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RESEARCH ARTICLE

Crowdsourcing: Citizens as coproducers of public services

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Abstract
Crowdsourcing serves as a distributed problem-solving production model for modern governments, and it has the potential to transform citizens into coproducers of public services. To consolidate the theoretical basis, this article provides a typology for crowdsourcing public services based on theories of coproduction, public sector volunteerism, and government–citizen relations. This typology includes two dimensions—the policy stage, and the functionality of citizens' effort—and four types of crowdsourcing, namely, complementary crowdsourcing in service implementation, supplementary crowdsourcing in service implementation, complementary crowdsourcing in policy and service design, and supplementary crowdsourcing in policy design. Four cases are selected for illustration. Designing crowdsourcing based on citizen and government relationships will help designers align goals and tasks to the right coproducers and enhance relationships in a democratic way. Furthermore, this typology will allow the field to systematically and collectively build knowledge.

KEYWORDS
coproduction, crowdsourcing, policy design, public engagement, public policy

INTRODUCTION

Crowdsourcing has been adopted across different sectors and has become an important way for organizations to enhance their efficiency and effectiveness by improving service/product quality and customer relationships (Howe, 2006). Studies show that effective crowdsourcing initiatives can reduce administrative costs, improve service efficiency, and

enhance the government–citizen relationship (Brabham, 2015; Clark et al., 2016; Dutil, 2015; Mergel & Desouza, 2013; Nam, 2012; Prpić et al., 2015). In 2015, all US federal agencies were required to allocate at least one officer to coordinate crowdsourcing and citizen science projects. Studies documenting the outcomes of this federal action (e.g., Bowser & Shanley, 2013; Mergel & Desouza, 2013; Noveck, 2009) and local initiatives (e.g., Brabham, 2015) have demonstrated the impacts achieved through crowdsourcing in government agencies.

The increasing government adoption of crowdsourcing is driven by both governments and citizens. For governments, the complexity of public problems has increased because they need to address the different concerns held by diverse groups of stakeholders, the demand to incorporate service users' experiences into service delivery and design, and a restricted budget. At the same time, from the citizen perspective, information and ideas can be generated more efficiently and cost-effectively by actors outside the government, through the advancement of social media and online platforms. In the public sector, crowdsourcing is an emerging online-distributed problem-solving and production model (Brabham, 2015); it provides solutions to both governments and citizens by connecting labor, experience, knowledge, creation, review, and preferences online to existing service provisions and policymaking processes (Linders, 2012), and it has the potential to improve the quality and efficiency of public services (Liu, 2017a). However, more conceptual crowdsourcing studies are needed to consolidate practices in a way that is relevant to both academics concerned with the development of a framework or typology for actual policy implementation and practitioners interested in adopting and implementing crowdsourcing in their organization (Brabham, 2015).

Furthermore, some scholars are skeptical of these efforts; they consider the increasing adoption of crowdsourcing to be a symbolic action (Brabham, 2012) and challenge the substance of crowdsourcing outcomes (Johnson & Robinson, 2014; Liu, 2016). Other scholars point out the potential risks of implementing crowdsourcing, such as compensation, payment, rights of crowdsourcing outcomes, and crowdsourcing influences (Chatfield & Reddick, 2018; Johnson & Robinson, 2014). Furthermore, many believe that effectively designed crowdsourcing is one part of a continued effort to make governments more open to and inclusive of the public through Internet technologies (Aitamurto & Chen, 2017; Desouza & Bhagwatwar, 2014; Liu, 2017b). It is, therefore, important to re-examine the relationships and dynamics between governments and citizens who are engaged in crowdsourcing (Johnson & Robinson, 2014) and to develop a typology that is useful for the practitioners who design it.

The contributions of this article are threefold. First, we review the literature on crowdsourcing and systematically examine fundamental theories that are applied to define the role of citizens engaged in crowdsourcing practices in the public sector. Second, we elaborate on crowdsourcing in terms of the relationships between governments and citizens, as well as the stages of policymaking and implementation. Third, we present a typology of crowdsourcing functions and illustrate the implications of each type through a case.

THE CROWDSOURCING LITERATURE IN PUBLIC ADMINISTRATION

Crowdsourcing is defined as participative online activity performed by a group of individuals in response to an online call by an organization (Estellés-Arolas & González-Ladrón-de-Guevara, 2012; Howe, 2006). It is increasingly common for governments and the public sector to adopt crowdsourcing to perform various activities, including deliberation (Aitamurto & Landemore, 2016), regulation (Lodge & Wegrich, 2015), policymaking (Prpić et al., 2015; Taeihagh, 2017), public services (Dutil, 2015; Liu, 2017a), and open innovation (Johnson & Robinson, 2014; Mergel & Desouza, 2013). For instance, Chatfield and Reddick (2018)

show the success of the vulnerability reward program of the Pentagon, which demonstrates how governments can utilize effective crowdsourcing design for national security. In transferring private sector experiences, the study shows that "the discovery of vulnerabilities by external researchers is cost-effective for vendors compared to hiring in-house security researchers" (p. 184). Therefore, crowdsourcing has been accepted as an "online, distributed problem-solving and production model" (Brabham, 2015, p. 7) in the public sector.

Several important studies have provided conceptual frameworks to understand various crowdsourcing practices (Brabham, 2015; Clark et al., 2016; Taeihagh, 2017). Brabham (2015) investigates the appropriateness of adopting crowdsourcing for governance and highlights two decision-making steps: The type of problem (information management or ideation) and the type of information/outcome (internal or external information/empirically true or esthetic result). This framework defines four types of crowdsourcing: knowledge discovery and management, distributed human intelligence tasking, broadcast search, and peer-vetted creative production (Brabham, 2015). Clark et al. (2016) extend this framework, incorporate the characteristics of crowds, and discuss the role of government in different types of crowdsourcing based on the problem scope from simple to complex. Their framework includes two dimensions, administrative ability (expertise) and diversity of thought, and results in four areas of focus in crowdsourcing: Collective opinion, individual opinion, the wisdom of crowds, and the wisdom of experts. This framework illustrates the complexity of crowdsourcing and the essential roles of the crowd (Clark et al., 2016).

In a thorough review, Prpić et al. (2015) find that most research on policy crowdsourcing has developed since 2010, and this study has continued to grow in recent years. In their literature review, they propose a policy crowdsourcing framework with a policy cycle and three types of policy crowdsourcing: A virtual labor marketplace, tournament crowdsourcing, and open collaboration. The virtual labor marketplace refers to an IT-based job market for matching job seekers with online tasks, such as generating online transcripts, writing reviews, and performing translations (e.g., Amazon Mechanical Turk). Tournament crowdsourcing is an online idea competition where organizations post their problems to seek solutions from online participants; an example of such an organization is Challenge.gov. Finally, open collaboration allows organizations to post their problems to elicit online participation and provides users the opportunity to generate content through a wiki, Facebook, or other collaborative social media. Prpić et al. (2015) find that most crowdsourcing initiatives adopted in the public sector take the form of open collaboration and argue that the virtual labor marketplace is underutilized. Additional crowdsourcing functions, such as crowdsensing, situated crowdsourcing, spatial crowdsourcing, and wearable crowdsourcing, can also enhance public policies and services (Taeihagh, 2017).

However, Johnson and Robinson (2014) point out the potential risks of crowdsourcing through hackathons, such as risks related to compensation, payments, and rights of outcomes. For instance, unlike private market hackathons and crowdsourcing, it is difficult to set the market price for a government-sponsored hackathon and crowdsourcing project. In the case of the Pentagon's vulnerability reward program, Chatfield and Reddick (2018) also argue that proper monetary rewards are needed to prevent security researchers from selling their results to the black market. Furthermore, as Johnson and Robinson (2014) clearly point out through the civic hackathon example, hackathons are not a substitution for procurement. For instance, they find that "software applications developed in hackathons have not yet been proven to have the same longevity or mission-critical nature of the typical government IT systems" (p. 352). All of these potential risks call for redefining the relationship between governments and crowdsourcing participants.

To answer this call, we systematically examine fundamental theories applied to defining the roles of citizens engaged in crowdsourcing. The key characteristic of crowdsourcing has led public scholars to re-examine the relationships between citizens and governments in the

process of policy design and public service provision. For instance, citizen coproduction in public services through social media has allowed citizens to be actively involved in jointly tackling social problems or issues of concern to citizens, such as through SeeClickFix and FixMyStreet. This highlights the new possible ways that citizens can resolve their own concerns about daily issues (Linders, 2012). Instead of waiting passively for the government to resolve issues, citizens can now actively participate in the process of public services by providing ideas, monitoring, or reporting and can be involved in implementation (Linders, 2012). However, though Linders (2012) introduces the concept of coproduction to understand new forms of citizen engagement in the public sector, he also recognizes that the lack of conceptualization might hinder the development of this trend. Therefore, we will now turn to review studies that have introduced essential theories, including coproduction, public sector volunteerism, and direct public engagement through new forms of technologies and social media, to consolidate the theoretical ground for crowdsourcing.

Coproduction

Coproduction refers to citizens working in partnership with the government to improve the quality and effectiveness of policy, and it consists of citizen involvement or participation in the delivery of public services (Brudney & England, 1983; Ostrom et al., 1978; Whitaker, 1980). Studies have shown that coproduction can enhance relationships between citizens and government (Levine, 2008; Ostrom, 1996), create synergy between the policy work of citizens and government (Brandsen & Pestoff, 2006), and enhance service efficiency and effectiveness (Clark et al., 2013; Parks et al., 1981). Table 1 lists studies discussing crowdsourcing and coproduction. Though some studies emphasize that crowdsourcing adopts coproduction as a

TABLE 1 Crowdsourcing and coproduction studies

Studies on coproduction and crowdsourcing	References
Conceptualize crowdsourcing through coproduction	
Crowdsourcing and technology-mediated activities, as a type of coproduction, can bring substitution value and supplementary value to the government.	Brabham (2015)
For the Department of Defense (DoD), adopting "the polycentric structure for coproduction partners (whether they are GIS producers or users) would accommodate the DoD's needs for information power and discretion by fostering interdependence and mutual adjustment." (p. 396)	Franklin et al. (2013)
Coproduction involves the process of delivering a specific service with the assistance of citizens and requires that "both government and citizens share power" (p. 602). However, crowdsourcing should be distinguished from coproduction because adopting crowdsourcing does not guarantee power-sharing.	Mergel (2015)
Demonstrate coproduction enhanced by crowdsourcing	
ICT-facilitated coproduction enables "Citizen Sourcing, Government as a Platform, and Do-It-Yourself Government." (p. 446)	Linders (2012)
The purposes of citizen-sourcing including image-making, information creation, service coproduction, problem-solving, and policymaking, and citizen-sourcing creates a new service coproduction model compared with the service provision model in traditional government (p. 14).	Nam (2012)
The new information technology has extended the applicability of the coproduction model in government service delivery (p. 3), such as online-based 311 services.	Clark et al. (2013)

fundamental theoretical basis (Franklin et al., 2013; Liu, 2017a; Mergel, 2015; Prpić et al., 2015; Royo & Yetano, 2015), other studies adopt crowdsourcing as an illustration of how coproduction can be implemented through the enhancement of technology (Clark et al., 2013; Ebdon & Franklin, 2006; Linders, 2012; Nam, 2012).

A common theme evolving from those articles is that technology can enhance coproduction in the public sector. For instance, recent scholars believe that the advancement of technology has increased the capacity of governments to conduct coproduction activities through crowdsourcing (Alford, 2002; Barnes & Williams, 2012; Clark et al., 2013) and has enhanced information exchange between citizens and their government through coproduction (Meijer, 2011). Examples of this include 311 services (Clark et al., 2013) and participatory budget planning through technology (Ebdon & Franklin, 2006). Furthermore, King (2007, p. 59) argues that technology "enables a group of stakeholders to get together at the most appropriate location (e.g., in the citizen's home) and to work together in a way that is understandable to all, is seen as more promising than the storing of vast amounts of data in a centralized system accessible only to a few professionals."

On the contrary, some argue that crowdsourcing should be distinguished from coproduction (Bovaird, 2007; Mergel, 2015; Voorberg et al., 2014). First, coproduction involves the process of delivering a specific service with the assistance of citizens and requires that "both government and citizens share power" (Mergel, 2015). However, adopting crowdsourcing in the public sector does not guarantee power-sharing between governments and citizens (Mergel, 2015) because governments retain the initial design power or the final approval of decisions during the crowdsourcing process (Clark et al., 2013; Linders, 2012; Prpić et al., 2015). Second, the participants in coproduction are often the direct beneficiaries of the organizations (Alford, 2009), whereas the participants in crowdsourcing are defined as a group of individuals who might not know of each other and are outside the organization (Howe, 2006). In other words, coproduction involves service users in the production of public services (Alford, 2009), whereas crowdsourcing has less restriction, involves only its service users and incorporates a broader scope of participants. To resolve this blurriness, this study incorporates literature on volunteering in the government sector and direct public engagement to refine the relationship between government and citizens in crowdsourcing.

Volunteering in the government sector

Crowdsourcing can be viewed as a type of volunteering action in the government sector (Clark et al., 2017). Crowdsourcing in the public sector requires governmental agencies to make an open call for participants to contribute online. Similarly, calling for help from the public to resolve public problems and deliver public services is not new for volunteerism in the government sector. Brudney and Kellough (2000) note that approximately 36% of US state agencies involve volunteers in the delivery of public services. Their survey shows that state agencies' missions related to health, welfare, environmental protection, natural resources, and parks and recreation are more likely to involve volunteers; these findings largely align with studies on volunteering in the public sector at the city (Miranda & Andersen, 1994), county (Lane & Shultz, 1996), and federal levels (Reeves, 1988). Crowdsourcing provides a new way for governments to incorporate to generate user-generated geographical data (Parker et al., 2014), perform translation jobs during crises (Sutherlin, 2013), and collect intelligence and information (Clark et al., 2017).

On the contrary, the public sector volunteerism literature provides conditions for incorporating volunteers for public services. Often, governments consider recruiting public volunteers when they require local or specialized knowledge, cost efficiency, and large-scale data collection that is otherwise costly or time consuming for a governmental agency to

perform alone. For instance, many recent citizen initiatives for collecting nationwide community-level rain, snow, and biological information through volunteer efforts not only improve aggregated data quality but also reduce data collection costs (Bowser & Shanley, 2013). Furthermore, Brudney and Kellough (2000, p. 126) argue that to achieve greater benefits from involving volunteers in state agencies, managers need to invest in program management, such as "job training for volunteers, recognition activities to reward them, the presence of a volunteer coordinator, [and] written policy statements governing volunteer involvement."

In other words, managing and retaining volunteers in the public sector also involve costs and a high degree of management. For instance, Brudney and Kellough (2000, p. 126) show that "recruiting sufficient volunteers" and "providing paid staff time to train and supervise volunteers" are the main costs and challenges. Though direct compensation for public sector volunteers is difficult to fund, indirect subsiding that requires equipment or services for volunteers to perform tasks allows better recruitment and retention of volunteers in public agencies (Brudney & Kellough, 2000). In addition, Saxton et al. (2013) find that adaptation of a collaborative approach and managerial control systems are key to building an effective crowdsourcing community. Similar to managing volunteers in the public sector, managing crowds requires program management, including compensation schemes, trust-building systems, and voting and commenting channels through which participants can express their opinions.

Direct public engagement

Crowdsourcing has also been recognized in the planning literature as a form of public engagement (Brabham, 2009; Certomà et al., 2015; Seltzer & Mahmoudi, 2013), which includes a broad scope of different types of engagement approaches. In particular, direct public engagement can provide insights into understanding crowdsourcing as a means of expression. Direct public engagement refers to "in-person and online processes that allow members of the public to personally and actively exercise voice such that their ideas, concerns, needs, interests, and values are incorporated into governmental decision-making" (Nabatchi & Amsler, 2014). Barber (1984) and Pateman (1970) state that direct citizen engagement can be put into practice if citizens are given an opportunity to build up their capacity by participating more frequently in the public policy process. Technology can thus potentially enhance the design of effective direct citizen engagement, such as in wiki planning (Liu, 2016), SeeClickFix (Brabham, 2015), and participatory budgeting (Hong, 2015). Despite the challenges of attracting a sufficient number of citizens to participate in public engagement, a recent study shows that ICTs can facilitate a higher participation rate because technology allows participants to access more information about their concerns (Hong, 2015).

The direct public engagement literature clearly distinguishes the roles of citizens according to the consultation context. For instance, in studying policy consultation on CO_2 emission levels, Royo and Yetano (2015) classify existing crowdsourcing based on (1) whether the government seeks input from the crowd, and (2) whether the information is used for decision-making. On the basis of these two dimensions, Royo and Yetano (2015) outline four types of crowdsourcing: No participation, idea generation, a crowd referendum, and full crowdsourcing. According to these authors, full crowdsourcing indicates that governments seek input from citizens and incorporate information for policy decision-making. However, they note two other possible situations: Governments seeking input only without incorporating the ideas or citizens expressing only their preferences for certain policy options without providing their own ideas.

A TYPOLOGY FOR CROWDSOURCING

Our review shows that previous studies have established different categories to conceptualize the practices and applications of crowdsourcing in the public sector and help to differentiate a variety of crowdsourcing implications (Aitamurto & Landemore, 2016; Brabham, 2015; Clark et al., 2016; Desouza & Bhagwatwar, 2014; Linders, 2012; Prpić et al., 2015; Royo & Yetano, 2015). In particular, our review reveals two dimensions of crowdsourcing that allow us to construct a typology: (1) The stages of the policy process and (2) the functions of citizens' inputs.

Execution versus design

The process of coproducing public service delivery through crowdsourcing includes policy implementation and design. By clarifying the volunteering nature of the coproduction process, Brandsen and Honingh (2016) argue that "the extent to which citizens are allowed to design the production of the service delivered to them is a dimension along which to distinguish different types [of coproduction]" (p. 432). Similarly, by analyzing the White House's Open Government Innovation Gallery, Linders (2012) distinguishes between "delivery" and "design" in crowdsourcing. He shows that "crowdsourcing and codelivery citizens can "claim" streets for cleaning and volunteer for a "Snow Corps" to help the disadvantaged," whereas "designing" would involve "consultation and ideation in which citizens can provide suggestions and ideas via the snow portal's Facebook and Twitter accounts" (p. 451). Therefore, the extent to which citizens are able to execute or design is a dimension for distinguishing different types of crowdsourcing.

Complementary versus supplementary

In addition to the delivery process, the function of the task is another important dimension for understanding the diversity of crowdsourcing. In the coproduction literature, Ostrom et al. (1978) distinguishes between citizens' efforts in "contributing to the provision of public services" and those "providing inputs used to produce a good and service." Brandsen and Honingh (2016) further note that the degree of coproduction can be seen as "the proximity of the tasks that citizens perform to the core services of the organization" (p. 432). Additionally, Royo and Yetano (2015) show that crowdsourcing varies depending on (1) whether the government seeks input from the crowd and (2) whether the information is used for decision-making. Therefore, this study considers two types of functions of inputs from citizens, namely, complementary and supplementary functions.

Crowdsourcing can be complementary to the government's provision of services or policymaking when the government seeks input from the crowd and directly incorporates that input into policy decision-making. For instance, the definition of complementary crowdsourcing is similar to the definition of full crowdsourcing in Royo and Yetano's (2015) case, which demonstrates how governments seek input from citizens and incorporate that input into policy decision-making in deciding on CO_2 emission levels.

Meanwhile, crowdsourcing can be supplementary when information and inputs obtained from citizens are used as a reference or in support of the government's provision of services but are not directly incorporated into policy decision-making. For instance, Linders (2012) reveals additional tasks performed by citizens that are supplementary to the production of services, such as monitoring. Linders (2012) shows that citizens, by reporting, can help the public to monitor service or can help by placing a 311 service request to provide the

government with information. Thus, a distinction is made between a complementary and supplementary task.

Having multiple dimensions allows the systematic consideration of the functions of crowdsourcing and the way that citizens can perform as coproducers of public service provision. Table 2 shows the combination of these two dimensions and the resulting four types of crowdsourcing.

These two dimensions include the following:

- The extent to which citizens are involved not only in the execution of services but also in the design of the policy.
- The extent to which citizens contribute to complementary or supplementary tasks.

VARIETIES OF CROWDSOURCING CASES

When involving citizens in the process of public service provision and policy design, one of the concerns is how to define the roles of citizens, as discussed in the literature on co-production (e.g., Parks et al., 1981), public sector volunteerism (Brudney & Kellough, 2000), and direct public engagement (Nabatchi & Amsler, 2014). Drawing from these discussions, this study presents four types of crowdsourcing based on the process of producing public policy and services and the function of citizens' inputs.

Four case studies will be presented in this section to illustrate the key characteristics of the different types of crowdsourcing that enable the coproduction of public policies. Each case illustrates one type of crowdsourcing shown in Table 2. These cases were selected based on theoretical sampling (Yin, 2004) to demonstrate key aspects of each type of crowdsourcing, with well-studied cases selected to provide more validity to the illustration. A full case study methodology was followed (Yin, 2004), and evidence and information for each case were collected through documents, interviews, and web content analysis.

Complementary crowdsourcing in service implementation: Peer to patent

In complementary crowdsourcing in service implementation, citizens are involved in implementing services through a complementary task but not in designing policy. Additionally, governments seek citizens' efforts and incorporate their inputs into service provisions. For instance, in the Peer to Patent (PTP) case, citizens are involved in patent review, and these reviews are compiled into a final report for the government's patent officer to make patent approval decisions. Citizens' diverse knowledge of the latest inventions and their access to a wider range of databases can complement the limitations of the patent office's own review process (Noveck, 2009).

TABLE 2 A typology of crowdsourcing in the public sector

	Implementation	Design
Complementary	Complementary crowdsourcing in service implementation	Complementary crowdsourcing in policy design
Supplementary	Supplementary crowdsourcing in service implementation	Supplementary crowdsourcing in policy design

The PTP pilot was a joint effort by New York University and the United States Patent and Trademark Office that lasted from 2007 to 2009 and aimed to coproduce patent review services. The PTP pilot involved a large number of volunteer reviewers who conducted research and reviews through the online PTP platform. Before the patent officers reviewed the patents, the initial review and research process was often performed by a single patent reviewer, who was usually an undergraduate student with no prior knowledge about the reviewed patent (Noveck, 2009). Lacking knowledge and access to sufficient information in a timely manner, this closed review process created a huge backlog (Government Accountability Office, 2008). Mobilizing citizens to contribute their knowledge to the patent review system improved the efficiency and effectiveness of the patent review (Noveck, 2009).

The complementary crowdsourcing tasks include five review procedures for reviewers and attracted over 2,000 registered reviewers (Liu, 2012; USPTO, 2010). Reviewers could conduct research, find previous patents, and evaluate other submissions to patent officers. The research performed by the reviewers was voted upon and selected by the reviewer community. Compiled reports were generated for each of the reviewed patents under the PTP project for the patent officers to make the final decision of patent approval. With the evidence of participation from the pilot, the US PTP has institutionalized the PTP review process through the America Invents Act of 2011 (Wilkinson, 2013), which requires all patents to be reviewed publicly. The PTP case illustrates complementary service in service implementation.

Supplementary crowdsourcing in service implementation: Citizen archivist

In supplementary crowdsourcing in service implementation, citizens are involved in implementing services for a supplementary task and not in designing policy. For this type of crowdsourcing, citizens provide information or put forward effort that can be used to improve public services but do not provide essential services. For instance, the US National Archives Records Administration launched the Citizen Archivist initiative. Citizens receive training to transcribe and classify documents and records that are maintained and preserved by the government. The involvement of citizens' efforts in transcribing and classifying improves the quality of digitalization, but citizens do not directly provide digitalizing services.

As part of the open government movement, the US National Archives Records Administration (NARA) experimented with several ICT-facilitated platforms to solicit public effort to supplement the archive and record services. On March 7, 2015, NARA hosted the Citizen Archivist Dashboard as an ICT platform to reach a broad range of volunteers who could help digitalize NARA's records (see Figure 1). These activities included transcribing documents, tagging archival records, indexing, and so forth. (see Figure 1). To help transcribe, tag, or index the NARA records, volunteers first needed to register an account and obtain basic online training about how to transcribe. As a result of this initiative, Citizen Archivists achieved NARA's goals by transcribing millions of records into electronic form. According to Bowser & Shanley (2013), more than 170,000 participants helped to index 132 million names within 5 months. Citizen Archivists later won the 2012 Walter Gelhorn Innovation Award for innovation and best practices in government.

NARA has thus conducted effective supplementary crowdsourcing activities through its Citizen Archivists platform, which solicits volunteer work from the public to help digitalize the records owned by NARA. NARA is an example demonstrating the importance of selecting the appropriate functions in which to involve citizens. In the first phase of the initiative, NARA had to suspend their wiki platform though it allowed citizens to scan their own archives and

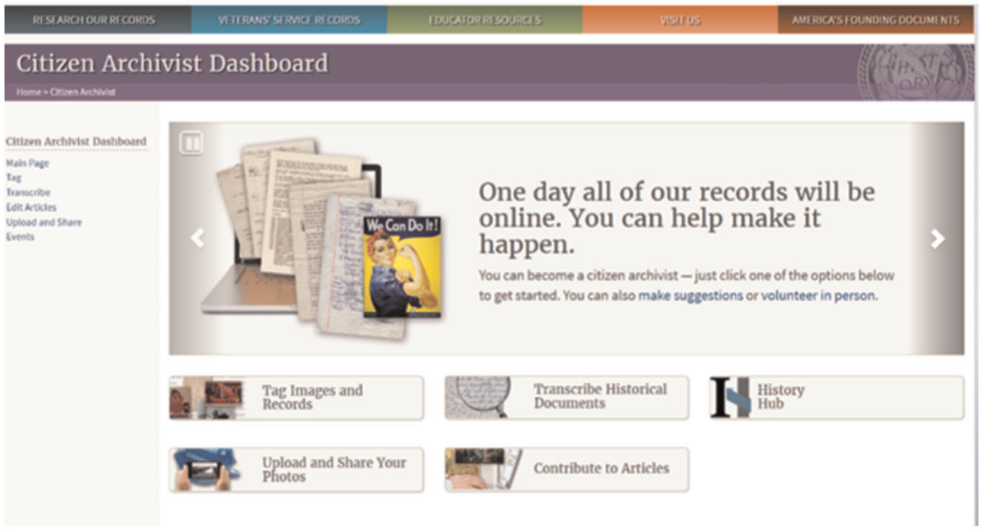

FIGURE 1 Citizen Archivist dashboard

records to complement NARA's collections. However, the tasks involved in the wiki platform were too complicated, resulting in low participation and high maintenance costs of the platform. In the second phase, NARA designed simpler tasks, such as transcribing documents, tagging archival records, and indexing. NARA's experiences show the significance of selecting appropriate types of crowdsourcing for incorporating citizens' efforts.

Complementary crowdsourcing in policy design: NASA challenges

In complementary crowdsourcing in policy design, citizens are involved in the policy design of a complementary task, and innovative ideas from citizens contribute directly to policy-making or public service design. Examples can be found in challenges or idea competitions in which citizens contribute innovative solutions to a specific issue or problem. For instance, the National Aeronautics and Space Administration's (NASA) Centennial Challenges call for citizens, universities, research institutions, and private firms to provide solutions to technical problems of interest to NASA and the nation.

NASA has a long history of utilizing crowdsourcing to complement its operations. For instance, in 2007, the Human Health and Performance Directorate (HH&P) at the NASA Johnson Space Center responded to its budget reduction in 2005 by soliciting innovative solutions to small-scale technology challenges from the public (Davis et al., 2015). The HH&P initiated 12 challenges to seek designs from the public from 2009 to 2010 (Boudreau & Lakhani, 2013; Davis et al., 2015). From 2005 to 2015, Gustetic et al. (2015) show that 50 NASA challenges produced various outcomes, including research advancement, NASA operational integration/use, external use for other agencies, education and public outreach, advancing state of the art and demonstrating proof of concept, enabling products to be brought to market, and creating new aerospace vendors and companies. Adopting complementary crowdsourcing allows NASA to coproduce with the public and to generate a broader range of solutions than would be possible with a contract with a single company (Kaminski et al., 2016).

Solicited ideas from the prize competition complemented the mission of NASA and resolved issues related to data applications, hardware prototype development, and concepts for research and technology advancement (Kaminski et al., 2016). As an example, the Mapping Dark Matter Challenge aimed to create a cosmological image analysis program to measure the small distortion in galaxy images caused by dark matter. Among the 75 participants and 760 submissions, a PhD student named Martin O'Leary created an advanced algorithm that is now commonly used in astronomy (Mapping Dark Matter, 2015).

Supplementary crowdsourcing in policy design: My2050

In supplementary crowdsourcing in policy design, citizens' inputs are used as a reference in policy design. Inputs from citizens in crowdsourcing activities serve only as references for policymakers and are not part of the policy itself. For instance, in 2011, the United Kingdom's Department of Energy and Climate Change (DECC) launched My2050 to solicit preferences for energy usage from the public as a reference for strategic planning for greenhouse gas emission reduction. Through the 2008 Climate Change Act, the United Kingdom pledged to reduce its greenhouse gas emissions by 80% by 2050 compared with the emission level in 1990. As a result, the government published a white paper, “The Low Carbon Transition Plan,” in July 2009, which later developed into a carbon plan that outlined the strategies and actions for this transition. The 2050 Calculator was developed as part of the Carbon Plan, and it serves as a deliberation platform to facilitate a national consensus on how the United Kingdom can transition to a low carbon economy (Department of Energy & Climate Change [DECC], 2011). Because of the complexity and difficult scientific terminology of the original 2050 Calculator (see Figure 2), the DECC decided to create the My2050 simulation, which simplified the complex data processing of energy policy and allowed users to express their preferences for energy levels in an informative and simulated environment.

As a form of supplementary crowdsourcing, the My2050 simulation shows what the future would be like in 2050 based on how users adjust their energy use levels through a

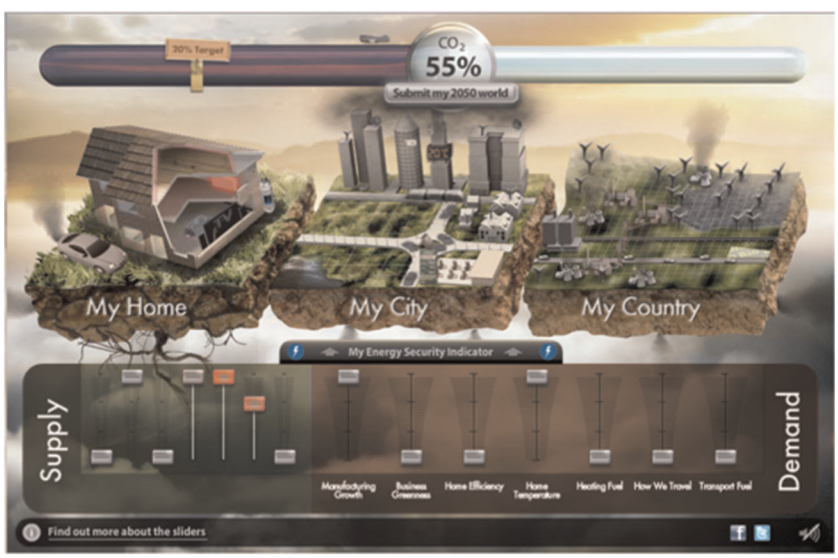

FIGURE 2 Simulation game version—My2050 simulation

simulation game. This simulation allows the public to express their preferences and actions related to energy policy and helps them understand how their daily consumption of energy will affect climate change in the United Kingdom. With regard to outcomes, My2050 has received over 22,000 "pathways" submitted since 2011 (Cabinet Office, 2014). Laura Aylett, a Policy Analyst at the DECC, observed that the My2050 simulation provides reference points and important preferences for the DECC to understand public opinion about different energy options and policies. For instance, the DECC has now published paths of energy choices by the governments, third parties, and industries (DECC, 2014; Serrenho et al., 2016). With the simulator, people can now understand diverse views of the issues and the reasons behind each choice.

DISCUSSION

Though crowdsourcing initiatives by governments have grown rapidly since 2010 (Prpić et al., 2015), there are also skeptics on the substance of crowdsourcing outcomes (Johnson & Robinson, 2014) and people who view crowdsourcing as a symbolic action (Brabham, 2012) due to the difficulty of defining the roles of citizens. In the wide adoption of crowdsourcing, examples of crowdsourcing activities can be found in both policy design and service implementation. As found in the coproduction literature, some crowdsourcing applications include both design and implementation, such as challenges or tournaments in which crowdsourcing participants are involved in policy design by submitting their proposals and in implementation if they win the final prizes. However, the aspects of supplementing and complementing crowdsourcing applications in policy design and service implementation are based on how governments perceive the roles of citizens. The significance of this typology is that it re-examines the relationship and dynamics between government and citizens so that the roles of citizens can be defined and democratic values enhanced.

Government and citizen relationships: Citizens as coproducers

In a classical work that defines citizens' roles, Thomas (2013) provides an early framework to understand the relationships between governments and citizens by focusing on three roles that the public plays: As citizen, customer, and partner. First, Thomas (2013) notes that the public role of citizens evolved from the wave of public administration reforms in the 1990s. Second, as a market focus was introduced into the public sector, public managers were advised to view the public as customers and to focus on "customer-driven government" (Osborne & Gaebler, 1993, p. 166). The public interacts with the government as customers who experience services delivered by the government. Third, Thomas (2013) argues that the need for coproduction has expanded because the government is becoming more focused on the quality of services and user experiences.

However, effectively implementing a policy, such as an antidrug or antismoking campaign, depends not only on the policy education but also on changes in the behaviors of the targeted drug users or smokers (Thomas, 2013). Therefore, Thomas (2013) argues that governments need to partner with citizens in the policy process. Bovaird (2007) provides a conceptual framework to further categorize the relationships between service professionals (providers) and citizens (users) when planning and delivering public services, and he redefines citizens as coproducers. Our typology, through building on previous literature applying coproduction, volunteering, and direct public engagement to crowdsourcing, shares a common theme of redefining the roles of and relationships between governments and citizens (Clayton, 2013).

Our study also confirms King's (2007) concept of insightful citizens who can inform policy empowered with transparent information and appropriate tools. According to King (2007), citizens can become insightful if they are allowed to access information and systems such as portals that are linked to GIS and service rating functions. King (2007) argues that insightful citizens build on insightful councils that are informed by citizens' opinions and complaints from call centers. Therefore, the more the government views citizens as coproducers, the more crowdsourcing activities can become complementary; citizens can have a greater impact on policy design and deeper involvement in service implementation.

Government and citizen relationships: Crowdsourcing for democracy-building

The proposed typology can help policymakers and designers clarify the functions of crowdsourcing adoption; thus, it can reduce misunderstanding between governments and citizens. For instance, Royo and Yetano (2015) argue that partial adoption of crowdsourcing is more likely to lead citizens to mistrust the process, as citizens expect their ideas to be adopted by the government. Additionally, existing studies have noted the limitation of adopting crowdsourcing for deliberation. Lodge and Wegrich (2015) show that the United Kingdom's “Red Tape Challenge,” an online consultation process to reduce red tape in the UK government, did not provide evidence of deliberation among the participants, despite high participation. Thus, to make crowdsourcing work in the online consultation setting and attract informed contributions, administrators should have a restrictive focus and make transparent to citizens whether their inputs are supplementary or complementary functions to the government.

It is, therefore, important to adopt the proposed typology to clearly distinguish how inputs from citizens will affect the outcomes of a policy or service. Our typology is consistent with several important studies that aim to apply crowdsourcing for democracy-building. For instance, Aitamurto and Landemore (2016) define crowdsourced democratic deliberation as a process embedded in a larger policy-making process that is governed and controlled by crowdsourcers with a strong policy focus. To achieve a policy goal, crowdsourcing includes a mechanism for synthesizing and analyzing crowdsourced input. In other words, through direct participation, the crowdsourcing process of the policy design itself is to realize democratic deliberation if the functionalities of the crowdsourcing activities are well defined and clarified. Furthermore, using Finland's lawmaking as an example, Aitamurto and Chen (2017) argue that crowds can provide experience and expertise-based knowledge in crowdsourced policymaking, such as through complementary crowdsourcing. Additionally, Desouza and Bhagwatwar (2014) analyze participatory platforms in the 25 most populated US cities and show citizen involvement in various technology-enabled participatory platforms, thus providing supplementary crowdsourcing examples in both policy design and service implementation.

CONCLUSIONS

The present findings contribute to the field's understanding of the various functions of crowdsourcing and can allow the government to enhance the ability of citizens to coproduce services, generate needed information, create innovative solutions to public problems, and express their public policy preferences. The typology could also be applied to improve systematically accumulated research and practical lessons. First, building on the literature on coproduction, volunteering in the public sector, and direct public engagement, this

typology improves the theoretical bases for crowdsourcing and proposes possible ways that citizens can be coproducers of public services. Crowdsourcing thus serves as a vehicle for citizens to coproduce public services, perform online volunteering, and engage directly in policy design. Specifically, the typology further distinguishes the roles of citizens in terms of levels of involvement and the stages of policy for crowdsourcing public services.

Because this typology emphasizes the roles of citizens, understanding the variation in levels of citizen involvement in crowdsourcing can reduce the challenges associated with comparative research. For instance, Royo and Yetano (2015) show two different types of citizen involvement in crowdsourcing activities. Furthermore, scholars can adopt the four cells in the typology to map cases of crowdsourcing that have grown rapidly in the public sector. For instance, most crowdsourcing activities are supplementary (Linders, 2012) and more complementary types of crowdsourcing activities can be designed to increase the level of citizen involvement (Royo & Yetano, 2015).

Second, this study provides an initial means to examine government–citizen dynamics and has implications for practice. The typology provides policymakers with a tool for decision-making about the selection of different types of crowdsourcing. An effective crowdsourcing design requires a match between tasks, policy goals, and participants' capacities (Liu, 2017a). The typology shows differences between what a government does and what citizens do through crowdsourcing and the power/responsibility of governments and citizens. For instance, governments that respond to citizen-supplied crowdsourced data can build more sustainable cities (Certomà et al., 2015) through supplementary crowdsouricng in policy and service design.

Lastly, the typology enables practitioners to adopt crowdsourcing that aligns with their policy goals (Liu, 2017a), which helps them decide when to involve citizens in what types of crowdsourcing activities. A recent review of applications of crowdsourcing for urban sustainability governance indicates that crowdsourcing will impact the future by increasing participation in science and policy production, generating solutions to public problems, generating data for policy decisions or service delivery, and so forth (Certomà et al., 2015). They note that organizations that can respond to citizen-supplied crowdsourced data will gain a competitive advantage in the long run (Certomà et al., 2015). Meanwhile, the role of the government will remain essential to ensure the effective implementation of crowdsourcing initiatives. Additionally, Liu (2017a) shows that an effective crowdsourcing design requires a match between the tasks and goals of the policy as well as between the tasks and capacities of citizens. By examining the policy process and the extent to which the tasks complement government efforts, this typology will help designers select the right type of crowdsourcing initiative to achieve their organizational goals.

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CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

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