19 patient monitoring in locales including ERs, general wards, communities and homes*".[6] Services that were further away from commercialization and/or did

not necessarily require standard approval procedures by health authorities, took various other forms and were more often positioned in the 'high' end of the co-creation spectrum. For example, among the challenges we classified as open co-creation, we included a challenge issued by a consortium of municipalities and other organizations in Colombia and various other countries, which consisted of a "*hackathon to provide solutions to the challenge of mobilizing critical workers at the same time as reducing contagion among citizens due to COVID-19 pandemic*".[7] Therefore, we suggest that a first important driver in the government's decision to use a specific type of challenge might be the nature of the product or service that is the object of the challenge.

The second driver is the familiarity with open government practices of the public administration issuing the challenge. We found that some governments (e.g., Canada or the European Union) tended to issue challenges that were positioned at the 'low' end of the co-creation and openness dimensions. First, they mostly used the crowd selectively. Second, the object of collaboration was usually a well-structured project, pre-defined in detail by the public authority; for example, "*a solution that will provide alternative filtration materials at large scale volumes that are suitable for use in the manufacture of N95 respirators and surgical masks for healthcare workers*"[8] and "*solutions related to robotic technologies, that are in later stages of development and can be applied quickly to the healthcare sector to support healthcare professionals in fighting COVID-19*"[9]. Third, the challenge was usually not open to an indistinct crowd, but restricted to certain categories of agents (companies or individuals), located in specific countries, contrary to the idea that global wicked problems require global mobilization (Moon, 2020). Fourth, in the majority of these crowdsourcing challenges, participants retained their IPR and were not obliged to share data, which might lead to fragmented responses to particular aspects of the COVID-19 problem rather than a mutualization of efforts to tackle the pandemic as a whole. Instead, in the United States, many

challenges were open to the collaboration of an indistinct crowd, and more consistent with open innovation practices. In particular, considering the challenges issued by US public administrations (such as, among others, The White House Office of Science and Technology Policy, DARPA, National Science Foundation, National Institute of Health, National Institute of Standards and Technology), we noticed that none of them imposed restrictions on the type or geographical location of participants, and they all required the participants to make their data publicly available, with few restrictions on IP use. Many of them provided very loose descriptions of the expected outcomes, such as "*design a binder against COVID-19*"[10] or "*design an anti-inflammatory protein for COVID-19*".[11] We suggest that this has to do with the fact that, in countries like the United States, open government practices are more established in public administrations than they are in other countries.

Insights for public administrations

The evidence provided by some of the main crowdsourcing platforms shows that public administrations worldwide have resorted to crowdsourcing in search of solutions to problems triggered by the crisis. Such challenges have been launched by either public administrations or a mix of public administrations and private organizations and have been managed by public actors located in many different countries (from Brazil to the United States, the Netherlands, or South Korea), operating mainly at the national level.

Our analysis identifies and discusses four main types of crowdsourcing challenges. Some of these quite closely resemble more 'traditional' policy instruments in which crowdsourcing is used mainly as a platform to potentially reach a wider public, instead of embodying a more innovative approach to knowledge creation and sharing. The latter would be the case if, for example, crowdsourcing was used to develop open and collaborative solutions to complex problems; this, however, is a relatively less prevalent approach to crowdsourcing. We have

found that 'open co-creation' is more likely to be used when the object of the challenges are goods and services that are far from commercialization, not requiring standard approval procedures; it is also more likely to be used when the government issuing the challenge is more experienced with 'open government' practices.

Our study presents certain limitations that open avenues for future research. While our focus was on public administrations, it would be worthwhile to examine challenges from the perspective of the participants: their type and the reasons incentivizing them to participate (especially when no monetary reward is proposed). Another promising area of investigation relates to intellectual property protection and openness. What kind of public or social issues are more prone to openness, and what kinds of participants are ready to share their intellectual property and for which kind of return (tangible or intangible)? Qualitative studies based on in-depth interviews could be deployed to dig deeper into the mechanisms that link seekers and solvers through crowdsourcing challenges. Moreover, while our investigation is limited to COVID-19, we believe that there is a need for a better understanding of the use of crowdsourcing by public administrations, not only in response to a pandemic, but also to other economic or societal challenges. An investigation focusing on the geographical location of seekers and/or solvers and the type of governments/administrations in place would also lead to better understanding of some of the locational specificities influencing the use of crowdsourcing by public administrations. Finally, we expect that public administrations, over time, would learn from their and others' experience of using crowdsourcing to address urgent and complex challenges, and modify their use of this instrument accordingly. Our dataset is not large enough, and the period in which data were collected is not long enough, to allow us to derive insight about how public administrations change their approach to crowdsourcing as they gain more experience with the instrument and as the nature of the problem they face evolves. It would be valuable if further research could investigate how the use of

crowdsourcing on the part of public administrations changes over time, why, and in which direction.

In conclusion, while the use of crowdsourcing by public organizations is certainly very positive and valuable, the experience gained during the pandemic period should pave the way to a much deeper and more comprehensive use of crowds to tackle issues of public interest.

Notes

[1] This applies, for instance, to hackathon pages that have been closed after the end of the hackathon.
[2] The quote is taken from the website http://www.ic.gc.ca/eic/site/101.nsf/eng/00110.html, last accessed on November 24, 2021.
[3] The quotes are taken from the website https://digital-strategy.ec.europa.eu/en/news/coronavirus-response-eu56-million-solutions-using-medical-technologies-digital-tools-and-artificial, last accessed on November 24, 2021.
[4] The quote is taken from the website https://app.jogl.io/program/opencovid19, last accessed on November 24, 2021.
[5] The term "pre-commercial procurement" was used by one of the promoters of a crowdsourcing challenge that we classified as e-procurement, whom we interviewed in October 2021.
[6] The quote is taken from the website http://www.ic.gc.ca/eic/site/101.nsf/eng/00078.html, last accessed on February 11, 2022.
[7] The quote is taken from the website https://github.com/datasketch/movid19, last accessed on February 11, 2022.
[8] The quote is taken from the website https://dih-hero.eu/supporting-professionals-in-the-fight-against-covid-19/, last accessed on February 11, 2022.
[9] The quote is taken from the website http://www.ic.gc.ca/eic/site/101.nsf/eng/00102.html, last accessed on February 11, 2022.
[10] The quote is taken from the website https://fold.it/portal/node/2010049, last accessed on February 11, 2022.
[11] The quote is taken from the website https://fold.it/portal/node/2010090, last accessed on February 11, 2022.

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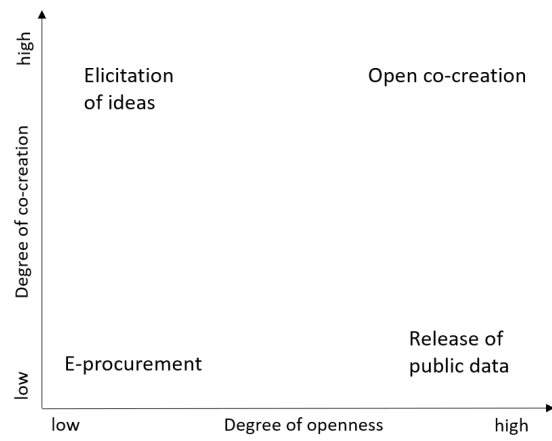Figure 1. Types of crowdsourcing challenges

Table 1. General features of the crowdsourcing challenges

		Challenges (%)
Type of public funder*	National governments	52.1
	Supra-national governments	6.3
	Local governments	4.2
	Research organizations	22.9
	Research and government	12.5
	Health organizations	2.1
Reward for winners	Winners receive monetary funds	34.9
	Winners receive other rewards	25.3
	No reward	39.8
Total budget of the challenge*	Below USD100,000	24.1
	From USD100,000 to USD1,000,000	27.6
	Above USD1,000,000	48.3
Geographical target	Worldwide	36.1
	Restricted to one or more countries	63.9

*Refers only to the challenges that have a monetary prize

Table 2. Attributes used to operationalize the degree of co-creation and openness of the crowdsourcing challenges

Attributes			Challenges (%)
Degree of co-creation between seekers and solvers	Level of detail of the tasks and the timeframe in which they are to be carried out	High	21.7
		Medium-high	30.1
		Medium-low	14.4
		Low	18.1
		NA	15.7
	Participants' location	Worldwide	53.0
		Restricted to one or more countries	47.0
	Participants' types	All types	44.6
		Only individuals and teams	42.2
		Only organizations	13.3
Degree of openness of the solution	IPR	Seekers handle IPR	8.4
		Proponents have exclusive ownership of IPR	68.7
		Not determined in advance	22.9
	Licensing	Participants required to grant free license to proponent	2.7
		Participants required to issue open-source license	9.5
		License not required	52.7
		Not determined in advance	35.1
	Data sharing conditions	Participants not required to share data	17.6
		Participants required to share data	58.1
		Not determined in advance	24.3