

# Usability Evaluation of Open Data Portals on the National Level: Dealing with the Discoverability, Accessibility and Reusability for Stakeholders

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## Abstract

**Purpose** – The purpose of this paper was to conduct a usability evaluation of open data portals on national level and provide a list of best practices for improving stakeholders' ability to discover, access, and reuse of these online information sources.

**Design/methodology/approach** – The methodology was developed based on the comprehensive literature review that resulted in a benchmarking framework of the most important criteria. A usability evaluation method was then applied with accordance to unique requirements of open data portals. This approach was demonstrated using a case study.

**Findings** – The main weakness found was a lack of support for active engagement of stakeholders. The list of best practices was introduced to improve the quality of these portals. This should help to improve the discoverability and facilitate the access to datasets in order to increase their reuse by stakeholders.

**Social implications** – The creation of open data portals aims to fulfil the principles of open government, i.e. to promote transparency and openness through the publication of government data, enhance the accountability of public officials, and encourage public participation, collaboration and cooperation of involved stakeholders.

**Originality/value** – This paper proposed a new approach for usability evaluation of open data portals on national level and provided important insights on improving their quality.

**Keywords** Open data portals, Usability evaluation, Benchmarking framework, Best practices, Engagement of stakeholders

**Paper type** Research paper

## Introduction

In recent years, there has been an increasing interest in transparency, openness and accountability of public sector agencies and institutions. It was driven by government efforts to reform the public sector towards open government. In response to this pressure, the engagement of stakeholders has undergone a major transformation. It now underpins their participation, collaboration and cooperation in policy and decision making through Information and Communication Technologies (ICT) and various communication and delivery channels for open data, which together provide new opportunities to work with online information.

While initially e-government referred to the simple presence of government on the Internet, mostly in the form of an informative portal, the concept has since evolved (Attard *et al.*, 2015). With the introduction of the open government concept, related initiatives are considered to be an extension of e-government that has become a key enabler of public sector transformation for transparent, open and accountable governance (Attard *et al.*, 2015; Geiger and von Lucke, 2012; Veljković *et al.*, 2014). One requirement for realizing these goals is the free access to government data (Geiger and von Lucke, 2012). These data should be easily accessible to diverse stakeholders with an effort of engage them to contribute to the public policy making space (Kapoor *et al.*, 2015). Janssen *et al.* (2012) argued that opening up data should result in open government in which the government acts as an open system and interacts with its environment, i.e. with other stakeholders. In this context, a stakeholder is a person, group or



organisation that has an interest in, or is potentially impacted by, the operations of the public sector and its agencies or institutions.

A typical implementation to raise awareness of open government is to collect relevant datasets and their respective metadata and publish them on an open (government) data portal (Attard *et al.*, 2015; Kubler *et al.*, 2016; Lourenço, 2015). Open data portals are a great resource for innovation and growth through value creation, particularly when dealing with linking these data. These portals can be launched by an official government entity or a citizen initiative, and contain datasets related to different administrative levels and thematic categories (Lourenço, 2015; Máchová and Lněnička, 2017). To best serve the needs of the public, portals are required to be highly available services that provide reusable data that are universally available and consumable (Millette and Hosein, 2016). However, the question remains whether the way such data are organized and disclosed really facilitates the task of finding the required data (Lourenço, 2015). In addition, this raises questions regarding the actual use and usability of open data portals and the extent to which they fulfil the stated outcomes of open data (Kapoor *et al.*, 2015). For these reasons, it is important to identify the basis and theoretical background for the research of this issue and specify the key requirements of open data portals in the context of their usability. The main motivation behind this research was to help governments in improving the overall quality of their open data portals as well as enable other stakeholders to easily find, access, and reuse the relevant online information.

This paper is structured as follows. This introduction is followed by a section discussing the background. Subsequently, previous studies, literature and the key concepts of this paper are defined. Then, a benchmarking framework for usability evaluation of open data portals is proposed. A case study section consists of experiment method, participants and experiment design, and results and key findings. It is followed by discussion and limitations. List of best practices is provided afterwards. Finally, conclusions are made by addressing the contributions of the paper.

## **Background**

Nowadays, the usability has its fundamental role in software engineering as accented Nielsen (1994). Measuring the usability aspects of the system's User Interface (UI) with the help of particular methodologies is called the usability evaluation as is defined in Nielsen (1994). As stated in Ivory (2001), the usability evaluation is an important interface design process, since it allows discovering the problems of the design and better understanding of the targeted users. As reported by Gray and Salzman (1998), a usability evaluation method refers to any method or technique performing a usability evaluation of UI at any stage of its development. According to Nielsen (1994), the usability evaluation methods are divided into several groups, most commonly into: expert-based evaluations (inspection methods), user-centred evaluations (usability testing methods). These methods differ depending on the source of the evaluation. This source can be usability experts or users. A person using a usability evaluation method to evaluate usability is called an evaluator. It might be a person with expert knowledge as well as a person who is in charge on supervising the usability evaluation process. A person using a usability inspection method is also often called an inspector, see Hartson *et al.* (2001). The fundamental goal of all inspection methods is to find usability problems in an existing interface design and then use these problems to make recommendations for improving the usability of the UI.

Usability evaluation typically only covers a subset of the possible actions users might take. For these reasons, Nielsen (1994) recommend to use several evaluation methods. The evaluator examines the usability aspects of the UI design with a respect to its conformance to a set of guidelines that can range from highly specific recommendations to broad principles, see Ivory



(2001). Guidelines list well-known principles for the UI design, which should be followed in the development project. Wide variety of usability guidelines have been established by different authors and can be found in Shneiderman and Plaisant (2004) or Preece *et al.* (1994). As for the user-centred evaluations, Nielsen (1994) considered testing with real users as the most fundamental usability evaluation method, since it provides direct information about how people use products and what their exact problems are with the concrete UI being tested. During usability evaluation, participants use the system to complete a specified set of tasks while the evaluator or specialized software records the results of their work. The evaluator uses these results to derive usability measures, such as the number of errors and task completion time, see Shneiderman and Plaisant (2004).

Usability evaluation of open data portals is crucial since it indicates how easy users can find data they are looking for. The key goal is to evaluate the usability with regard to the availability of functionalities. The importance of usability in the context of open data portals was examined by various authors. According to Attard *et al.* (2015), usability is the most generic quality criterion, which means how easily can be the published data used. It is directly related to what degree open data are accessible, interoperable, complete, and discoverable. The more the published data are usable, the more potential data consumers are encouraged to reuse and exploit these data. Lourenço (2015) argued that the concept of usability has a dual meaning in the context of web-based governmental transparency. On the one hand, usability takes into account technical aspects of website design. On the other hand, it is referred to as a required characteristic of open data and closely related to their quality. The context of transparency in relation to usability was also explored by Ojo *et al.* (2016). Their results provided details on what kinds of data are needed by stakeholders, the features required to support their interactions and collaboration around open data and features that could enhance the understandability, usability, and decision making needs of users.

## **Previous Studies and Literature**

### *Defining Open Government and Open Data*

The main idea behind open government is that government acts as an open ecosystem and interacts with other stakeholders (Zuiderwijk *et al.*, 2014). Countries committed to open government expect that this concept will promote transparency and accountability, fight corruption, energize civic engagement, and facilitate the creation of new services that deliver social and commercial value (Attard *et al.*, 2016; Janssen *et al.*, 2012; Sayogo *et al.*, 2014). However, before transparency or any of the other benefits expected from open data can happen, these data have to be available in the first place (Barry and Bannister, 2014).

Although there are many different sources of open data, government data are particularly important because of their scale, breadth, and status as the canonical source of information on a wide range of subjects (Kučera *et al.*, 2013; Van der Waal *et al.*, 2014). These are a subset of open data, and are simply government-related data that are made open to the public (Attard *et al.*, 2015). A more specific definition was given by Geiger and von Lucke (2012) asserting that open government data are “*all stored data of the public sector which could be made accessible by government in a public interest without any restrictions for usage and distribution.*” Janssen *et al.* (2012) then added the aspect of funding sources and define them as “*non-privacy-restricted and non-confidential data which are produced with public money and are made available without any restrictions on its usage or distribution.*” In this regard, an access to some datasets may be restricted for national security reasons, data may contain personal information or other sensitive data, and thus they cannot be made publicly available (Janssen *et al.*, 2012; Kučera *et al.*, 2013).



### *Open Data Portals and their Importance*

An ability to easily discover the relevant data is a prerequisite to unlocking the potential of open data (Kučera *et al.*, 2013). To solve the problem of data discoverability, accessibility, and reusability, in the last few years, an increasing number of governments have set up open data portals, specialised websites where a publishing interface allows datasets to be uploaded and equipped with high-quality metadata and organized them into a searchable catalogue (Kubler *et al.*, 2016; Kučera *et al.*, 2013; Máchová and Lněnička, 2017; Van der Waal *et al.*, 2014). Open data portals usually provide information about a dataset in form of a description with metadata and allow for direct access to datasets via download and additionally via Application Programming Interface (API). They help users search for relevant datasets or browse datasets by categories, tags, organizations, or formats. There are free and open data management systems such as Comprehensive Knowledge Archive Network (CKAN) or Drupal Knowledge Archive Network (DKAN) that have been adopted by many governments. Some portals provide extra features, APIs or SPARQL endpoints, lists of applications built with a certain dataset, discussion and comment features, and built-in tools to visualize data. A good practice is to offer a way to request for additional datasets that are not yet published (Charalabidis *et al.*, 2014; Máchová and Lněnička, 2017; Millette and Hosein, 2016). Some of these systems are comprehensively described and compared in Kubler *et al.* (2016), Millette and Hosein (2016), Ojo *et al.* (2016), or Umbrich *et al.* (2015).

Publishing data on open data portals enables data providers to add their data to the global data space. This allows data consumers to discover and reuse these data in various applications and online services (Attard *et al.*, 2016; Máchová and Lněnička, 2017). Additionally, for governments, data release through open data portals saves costs because it is cheaper than transforming them into reports and applications. On the other hand, Ubaldi (2013) claimed that many governments focus on the development of a national open data portal as if it were a higher priority than developing technical infrastructures to open up government data.

### *Evaluation and Comparison of Open Data Portals*

The big investments made by governments for the development of data infrastructures, makes it necessary to evaluate them systematic (Charalabidis *et al.*, 2014). This issue is often mentioned by research studies as one of the open data barriers (Barry and Bannister, 2014). For example, Janssen *et al.* (2012) classified the lack of ability to discover the appropriate data and the lack of knowledge to make use of or to make sense of data as the key obstacles. Similarly, Attard *et al.* (2015) and Van der Waal *et al.* (2014) mentioned discoverability as one of the first challenges to be solved when working with any data. The discoverability is often bound to the quality of metadata describing open data which is not always complete or accurate (Attard *et al.*, 2015; Kučera *et al.*, 2013).

Among the factors leading to difficulties in finding useful data quickly Alexopoulos *et al.* (2014) found that some portals support only simple search functions, which do not return relevant data. This may result in information overflow (Zuiderwijk *et al.*, 2014) and having to go through all the results to potentially identify the relevant datasets (Attard *et al.*, 2015). Moreover, most portals only allow users to simply download the available data, with no possibility of exploring them directly through visualisation tools (Máchová and Lněnička, 2017). Accessibility may be also affected by the format in which data are published, the search tool used, and the metadata of the dataset (Maali *et al.*, 2010).

One of the first comparisons of the selected open data portals was conducted by Maali *et al.* in 2010. They aimed to identify commonalities and overlap in the structure and to document challenges and practices. Sayogo *et al.* (2014) used web content analysis in order to demonstrate the application of data manipulation and engagement capability of these portals. Their results



identified the different stages of open data portal development in terms of data content, data manipulation capability, and participatory and engagement capability. Furthermore, Umbrich *et al.* (2015) monitored and assessed the quality of open data portals, which were powered by CKAN. A high heterogeneity across these portals for various aspects together with insights on openness, contactability, and the availability of metadata were found. Lourenço (2015) assessed whether the current structure and organization of some of the most prominent open government portals is adequate for supporting transparency for accountability. This research did not focus on the data themselves being disclosed, but rather on structural and organizational aspects, which might influence citizens' ability to better access and use the available data.

Although some research on the usability of open data portals from a citizen's perspective was conducted by Kapoor *et al.* (2015), their framework was never applied in practice and there is no empirical evidence supporting the validity of the framework. Another framework for usability evaluation was proposed by Osagie *et al.* (2017). However, they evaluated the second alpha release of a next generation open data platform designed explicitly to support non-technical users, which is still under development. Their results are also dependent on the quality of datasets they used in their scenario. Similarly, Veljković *et al.* (2014) presented a benchmark proposal for open government and its application from the open data perspective. However, they argued that "*there are long-term considerations that pertain to information usability by all*" and this issue requires defining new tasks that help to achieve information usability and accessibility. Thus, to the authors' best knowledge, so far, nobody has yet exploited and quantified the usability of open data portals on national level.

### **Benchmarking Framework for Usability Evaluation of Open Data Portals**

As usability evaluation focuses on how well users can use a particular portal to achieve their goals, specific characteristics of open data portals had to be identified at first. The literature review suggests that the most important step is to find the concrete dataset and its metadata to make a decision about the suitability of information for intended use. In this regard, each dataset should meet a set of principles for open data. Since the number of them differs among various organizations, it is recommended to follow some of the generally accepted principles. Further, open data portals are characterized by the active engagement of stakeholders in reusing open data. Therefore, there should be provided capabilities that support these tasks. Taken these requirements into account, Figure 1 conceptualizes these specific characteristics. It is important to note that this engagement can take place through many channels. A data provider is responsible for ensuring that published data comply with the open data principles. A data user is involved in engagement activities resulting in the generation of value.



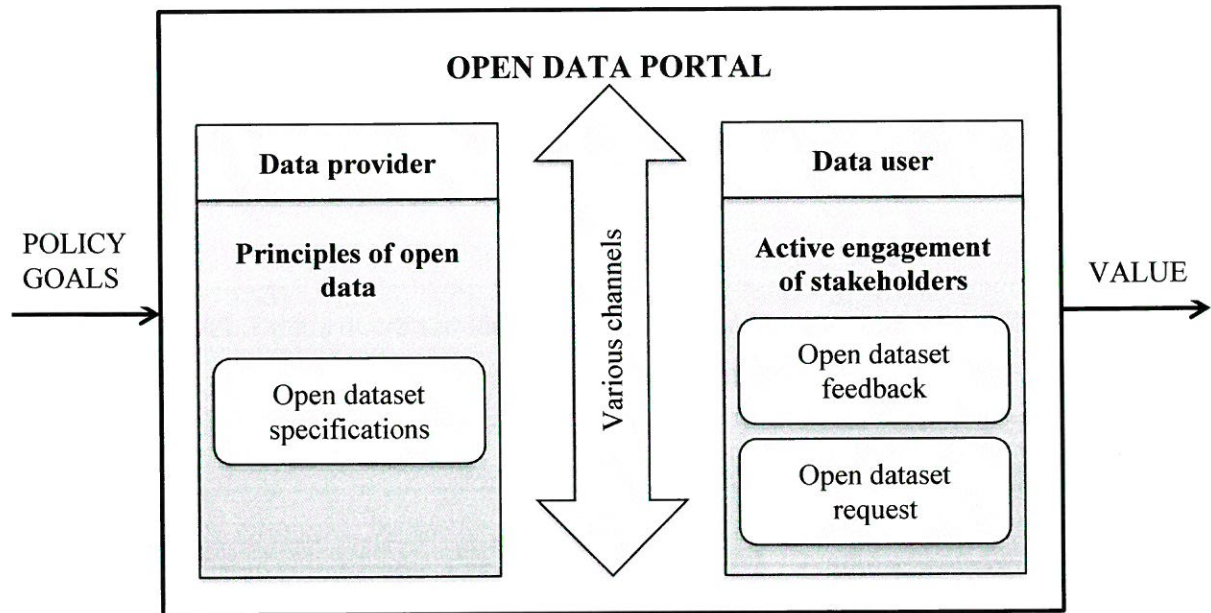


Figure 1: Conceptualizing the specific characteristics of open data portals

The benchmarking framework, including literature sources, is in Table 1.

Table 1: List of criteria for the usability evaluation of open data portals

Dimension	Criteria	Description	Literature sources
1. Open dataset specifications	a. Description of dataset	Portal provides datasets together with their description and how and for what purpose they were collected.	Charalabidis <i>et al.</i> (2014), Kubler <i>et al.</i> (2016), Kučera <i>et al.</i> (2013), Lourenço (2015), Maali <i>et al.</i> (2010), Ubaldi (2013)
	b. Publisher of dataset	Portal provides information about organization that published datasets.	Lourenço (2015), Maali <i>et al.</i> (2010), Máchová and Lněnička (2017), Petychakis <i>et al.</i> (2014)
	c. Thematic categories and tags	Portal provides thematic categories of datasets to address the main topics covered. It distinguishes categories (themes) from tags (keywords).	Charalabidis <i>et al.</i> (2014), Kučera <i>et al.</i> (2013), Lourenço (2015), Maali <i>et al.</i> (2010), Máchová and Lněnička (2017), Petychakis <i>et al.</i> (2014)
	d. Release date and up to date	Portal provides datasets associated with a specific time or period tag, i.e. date published, date updated and its frequency.	Kučera <i>et al.</i> (2013), Máchová and Lněnička (2017), Lourenço (2015), Maali <i>et al.</i> (2010)
	e. Machine-readable formats	Portal provides datasets formats that are machine-readable and allow for easy reuse.	Charalabidis <i>et al.</i> (2014), Kučera <i>et al.</i> (2013), Máchová and Lněnička (2017), Petychakis <i>et al.</i> (2014), Ubaldi (2013)
	f. Open data license	Portal provides license information related to the use of the published datasets.	Heath and Bizer (2011), Kubler <i>et al.</i> (2016), Maali <i>et al.</i> (2010), Petychakis <i>et al.</i> (2014)
	g. Visualization	Portal provides visualization and analytics capabilities to gain	Alexopoulos <i>et al.</i> (2014), Heath and Bizer (2011), Máchová and Lněnička (2017), Millette and



	and analytics tools	information about a dataset, e.g. in charts or visualizations in maps.	Hosein (2016), Petychakis <i>et al.</i> (2014)
2. Open dataset feedback	a. Documentation and tutorials	Portal provides high-quality of documentation and tutorials to help users in learning how to use the portal.	Charalabidis <i>et al.</i> (2014), Máchová and Lněnička (2017), Ubaldi (2013)
	b. Forum and contact form	Portal provides an opportunity to submit feedback on a dataset from the users to providers and forum to discuss and exchange ideas among the users.	Charalabidis <i>et al.</i> (2014), Janssen <i>et al.</i> (2012), Petychakis <i>et al.</i> (2014), Ubaldi (2013), Zuiderwijk and Janssen (2015)
	c. User rating and comments	Portal provides capabilities allowing the collection of user ratings and comments on a dataset.	Charalabidis <i>et al.</i> (2014), Van der Waal <i>et al.</i> (2014), Zuiderwijk and Janssen (2015)
	d. Social media and sharing	Portal provides the integration with social media technologies to create a distribution channel for open data and sharing feedback.	Alexopoulos <i>et al.</i> (2014), Máchová and Lněnička (2017), Petychakis <i>et al.</i> (2014), Ubaldi (2013), Van der Waal <i>et al.</i> (2014)
3. Open dataset request	a. Request form	Portal provides a form to request or suggest new type or format type of open data.	Kučera <i>et al.</i> (2013), Maali <i>et al.</i> (2010), Máchová and Lněnička (2017), Zuiderwijk and Janssen (2015)
	b. List of requests	Portal provides a list of requests that were received from users, including the current state of request processing.	Charalabidis <i>et al.</i> (2014), Máchová and Lněnička (2017), Ubaldi (2013)
	c. Involvement in the process	Portal provides capabilities allowing the involvement in the active requests, i.e. express interest in the same dataset.	Máchová and Lněnička (2017), Ubaldi (2013), Zuiderwijk and Janssen (2015)

## Case Study

### Experiment Method

The usability concept was used with the purpose of measuring the existing design of selected open data portals from a user's perspective, i.e. user-centred evaluation as defined by Nielsen (1994), to identify the barriers that hinder the discoverability, accessibility, and reusability of open data by stakeholders. As stated by Lourenço (2015), portals should be designed in such a way that even ordinary citizens, without specialized technical skills, may use them to find data. Thus, the usability evaluation was conducted from an ordinary citizen's point of view.

A methodology for evaluating the usability of open data portals was developed based on the comprehensive literature review that resulted in a benchmarking framework of the most important criteria. A usability evaluation method was then applied with accordance to unique requirements of open data portals. First, there are policy goals defined by governments and are central to the mission of open government. These goals are achieved through engagement in particular activities, i.e. searching for data published on open data portals. Second, even if stakeholders are able to find these data, they may have problems reusing them without the interaction with other stakeholders through generating mechanisms. Figure 2 conceptualizes these issues and highlights the key research gap to be investigated. Successful solving of these



issues is important since these data might create significant value for the whole economy through participation, collaboration, cooperation, and innovations processes.

With these results, we can better characterize the basic requirements on these portals and improve their usability. We assume that these findings will help to simplify the process of open data reuse and the stakeholders will profit from the increased usability of open data portals. In this regard, a series of recommendations (best practices) was formulated to guide countries in achieving higher maturity of open data portals and increased discoverability, accessibility, and reusability of datasets.

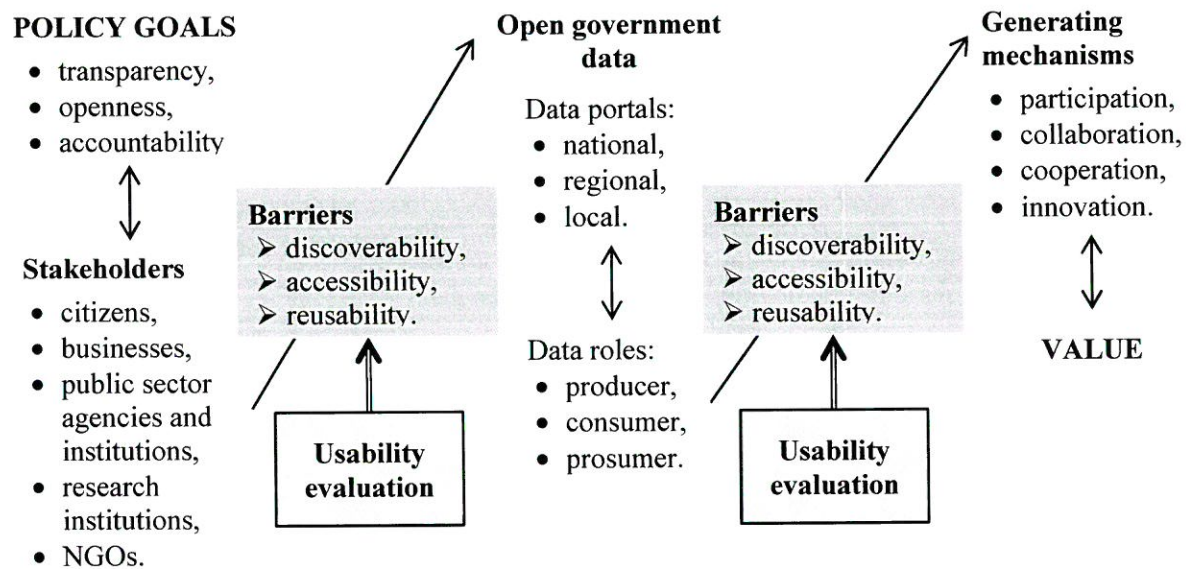


Figure 2: Usability of open data portals – research gap

The methodology process applied in this paper consists of steps that are displayed in Figure 3.

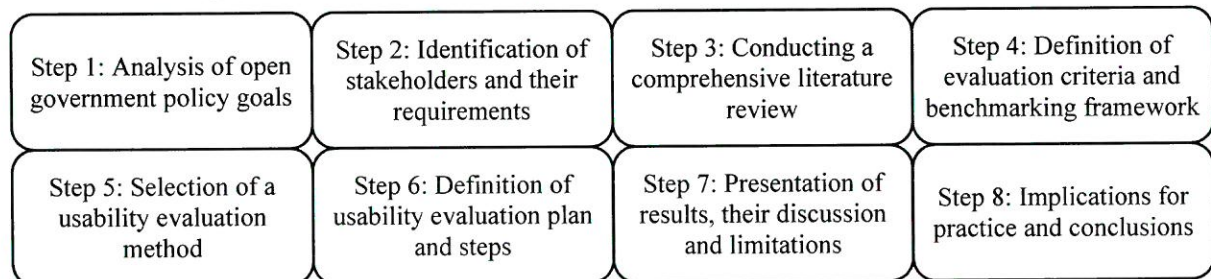


Figure 3: The main steps of conducting the research study

### *Participants and Experiment Design*

As mentioned above, the methodology process was developed through a modification of the user-centred methodology to reflect the open data portals specifics. The experiment design can be divided into thirteen steps:

1. Defining goals and concerns – the goal of our research was to compare open data portals with the usability point of view and to formulate the usability lacks of individual portals.
2. Deciding who should be participants – in this step we characterized the typical users and divided the user profile into distinct end user categories, defined and documented the criteria for each group and choose the number of participants to test.



3. Recruiting participants – we acquired participants from own sources, they were our bachelor and master students (faculty of economics and administration).
4. Selecting and organizing tasks to test – the tasks were developed from three dimensions that represents the usability of open data portals.
5. Creating task scenarios – task scenarios were real situations that could occur and which included the tasks defined in the previous steps.
6. Deciding how to measure usability – to measure usability, a three-level Likert scale was chosen through which the participants expressed their subjective feeling of accomplishing the task.
7. Preparing test materials – these materials are meant: screening questionnaire, orientation script, pre-test questionnaire, test scenarios, prerequisite training material and post-test questionnaire.
8. Preparing the test environment – a simple testing area in which there were no distractions was used.
9. Preparing the test team – the test was coordinated by a trained evaluator.
10. Conducting a pilot test – all problems were identified during the pilot test to be postponed before the subsequent testing.
11. Conducting a test – each participant tested only one portal to prevent the learning effect.
12. Assessing participant satisfaction with the test – the After-Scenario Questionnaire (ASQ) was used for this purpose.
13. Transforming data into findings and recommendations – data were firstly compiled and summarized, next, they were analysed and recommendations were developed and transformed to the final report.

This research study was interested in general purpose portals on national level, i.e. country wide portals. Although there are also various portals on regional or local levels (Lněnička and Máchová, 2015), these are still not well established and cannot provide a representative sample for the usability evaluation purposes. In addition, the portals on national level have emerged as flagship initiatives of open government efforts (Lourenço, 2015). In order to select the most representative portals, various open data related frameworks were explored.

There are multiple monitoring benchmarking frameworks, such as the Global Open Data Index, the Open Data Barometer Index or the Open Data Monitor focused on European countries. National open data portals were selected based on the most current open data indices and the results presented in Máchová and Lněnička (2017). Taken together, these frameworks provide information about more than 100 open data portals on national level. From this initial list, five portals were selected according to the following criteria: due to limitations of research resources, only portals with English interface were considered; and portals with fewer than 1000 published datasets were also excluded since it was considered that they would not have enough critical mass to provide useful insights. The selected portals are in Table 2.



Table 2: List of evaluated national open data portals

Country	Portal address
Australia	<a href="http://data.gov.au/">http://data.gov.au/</a>
Canada	<a href="http://open.canada.ca/">http://open.canada.ca/</a>
India	<a href="https://data.gov.in/">https://data.gov.in/</a>
United Kingdom	<a href="http://data.gov.uk/">http://data.gov.uk/</a>
United States	<a href="http://www.data.gov/">http://www.data.gov/</a>

Once the list of criteria was identified and the list of open data portals was selected, test participants were recruited. For this purpose, university students were asked to perform the usability evaluation. Since they are experienced in working with online information on a regular basis, they are able to provide valuable insights to the usability of this type of portals from an ordinary citizen's point of view. Each criterion was converted to a task to be included in a questionnaire to be distributed to participants. All these tasks were evaluated on a three point scale to measure the successful completion of a task, i.e. done = 3, partially fulfilled = 2, and unfulfilled = 1. Therefore, a total score can range from 14 to 42 points. Further, each participant evaluated one portal. There was no time limit and no registration on portal was required to fulfil a task. Time-on-Task wasn't measured, only the overall time for all the tasks was recorded. The authors' intention was to allow participants focusing on the tasks. Finally, the completed questionnaires were collected and processed.

### *Results and Key Findings*

All questionnaires were valid for further statistical analysis. The results of the usability evaluation for sample open data portals on national level are summarized in Table 3. The mean value (M) and standard deviation (SD) were calculated for each portal. The portals of Australia, Canada and the United Kingdom were evaluated by 13 participants, the portal of India by 14 participants, and the portal of the United States by 12 participants.

Table 3: Results of the usability evaluation for the selected portals

Tasks	Australia		Canada		India		United Kingdom		United States	
	M	SD	M	SD	M	SD	M	SD	M	SD
1a.	2.92	0.27	3.00	0.00	2.93	0.26	2.92	0.27	2.83	0.37
1b.	3.00	0.00	2.54	0.75	2.93	0.26	2.46	0.84	2.58	0.64
1c.	2.77	0.42	2.62	0.74	3.00	0.00	2.46	0.63	2.67	0.62
1d.	2.85	0.36	2.69	0.61	2.71	0.45	2.62	0.49	2.58	0.64
1e.	2.46	0.75	2.54	0.75	2.93	0.26	2.38	0.84	2.83	0.37
1f.	2.54	0.75	2.55	0.78	2.86	0.52	2.92	0.27	2.17	0.80
1g.	2.08	0.83	1.92	0.92	2.14	0.91	2.08	0.83	1.92	0.76
2a.	2.08	0.92	2.62	0.74	2.29	0.96	2.38	0.74	2.00	0.71
2b.	2.54	0.75	1.62	0.84	1.64	0.89	2.46	0.84	1.83	0.90
2c.	2.38	0.84	2.08	1.00	1.43	0.73	2.54	0.75	1.42	0.64
2d.	2.92	0.27	2.46	0.75	2.79	0.56	1.31	0.61	2.92	0.28
3a.	2.31	0.82	2.38	0.74	2.29	0.88	2.69	0.72	2.25	0.72
3b.	2.23	0.97	2.08	0.83	1.71	0.88	2.38	0.92	1.50	0.65



3c.	2.15	0.95	1.77	0.97	1.79	0.94	2.23	0.80	1.67	0.85
<b>M</b>	<b>2.52</b>	<b>0.64</b>	<b>2.35</b>	<b>0.74</b>	<b>2.39</b>	<b>0.61</b>	<b>2.42</b>	<b>0.68</b>	<b>2.10</b>	<b>0.64</b>

According to the results, the overall rating of Australia was the highest, i.e. the open data portal is the most usable as evaluated by the participants. Open data portal of India then provided the most quality information about concrete datasets and their metadata and thus improved their discoverability by following the common principles of open data. The dimension focusing on open dataset feedback was best evaluated in the case of Australia and the last dimension dealing with open dataset request received highest score on the portal of the United Kingdom. Finally, the portal of the United States performs the worst. These results are shown in Figure 4.

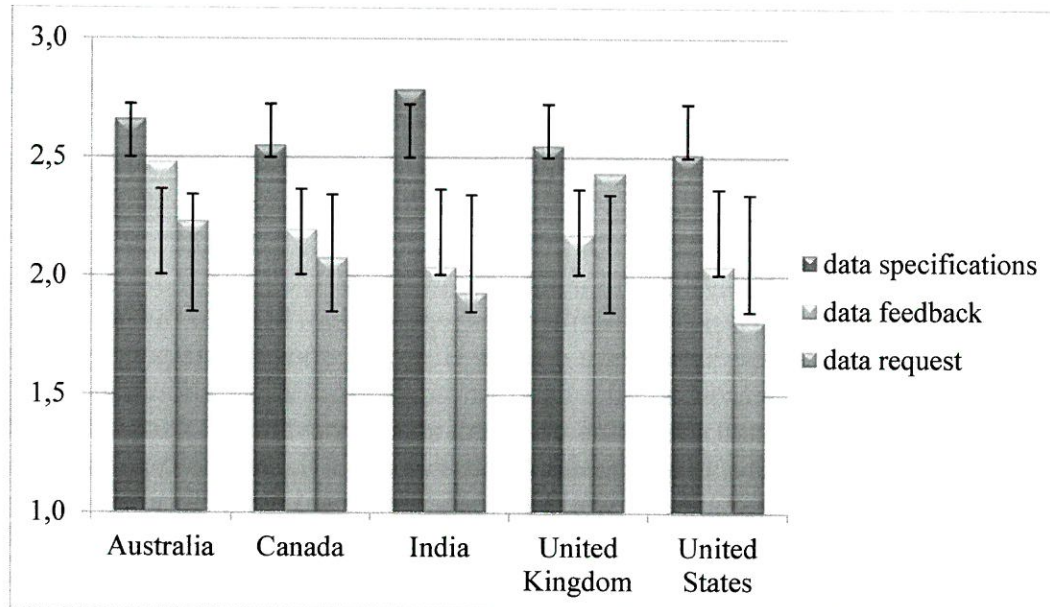


Figure 4: Mean value and standard deviation ( $\sigma = 1$ ) for each dimension evaluated

Overall, the portals were evaluated as quite usable. Standard deviation from the mean value for each of the tasks for the usability dimensions was also similar for all the portals. This proves that these portals were useful for almost all of the participants. However, although most of data providers are familiar with open data principles and these are provided by evaluated portals at a satisfactory level, capabilities and tools for active engagement of stakeholders are lacking at present. Further, the overall time needed to accomplish all the tasks listed in the test scenarios is in Table 4. It took an average of 19 minutes to test the portal of Australia, while the portal of India required more time to fulfil all the tasks. Since the portals of Australia and the United Kingdom are powered by CKAN, it may be suggested that this open data management system provides the best features for improving the usability of open data portals.

Table 4: The overall time needed for accomplishing all the tasks.

Country	M [mins]	SD [mins]	Min [mins]	Max [mins]
Australia	19.00	1.77	15.00	22.00
Canada	22.10	2.57	18.50	27.50
India	25.20	3.26	19.75	30.00
United Kingdom	20.10	2.33	16.00	24.00
United States	22.75	1.87	20.00	25.50

The first dimension focusing on open dataset specifications showed that the description of dataset is provided by all the portals as well as information about publisher of dataset. Contact



email was usually given for questions. The portals of Australia and the United States also offered additional information about publisher, i.e. number of published datasets, number of dataset requests, and activity stream. More detailed information about publishers was provided by the portals of the United Kingdom and India, e.g. publisher hierarchy, monthly statistics and various reports that summarize the activity of publisher, or contact information on chief data officer (India). Thematic categories and tags were available on all the portals, but their quality differs. Some portals have formally defined vocabularies for this purpose while the others generate tags from all the datasets and make the searching process less efficient. For example, the portal of India distinguishes datasets according to a three-level hierarchy: sectors, group, and keywords. Information about date published and date updated (modified) was available on all the portals. It was usually on the bottom of the page, only the portal of Canada had this information on the right side. Since metadata may include many fields, it is necessary to consider the priority and importance of each field, reflecting it visually through emphasis. Less important fields should be pushed to the bottom of the page or even hidden.

Further, all the portals offered to download data in various machine-readable formats. The preferred formats were Comma-Separated Values (CSV), JavaScript Object Notation (JSON), and Resource Description Framework (RDF) files. The portals of India and the United States provided most of their datasets in these formats. Open data license is nowadays a key part of each portal and all the evaluated portals fulfilled this requirement. Most of the portals had this information right under the description of a dataset. However, some participants were unable to fulfil this task. The main reason was the fact that they did not know about the meaning of open data licence. They expected some kind of a form and they evaluated this task as partially fulfilled. This finding contributes to an ongoing discussion about the necessity of these licences since most of the countries around the world have implemented some form of Freedom of Information Access legislation that allows the general public to make requests for public sector information.

Visualization and analytics tools on open data portals are still immature or missing. On the other hand, there are no standards or frameworks for how these functions should be defined and implemented. The portals of Canada and the United States did not enable to visualize a dataset. They only provided search filters and APIs. The portal of Australia provided a data explorer in which dataset can be explored. There are available these options: grid, graph, and map. In this regard, terminology is also an issue that may affect the results. This function is called a preview on the portal of the United Kingdom and is currently available for files such as CSV, spreadsheets, and plain text. Finally, the portal of India solved this by offering an external link to data provider.

Although the portal of India had received the highest score for this first dimension, it took a much longer time for participants to fulfil all the required tasks than in the case of other portals (see Table 4). This was due to the fact that the portal provided very detailed information on each dataset on a single page. In contrast to the portal of Canada, which combined simplicity and functionality, the portal of India used different colour schemes and icons to display information. The results suggest that participants prefer this way of publishing open data.

The results of the usability evaluation of the second and third dimensions dealing with open dataset feedback and request confirmed that the main weakness of the existing open data portals is the lack of support for active engagement of stakeholders. Documentation and tutorials are important for users since they can serve to explain technical terminology, offer guidance and answer questions. Most of the participants took advantage of these instructions to fulfil some of the tasks. In this regard, the portal of the United Kingdom provided the best support for the given tasks. The next elements evaluated were forums and contact forms. The results showed that all the portals provide contact information for giving feedback. However, only the portals



of India, the United Kingdom, and the United States contained the contact form with required fields, i.e. user's email address, subject, message, and category (reason) of question.

Forums for discussions and interactions among stakeholders were mostly missing on the evaluated portals. They were found only on the portal of the United Kingdom, which had for this purpose a specific section called "interact". Other portals preferred connection to social media or blogs and communities. The community sections with various topics were found on the portals of Canada and India, but they were not evaluated in this study. Each dataset could be rated for its quality on the portal of Canada where was this element on the top of the right side of the page. The portal of India provided a number of downloads for each dataset and the portal of the United States provided a number of views for each dataset. These measures may also represent the quality of a dataset. Comments were allowed on the portals of Australia, Canada, and the United Kingdom. These were always on the bottom of the page. Social media and sharing elements were available on all the portals except the United Kingdom.

A data request form was available on all the portals, but on the portals of Australia and the United Kingdom this functionality required registration of an account profile. The portal of the United States also allowed users to suggest new features of the portal. List of request was provided by all the portals except India. This list should include at least date submitted, status, and statistics about outcome. Involvement in the process of data requesting is on the most of the portals enabled by adding a comment to a request. A usability problem was found in the case of the portal of Canada. Although it provided all the features for requesting data, including the list of datasets suggested by users, their status, and votes, participants had difficulties to fulfil these tasks. The main reason was that the link was not on the title page, but it was accessible in three clicks from the title page of the portal. In addition, it was listed on the bottom of the page as a sixth link.

Finally, the overall satisfaction with the usability testing was measured using the ASQ. It is a three-item questionnaire that is used to assess participant satisfaction after the completion of all the tasks in the scenario of usability evaluation. Because the questionnaire is very short, it takes very little time for participants to complete, an important practical consideration for usability studies (Lewis, 1995). The scale ranges from strongly agree (1) to strongly disagree (7) with higher value indicating less satisfaction with the usability evaluation. The results are shown in Table 5. The first question of the ASQ is focused on the satisfaction with the ease of completing the tasks in this scenario. The second question measures the satisfaction with the amount of time it took to complete the tasks in this scenario. The third one is then focused on the satisfaction with the support information (online-line help, messages, documentation) when completing the tasks. The results of the ASQ support the findings discussed above.

Table 5: The overall time needed for accomplishing all the tasks.

Country / no. of question in ASQ	M			SD			Min			Max		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
Australia	2.54	2.15	3.00	0.75	0.53	0.55	1.00	1.00	2.00	4.00	3.00	4.00
Canada	3.31	3.00	2.15	1.07	0.88	0.86	2.00	2.00	1.00	5.00	5.00	4.00
India	2.86	3.57	2.71	0.64	1.05	0.59	2.00	2.00	2.00	4.00	5.00	4.00
United Kingdom	2.46	2.38	2.31	1.01	0.74	0.46	1.00	1.00	2.00	4.00	3.00	3.00
United States	3.00	3.33	3.75	0.82	0.75	0.83	2.00	2.00	3.00	4.00	4.00	5.00



## Discussion and Limitations

This research study was based on the assumption that there is an interest of public sector agencies and institutions in publishing their data on open data portals and providing online information. Although recent research confirmed the increasing number of open data portals around the world (Kubler *et al.*, 2016; Máchová and Lněnička, 2017; Umbrich *et al.*, 2015), some authors are sceptical about what the actual potential of open data is (Barry and Bannister, 2014; Janssen *et al.*, 2012). These include the belief that opening data leads automatically to more open and transparent government. Besides that, much of current criticism on national open data portals is based on the fact that governmental interest appears to be on presenting data in a particular fashion, which distracts from, and thereby limits, the increasing provision to stakeholders of data that they are really interested in using for their own purposes (Sieber and Johnson, 2015; Ubaldi, 2013).

However, this paper offered the results of the usability evaluation for those governments who recognize the importance of open data portals and want to improve their discoverability, accessibility, and reusability. It should be also noted that this research study did not evaluate the quality of data and their metadata on the portals. Although this issue is widely discussed by many research studies, the responsibility for data quality is on the provider's side. Nevertheless, a feedback mechanism, which should be available on each portal to report any problems with datasets, was incorporated in a benchmarking framework. Furthermore, the findings derived from the usability evaluation are only the first step in process of ensuring that open data portals will serve as a tool to increase openness, transparency, and accountability of public sector agencies and institutions.

With the increasing spread of open data portals, it is important to continue to reflect on various possibilities for open data, rather than settling for data provision as a simple end point (Sieber and Johnson, 2015). Since the number of open data portals worldwide is increasing rapidly, the digital divide will alienate many data consumers who are unable to acquire or employ the technical skills to access or decipher open data (Millette and Hosein, 2016). As stated by Sussha *et al.* (2015), public sector institutions find it challenging to set up support for open data users having various requirements and skills. In this regard, Foulonneau *et al.* (2014) emphasized the advertising of new datasets and applications on virtual community channels, the harmonization of metadata vocabularies used to describe datasets, visualizing datasets in maps, and providing a large set of documentation and tools to assist them in data reuse. Bertot and Choi (2013) pointed out that in the big data era open data portals will require significant computing power to process, analysing, manipulating, and representing open data through visualizations.

Based on the results of the usability evaluation, we may conclude that some of these recommendations were already implemented in practice. Particularly the connection to social media is supported by most of the portals as well as an option to visualize a dataset in a map. There were also found various materials and documentations to support stakeholders and their ability to reuse these data. However, the quality of them varies.

Although the main implementations of open data initiatives are open data portals, there exist a number of different implementations with various characteristics (Attard *et al.*, 2015). These so-called open data aggregators or metadata repositories (Lněnička and Máchová, 2015) that store structured descriptions (metadata) about datasets available on various open data portals on different administrative levels can also improve the discoverability of open data for stakeholders. While it can be difficult to find datasets buried deep in various open data portals, Van der Waal *et al.* (2014) recommended harvesting metadata from these portals to be aggregated and published in metadata repositories, which provide a single point of access to open datasets from across various countries. They also reported that the discoverability can be



increased by preparing respective vocabularies and providing linking to other data sources available on the Web. Another categorization of the open data portals can be made based on the web paradigm they are based on, i.e. the traditional Web 1.0 paradigm, or the more recent Web 2.0 paradigm (Alexopoulos *et al.*, 2014; Charalabidis *et al.*, 2014). This might be taken into account while evaluating open data portals and discussing results. However, this categorization was out of the scope of this study.

Another important aspect is interoperability of these portals and portability of datasets. Maali *et al.* (2010) proposed an RDF schema vocabulary as an interchange format among data catalogues and as a way of bringing them into the Web of linked data. It increases interoperability among themselves and with other deployed datasets as well as findability of these datasets by search engines. On the other hand, as most of these portals are powered by CKAN or DKAN (Máchová and Lněnička, 2017), using open standards as stable and published formats for data and services that are independent of any individual supplier is ensured. As reported by Kubler *et al.* (2016), there are existing issues with the quality of the metadata in data portals and data themselves. This is a risk that could disrupt the open data project, as well as e-government initiatives since data quality needs to be managed to guarantee the reliability of e-government to the public. Thus, this issue should be solved by data providers. Finally, it should be also taken into account that open access to data can raise questions regarding data security and trust (Barry and Bannister, 2014). A study conducted by Ojo *et al.* (2016) revealed that the stakeholders require a strong need for anonymity while using open data. In this regard, each open government initiative has to deal with these issues as well.

It is also evident that not all of government data have the same potential to support the engagement of stakeholders and not all of these data have the same relevance for transparency, accountability, participation, collaboration, and cooperation efforts. Further research should be focused on different thematic data categories on open data portals and which data stakeholders need for their analyses. Some of these portals already offer statistics about datasets, see Máchová and Lněnička (2017). More research is needed to identify and define methodologies and best practices for open data publication. An overview to this topic was provided Kučera *et al.* (2015). Although they reported that their methodology should help to improve discoverability of datasets, they did not take into account the usability aspect of open data portals.

Finally, the number and type of participants and the procedure of their selection may limit the ability to understand the diversity of uses for open data portals. Currently, the findings of this research study are valid for the participants and methods used. Students were involved as a representative with specific knowledge. The experiment should use a more diverse participant pool if it wanted to generalise the results for ordinary citizens beyond this group. The choice of methods depends on the aims of the research (Shneiderman and Plaisant, 2004). Since this study did not aim to provide a robust framework to improve the usability of open data portals, it rather presented ongoing research that should contribute to the discussion of the importance of the usability evaluation. In this regard, the utilization of user-centred evaluation forms the basis for further research, especially towards a list of heuristics. Further, this research study did not evaluate the quality of data or their metadata on these portals. We also did not deal with open government data initiatives or various security or privacy restrictions, which may affect the availability of relevant information in datasets.

## **Implications for Practice**

In contrast to traditional recommendations for the usability of websites, open data portals require emphasizing other characteristics and elements. While the news section of a portal is relevant for indicating new datasets and other statistics about them, most of users will probably



be looking for concrete datasets. Thus, a data catalogue should be the first thing a user sees when landing on the front page of a portal. Data are the centrepieces and the rest should be a way to highlight them. Based on the results, we further recommend addressing the following features in the context of national open data portals, i.e. improvements in provided services:

- strictly follow the principles of open data disclosure since they provide a generally accepted way to find information about datasets;
- description of a dataset should be short and concise since descriptions longer than five lines are distracting;
- contact information on data publishers should be provided together with the organization that published a dataset, additional information should include the list of activities for each publisher to ensure transparency of their interactions with users;
- thematic categories and tags should be created on the portal and organized by category first, and then become more specific, especially they should be formulated in understandable terms, i.e. no abbreviations that may obscure the meaning of a page or section for users;
- machine-readable formats should be used to enable users to process datasets in a structured way, i.e. in CVS, JSON and RDF formats;
- open data licenses should be provided together with a link to a detailed description;
- dataset preview should be available for each dataset in machine-readable format, even if the file contains a large amount of records, it should be also highlighted that a dataset can be visualized;
- site analytics should be provided in order to obtain information on who uses the portal, which datasets are downloaded, and how many downloads take place;
- feedback mechanisms should be set up and linked together under one main section on a title page, right next to the data catalogue;
- list of data requests should be also included on a title page since this is one of the first actions that users want to undertake if they did not find required dataset, in addition, date submitted, status, outcome, and votes should be available for each request;
- interface elements that can help users in navigating through the content should be provided, i.e. advanced search capabilities and filters for categories, tags, organizations, formats, and licenses; and
- portal should not have too much content or features that require users to register.

## Conclusions

Generally, the concept of open data portals is to provide a central point to go to for searching online information and downloading datasets that follow the principles of open data. As it can be a challenge for potential users to find relevant online information within the structures of the public sector, this paper utilized established usability evaluation techniques to improve the discoverability, accessibility, and reusability of datasets on these portals and thus increase the awareness of open data and open government movement, respectively.

An open data portal can help address these issues if it follows the basic principles of open data and provides metadata on each dataset. In addition, countries need to extend the features on their portals such as advanced search capabilities, visualization and analytics tools, promote the availability and feedback on datasets through social media and other channels for improving engagement of stakeholders, and offer further training, proper materials, documentations and guidelines to support stakeholders in open data reuse. Furthermore, an integration of regional and municipal portals into national portals may increase the discoverability, accessibility, and reusability of data throughout the country. Finally, continuous benchmarking of the open



government and open data success can help identify benefits and areas for improvement. It should also monitor activities of users on the portal, i.e. metrics such as number of unique visitors per month, total number of online views for a dataset, total number of downloads for a dataset, etc.

We expect that our recommendations will help responsible authorities to focus better on the key features of open data portals. These should result in easier access to datasets and increase in their discoverability, accessibility, and reusability, create new communication and delivery channels, and empower the participation, collaboration, cooperation, and innovation opportunities of stakeholders. Future research will be focused on more extensive evaluation and experiments with different options for user interaction with open data portals and various datasets using advanced usability evaluation methods, i.e. expert-based evaluations. This will take into account the investigation why still so many open data portals still don't fully adhere to the recommended principles.

## References

- Alexopoulos, C., Zuiderwijk, A., Charalabidis, Y., Loukis, E. and Janssen, M. (2014), "Designing a Second Generation of Open Data Platforms: Integrating Open Data and Social Media", in *Electronic Government: Proceedings of the 13th IFIP WG 8.5 International Conference, EGOV 2014*, Springer, Berlin Heidelberg, pp. 230-241.
- Attard, J., Orlandi, F. and Auer, S. (2016), "Data Driven Governments: Creating Value Through Open Government Data", in *Transactions on Large-Scale Data-and Knowledge-Centered Systems XXVII*, Springer, Berlin Heidelberg, pp. 84-110.
- Attard, J., Orlandi, F., Scerri, S. and Auer, S. (2015), "A systematic review of open government data initiatives", *Government Information Quarterly*, Vol. 32, No. 4, pp. 399-418.
- Barry, E. and Bannister, F. (2014), "Barriers to open data release: A view from the top", *Information Policy*, Vol. 19, No. 1,2, pp. 129-152.
- Bertot, J.C. and Choi, H. (2013), "Big Data and e-Government: Issues, Policies, and Recommendations", in *Proceedings of the 14th Annual International Conference on Digital Government Research*, ACM, New York, pp. 1-10.
- Charalabidis, Y., Loukis, E. and Alexopoulos, C. (2014), "Evaluating Second Generation Open Government Data Infrastructures Using Value Models", in *Proceedings of the 47th Hawaii International Conference on System Sciences*, IEEE, pp. 2114-2126.
- Foulonneau, M., Turki, S., Vidou, G. and Martin, S. (2014), "Open data in Service design", *Electronic Journal of e-Government*, Vol. 12, No. 2, pp. 99-107.
- Geiger, C.P. and von Lucke, J. (2012), "Open Government and (Linked) (Open) (Government) (Data)", *JeDEM-eJournal of eDemocracy and Open Government*, Vol. 4, No. 2, pp. 265-278.
- Gray, W.D. and Salzman, M.C. (1998), "Damaged Merchandise? A Review of Experiments that Compare Usability Evaluation Methods", *Human-Computer Interaction*, Vol. 13, No. 3, pp. 203-261.
- Hartson, H.R., Andre, T.S. and Williges, R.C. (2001), "Criteria For Evaluating Usability Evaluation Methods", *International Journal of Human-Computer Interaction*, Vol. 13, No. 4, pp. 373-410.
- Heath, T. and Bizer, C. (2011), "Linked Data: Evolving the Web into a Global Data Space", *Synthesis lectures on the semantic web: Theory and technology*, Vol. 1, No. 1, pp. 1-136.
- Ivory, M.Y. (2001), *An Empirical Foundation for Automated Web Interface Evaluation*, PhD Dissertation, University of California, Berkeley, Computer Science Division.
- Janssen, M., Charalabidis, Y. and Zuiderwijk, A. (2012), "Benefits, Adoption Barriers and Myths of Open Data and Open Government", *Information Systems Management*, Vol. 29, No. 4, pp. 258-268.



- Kapoor, K., Weerakkody, V. and Sivarajah, U. (2015), "Open Data Platforms and Their Usability: Proposing a Framework for Evaluating Citizen Intentions", in *Open and Big Data Management and Innovation*, Springer International Publishing, Cham, pp. 261-271.
- Kubler, S., Robert, J., Le Traon, Y., Umbrich, J. and Neumaier, S. (2016), "Open Data Portal Quality Comparison using AHP", in *Proceedings of the 17th International Digital Government Research Conference on Digital Government Research*, ACM, New York, pp. 397-407.
- Kučera, J., Chlapek, D. and Nečaský, M. (2013), "Open Government Data Catalogs: Current Approaches and Quality Perspective", in *Technology-Enabled Innovation for Democracy, Government and Governance*, Springer, Berlin Heidelberg, pp. 152-166.
- Kučera, J., Chlapek, D., Klímek, J. and Nečaský, M. (2015), "Methodologies and Best Practices for Open Data Publication", in *Proceedings of the DATESO 2015 Annual International Workshop on Databases, TExts, Specifications and Objects*, Matfyzpress, Praha, pp. 52-64.
- Lewis, J.R. (1995), "IBM computer usability satisfaction questionnaires: psychometric evaluation and instructions for use", *International Journal of Human-Computer Interaction*, Vol. 7, No. 1, pp. 57-78.
- Lněnička, M. and Máchová, R. (2015), "Open (Big) Data and the Importance of Data Catalogs and Portals for the Public Sector", in *Proceedings in Global Virtual Conference: The 3rd International Global Virtual Conference (GV-CONF 2015)*, EDIS - Publishing Institution of the University of Zilina, Zilina, pp. 143-148.
- Lourenço, R.P. (2015), "An analysis of open government portals: A perspective of transparency for accountability", *Government Information Quarterly*, Vol. 32, No. 3, pp. 323-332.
- Maali, F., Cyganiak, R. and Peristeras, V. (2010), "Enabling Interoperability of Government Data Catalogues", in *Proceedings of the 9th IFIP WG 8.5 International Conference: EGOV 2010*, Springer, Berlin Heidelberg, pp. 339-350.
- Máchová, R. and Lněnička, M. (2017), "Evaluating the Quality of Open Data Portals on the National Level", *Journal of Theoretical and Applied Electronic Commerce Research*, Vol. 12, No. 1, pp. 21-41.
- Millette, C. and Hosein, P. (2016), "A Consumer Focused Open Data Platform", in *Proceedings of the 2016 3rd MEC International Conference on Big Data and Smart City: ICBDS*, IEEE, pp. 1-6.
- Nielsen, J. (1994), *Usability Engineering*, Morgan Kaufmann, San Francisco.
- Ojo, A. et al. (2016), "Realizing the Innovation Potentials from Open Data: Stakeholders' Perspectives on the Desired Affordances of Open Data Environment", in *Working Conference on Virtual Enterprises*, Springer International Publishing, Cham, pp. 48-59.
- Osagie, E., Waqar, M., Adebayo, S., Stasiewicz, A., Porwol, L. and Ojo, A. (2017), "Usability Evaluation of an Open Data Platform", in *Proceedings of the 18th Annual International Conference on Digital Government Research*, ACM, New York, pp. 495-504.
- Petychakis, M., Vasileiou, O., Georgis, C., Mouzakitis, S. and Psarras, J. (2014), "A State-of-the-Art Analysis of the Current Public Data Landscape from a Functional, Semantic and Technical Perspective", *Journal of Theoretical and Applied Electronic Commerce Research*, Vol. 9, No. 2, pp. 34-47.
- Preece, J., et al. (1994), *Human-Computer Interaction*, Addison Wesley, Boston.
- Sayogo, D.S., Pardo, T.A. and Cook, M. (2014), "A Framework for Benchmarking Open Government Data Efforts", in *Proceedings of the 47th Hawaii International Conference on System Sciences*, IEEE, pp. 1896-1905.
- Shneiderman, B. and Plaisant, C. (2004), *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, Addison Wesley, Boston.
- Sieber, R.E. and Johnson, P.A. (2015), "Civic open data at a crossroads: Dominant models and current challenges", *Government Information Quarterly*, Vol. 32, No. 3, pp. 308-315.
- Susha, I., Grönlund, Å. and Janssen, M. (2015), "Organizational measures to stimulate user engagement with open data", *Transforming Government: People, Process and Policy*, Vol. 9, No. 2, pp. 181-206.



Ubaldi, B. (2013), Open government data: Towards empirical analysis of open government data initiatives, *Working Papers on Public Governance*, 22, OECD Publishing, Paris.

Umbrich, J., Neumaier, S. and Polleres, A. (2015), "Quality Assessment & Evolution of Open Data Portals", in *Proceedings of the 3rd International Conference on Future Internet of Things and Cloud, FiCloud*, IEEE, pp. 404-411.

Van der Waal, S., Węcel, K., Ermilov, I., Janev, V., Milošević, U. and Wainwright, M. (2014), "Lifting Open Data Portals to the Data Web", in *Linked Open Data – Creating Knowledge Out of Interlinked Data*, Springer International Publishing, Cham, pp. 175-195.

Veljković, N., Bogdanović-Dinić, S. and Stoimenov, L. (2014), "Benchmarking open government: An open data perspective", *Government Information Quarterly*, Vol. 31, No. 2, pp. 278-290.

Zuiderwijk, A. and Janssen, M. (2015), "Participation and data quality in open data use: Open data infrastructures evaluated", in *Proceedings of the 15th European Conference on E-Government 2015: ECEG 2015*, Academic Conferences and Publishing International Limited, Reading, pp. 351-359.

Zuiderwijk, A., Janssen, M. and Davis, C. (2014), "Innovation with open data: Essential elements of open data ecosystems", *Information Polity*, Vol. 19, No. 1,2, pp. 17-33.



