



The Landscape of Digital Platforms for Bottom-Up Collaboration, Creativity, and Innovation Creation

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Abstract. The widespread use of digital networks, technologies, and platforms, that allow humans, physical objects, and machines to interact with each other, has significantly affected the structure, components, and knowledge processes of innovation systems that have been transformed into cyber-physical innovation environments. Such environments operate at various scales and spaces, involve a wider set of actors, and demonstrate collective intelligence, exhibiting, thus, higher efficiency and impact than traditional innovation systems. Therefore, it is justified that there is an increasing research interest for understanding digital crowdsourcing platforms and online communities as a channel of collaborative innovation. Despite the attention such systems receive from different disciplines, there is still limited empirical evidence on their structure and coordination, as well as the mechanics that lead to sustained user participation and the generation of inventive and creative ideas, especially in urban planning and civic participation. This paper aims to conduct an overview of key platform attributes and common human-computer interaction patterns, based on an examination of the pertinent literature, as well as an indicative sample of notable platforms which allow large networks of individuals or communities to access, explore, and exchange knowledge and ideas.

Keywords: Digital platforms · Human-computer interaction · Crowdsourcing · Planning & urban design · Citizen engagement

1 Introduction

Over the last decade, we have witnessed the emergence of new digital tools and technologies that transform modern societies, bringing together people, organizations, and resources, creating cyber-physical interactive ecosystems characterized by novel ways of innovation and value creation. A core component of these tools are platforms; digital participative infrastructures accompanied by new governance conditions that create network effects and externalities by consummating matches and facilitating the exchange of goods, services, ideas, and data [1].

Platforms disrupt industries, economies and have a detrimental effect on society. Due to their intrinsic characteristics that leverage technology to trigger social creativity [2], they are increasingly linked to grand societal challenges such as those of sustainability and climate change, as well as to complex and persistent urban problems that are characterized by multiple conflicting forces, such as those of congestion, pollution and economic degradation [3].

Digital innovation and platform-based solutions in the urban environment fuel new processes for creativity and innovation creation, form new governance conditions, but also pose implications that city authorities must address. Given their broad/universal character and the interconnected processes that they trigger, it is suggested here that their full potential and dynamics have not been thoroughly analyzed. Empirical studies from different disciplines (economics, ICT) focus on different dimensions of the platforms, such as their structure (technical architecture and specifications), value proposition (new product development and entrepreneurship), and network effects. What these studies rarely consider is the dynamic effects that these attributes have at the spatial level, especially through the interaction of digitalization-enabled factors with any non-digital elements in an urban context.

This paper aims to contribute towards filling this gap by clustering digital platforms with regards to several characteristics that reflect their way of operation, governance, and outcomes. More specifically, we review the literature of digital platforms and collect attributes that seem to affect their impact and prospect of innovation creation, such as ownership, openness, and application domain. We use these attributes to examine twenty (20) different digital crowdsourcing platforms and reach insights on the elements that differentiate digital platforms compared to analog means of collective intelligence.

2 Digital Crowdsourcing Platforms: Definition and Key Attributes

Digital platforms constitute a new organizational form; based on digital technology, they mediate the relationships between producers or workers and consumers. Common types of digital platforms include transaction platforms, such as Amazon and Airbnb, and technology platforms, such as the app stores of Google and Apple [4]. The rise of digital platforms is rapidly changing the landscape of many industries, such as transportation, software development, and hospitality [5], leading to increasing research interest. Prior research has offered various definitions for digital platforms, i.e., definitions based on a technical view that addresses the technical elements and processes that interact to form a digital platform, as well as definitions based on a non-technical view that present platforms as commercial or two-sided networks that enable interactions between interdependent groups of users [5]. Similarly, in [1] the authors define a platform as a business based on enabling value-creating interactions between external producers and consumers. The platform provides an open, participative infrastructure for these interactions and sets governance conditions for them, to consummate matches among users and facilitate the exchange of goods, services, or social currency [1].

Recently, there has also been an ongoing interest in crowdsourcing platforms. In his defining work, Howe [6] suggested that crowdsourcing is “*the act of a company or institution taking a function once performed by employees and outsourcing it to an*

undefined network of people in the form of an open call". According to a comprehensive study that compiled and examined several different definitions of crowdsourcing [7], crowdsourcing *constitutes a distributed online process that requires the participation of the crowd for the accomplishment of specific tasks*. Thanks to the recent advances in information technologies and the emergence of collaborative Web 2.0 digital platforms, organizations or companies can now benefit from the "wisdom of the crowd", which is typically heterogeneous, comprising volunteers, enthusiasts, amateurs, as well as experts and companies [8]. Furthermore, crowdsourcing is also considered a mechanism that can be used to organize and facilitate worldwide volunteer efforts, or "collective intelligence" [9].

Crowdsourcing has already been applied in many areas, from business projects to non-profit initiatives, and there are many examples of successful crowdsourcing platforms, such as Amazon Mechanical Turk (a crowdsourcing website where businesses can find remotely located "crowdworkers" to perform micro tasks), Wikipedia (a free, multilingual online encyclopedia created and maintained by a community of volunteers), and InnoCentive (an open innovation platform which allows organizations to post their unsolved problems to InnoCentive's "solver" network).

Furthermore, it has also been suggested that crowdsourcing is an appropriate method for motivating and facilitating citizen participation in urban projects [10]. Indeed, many scholars have advocated for more participatory processes where civic technologies are publicly owned and led by citizen initiatives [11]. Participatory innovation is thought to provide a viable alternative to more traditional official-led planning, as it is believed that the increasing number of open data sets could facilitate citizens in becoming active participants and urban innovators, instead of mere civic technology users [12]. Accordingly, there is also an ongoing research interest on the design and use of crowdsourcing platforms as participative ecosystems for *e-governance*, see, e.g. [13–15]; *urban planning*, see, e.g. [16–19]; *transit planning*, e.g., [20, 21]; as well as *air quality and environmental awareness*, e.g., [22, 23], among others.

So far, several crowdsourcing platforms that facilitate citizens have been created around the world in finding information, collaborating, and voicing their perspectives on important urban issues. Some noteworthy examples comprise: (a) Better Reykjavik, an online civic participation and open innovation platform; (b) Spacehive, a UK-based crowdfunding platform for citizen-led neighborhood improvement projects; (c) Ushahidi, a Kenyan-based platform allowing people to submit, collect and map crowdsourced information for crisis response, environmental justice, election monitoring, etc.; (d) Carticipe, or Debatomap for non-French speakers, a participatory mapping tool designed to promote citizen debates and consultation on a city or urban territory; (e) Colouring London, a knowledge-exchange platform providing open data on London buildings to help make the city more sustainable, and (f) Decide Madrid, a platform aiming to engage the public in decision-making and to ensure transparency of government proceedings. These platforms vary greatly in aims, characteristics, and organizational structures; for example, they can be instigated by researchers or governing bodies, or they can be bottom-up community-led ones, where citizens are directly involved in the organization of the project and the development or improvement of the platform.

Due to their broad spectrum and sociotechnical implications, it is difficult to truly understand the attributes of digital platforms, especially since research on the subject is fragmented into many different domains. Efforts have been made to create taxonomies and analyze their specific characteristics. [24] and [25] both use the method of taxonomy mentioned in [26] to group digital platforms' instances and conceptualizations, facilitating thus the identification of archetypes. The first study is focused on dimensions and characteristics and suggests that digital platforms exhibit characteristics on at least four dimensions—namely, infrastructure, core, ecosystem, and service dimensions. The second one analyzes digital platforms from a business model perspective and derives four archetypes with distinct design configurations, i.e., business innovation platforms, consumer innovation platforms, business exchange platforms, and consumer exchange platforms. Other efforts to create a classification system focus on digital platforms' core building blocks such as platform architecture, platform orchestrator and ownership, value-creating mechanisms, coordination mechanisms, as well as market control [27–29]. Based on an extended review of this literature we have identified attributes that seem to define the nature of digital platforms and affect their overall impact, not only in terms of innovation outcome within the specific context in which they are being used but also with regards to their prospect for facilitating innovation in wider contexts. These attributes and characteristics include the type of crowdsourcing, the platform's ownership, openness, and affordance and are analytically explained below.

2.1 Typology of Crowdsourcing Platforms

Concerning crowdsourcing platforms, an overview of relevant studies revealed various proposed typologies. First, a more generic categorization would be based on the mode of interaction between contributors, so platforms could be characterized as either competitive or collaborative. In the first category, contributors provide competing products/services or take part in contests for rewards. In the second category, open access to information is promoted among contributors [5]. There are also other categorizations based on various dimensions, e.g., the objective of the platform and the type of need it addresses. In [8], the authors propose an integrated typology composing five main types of crowdsourcing: (a) *Crowdcasting* – contests where participants are presented with a problem and the best solution is rewarded; (b) *Crowdcollaboration* – crowdsourcing initiatives in which the initiator remains on the sidelines in order to allow participants to interact on their own. It can be divided into *Crowdstorming* (online brainstorming sessions, in which the crowd can vote for preferred ideas) and *Crowdsupport* (where the customers themselves solve the problems of other customers); (c) *Crowdcontent* – in this category of crowdsourcing tasks, the crowd creates or finds content on the Internet or inside multimedia documents, but not in a competitive way; (d) *Crowdfunding* – the crowd can fund various initiatives, in exchange for a reward; and (e) *Crowdopinion* – participants contribute by sharing their opinions about a particular issue or product through votes, comments, shares, etc.

Common subtypes of crowdsourcing have also been used effectively in the commercial world. These include e.g. microwork (online platforms that allow users to do small tasks that cannot be automated but also do not require any special training or expertise, for low amounts of money, e.g. Toloka, Amazon Mechanical Turk); macrowork (online

platforms that in which tasks require specialized skills and typically take longer, e.g. Upwork, Fiverr); creative crowdsourcing (online platforms where clients can solicit a wide variety of creative work, such as graphic or apparel design, at lower cost, e.g. 99designs, DesignCrowd); crowdvoting (a subtype of crowdopinion where a platform gathers users' opinions on a certain topic by upvoting/downvoting, e.g. Reddit), and others. Even though this is not an exhaustive list, the above-mentioned types and subtypes of crowdsourcing cover the present major ways in which people use the wisdom of the crowds to perform tasks.

2.2 Capabilities of Platform Leaders or Suppliers

Capabilities may refer to the distribution of benefits and the nature of the motivation to participate [9] or the platform ecosystem orchestration [30]. Regarding supplier capabilities, these can be characterized based on the simplicity of the outsourced task. Simple tasks are of relatively low complexity, can easily be performed without formal training, and can be easily evaluated; moderate tasks require a moderate level of complexity and difficulty, and, finally, sophisticated tasks are complex and require highly skilled suppliers [9]. The distribution of benefits refers to who has benefited from the crowdsourcing activity. Based on that, crowdsourcing can be labeled individualistic (activities that provide personal or company benefits), community (activities that are designed to benefit a community of some kind), and mixed (both individualistic and community) [9]. Finally, crowdsourcing can also be characterized by users' incentives for participation. Some common incentives include learning and motives related to personal achievement, (ii) altruism, (iii) enjoyment and intellectual motives, i.e., curiosity, (iv) social motives, (v) self-marketing, and (vi) financial motives [31].

Lastly, crowdsourcing can be characterized as implicit or explicit, based on the way users contribute data to the platform. More specifically, crowdsourcing platforms can be distinguished between platforms where data is provided directly by users (explicit crowdsourcing), and platforms where data is indirectly provided by users' sensors, e.g., geolocation info from mobile devices (implicit crowdsourcing or "crowdsensing") [31]. Usually, the goal of these applications is to monitor indicators such as radiation levels or air quality and to raise awareness on local issues.

2.3 Platform Ownership

Platform ownership is not just about the legal entity that owns the digital platform; it is also related to content ownership, the relationships among partners, and the distribution of power in the ecosystem, which can be centralized or decentralized. Rules of ownership and governance mechanisms are usually stated in the Terms of Service, although in most cases it is not very well-suited for governing the relationship between user and platform [32]. In [27] three categories of platform ownership are defined: (a) centralized platforms, controlled by a single owner (usually a company or an organization), who defines, establishes, and maintains the governance mechanisms of the platform (e.g. Google, Apple); (b) owned by consortia, a group of actors or a community of independent developers, where there is a distribution of power over multiple stakeholders (e.g. Cloud Foundry); and (c) decentralized platforms, governed by peer-to-peer communities that

allow individuals to make changes in the design and functionality of the platform (e.g. blockchain platforms).

2.4 Platform Openness

Openness, an important factor for knowledge sharing and innovation creation, refers to the degree to which other firms or individuals can freely use, modify, and develop the platform technologies, terms of use, and outcomes [33]. It is directly linked to platform ownership and affordance and can be examined through different dimensions. Several aspects of openness are identified in the relevant bibliography, such as (i) architectural openness, (ii) standards compliance, (iii) open intellectual property regime, (iv) absence of lock-in mechanisms, (v) free and open market, and (vi) open governance [34].

2.5 Platform Affordance

It is a relational property comprising (a) decoupling, that reduces the importance of asset specificity in regulating power and dependency relationships within manufacturing value chains, (b) disintermediation, the ability to support direct interactions between service providers and users, thereby enabling them to bypass intermediaries, and (c) generativity, i.e. facilitate unprompted innovative inputs from large, uncoordinated audiences, the outcome of several architectural features that jointly reduce transaction costs in interactions conducted through the internet and infuse an extent of unpredictability and fluidity into innovation outcomes) [35].

The literature on platform attributes and characteristics is going on with studies focusing on a) resource richness, i.e. the types of inputs or contributions b) the platform's structure, either as an innovation platform that facilitates collaboration between customer groups or as an exchange platform that promotes transactions between them, c) the network's attributes, such as network structure and intensity, since the platform can be considered as an intermediary interface that facilitates interactions between entities (nodes) comprising both individual participants and collectives [36].

3 Methodology

We collected and analyzed 20 international crowdsourcing platforms based on specific attributes that have been described in the section before. Compared to previous empirical studies we analyze platforms of different types (crowdcontent, crowdfunding, crowdopinion, crowdcasting) as they are listed below.

Crowdcontent platforms

- Ushahidi (<http://www.ushahidi.com/>): Crowdsourcing tools for democratizing information, increasing transparency, and lowering the barriers for individuals to share their stories. Users can submit their reports by text message, e-mail, online posts, etc. Ushahidi tools have been used for crisis response, election monitoring, advocacy, and human rights.

- Neighborland (<https://neighborland.com/>): Neighborland is a proprietary public engagement platform designed for government agencies, developers, and civic organizations. It allows stakeholders to publish their feedback (ideas, votes, comments) on maps and scenario renderings, interact with others on the discussion forum, and take part in surveys. Resident ideas, insights, and solutions are mapped to specific locations and categorized by topic. It can also be characterized as a crowdopinion/crowdvoting and crowdcollaboration platform.
- Actipedia (<https://actipedia.org/>): An open-access, user-generated database of creative activism, that can also be characterized as a crowdopinion/crowdvoting platform. Users can share projects they found on the Web or participated in themselves, improve the platform's user-generated content, keep track of projects they like, and upvote their favorite projects.
- ColouringLondon (<https://colouringlondon.org/>): A free knowledge exchange platform designed to provide over fifty types of open data on London buildings, to help make the city more sustainable. Users can contribute their knowledge on London's building, check the platform's data, and submit links to databases of relevance.
- OpenStreetMap (<https://www.openstreetmap.org/>): A collaborative project to create a free editable geographic database of the world. Contributors use aerial imagery, GPS devices, and low-tech field maps to verify that the platform's maps are accurate.
- WikiHouse (<https://www.wikihouse.cc/>): An open-source project aiming to democratize the creation of low-cost, low-energy homes. Contributors include a distributed network of small, local fabricators and assemblers, as well as architects, designers, engineers, entrepreneurs, etc.
- Block by Block (<https://www.blockbyblock.org/>): A project providing the tools and platform to involve community members—especially underrepresented, such as kids, elders, disabled residents, and refugees—by integrating the computer game Minecraft into public space planning. Given the fact that Minecraft is easy to learn and to play by people of all ages and backgrounds, it is used to enable neighborhood residents to model their surroundings, visualize possibilities, and express ideas.

Crowdfunding platforms

- Spacehive (<https://www.spacehive.com/>): UK-based crowdfunding platform for projects aimed at improving local civic and community spaces. Individuals, local groups, and businesses can start a project on the platform and raise funds from the crowd or partners of the platform.
- DigVentures (<https://digventures.com/>): Platform for crowdfunded and community archaeology and heritage projects. Users can support and take part in various crowdfunded projects.
- IOBY (<https://ioby.org/>): US-based civic crowdfunding platform that connects local leaders with support and funding from their communities to make neighborhoods more sustainable, healthier, and greener.

Crowdopinion/crowdvoting platforms

- Crowdscope (<https://www.crowdoscope.com/>): Survey and discussion tool for gathering quantitative and qualitative data and generating real-time collective intelligence.
- Polis (<https://pol.is/home>): Open-source real-time system for gathering, analyzing, and understanding large groups of people's opinions, enabled by advanced statistics and machine learning. Used by governments, academics, independent media, and citizens.
- Terrifica (<http://climatemapping.terrifica.eu/>): A crowdmapping platform built to collect people's experiences and opinions regarding climate change in their local environment. Users are invited to put marks on an interactive map and explain why they decided to mark this place.
- MindMixer (<https://www.mindmixer.com>): Online community engagement platform that connects municipal decision-makers and elected officials with their constituents in a cost-effective manner. Participants can submit their ideas or support other ideas. They can also vote in instant polls or take part in surveys.
- DecideMadrid (<https://decide.madrid.es/>): Open-source platform which can be used to engage the public in decision-making and ensure transparency of government proceedings. Participants can propose and support ideas for new legislation, and provide opinions about/vote on council proceedings, among others.
- Decidim (<https://decidim.org/>): Free open-Source digital platform providing spaces for participatory democracy for cities and organizations enriched with tools such as proposal creation, voting, surveys, comments, etc.
- Better Reykjavik (<https://betrireykjavik.is/domain/1/communities>): The City of Reykjavik's online engagement platform is used for the crowdsourcing of solutions to urban challenges. Better Reykjavik uses Your Priorities (open-source software to organize and crowdsource ideas). Participants can submit ideas and vote on proposals submitted by other users.

Crowdcasting and Open Innovation platforms

- Innocentive (<https://www.innocentive.com/>): Open innovation and crowdsourcing platform. Solvers can visit the platform's challenge center and find open challenges to tackle. If their submission is selected they may receive a monetary reward.
- OpenIdeo (<https://www.openideo.com/>): An open innovation platform where people collaboratively tackle global issues. The purpose of the platform is to virtually drive the creative process to solve challenges, by facilitating people of different expertise and backgrounds to collaborate, innovate, and win various prizes.
- IdeaScale (<https://ideascale.com>): Innovation management platform allowing organizations to crowdsource the opinions of public and private communities regarding various challenges. Users can create a profile on IdeaScale and submit ideas as members of a community. They can also comment and vote on other ideas.

We analyze the platforms comparatively based on three characteristics: the domain they are used, the type of the platform, the contributors' incentives, the platform ownership as well as their openness. First, with regards to platform typology, we use the

following types: (i) crowdcollaboration, mainly crowdstorming, (ii) crowdcreation, (iii) crowdopinion and crowdvoting, and (iv) crowdfunding, although we have noticed that some platforms can incorporate attributes from several crowdsourcing types at the same time. We then categorize platforms according to ownership status. We also focus on three different dimensions of openness: a) the platform's technological openness, i.e. the openness of the digital platform architecture and the boundary resources (APIs) that affects the ability of external entities to build on and complement one another's contributions, b) access openness, i.e. the platform's rules for entrance and exit along with the ability of different types of actors to participate, and c) outcome openness, i.e. the openness of data and the ability to use the platform outcomes for purposes outside the scope of the platform. These dimensions show that openness is not just about the platforms' artifacts but also refers to the transparency and inclusiveness of its governance [34].

4 Research Findings

The findings are based on the analysis of the sample of 20 crowdsourcing platforms based on five attributes: their domain of application, their type, the incentives of platform contributors, the platform's ownership, and openness. More specifically, most of the platforms analyzed aim at community engagement and civic participation, while a limited number of others focus on volunteered geographic information, crisis mapping, knowledge exchange, participatory democracy, and election monitoring. Participation is considered a key feature in the innovation process, as it strengthens and seizes network effects, and enhances the ability of people to collaborate and create bottom-up innovative solutions to complex problems.

With regards to their type, 45% of the sample platforms were crowdopinion platforms, 35% crowdcontent platforms, and a smaller percentage was crowdfunding, collaborative project creation, crowdmapping, and crowdcasting platforms. Most of the reviewed platforms facilitate collaboration among participants, while only a few platforms (i.e., crowdcasting/open innovation platforms) urge the participants to compete –as individuals or members of a team– in order to submit the best solution and gain a reward. Reflecting on the context of grand challenges and of complex urban problems, crowd-opinion moves one step further from collecting resources and captures the collective wisdom of the crowd facilitating, complementing, and increasing thus the capacities and effectiveness of urban authorities, leading to better-informed decision-making processes and empowered governmental entities and citizens.

With regards to ownership, most platforms are owned by non-profit organizations, and only a small percentage of them are owned by a private company. The non-profit nature of ownership does not affect the technological openness of the platform, since a large percentage of them is using proprietary software. Finally, almost all platforms give open access to users (either individuals or organizations) with the requirement to create an account although the openness to different types of contributions may vary depending on the platform. For example, in almost all platforms anyone can register and contribute content to the platform, but there may be limitations or specific rules for editing inputs from other users, participating in conversations, voting, etc. (Table 1).

Table 1. Crowdsourcing platforms and their attributes

	Domain	Contributors' motives	Platform ownership	Technological openness	Access openness	Outcome openness
<i>Crowdcontent</i>						
Ushahidi	Human rights & Crisis mapping Election monitoring	- Altruism - Learning - Personal achievement - Intellectual motives	Non-profit company	Open-source technology Paid plans for custom enterprise platform	Anyone can participate through various channels, e.g., SMS, e-mail, Twitter	Supports import and export of user-contributed data
Neighborland	Public engagement	- Altruism - Learning - Personal achievement - Intellectual and social motives	Private for-profit company	Proprietary software	Citizens, governments, and civic organizations	Material and platform code cannot be modified, used, or distributed without permission
Actipedia	Creative activism	- Altruism - Learning - Personal achievement - Intellectual motives	Non-profit company	Proprietary software	Anyone can participate by creating a free account	Collect and share users' submissions outside of the platform
Colouring London	Citizen social science & knowledge exchange platform Volunteered Geographic Information	- Altruism - Learning - Personal achievement - Intellectual motives	Non-profit company	Open-source software	Anyone can participate by creating a free account	All data and code are free to download, use and share under our open license terms
OpenStreetMap	Volunteered Geographic Information	- Altruism - Learning - Personal achievement - Intellectual motives	Non-profit organization	Not open source	Anyone can edit the maps	Open data: users are free to copy, distribute, transmit and adapt OSM data if they credit the platform and its contributors
Wikihouse	Open-source architecture	- Altruism - Learning - Personal achievement - Intellectual and social motives	Non-profit company	Open-source project	Anyone can contribute, improve or even create a new product based on the WikiHouse building system	Users can download Creative Commons-licensed files, customize them and use them in construction

(continued)

Table 1. (continued)

	Domain	Contributors' motives	Platform ownership	Technological openness	Access openness	Outcome openness
Block by Block	Community engagement Urban planning	- Altruism - Learning - Personal achievement - Intellectual and social motives	Non-profit foundation	Workshops using Minecraft (proprietary software)	Local community members can participate and contribute	The Block by Block Methodology is free to download
<i>Crowdfunding</i>						
Spacehive	Community engagement Civic projects	- Altruism - Learning - Personal achievement - Intellectual and social motives	Private company	Proprietary platform. It also provides specialized software to foundations that it partners with to fund projects	Anyone can submit a project after registering. Organizations can become fund owners	The content of the platform may be accessed only for non-commercial use and cannot be distributed or modified
DigVentures	Community engagement in archeology and heritage projects Civic participation	- Altruism - Learning - Personal achievement - Enjoyment - Intellectual and social motives	Private company	Proprietary platform. They also offer consultation services	Anyone can use the platform to back a project and take part in community projects	The material or the platform cannot be modified. Users cannot contribute or edit content
IOBY	Civic participation Community engagement	- Altruism - Learning - Personal achievement - Intellectual and social motives	Non-profit company	Proprietary platform	Users can submit ideas as individuals or organizations or back projects	Users retain ownership of their works but cannot modify or use other users' projects
<i>Crowdopinion/Crowdvoting</i>						
Crowdscope	Collective intelligence	- Personal achievement - Social and professional motives	Private company	Proprietary platform	Users participate in surveys and discussions	Users retain ownership of their content
Polis	Collective intelligence Civic participation	- Altruism - Learning - Personal achievement - Intellectual and social motives	Non-profit organization	Open source	Organizations can invite citizens to take part in conversations	Users can store, transfer, display and distribute content from the platform

(continued)

Table 1. (continued)

	Domain	Contributors' motives	Platform ownership	Technological openness	Access openness	Outcome openness
Terrifica	Community engagement	- Altruism - Learning - Personal achievement - Intellectual and social motives	Non-profit organization EU-funded project	Proprietary software	Anyone can register and contribute. Users from six pilot region	No data policy in place. Users can contribute but not export data
MindMixer	Community engagement	- Altruism - Learning - Personal achievement - Intellectual and social motives	Private company	Proprietary platform	Municipal decision makers and elected officials can connect with citizens	Users can view/download content solely for personal and non-commercial purposes
DecideMadrid	Community engagement Participatory democracy	- Altruism - Learning - Personal achievement - Intellectual and social motives	Non-profit organization	Open-source software	Anyone can participate, vote and collaborate	Data is open to be freely used, reused and redistributed
Decidim	Community engagement Participatory democracy	- Altruism - Learning - Personal achievement - Intellectual and social motives	Non-profit organization	Open-source platform	Any group of people can use it. However, it is addressed primarily to users based in Barcelona	The data available through the platform will be published and licensed under Open Data Commons Open Database License
Better Reykjavik	Community engagement Participatory democracy	- Altruism - Learning - Personal achievement - Intellectual and social motives	Non-profit organization	Open-source software provided by Citizens.is	Anyone can participate, even anonymously	Supports easy access and export of data for administrators. Ideas can be shared on social media
<i>Crowdcasting/Open innovation</i>						
Innocentive	Open innovation	- Altruism - Learning - Personal achievement - Intellectual - Social and financial motives	Private for-profit company	Proprietary platform	Open participation after signing a specific agreement	The solvers own their proposed solutions. They can transfer the intellectual property rights to seekers

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Table 1. (continued)

	Domain	Contributors' motives	Platform ownership	Technological openness	Access openness	Outcome openness
OpenIdeo	Open innovation	- Altruism - Learning - Personal achievement - Intellectual - Social and financial motives	Private for-profit company	Proprietary platform	Open participation from anyone in most cases	All ideas publicly contributed to OpenIDEO become shareable, remix-able and reusable by anyone
IdeaScale	Open innovation management	Rewards (and subsequently user motives) are dependent on the company or organization that uses IdeaScale's platform	Private for-profit company	Proprietary platform	Freemium model and paid subscriptions	Users retain ownership of the intellectual property rights of the content they submit. They cannot reproduce or modify derivative works of the platform's content

5 Discussion and Further Research

The open collaborative approach of innovation has resulted in fundamental changes in problem-solving capabilities as (a) it enhances wider participation in the innovation process, and (b) it enables network effects to take place while also reducing transaction costs. Digital platforms and web-based tools for open collaborative innovation provide a virtual environment for knowledge transfer and integration and can be leveraged for the design and implementation of bottom-up innovative solutions to complex problems, creating new sources of value. The digital, collaborative platform provides an open, participative infrastructure of interactions and sets governance conditions for them while the Internet allows wider aggregation and integration of different members in an innovation community [37]. We approached the different aspects of digitalization and openness of the innovation process through the analysis of different attributes of platforms that vary significantly with regards to their domain and type. We find that most platforms present similar features of ownership and openness which might be characteristics innate to digital technologies that set motion to the mechanisms for engagement, sharing, collaboration, and co-creation.

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