

1 *Review*

2 **Mitigating Challenges of Open Government Data**

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

19 **Keywords:** Open access initiative; Challenges of data sharing; Data management; open government
20 data; human-computer interaction; Documentation; Human Factors; Standardization; information
21 policy
22

23 **1. Introduction**

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

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

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

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

51 Being aware of how potential users seek and utilize OGD are now becoming priorities for a
52 successful open data plan [10]. We have identified some key factors in HCI regarding OGD
53 applications' effectiveness, that can, in fact, be impactful on the effectiveness of the open data
54 programs.
55

56 2. Background: The significance of open data

57 Open data suggests that federal information be available to the public as the constituents of the
58 government. Although opening public information is not a new concept, it has been recently
59 revitalized through the open data movement. This revitalization responds to both technical and social
60 trends. Recent technological advancements have created the opportunity of sharing data in open and
61 re-usable formats [11]. Nowadays, humans are generating massive amounts of data at an increasing
62 rate. This is because new technologies have reduced the cost of information storage significantly, and
63 digitization has made us capable of recording things that were not recorded historically.
64 Traditionally, data stakeholders had been among the original data owners, data producers, data
65 transformers and interim users, and direct or indirect¹ end-users of the data. Procedures governing
66 data storage and retrieval are designed to meet the requirements of these primary stakeholders [12]
67 and to satisfy their desired service levels.

68 Given the growing interest of the public in taking advantage of OGD in recent years, a growing
69 number of governments around the world have started open data plans and have joined global open
70 data causes² [13].

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

73 Transparency, and consequently accountability of government agencies and public officials;
74 Releasing social and commercial value, by creating an environment in which the needs of end-
75 users can be identified and addressed in a crowdsourced manner; and

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

78 However, generating benefits from open data initiatives is not a one-way street. As the society
79 and the government communicate, the benefits can also leverage the government as well [15]. In
80 recent years an 'ecosystem' perspective has emerged that takes into account this feedback from the
81 society back to the government in response to opening data [15]. In this ecosystem perspective, the
82 benefits generated in the society also affect the government's open data capacity, and reinforces open
83 data initiatives for more value creation through opening data, as a delayed and secondary effect [16–
84 18]. As a result, once the benefits of opening data are realized by the society, the government will be
85 pushed by the ecosystem to open more data, and this reinforcing mechanism can cause growth and
86 reinforce itself until it reaches a system barrier. The downside though is that the same structure can
87 also cause a reinforcing decline. Thus it is important to know exactly how to set the ground for open
88 data ecosystem so it would go through the desired – growth – direction.

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

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 has to 75 as early 2017. (See <http://www.opengovpartnership.org>)

94 3. Identifying the challenges

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

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

114 3.1 Information Organization

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

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

124 3.1.1 Data discoverability issues

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

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

135 3.1.2 Data identifiability issues

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

141 Although there is some software available as open data infrastructure that aimed to deal with
142 some of the challenges and complexities of OGD, they have not been effective so far [25], mostly
143 because of the shortcomings above. These challenges call for some considerations regarding data
144 architecture and data governance procedures at the data recording stage, in which the whole life cycle
145 of the data from within the organization through the opened datasets for public use has been
146 considered. These architectures should not only respond to the immediate organizational needs of
147 the corresponding government agencies which host the data, but they should also make data sharing
148 – which in many instances includes merging data from different organizations – doable with a lower
149 burden of overheads, more effective, and less challenging. Following this agenda and also enabling
150 extraction of more information out of the stored government data [26] can lead to better results (i.e.,
151 lower cost and higher achievements) from OGD programs, and facilitate linking of open datasets.

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

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

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

177 3.2 Human-Computer Interaction

178 The other set of challenges refer to issues relating to the users, and the way they interact with
179 the data through the technological system. Information systems development and growth are
180 based on in-depth understanding of Human-Computer Interaction (HCI), which entails that closer
181 attention is paid to the motivations and behaviors of diverse users. In addition to current literature,
182 we will look at two large scale studies that studied OGD: The first is by Rainie et al. [28] in
183 collaboration with Pew Research Center, which is based on a national survey (N=2,796 American
184 adults) to look at how people seek information, in particular, OGD, to address common problems
185 related to government agencies and programs. The second is by Verhulst et al. [29], who have studied
186 19 large open data projects from around the world. These research projects uncovered major
187 challenges confronting open data initiatives and various factors that illicit cognitive, psychological
188 and behavioral responses. We recognized congruence between information organization and HCI in
189 key areas: Information seeking behavior - user readiness and “the digital divide”; attitudes and
190 perceptions - Familiarity, Perceived Risks and Usefulness; and ease-of-use - Information Access Cost,

191 Visual Information Processing, and Complexity. We also suggest solutions to mitigate noticeable
192 issues to lead to adoption and acceptance.

193 3.2.1 Information Seeking Behavior

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

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

206 3.2.2. The Digital Divide

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

217 3.2.3 Data Presentation Complexities

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

225 The average American is exposed to as many as 5,000 marketing messages per day and has an
226 attention span of fewer than 8 seconds. Working memory and control of attention are inseparable
227 [33]. According to George Miller, working memory (the part of your brain that temporarily stores
228 and processes information in the course of a few seconds) is considered to have limited capacity.
229 Processing the information is too demanding & the working memory disengages and moves on [34].
230 Hick's law, or the Hick-Hyman Law - describes the time it takes for a person to decide because of
231 the possible choices s/he has: increasing the number of choices will increase the decision
232 time logarithmically. Hick-Hyman law is known as the information access cost. When the user's
233 attention is diverted from one location to another to access necessary information, there is a cost
234 associated to that for the time and effort.

235 The presentation and framing of open data information have been shown to have a great impact
236 on end-user behavior [35,36]. "Simple" is scientifically easier to process. Less "visually
237 complex" websites are considered more beautiful partly because low complexity websites do not
238 require the eyes and brain to physically work as hard to decode, store and process the information.

239 In a joint online study by Harvard, the University of Maryland, and the University of Colorado,
240 researchers found that users make lasting judgments about a website's appeal after viewing a
241 website for only 500ms [37]. The study also found strong mathematical correlations between
242 complexity and aesthetically pleasing – the more visually complex a website was, the lower it's visual
243 appeal. This is also because low complexity websites do not require the eyes and brain to physically
244 work as hard to decode, store and process the information.

245 3.2.4 Familiarity, Perceived Risks, and Usefulness

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

252 Another issue is perceived risks: for all its potential, open data does pose certain risks, notably
253 to privacy and security; Concerns about privacy and security afflicted many of the OGD projects
254 around the world [29]. A major challenge arises from the trade-offs between the potential of open
255 data and the risks posed by privacy and security violations. When an initiative fails to take steps to
256 mitigate this tension, it risks not only harming its prospects, but more broadly they harm the
257 reputation of open data in general. For example, In Brazil, over 100 legal actions were brought against
258 the Open Budget Transparency Portal when it inadvertently published the salaries of public servants.
259 The clearest example of open data leading to privacy concerns can be found in the case of Eightmaps,
260 which used public campaign finance disclosure laws to publish various identifiable information and
261 home addresses for donors to California's Proposition 8, leading to instances of intimidation and
262 harassment [40].
263

264 4. Discussion

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

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

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

284 **Responsiveness** – Open data could be significantly more impactful if it remains agile and
285 responsive—adapting, for instance, to user feedback or early indications of success and failure.

286 Therefore, the release of open data would be complemented with responsiveness to act upon
287 insights generated.

288 **Resource Allocation** – open data projects can often be launched cheaply. Therefore, many of the open
289 data projects suffer from lack of monetary investment in their design and infrastructure, as well
290 some level of uncertainty about their long-term sustainability. Indonesia’s Kawal Pemilu, for
291 example, was assembled with a mere \$54. U.K.’s Ordnance Survey, meanwhile, is required to be
292 self-financing, forcing the agency to rely heavily on private sector customers paying to access the
293 more sophisticated data products not included in OS Open Data. Greater investment is necessary
294 for users’ trust and adoption. The lack of readiness or capacity at both the supply and demand side
295 of open data hampers its impact. Open data does pose a certain set of risks, notably to privacy and
296 security. These risks are inherent to any open data project – by its very nature, greater transparency
297 exists in tension with privacy and security. A greater, more nuanced understanding of these risks
298 will be necessary to address and mitigate them.

299 5. 5. Conclusions

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

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

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