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Review

Mitigating Challenges of Open Government Data

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Abstract: The Release of government dataset for public use can potentially strengthen the relationship between the government and its constituents. However, research shows that there are several challenges for open data effectiveness. This paper reviews current determinants and issues associated with the open government data (OGD) procedures. The review concentrates on two ends of the spectrum: First, from the perspective of the preparation by the government, focusing on the organization of traditional governmental datasets and how the recording of the data is administered. Second, from the perspective of the users, focusing on the way in which the data is released to the general public and on human-computer interaction (HCI) issues between end-user and data-consumption interfaces. Following a thorough analysis of these two opposing challenges, the paper proposes approaches to mitigate them. This review and subsequent recommendations contribute and expand current understanding of open government data effectiveness and can lead to public policy changes, development of new procedures and strategies, and ultimately improvements at both ends of the federal open data endeavor.

Keywords: Open access initiative; Challenges of data sharing; Data management; open government data; human-computer interaction; Documentation; Human Factors; Standardization; information policy

1. Introduction

According to the memorandum of "Open Data Policy-Managing Information as an Asset" [1], open data refers "to publicly available data structured in a way that enables the data to be fully discoverable and usable by end users." This document suggests that by default, government data should be public, accessible, described, reusable, complete, timely, and managed post-release. Open data is increasingly becoming a popular initiative for governments around the world due to its potential to create public and commercial benefits for the economy, for the society, and for the government itself. It has also been promoted by the US initiative, expressed in President Obama's memorandum on his first day in office to have a transparent, participatory, and collaborative government [1–3]. It has also been followed by global open data initiatives to unleash an innovation potential for economic development [4]. Most democratic societies recognize the right to access, use, and reuse information produced by the state [5] – except in cases that data openness and disclosure can conflict with another social value such as individual privacy or national security [6]. In fact, considering the structure and settings of modern societies, some researchers have suggested that having access to public information is no longer a privilege but a human right [7].

However, there are several challenges to have an effective open government data (OGD) program in place [8]. One category of challenges is associated with the storage retrieval of the information. While the storage elements is associated with the governmental agency which hosts the data, retrieval challenges are mostly a challenge of the whole open data ecosystem. The barriers in this stage are stemming from lack of knowledge about the stored data – e.g., whether if it exists or not, where to find specific datasets and more related datasets, and also having access to enough information about the data that allows a reasonable understanding of the data [9]. Thus, the roots of at least some of these challenges are in fact in the information storage stage.

Another set of barriers are those associated with the limited span of human attention and thus is associated to the Human-Computer Interaction (HCI) factors of open data applications that are

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developed for the citizens, utilizing open data. Improvements in the design and accessibility of OGD datasets has opened the door of using open data to new and less skilled users. However, people still might need help in making sense of published data.

Being aware of how potential users seek and utilize OGD are now becoming priorities for a successful open data plan [10]. We have identified some key factors in HCI regarding OGD applications' effectiveness, that can, in fact, be impactful on the effectiveness of the open data programs.

2. Background: The significance of open data

Open data suggests that federal information be available to the public as the constituents of the government. Although opening public information is not a new concept, it has been recently revitalized through the open data movement. This revitalization responds to both technical and social trends. Recent technological advancements have created the opportunity of sharing data in open and re-usable formats [11]. Nowadays, humans are generating massive amounts of data at an increasing rate. This is because new technologies have reduced the cost of information storage significantly, and digitization has made us capable of recording things that were not recorded historically. Traditionally, data stakeholders had been among the original data owners, data producers, data transformers and interim users, and direct or indirect[1] end-users of the data. Procedures governing data storage and retrieval are designed to meet the requirements of these primary stakeholders [12] and to satisfy their desired service levels.

Given the growing interest of the public in taking advantage of OGD in recent years, a growing number of governments around the world have started open data plans and have joined global open data causes[2] [13].

Opening data creates public and commercial benefits directly via one or more of the categories below [14]:

Transparency, and consequently accountability of government agencies and public officials;

Releasing social and commercial value, by creating an environment in which the needs of end-users can be identified and addressed in a crowdsourced manner; and

The participatory government, which fosters the soul of democracy by giving people a voice and a mechanism to take their part in public decision-making processes.

However, generating benefits from open data initiatives is not a one-way street. As the society and the government communicate, the benefits can also leverage the government as well [15]. In recent years an 'ecosystem' perspective has emerged that takes into account this feedback from the society back to the government in response to opening data [15]. In this ecosystem perspective, the benefits generated in the society also affect the government's open data capacity, and reinforces open data initiatives for more value creation through opening data, as a delayed and secondary effect [16–18]. As a result, once the benefits of opening data are realized by the society, the government will be pushed by the ecosystem to open more data, and this reinforcing mechanism can cause growth and reinforce itself until it reaches a system barrier. The downside though is that the same structure can also cause a reinforcing decline. Thus, it is important to know exactly how to set the ground for open data ecosystem so it would go through the desired – growth – direction.

As public-sector organizations are moving toward opening their data, open data is becoming more of a 'core expectation' in the society, for more and more constituents, and the government is pushed even more to increase the capacity and the effectiveness of its open data programs. And of course, any improvement in the effectiveness of OGD programs will affect the reinforcing loop of the ecosystem.

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[1] Indirect users are those who use an outcome of some processed data by computer or human intermediaries

[2] For instance, the Open Government Partnership which started by 8 countries in 2011, and now must 75 as early 2017. (See http://www.opengovpartnership.org)

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3. Identifying the challenges

The concept of open data is based on the secondary use of federal data that adds a new layer of users to the stakeholders of governmental datasets – the datasets which are built through traditional or even legacy governmental processes – by making those datasets available to the public. This new layer of stakeholders is comprised of some governmental agencies, some open data application developers, and corporate or individual end-users. The chain of benefits corresponding to the flow of data in this ecosystem starts from the datasets already residing in governmental databases, feeds into the applications developed by governmental or non-governmental developers, and transforms into benefits when the end-users use the applications in the society.

However, this secondary use of the stored data will impose a new set of requirements that is not necessarily met by the data architecture and status quo of the datasets, as they had been designed to meet their residing agency's original requirements – based on the needs of their primary set of stakeholders, before 'open data applications' were considered at all. In other words, since the dataset is originally designed for its primary purpose, it is not a 'fit for purpose' (does not have "warranty") nor 'fit for use' (it also does not have "utility") for this secondary type usage. Even worse, in some instances, opening this data to the public might create misinterpretation in the absence of proper metadata. Moreover, this data might also lack information and instructions that are required for non-expert users of data – the users that are not familiar with the context and procedures in which the data has been governed and interpreted by.

3.1 Information Organization

Concerning the aforementioned new stakeholders of public information, several studies have pointed out that a mismatch between new requirements (associated with new stakeholders) with the existing information architecture, information organization procedures, and information tools, is a major impediment for the effectiveness of open data programs [19–22]. Some of the most important challenges related with OGD are (but not limited to) the difficulty of finding the needed information, processing the information especially if it is not in a machine-readable format, and maintaining a legitimate license for reusing the information.

Bizer et al. [23] have suggested the following categories for studying these and similar challenges:

3.1.1 Data discoverability issues

These challenges refer to the difficulty in finding useful data promptly for various reasons:

1. It is not easy for new stakeholders to locate the datasets they are looking for without understanding the data structures and the activities/responsibilities that lead to generation and storage of the data;
2. There is not a uniform data categorization. Thus different sources use different and sometimes conflicting categories; and
3. Some tools offered by some of the hosting agencies only support very basic search and seek functions. Also, the Principle of Least Effort (the fact that people prefer easy-to-use, accessible sources to sources of information) is also recognized as one of the most solid problems in seeking information [22].

3.1.2 Data identifiability issues

The lack of metadata (data description) and consequently the difficulty in identifying and linking corresponding and related datasets, stemming from a) The semantic ambiguity; and b) the difficulty in understanding the data, its granularity, and the spatial and temporal datasets. However, the use of the tools created by the Web 2.0 and semantic web opens more opportunities for moving toward a socially-constructed organization of knowledge [24].

Although there is some software available as open data infrastructure that aimed to deal with some of the challenges and complexities of OGD, they have not been effective so far [25], mostly

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because of the shortcomings above. These challenges call for some considerations regarding data architecture and data governance procedures at the data recording stage, in which the whole life cycle of the data from within the organization through the opened datasets for public use has been considered. These architectures should not only respond to the immediate organizational needs of the corresponding government agencies which host the data, but they should also make data sharing – which in many instances includes merging data from different organizations – doable with a lower burden of overheads, more effective, and less challenging. Following this agenda and also enabling extraction of more information out of the stored government data [26] can lead to better results (i.e., lower cost and higher achievements) from OGD programs, and facilitate linking of open datasets.

Conradie [9] has found that the way in which data is collected/generated, stored, and used (by a governmental department) are all critical for open data success. However, many of the local governments lack structures for leveraging their data release initiatives. Janssen [19] found that there are several barriers to the success of open data regarding data architecture and data organization, such as metadata explaining the meaning of data, metadata on quality of data, incompatibility of the formats in which the data is stored, no index or other means to ensure easy search, and absence or lack of metadata standards. They found that lack of standards at the dataset level is a major barrier to the ultimate secondary use of the open governmental datasets. In another related study, Zuiderwijk et al. [21] have also found that usability, understandability, quality, linking and combining, and metadata are among top impediments to successful open data implementations.

Hester [27] also suggests that "the reusability of datasets is improved by community adoption of comprehensive metadata standards." More specifically, he has suggested a set of specific steps toward increasing the effectiveness of open data programs, including "the development of metadata standards as soon as possible" for storing metadata, data architectures, and organization, data quality measures, etc.

Although scholars have suggested development of a comprehensive standard in the government layer regarding data governance procedures, in fact coming up with such a standard in practice is not an easy task, since all bodies that are a part of OGD initiative (virtually all governmental agencies) are a stakeholder of this new standard [9] and should fully comply with it to let it be effective. Thus, even when the governments decide to come up with such a standard, there are still myriads of challenges to deal with to make the governmental bodies follow it, and it takes a long time for governmental new datasets to comply under this comprehensive standard fully. Upgrading older datasets under these set of standards is also another category of challenges that require even more efforts and resources. More study is needed to find out how these challenges and their corresponding risks can be addressed effectively.

3.2 Human-Computer Interaction

The other set of challenges refer to issues relating to the users, and the way they interact with the data through the technological system. to Information systems development and growth are based on in-depth understanding of Human-Computer Interaction (HCI), which entails that closer attention is paid to the motivations and behaviors of diverse users. In addition to current literature, we will look at two large scales studies that studied OGD: The first is by Rainie et al. [28] in collaboration with Pew Research Center, which is based on a national survey (N=2,796 American adults) to look at how people seek information, in particular, OGD, to address common problems related to government agencies and programs. The second is by Verhulst et al. [29], who have studied 19 large open data projects from around the world. These research projects uncovered major challenges confronting open data initiatives and various factors that illicit cognitive, psychological and behavioral responses. We recognized congruence between information organization and HCI in key areas: Information seeking behavior - user readiness and "the digital divide"; attitudes and perceptions - Familiarity, Perceived Risks and Usefulness; and ease-of-use - Information Access Cost, Visual Information Processing, and Complexity. We also suggest solutions to mitigate noticeable issues to lead to adoption and acceptance.

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3.2.1 Information Seeking Behavior

On the other hand, not all impediments are going to be resolved even if all the capacities are correctly developed in the information storage and publication phase at the hosting agency. For better results, we should also consider the way in which humans communicate, and thus have standards in place for open data applications as well. This can come as part of the supporting activities done either by the government or by the infomediaries to sustain an effective open data ecosystem [11].

According to Rainie et al. [28] and Verhulst et al. [29], the most common problems people try to address using OGD were: health concerns; education (making a decision about school enrollment, financing school, or upgrading work skills); Taxes and finance; Employment (changing a job or starting a business); and getting information about major programs such as social security, Medicare, and Medicaid. According to Rainie et al. [28], the major finding on information seeking behavior in the US is that the Internet is the dominant source for information seeking: 58% Americans turn to the Internet, more than any other source of information and support.

3.2.2. The Digital Divide

A major HCI issue is user readiness and the digital divide: 36% of American adults are considered "low-access population," i.e., they have limited access to the internet [28]; 23% of Americans do not have any internet access, and 13% of Americans only have slow and less-reliable dial-up connections. This group has different issues and different search habits and strategies when they are looking to find informational resources. They are also less successful in getting the material they need to address their problems, in comparison to those with high-access to the internet. This phenomenon also exists in other parts of the world. Perhaps, unsurprisingly, countries or regions with overall lower technical human capacity often posed inhospitable environments for open data projects. (The lack of technical capacity could be indicated by several variables: low internet penetration rates, overall poor technical literacy, and a noticeable digital divide.)

3.2.3 Data Presentation Complexities

Relating again to the issue of the usefulness of dataset, we can apply the same logic to the open data applications. For instance, sometimes a website utilizes open data to give some services to the citizens. 76% of consumers say the most important factor in a website's design is "the website makes it easy for me to find what I want" [30]. A major HCI issue of OGD is the cost of information access, visual information processing, and complexity for the users. The concept of "processing fluency" states that the brain prefers to think about things that are easy to think about [31]. This fluency affects judgment, choice, and processing style [32].

The average American is exposed to as many as 5,000 marketing messages per day and has an attention span of fewer than 8 seconds. Working memory and control of attention are inseparable [33]. According to George Miller, working memory (the part of your brain that temporarily stores and processes information in the course of a few seconds) is considered to have limited capacity. Processing the information is too demanding & the working memory disengages and moves on [34]. Hick's law, or the Hick–Hyman Law - describes the time it takes for a person to decide because of the possible choices s/he has: increasing the number of choices will increase the decision time logarithmically. Hick–Hyman law is known as the information access cost. When the user's attention is diverted from one location to another to access necessary information, there is a cost associated to that for the time and effort.

The presentation and framing of open data information have been shown to have a great impact on end-user behavior [35,36]. "Simple" is scientifically easier to process. Less "visually complex" websites are considered more beautiful partly because low complexity websites do not require the eyes and brain to physically work as hard to decode, store and process the information. In a joint online study by Harvard, the University of Maryland, and the University of Colorado, researchers found that users make lasting judgments about a website's appeal after viewing a website for only 500ms [37]. The study also found strong mathematical correlations between

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complexity and aesthetically pleasing – the more visually complex a website was, the lower it's visual appeal. This is also because low complexity websites do not require the eyes and brain to physically work as hard to decode, store and process the information.

3.2.4 Familiarity, Perceived Risks, and Usefulness

Cognitive fluency stems from another area of behavior known as The Mere Exposure Effect, which states that the more you're exposed to a stimulus, the more you prefer it [38]. Stanford Persuasive Technology Lab's web credibility project [39] defines the well-established fluency-–familiarity link, familiarity enables easy mental processing, it feels fluent. So, people often equate the feeling of fluency with familiarity. Therefore, users tend to avoid unfamiliar environments and perceive them as having low-usability.

Another issue is perceived risks: for all its potential, open data does pose certain risks, notably to privacy and security; Concerns about privacy and security afflicted many of the OGD projects around the world [29]. A major challenge arises from the trade-offs between the potential of open data and the risks posed by privacy and security violations. When an initiative fails to take steps to mitigate this tension, it risks not only harming its prospects, but more broadly they harm the reputation of open data in general. For example, In Brazil, over 100 legal actions were brought against the Open Budget Transparency Portal when it inadvertently published the salaries of public servants. The clearest example of open data leading to privacy concerns can be found in the case of Eightmaps, which used public campaign finance disclosure laws to publish various identifiable information and home addresses for donors to California's Proposition 8, leading to instances of intimidation and harassment [40].

4. Discussion

This review is the starting point towards mitigating the unique challenges brought by governmental open data initiatives. By recognizing and analyzing the obstacles on both ends of the open data process, their implications can be analyzed to suggest recommendations and highlight future research directions. Specifically, review of current research suggests a few possible solutions mitigate the issues previously discussed:

Assistance in the Form of Libraries or Professionals – A possible solution is implementing a system of assistance in the form of libraries or professionals. 13% of the "Low-Access Population" said they went to the public library for problem-solving help (access to computers, particularly the internet, was a key reason they go to the library for help). Also, 53% of the general population said they turned to professionals and consult government agencies, librarians, and the internet (searchers usually end up satisfied). Also, technical readiness can also be indicated by the existence of a group of individuals or entities that are technically sophisticated, and that believe in the transformative potential of technology, particularly of open data. Verhulst et al. [41] have noted that such "data champions" or "technological evangelists" play a critical role in ensuring the success of projects.

Various Forms Of OGD – The majority of the American public believe government documents should be delivered in all shapes and sizes [28]. While the majority of the public prefer access to government documents on the internet, significant numbers still would prefer to get printed government publications by mail or from government offices and libraries.

Responsiveness – Open data could be significantly more impactful if it remains agile and responsive—adapting, for instance, to user feedback or early indications of success and failure. Therefore, the release of open data would be complemented with responsiveness to act upon insights generated.

Resource Allocation – open data projects can often be launched cheaply. Therefore, many of the open data projects suffer from lack of monetary investment in their design and infrastructure, as well

some level of uncertainty about their long-term sustainability. Indonesia's Kawal Pemilu, for example, was assembled with a mere $54. U.K.'s Ordnance Survey, meanwhile, is required to be self-financing, forcing the agency to rely heavily on private sector customers paying to access the more sophisticated data products not included in OS Open Data. Greater investment is necessary for users' trust and adoption. The lack of readiness or capacity at both the supply and demand side of open data hampers its impact. Open data does pose a certain set of risks, notably to privacy and security. These risks are inherent to any open data project – by its very nature, greater transparency exists in tension with privacy and security. A greater, more nuanced understanding of these risks will be necessary to address and mitigate them.

5. 5. Conclusions

This section is not mandatory but can be added to the manuscript if the discussion is unusually long or complex.

There are several challenges for an effective open data program. These challenges are in different stages of the data lifecycle ranging from the recording of the data down the chain to the way in which the data is released publicly to the secondary users in the society. Addressing these issues is specifically important because an effective open data can unleash massive economic and societal value and move in this direction is more becoming a 'core' expectation demanded by constituents of governments. Every small improvement in the open data program effectiveness can turn into big results considering the closed-system feedback loop that connects all open data actors through the open data ecosystem. In fact, many of the challenges can be mitigated if the secondary use of data is considered in redesigning knowledge organization system in the data sources, and the way in which the data can – or must – be released to the public.

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