Open data evaluation models

Theory and practice

Charalabidis, Yannis; Zuiderwijk, Anneke; Alexopoulos, Charalampos; Janssen, Marijn; Lampoltshammer, Thomas; Ferro, Enrico

DOI
10.1007/978-3-319-90850-2_8

Publication date
2018

Document Version
Final published version

Published in
Public Administration and Information Technology

Citation (APA)
Charalabidis, Y., Zuiderwijk, A., Alexopoulos, C., Janssen, M., Lampoltshammer, T., & Ferro, E. (2018). Open data evaluation models: Theory and practice. In *Public Administration and Information Technology* (pp. 137-172). (Public Administration and Information Technology; Vol. 28). Springer. https://doi.org/10.1007/978-3-319-90850-2_8

Chapter 8
Open Data Evaluation Models: Theory and Practice

"There is no unique model for open data evaluation. It depends on the perspective under evaluation."

8.1 Introduction

Evaluation of Open Data is a systematic determination of open data merit, worth and significance, using criteria governed by a set of standards (Farbey, Land, & Targett, 1999). It is an essential procedure trying to ignite a learning and innovation process leading to a more effective data exploitation. Examples of questions to be answered by open data evaluation could be: what is the current status of published data against the best practices identified, how effectively these data are published or used, what are the most valuable data for users, what are the problems and barriers discouraging the publication and use of open data and in which extend these barriers affects users' behaviour towards data usage. The answers on these questions will affect the next developments of an open data portal or initiative and the publication procedure.

A big challenge in the open data domain is how to evaluate open data in general and the platforms or infrastructures offering it and what are the metrics to be evaluated against to. For this reason, the value proposition of open data towards economic benefits for both governments and businesses and transparency for citizens has to be forecasted and evaluated. Different models and validation procedures have been used for the evaluation of open data and their provision portals examining different aspects of them. An aspect of evaluation could be the ability of both publishers and users to adopt and/or accept innovation or technology. Other aspects of evaluation could be the data maturity level or the quality of the published data. Another important aspect is the evaluation of impact originated and value created (net benefits) from the publication, use and reuse of open data. In order to assess those diverse aspects, several evaluation models and frameworks were developed in the domain of information systems.

We initially studied the developed evaluations models in the information systems domain providing insights about the targets of the evaluation procedure. Following these evaluation models, a first set of metrics and measures compiled targeting open

Y. Charalabidis et al., *The World of Open Data*, Public Administration and Information Technology 28, https://doi.org/10.1007/978-3-319-90850-2_8

data functionalities. As a next step, we were furthering our study to already developed metrics existing in the literature and classified them in specific categories. The main reason is the development of an overall assessment taxonomy, which includes every dimension of the quality of Open Data and their sources.

Following the "information system success" model, we are going to categorize different evaluation measures and benchmarks for the evaluation of data (Information Quality), platforms offering them (System Quality) and additional capabilities of those systems (Service Quality). Metrics for covering advanced functionalities based on the identified open data life cycle coming from various users (providers, users, pro-cumers) in Chap. 2 will also be demonstrated. In other words, the main objective throughout the chapter is to provide a classification of metrics, which could be used by public organizations and other stakeholders, in order to further develop evaluation models against different aspects of evaluation (readiness, impact and value creation, performance, quality, post-adoption etc.). The taxonomy aims at proposing various metrics, targeting different aspects of the evaluation: a public organization would then choose a different metric within the proposed taxonomy, according to each different aspect under assessment.

Furthermore, this chapter clarifies the distinction between the subjective and objective models for the evaluation of open data based on the identified evaluation models from the domain of Information Systems. Subjective are those models that concentrate on collecting users' opinions about a system towards the prediction of future behaviour or net benefits based on its perceived usefulness for the users. Objective models are those which are based on predefined metrics and values of them towards the assessment of specific benchmarks regarding the evaluated aspect (e.g. impact and readiness assessment).

The collected metrics could be used for the construction of both subjective and objective models regarding the utilisation of them in the formation of questions or the values space definition. For the subjective models, questions could be formed in order to ask users' opinions about a specific metric (to which extend does the system provide sufficient data?). For the same metric an absolute metric used in another model could be defined assigning values (<1000, 1000–100,000, >100,000 datasets) and searching for the answer in the platform under evaluation. Another example of absolute and quantities measurement is the percentage of completeness of a dataset (number of non-null values divided by the total number of all values) towards the assessment of its quality.

Both subjective and absolute metrics could be useful since they capture different views of the platform or infrastructure under evaluation. In the first case, the appraisal focuses on capturing the opinions of different types of users trying to assess in which extend they find the open data of their interest. The second case measures the values predefined metrics that could be used to categorise an open data platform based on its impact (low, medium, high) and/or maturity (allocating the platform under evaluation in one of the pre-defined maturity levels). It is worth to mention at this point that the metrics do not work alone, but in conjunction with other ones in order to reach a specific conclusion as it will be presented in the following sections.

Even more, subjective and/or objective metrics could be defined being part of the same evaluation model. Developing an evaluation framework, a researcher could utilise both subjective and objective metrics and measures. Finally, until now the presented models and examples falling in the category of quantitative research and evaluation. Qualitative methods could be used in order to capture unidentified aspects and difficulties in the domain of open data but using different techniques (interviews, SWOT analysis etc.). The qualitative methods could be used to generate questions based on the identified metrics towards revealing unknown problems, barriers and difficulties and getting deeper insights. An evaluation framework could utilise both quantitative and qualitative methods of assessment.

According to the above-mentioned objectives, the chapter consists of the following sections. Section 8.2 summarizes on basic background research in the domain of information systems evaluation models. It defines concepts, models and metrics used on Open Data and aims at both presenting the bibliographic research conducted on the issue and listing the criteria upon which the taxonomy/ analysis framework is later built. Section 8.3 presents applications of evaluation models in the open data domain while Sect. 8.4 compiles the evaluation metrics for open data in a taxonomy. Section 8.5 concludes the chapter and provides insights for further evaluation developments.

8.2 Evaluation Models in Information Systems

The scientific field of Open Data is very broad. In such a large problem space, the identification of focal points of assessment is essential. In general, when building an evaluation framework, a researcher decides on the aspect to evaluate and the model to use. The model could be either subjective or objective. Then she/he defines the problem space (functionality and/or quality) and poses the basic questions. The questions are posed according to the open data metrics, which will formulate the desired analysis framework. In this section, we provide the bibliographic background of the information systems evaluation models used for the evaluation of any information system, such as open data platforms and e-infrastructures.

For the development of any methodology we should take into account approaches and frameworks developed from **four subjective and quantitative relevant streams** of previous IS research on: (i) IS evaluation, (ii) IS acceptance, (iii) IS success and (iv) e-services evaluation. Additionally, several **subjective evaluation models** have been acknowledged covering different aspects of open data evaluation, namely, (i) maturity assessment, (ii) readiness assessment, (iii) post adoption and (iv) impact assessment. The latter group of evaluation models could be either qualitative (in their first stages) or quantitative (more advanced ones). Finally, some **objective, obsolete and quantitative indexes** are presented within this section.

8.2.1 Subjective Evaluation Models

This section emphases on the subjective models of evaluation in the domain of information systems. The above research streams of information systems evaluation are concentrated in capturing users' opinions about different aspects (perceived ease of use, perceived usefulness, attitude, intention to use, future behaviour etc.) of the system under evaluation. They formally raise questions and quantifies them using a five or seven-point Likert-scale towards the measurement of users' judgements.

8.2.1.1 IS Evaluation

Extensive research has been conducted on IS evaluation in the last 20 years (Farbey et al., 1999; Gunasekaran, Ngai, & McGaughey, 2006; Irani & Love, 2008; Smithson & Hirscheim, 1998; Willcocks & Graeser, 2001). Its main conclusion has been that IS evaluation is a difficult and complex task, since IS offer various types of benefits, both financial and non-financial, and also tangible and intangible ones, which differ among the different types of IS. Therefore, each particular type of IS requires a different evaluation methodology, which takes into account its particular objectives and capabilities. Smithson and Hirscheim (1998) distinguish between two basic directions of IS evaluation.

The first one is 'efficiency-oriented', evaluating IS performance with respect to some predefined technical and functional specifications; it focuses on answering the question of whether the IS 'is doing things right'. The second direction is 'effectiveness-oriented', evaluating to what extent the IS supports the execution of business-level tasks or the achievement of business-level objectives; it focuses on answering the question of whether the IS 'is doing the right things'. The conclusions of this research stream indicate that a comprehensive methodology for evaluating a particular type of IS should include evaluation of both its efficiency and its effectiveness, based on its particular objectives and capabilities.

8.2.1.2 Technology Acceptance Models

Another central topic in IS research has been the identification of characteristics and factors of IS that affect the intention to use them and finally the extent of its actual usage. This research has led to the development and extensive validation of the Technology Acceptance Model (TAM) and its subsequent extensions (Davis, 1989; Schepers & Wetzels, 2007; Venkatesh & Davis, 2000; Venkatesh, Morris, Davis, & Davis, 2003; Wixom & Todd, 2005). According to this model two characteristics of an IS, its perceived usefulness (= the degree to which users believe that using it will enhance their job performance) and its perceived ease of use (=the degree to which users believe that using it would require minimal effort), are the main determinants of individuals' intention to use it in the future and finally the actual use of it. The conclusions of this IS acceptance research stream indicate that a methodology for

evaluating a particular type of IS should assess its ease of use, usefulness and users' intention to use it in the future.

Technology Acceptance Models have been influenced by Theory of Reasoned Action introduced by Fishbein & Ajzen, in 1975, and Theory of Planned Behavior (TPB) introduced by Ajzen, in 1991 and "posits that perceived usefulness and perceived ease of use determine an individual's intention to use a system with intention to use serving as a mediator of actual system use". Perceived usefulness is also seen as being directly impacted by perceived ease of use. Researchers have simplified TAM by removing the attitude construct found in TRA from the current specification by Venkatesh and Davis, in 2000, and Venkatesh et al. (2003). Attempts to extend TAM have generally taken one of three approaches:

(a) by introducing factors from related models,
(b) by introducing additional or alternative belief factors, and
(c) by examining antecedents and moderators of perceived usefulness and perceived ease of use as concluded by Wixom and Todd, in 2005.

TRA and TAM, both of which have strong behavioural elements, assume that when someone forms an intention to act, that they will be free to act without limitation. In practice constraints such as limited ability, time, environmental or organizational limits, and unconscious habits will limit the freedom to act is an information systems theory that models how users accept and use a technology. The model suggests that when users are presented with a new technology, a number of factors influence their decision about using it, but the two main factors (according to Davis et al., 1989):

- Perceived usefulness (PU), defined by F. Davis as "the degree to which a person believes that using a particular system would enhance his or her job performance".
- Perceived ease-of-use (PEOU) – defined by F. Davis as "the degree to which, a person believes that using a particular system would be free from effort"(Fig. 8.1).

Each of these two factors can be developed into a detailed set of variables for each particular type of Information System. Based on this framework, extensive research has been conducted for understanding better, and predicting user acceptance of various types of Information Systems (as concluded by Schepers & Wetzels,

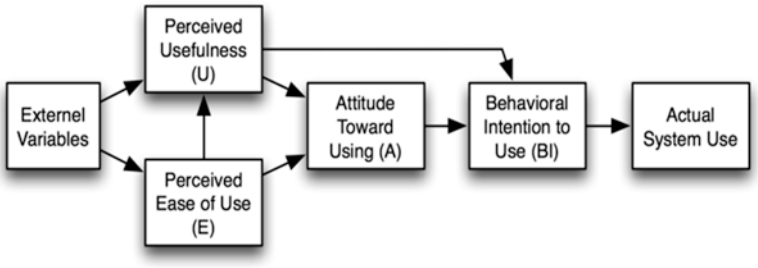

Fig. 8.1 Technology acceptance model

2007). As referred by Venkatesh and Davis (2000, TAM is continued to expand, the two major upgrade being the TAM2 and the Unified Theory of Acceptance and Use of TAM2 explains perceived usefulness and usage intentions in terms of social influence and cognitive instrumental processes. Both social influence processes (subjective norm, voluntariness, and image) and cognitive instrumental processes (job relevance, output quality, result demonstrability, and perceived ease of use) significantly influenced user acceptance.

In articles by Venkatesh et al. (2003), and Venkatesh and Zhang (2010) it is being shown that the theory of acceptance and use of technology (UTAUT) is useful to enrich one's understanding of research on technology adoption. The theory was developed through a review and consolidation of the constructs of eight models that earlier research had employed to explain information systems usage behaviour. The theory uses constructs of: theory of reasoned action, technology acceptance model, motivational model, theory of planned behaviour, a combined theory of planned behaviour/technology acceptance model, model of PC utilization, innovation diffusion theory, and social cognitive theory. UTAUT provides the rationale for the survey questions.

According to Venkatesh, UTAUT identifies

1. 3 direct determinants of behavioural intention to use a technology:
   (a) Performance expectancy (PE): *the degree to which an individual believes that using the system will help him or her to attain gains in job performance*
   (b) Effort expectancy (EE): *the degree of ease associated with the use of the system*
   (c) Social influence (SI): the degree to which an individual perceives that important others believe he or she should use the new system
2. 2 direct determinants of technology use
   (a) Behavioural intention
   (b) Facilitating conditions (FC): the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system
3. 4 contingencies
   (a) CG-1: Gender
   (b) CG-2: Age
   (c) CG-3: Experience with the technology
   (d) CG-4: Voluntariness of use (mandatory or voluntary setting) (Fig. 8.2)

TAM3 have also been proposed by Venkatesh and Bala, 2008. They combine TAM2 and the model of the determinants of perceived ease of use (by Venkatesh & Davis, 2000) to end to the above extended model.

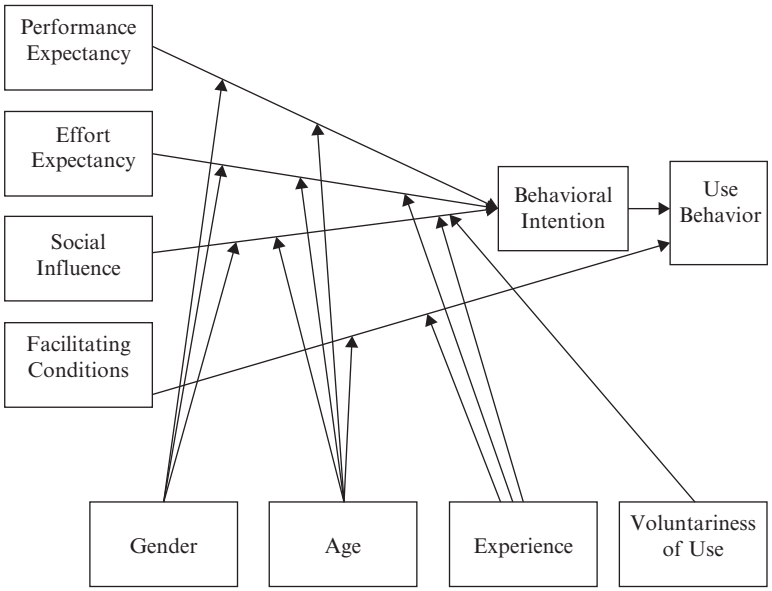

Fig. 8.2 Unified theory of acceptance and use of technology

8.2.1.3 Information Systems Success Models

Another research stream that can provide useful elements is the IS success research (DeLone & McLean, 1992, 2003; Seddon, 1997). The most widely used IS success model has been developed by DeLone and McLean (1992). It proposes seven IS success measures, which are structured in three layers: 'information quality', 'system quality' and 'service quality' (at the first layer), which affect 'user satisfaction' and also the 'actual use' of the IS (at the second level); these two variables determine the 'individual impact' and the 'organizational impact' of the IS. Seddon (1997) proposed a re-specification and extension of this model, which includes perceived usefulness instead of actual use. The conclusions of this research stream indicate that IS evaluation should adopt a layered approach based on the above interrelated IS success measures (information quality, system quality, service quality, user satisfaction, actual use, perceived usefulness, individual impact and organizational impact) and also on the relations among them.

The IS success theoretical model, was first developed by William H. DeLone and Ephraim R. McLean in 1992. The most widely used System Success Model is the one by DeLone and McLean: Model of IS success, developed in 2003. It proposes seven IS success measures, which are structured in three layers:

1. First layer: 'information quality', 'system quality' and 'service quality'
2. Second layer: Affecting 'user satisfaction' and
3. Third layer: 'actual use' of the IS.

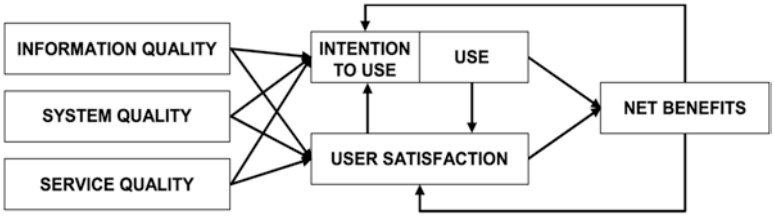

Fig. 8.3 DeLone and McLean: model of IS success. (Source: DeLone and McLean (2003))

Finally, these two variables determine the 'individual impact' and the 'organizational impact' of the IS. Seddon, in 1997, proposed a re-specification and extension of this model, which includes perceived usefulness instead of actual use. From this research stream, it has been concluded that IS evaluation should adopt a layered approach based on the above interrelated IS success measures (information quality, system quality, service quality, user satisfaction, actual use, perceived usefulness, individual impact and organizational impact) and on the relations among them (Fig. 8.3)

8.2.1.4 E-services Evaluation

The emergence of numerous Internet-based e-services (e.g. information portals, e-commerce, e-banking, e-government, etc.) lead to the development of specialised frameworks for evaluating them (Fassnacht and Koese, 2006; Lu and Zhang, 2003; Rowley, 2006; Saha and Grover, 2011; Sumak, Polancic, & Hericko, 2009); extensive reviews of this research are provided from Rowley (2006) and Sumak et al. (2009). These frameworks suggest useful e-services evaluation dimensions and measures. Most of them assess the quality of the capabilities that the e-service provides to its users (being oriented towards the abovementioned efficiency evaluation). Some others assess the support it provides to users for performing various tasks and achieving various objectives (being oriented towards the above-mentioned efficiency evaluation).

SERVQUAL is a service quality framework. SERVQUAL was developed in the mid-eighties by Parasuraman et al. 1998. and was initially used in a marketing context. Later Zeithaml (2002) applied to IS as a measure of success. SERVQUAL model consists of 22 service quality measures that are organized in five dimensions:

- tangibles (appearance of physical facilities, equipment, personnel and communication materials)
- reliability (ability to perform the promised service dependable and accurately)
- responsiveness (willingness to help customers and provide prompt service)
- assurance (knowledge and courtesy of employees and ability to convey trust and confidence)
- empathy (provision of caring, individualized attention to customers)

Parasuraman, Zeithaml, and Malhotra (2005) extended SERVQUAL for the evaluation service quality in web-based environments. So they named E-S-Qual, e-service quality. E-S-QUAL Scale, consisting of 22 items on four dimensions:

- Efficiency: The ease and speed of accessing and using the site.
- Fulfilment: The extent to which the site's promises about order delivery and item availability are fulfilled.
- System availability: The correct technical functioning of the site.
- Privacy: The degree to which the site is safe and protects customer information.

Parasuraman also tries to measure the quality of recovery service provided by Web sites. The e-recovery service quality scale (E-RecSQUAL) consisting of 11 items on three dimensions:

- Responsiveness: Effective handling of problems and returns through the site.
- Compensation: The degree to which the site compensates customers for problems.
- Contact: The availability of assistance through telephone or online representatives.

However, most of the above frameworks do not include advanced ways of processing the evaluation data collected from the users, in order to maximize the extraction of value-related knowledge from them. They include mainly simple calculations of average values of all evaluation measures and dimensions; the relations among the proposed evaluation dimensions and measures, which could form the basis for advanced multi-dimensional statistical analysis, are not exploited all for drawing more insights. Section 8.3 presents an evaluation framework based on value models prioritising future developments (Charalabidis, Loukis, & Alexopoulos, 2014).

8.2.1.5 Maturity Models

In the open data domain, maturity is defined as a measurement of the ability of an organization or a country for continuous improvement. The higher the maturity, the higher the probability of transforming incidents into improvement either in their quality or in their use. Most of the maturity models are subjective in terms of model conceptualisation and qualitative, but the more advanced ones specify quantitative techniques towards the assessment of their maturity and proposition of the next steps of development (Solar, Daniels, López, & Meijueiro, 2014). Concerning open data maturity models several authors have presented different stages to assess and diagnose open data (Alexopoulos, 2016; Kalampokis, Tambouris, and Tarabanis, 2011a; Reggy, 2011).

Open Government Data is a sub-domain of e-government and as such it follows its general principals. The overall approach to maturity in e-government has so far been evolutionary as stated by Krishnan, Teo, & Lim, in 2013 – governments are believed to progress through certain stages. Stages of growth models, in general, receive criticism for their limited applicability and misleading normative values: in practice, several stages may occur simultaneously. Furthermore, the models are

constructed in such a way that preceding stages appear to be "worse" than subsequent ones as demonstrated by K. V. Andersen & Henriksen, in 2006. The contemporary debate about e-government maturity has shifted from supply-side models to user-centric maturity indicators.

The view of e-government maturity as a function of integration and organizational and technological complexity in the early model by Layne and Lee (2001) can be considered a manifestation of technology bias. An alternative vision is proposed in the model by K. N. Andersen, Medaglia, and Henriksen (2012), which uses citizen orientation and activity centricity as the primary criteria for deriving the four e-government maturity stages, namely, cultivation, extension, maturity, and revolution (Susha, Zuiderwijk, Janssen, & Gronlund, 2014).

The recent study on the European data portal from Capgemini (Carrara, Chan, Fischer, & Steenbergen, 2015) has developed a maturity model for the EU28 countries regarding their portals development. *"To provide an accurate estimate of the benefits of Open Data, one first needs to look at the Open Data Maturity per country and how this maturity has evolved."* There are substantial differences between the EU28+ countries when measuring the progress made so far in terms of Open Data. To take these discrepancies into account count, a model was developed to classify the maturity of a country with regards to Open Data. Based on the scores on several indicators, countries were compared in terms of their maturity. This resulted in a matrix with different scores per country. A country can be classified as being either a Trend Setter, Follower, Advanced Beginner or Beginner. The model showed that in 2005, 63% of the Member States could be classified as a Beginner whilst not a single country could be classified as a Trend Setter. These numbers changed substantially over the past 10 years. In 2015, 31% of the countries can be classified as a Trend Setter whereas only 19% is still a Beginner. By 2020 all countries will have a fully operating portal. Additionally, countries will also introduce improvements to increase their Open Data Maturity.

8.2.1.6 Readiness Assessment

Opening up data by public bodies is a complex and ill-understood activity. Although many public bodies might be willing to open up their data, they lack any systematic guidance. A readiness assessment framework aims at the determination: (a) of the status of an organisation to open up its data for re-use as well as (b) of the data status in terms of format, licencing, means of provision in order to be useful for re-use. It is dealing with organisational issues covered in Chap. 4 and includes the processes of the open data life cycle towards publication of data covered in Chap. 2. It could also be referring to issues on deciding whether to open data or to publish them in restricted access. They might provide solutions dealing with privacy-sensitive data, deletion policies, publishing after embargo periods instead of not publishing at all. Examples of readiness assessment frameworks have been proposed by Zuiderwijk et al. (2012c) and the World Bank (2013a) through the creation of the Open Data Readiness Assessment tool.

The process of opening up public sector data demands considerable changes in the public sector, such as changes in the funding and reward systems of organizations. However, it is usually not possible to explain how those types of e-Government initiatives evolve over a certain period of time by the current e-Government linear progression models and the development of composite e-Government services is usually ad-hoc. The questions that are expected to easily rule out opening up a certain dataset are placed on top of the list, whereas questions that require further examination are placed at the bottom of the list. This is done so that data that cannot be opened are quickly identified. Aspects of institutional theory were taken into account by considering the risk avoiding governmental culture. For instance, due to the fear of wrongful interpretations of the data and the impact of wrongful interpretation on the organization, such as hitting the news with a damaged reputation, guidance is provided to make the chance on wrongful interpretations as small as possible.

8.2.1.7 Post Adoption

We define post-adoption stage what Hazen, Overstreet, and Cegielski (2012) drew from numerous literature where they tried to uncover whether the ambiguity after the innovation or technology has been accepted in an organization. The final stage of post adoption assessment is called “incorporated”. This incorporated stage may include three post-adoption activities where it includes acceptance, routinization, and assimilation (Nurakmal & Hamid, 2012). Several studies have proven that post-adoption assessment frameworks are useful in the investigation of a wide range of IT innovations in an organization.

Although, some studies have found new factors or measures to influence technology adoption, the factors will still fall in either one of the three already identified constructs. This shows that the three antecedents (technology, organization, environment) are dynamic and can be manipulated with various factors that influence organization to adopt innovation or technology. In (Nurakmal & Hamid, 2012), Tornatzky antecedents where further extended to the stages of post-adoption described by Hazen et al. (in 2012), which consist of assimilation, routinization, and acceptance stage. The actual factors in technology, organization and environment context will were mapped with the data gathered. Each of Tornatzky antecedents was assumed to have influence on post- adoption stages. Therefore, a set of hypotheses can be construct to test the relationship.

8.2.1.8 Impact Assessment

The impact of opening up data is often debated and espoused as the primary reason for publishing Open Data. While recourse to its economic and democratic impact is seen as a useful driver for publicizing more data, it is rarely easy to quantify the impact this initiative has on business and society. So far, efforts at measuring impact have been mixed and unable to produce concrete results on the usefulness of Open

Data. The crux of the issues lies in the fact that merely opening up datasets does not automatically mean that the public can use them meaningfully or that business can profitably utilize them.

Publication is a prerequisite, but also public interest and regular recourse to information is needed to ensure that large benefits are reaped. Apart from access, the impact of open data depends crucially on engagement, ability to analyse, and draw conclusions from information, and a suitable institutional and economic environment that is receptive of such innovation. In fact, barriers to usage of open data are sometimes seen as so high that some authors argue that open data empowers the already empowered – the highly educated persons and sophisticated businesses that can extract value from public information. All this is likely to put real-world open data impact in perspective, as it is likely smaller and more unequal than usually discussed in public policy circles.

Impact measurement has tended to center around two large groups of metrics – quality, usage, and access on the one hand; and results-based metrics on the other (Gerunov, 2016). As demonstrated in (Gerunov, 2016), impact metrics need to quantify both economic and political benefits brought about by the totality of open data, and also take account of the distribution of those benefits. We can outline three major approaches to measuring this impact depending on the level on which measurement takes place:

1. In macro-level approaches the researchers assume that opening data should have an overall effect on the economy and society, and therefore measurement and assessment should take place at the aggregate level. Since OGD is supposed to stimulate information and improve the public environment, it should be the case that it is associated with a measure of technological development such as total factor productivity (TFP).
2. Meso-level approaches look at the impact of OGD at the sector to which it pertains. Opening data in a specific sector should bring notable improvement in it, which can be seen in some predetermined data indicators. For example, opening procurement data should lead to more transparency and less corruption and thus lower the price for reference orders.
3. Micro-level approaches focus on specific datasets or groups of datasets, and follow them through their lifecycle. By doing this, the researcher gets a full and nuanced picture of usage, impact, and benefit distribution. The most common micro-level approach is the case study whereby each OGD dataset usage is described in detail, giving the context and measuring benefits to different stakeholders. Case studies generally use a mixed method design and serve as an excellent illustration of OGD potential. They can thus be leveraged as a powerful argument in favor of openness. The main issues with this approach are that it fails to scale well and is suffering from observer bias. What is more, this method poses challenge to the researcher to exhaustively identify all the benefits of the dataset and to quantify the full set of externalities. This is counterbalanced by the fact that the analysis is more intuitive to make and ends in tractable results. The method of choice for measuring impact naturally differs across situations and

has to adapt to the context of specific data openness. What is most important is not to overlook this key aspect of OGD policy.

The recent study on the European data portal from Capgemini (Carrara, Chan, et al., 2015) has collected, assessed and aggregated economic evidence to forecast the benefits of the re-use of Open Data for the EU28+. This study falls into the first two categories of impact assessment. The expected impact of the Open Data policies and the development of data portals is to drive economic benefits and further transparency. Four key indicators are measured: direct market size, number of jobs created, cost savings, and efficiency gains. Between 2016 and 2020, the market size of Open Data is expected to increase by 36.9%, to a value of 75.7 bn EUR in 2020. The forecasted public sector cost savings for the EU28+ in 2020 are 1.7 bn EUR. Efficiency gains are measured in a qualitative approach. A combination of insights around efficiency gains of Open Data, and real-life examples is provided.

8.2.2 Objective Evaluation Models

Since the publication of the eight principles of open government data, and the "five stars" test proposed by Bizer, et al. (2011), several authors and institutes have presented different objective criteria to assess and diagnose Open Data based on the development of quantitative indexes, such as the Open Data Institute,[1] the Open Data Research Network,[2] the Open Knowledge Foundation,[3] the Open Data 500,[4] the Open Data Monitor,[5] the Dynamic Linked Data Observatory,[6] the Open Data Barometer[7] and others. These indexes utilise specific metrics for the measurement of different aspects (e.g. data quality, popularity, and user feedback).

For instance, metrics such as number of views, downloads and reuses could be used to measure the popularity of open datasets. Metrics such as (a) accuracy: defined by the number of accurate values divided by the total number of all values, (b) completeness: number of non-null values divided by the total number of all values and (c) timeliness: number of values that are up-to-date divided by the total number of values formulate the quality index of a dataset. Another objective and quantitative evaluation model has been developed for the evaluation of linked data quality by Kontokostas, Westphal, Auer, Hellmann, et al. (2014b).

[1] https://theodi.org/

[2] http://www.opendataresearch.org/

[3] https://okfn.org/

[4] http://www.opendata500.com/

[5] http://opendatamonitor.eu/frontend/web/index.php?r=dashboard%2Findex

[6] http://swse.deri.org/dyldo/

[7] http://opendatabarometer.org/

8.3 Applying Evaluation Models on Open Data

This section presents different examples of different applications of Open Data assessment based on the analysed models in Sect. 8.2. The presented models have been adapted to the assessment of open data and their platforms assessing various aspects of open data using both objective and subjective methods of evaluation.

8.3.1 Adapting IS Success Model on Open Data Evaluation

The model proposed by Charalabidis et al. (2014), for the evaluation of the advanced second generation of OGD, was primarily based on the IS success model (adopting a layered evaluation approach, and including measures of both information and system quality, and also of user satisfaction and individual impact). The model aims at predicting the future behaviour of its users. It is a subjective model based on user opinions collected with the form of a questionnaire.

Particularly value dimensions are organized in three value layers adopting the structure proposed by (Loukis et al., 2012; Pazalos et al., 2012), which correspond to efficiency (value associated with the capabilities it offers to the users), effectiveness (value associated with the support of users for achieving their user-level and provider-level objectives) and future behavior (value associated with users' future behavior) respectively.

The first efficiency layer includes eight value dimensions in total. Three of them concern the user-level capabilities offered by the OGD infrastructure: data provision capabilities data search and download capabilities and user-level feedback capabilities. These value dimensions are expected to affect the 'support for achieving user-level objectives' value dimension of the second. The next three value dimensions of the first layer are: performance, accessibility and data processing capabilities. They are expected to affect both the 'support for achieving user-level objectives' and the 'support for achieving provider-level objectives' value dimensions of the second layer. The final two dimensions of the first layer concern the provider-level capabilities offered by the OGD infrastructure: data upload capabilities and provider-level feedback capabilities. They are expected to affect the 'support for achieving provider-level objectives' value dimension of the second layer. The second effectiveness layer includes the abovementioned two value dimensions concerning the support provided by the OGD infrastructure for achieving user-level and provider-level objectives respectively. Lastly, the third layer includes one value dimension associated with users' future behavior.

The above 11 value dimensions were further elaborated, and for each of them a number of individual value measures were defined. Each of these value measures was then converted to a question to be included in a questionnaire to be distributed to users of the infrastructure (who act both as data users and providers). The Table 8.1 presents the measures for each dimension:

Table 8.1 Value models – dimension measures

Data Provision Capabilities (DPV)	
DPV1	The platform provides a large number of datasets
DPV2	The platform provides datasets useful to me
DPV3	The platform provides to me complete data with all required fields and detail
DPR4	The platform provides accurate and reliable data on which I can rely for my studies
DPV5	There are datasets from many different thematic areas (economy, health, education, etc.)
DPV6	There are datasets from many different countries
DPV7	The platform provides sufficiently recent data
Data Search and Download Capabilities (DSD)	
DSD1	The platform provides strong dataset search capabilities using different criteria.
DSD2	The platform provides several different categorizations of the available datasets, which assists significantly in finding the datasets I need.
DSD3	The platform enabled me to download datasets easily and efficiently.
DSD4	The datasets are in appropriate file/data formats that I can easily use.
DSD5	The datasets have also appropriate and sufficient metadata, which allowed me to understand these data and also how and for what purpose they were collected.
DSD6	The platform provides strong API for searching and downloading datasets (data and metadata)
User-level Feedback Capabilities (UFB)	
UFB1	The platform provides good capabilities for giving feedback on the datasets I download, e.g. for rating datasets, for entering textual comments on them.
UFB2	The platform provides good capabilities for reading available feedback of other users of datasets I am interested in, e.g. ratings, comments.
Ease of Use (EOU)	
EOU1	The platform provides a user friendly and easy to use environment.
EOU2	It was easy to learn how to use the platform.
EOU3	The web pages look attractive.
EOU4	It is easy to perform the tasks I want in a small number of steps.
EOU5	The platform allows me to work in my own language.
EOU6	The platform supports user account creation in order to personalize views and information shown
EOU7	The platform provides high quality of documentation and online help.
Performance (PER)	
PER1	The platform is always up and available without any interruptions.
PER2	Services and pages are loaded quickly.
PER3	I did not realize any bugs while using the platform.
Data Processing Capabilities (DPR)	
DPR1	The platform provides good capabilities for data enrichment (i.e. adding new elements – fields)
DPR2	The platform provides good capabilities for data cleansing (i.e. detecting and correcting ubiquities in a dataset)
DPR3	The platform provides good capabilities for linking datasets.
DPR4	The platform provides good capabilities for visualization of datasets

(continued)

Table 8.1 (continued)

Data Upload Capabilities (DUP)	
DUP1	The platform enabled me to upload datasets easily and efficiently.
DUP2	The platform enabled me to prepare and add the metadata for the datasets I uploaded easily and efficiently.
DUP3	The platform provides good capabilities for the automated creation of metadata.
DUP4	The platform provides good capabilities for converting datasets' initial metadata in the metadata model of the platform easily and efficiently.
DUP5	The platform provides strong API for uploading datasets (data and metadata)
Provider-level Feedback Capabilities (PFB)	
PFB1	The platform allows me to collect user ratings and comments on the datasets I publish.
Support for Achieving User-level Objectives (SUO)	
SUO1	I think that using this platform enables me to do better research/inquiry and accomplish it more quickly
SUO2	This platform allows drawing interesting conclusions on past government activity
SUO3	This platform allows creating successful added-value electronic services
Support for Achieving Provider-level Objectives (SPO)	
SPO1	The platform enables opening and widely publishing datasets with low effort and cost.
Future Behaviour (FBE)	
FBE1	I would like to use this platform again.
FBE2	I'll recommend this platform colleagues.

According to model (Charalabidis et al., 2014) the above value can be adapted based on the capabilities offered by the particular second generation OGD infrastructure under evaluation (e.g. additional value dimensions can be added corresponding to additional capabilities it might offer). Furthermore, the above approach can be used for the evaluation of first generation OGD infrastructures as well, which are characterized by clear distinction between data providers and data users, by defining and estimating one value model for the former and one value model for the latter (Fig. 8.4).

8.3.2 Adapting UTAUT on Open Data Evaluation

According to (Zuiderwijk, Janssen, & Dwivedi, 2015) the ability to use open data partly depends on the availability of open data technologies. Therefore, the acceptance and use of Information Technology has been of significant importance for Information Systems research and practice. The UTAUT is an often used model that examines Information Technology acceptance and use.

Thus, a subjective model developed by (Zuiderwijk et al., 2015) to obtain the acceptance and use of open public sector from actual users of these data. The model has the form of questionnaire and is designed following the construct of the UTAUT research model with a modification. At the table below are seen the questions which were asked. Some of the questions are answered with the a five-point Likert scale to

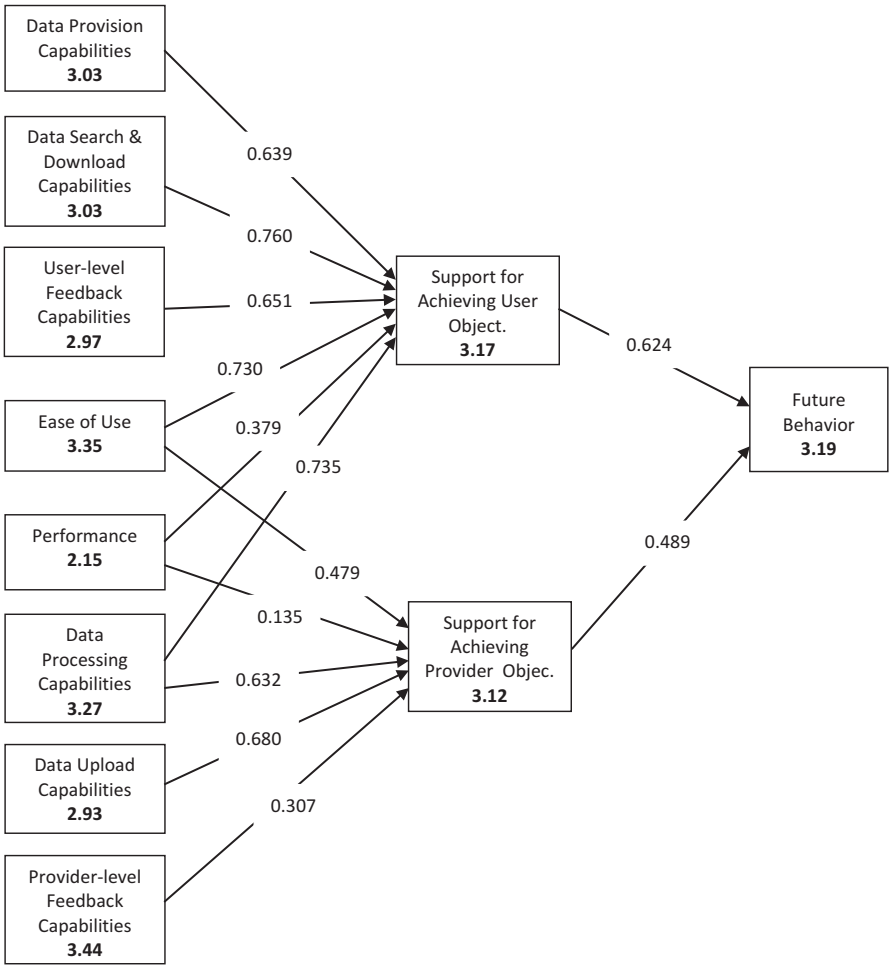

Fig. 8.4 Value model for Advanced Open Data Platforms Evaluation

which extent they agreed with the statement, ranging from "strongly disagree" to "strongly agree (Table 8.2).

8.3.3 Creation of an Objective Model for Open Data Platforms Assessment

Another approach analyses the main characteristics of OGD data portals from different perspectives and implemented by (Alexopoulos, Loukis, Petychakis, & Charalabidis, 2015). The model has focused on the objective evaluation of Open Data sources characteristics and it was applied for the assessment of the Greek open

Table 8.2 Questionnaire for the UTAUT model

UTAUT construct	Questionnaire item (statement or question)	Type of outcome
Performance expectancy (P'E)	Using open public sector data is of benefit tome (P'E1)	Five-point Likert scale (strongly disagree-strongly agree)
	Using open public sector data will enable me to accomplish my research more quickly (PE2)	Five-point Likert scale (strongly disagree-strongly agree)
	Using open public sector data will increase my productivity (PE3)	Five-point Llkert scale (strongly disagree-strongly agree)
	Using open public sector data improves my performance in my job (PE4)	Five-point Likert scale (strongly disagree-strongly agree)
Effort expectancy (EE)	It will be easy for me to become skillful at using open public sector data (EE1)	Five-point Likert scale (strongly disagree-strongly agree)
	Learning to use open public sector data will be easy for me (EE2)	Five-point Likert scale (strongly disagree-strongly agree)
	I clearly understand how to use open public sector data (EE3)	Five-point Likert scale (strongly disagree-strongly agree)
	I do not have difficulty in explaining why using open public sector data may be beneficial (EE4)	Five-point Likert scale (strongly disagree-strongly agree)
Social influence (SI)	People who influence my behavior think that I should use open public sector data (SI1)	Five-point Likert scale (strongly disagree-strongly agree)
	People who are important to me (e.g. family, friends) think that I should use open public sector data (SI2)	Five-point Likert scale (strongly disagree-strongly agree)
	People who are important to me (.e.g. colleagues) think that 1 .should use open public sector data (SI3)	Five-point Likert scale (strongly disagree-strongly agree)
Facilitating conditions (FC)	I have the resources necessary to use open public sector data(FC1)	Five-point Likert scale (strongly disagree-strongly agree)
	Open public sector data is compatible with other systems that I use (FC2)	Five-point Likert scale (strongly disagree-strongly agree)
	A specific person or group is available for assistance with di faculties concerning the use of open public sector data (FC3)	Five-point Likert scale (strongly disagree-strongly agree)
Behavioral· intention (BI)	I intend to use open public sector data in the future (BI1)	Five-point Likert scale (strongly disagree-strongly agree)
	I predict that I will use open public sector data in the future (BI2)	Five-point Likert scale (strongly disagree-strongly agree)
	I plan to use open public sector data in the future (BI3)	Five-point Likert scale (strongly disagree-strongly agree)

(continued)

Table 8.2 (continued)

UTAUT construct	Questionnaire item (statement or question)	Type of outcome
Voluntariness of use (VU)	Although it might be helpful, using open public sector data is certainly not compulsory for my research or other activities (VU1)	Five-point Likert scale (strongly disagree-strongly agree)
	My research and other activities do not require me to use open public sector data (VU2)	Five-point Likert scale (strongly disagree-strongly agree)
	My superiors expect me to use open public sector data (VU3) (R)	Five-point Likert scale (strongly disagree-strongly agree)
	My use of open public sector data is voluntary (it is not requited by my superiors/research/other activities) (VU4)	Five-point Likert scale (strongly disagree-strongly agree)
Gender (G)	Are you male or female? (G)	Multiple choice (male or female)
Age (A)	What is your age? (A)	Eight-point scale (under 18–61 or over)
Purpose of use (P)	To what extent are the following purposes important for your use of open public sector data? (P)	Five-point Likert scale (very unimportant-very important)
Type of data (T)	Which of the following types of open data from the public sector do you use or have you used? (T)	Multiple choice (type of public sector data: geographic, legal, meteorological, social, transport, business, other, namely...)

Each statement or question was given a code, referring to the UTAUT construct. The items labeled "(R)" are reverse-coded

data sources. Four dimensions/perspectives have been defined evaluating different aspects of the sources offering open data. These perspectives are as follows:

1. Thematic Analysis Perspective: It includes analysis of the thematic categories of the datasets provided by the OGD sources.
2. Functional Analysis Perspective: It includes analysis of the functionalities provided by the OGD sources.(Datasets discovery, Data provision, Language, Visualizations and feedback)
3. Semantic Analysis Perspective: It includes analysis of the use of Semantic Web technologies for the representation and structure of OGD. using the well established 5-stars Berner Lee's rating system for open data and then an analysis of the metadata and of licence information.
4. Technological Analysis Perspective: It includes analysis of the technologies and products that have been used for the development of the OGD source at the main technological layers: web server, Content Management System (CMS) or platform, user interface, data format and API.

8.3.4 Developing Maturity Models for Open Data

The maturity model concept stands for a model categorising the capabilities of OGD infrastructures through time as described in (Alexopoulos, Diamantopoulou, & Charalabidis, 2017). OGD portals are distinguished in two main categories: traditional and advanced infrastructures. The identified elements of OGD portals are categorized in 4 dimensions as it is seen above: general; information quality; system quality and service quality. Last three dimensions are based in IS Success model. Each of these elements defined by specific values. Thus, this maturity model constitutes an objective assessment. According to Alexopoulos the developed maturity model will guide policy makers by firstly identify the current level of their organization and secondly design an efficient implementation to the required state (Table 8.3).

Another more advanced maturity model has been created by (Solar, Concha, & Meijueiro, 2012). The proposed maturity model, named OD-MM (Open Data Maturity Model) assesses the commitment and capabilities of public agencies in pursuing the principles and practices of open data. It is a subjective (users' opinions) and quantitative model which consists of a three level hierarchical structure, called domains, sub-domains and critical variables. Four capacity levels are defined for each of the 33 critical variables distributed in nine sub-domains in order to determine the organization maturity level. The model is a very valuable diagnosis tool for public services, given it shows all weaknesses and the way (a roadmap) to progress in the implementation of open data.

8.3.5 Institutional Readiness Assessment for Open Data Publishers

The framework developed by (Agbabiaka & Ojo, 2014) for assessing institutional readiness into four main areas: people readiness; system readiness; technology readiness and process readiness. The framework focused on system readiness that constitutes in various sub-dimensions for assessment based on subjective evaluation as described below. Each of sub-dimensions can be assessed with the following values: no progress, some progress, real progress is being made, ready and effective corresponding to the following readiness level: poor, low, medium and high (Table 8.4).

8.4 Metrics Classification

The taxonomy of open data evaluation metrics is based on the "information system success" model, we are going to categorize different evaluation measures and benchmarks for the evaluation of data (Information Quality), platforms offering them (System Quality) and additional capabilities of those systems (Service Quality). Figure 8.5 presents an overview of the main classification categories.

Table 8.3 Maturity model for OGD portals

		Traditional OGD infrastructures		Advanced OGD infrastructures	
	Time	Point zero	**1st generation**	**2nd generation**	**3rd generation**
General	**Internet presence**	OGD existence in silos accessed by application	OGD web presence	OGD web presence	OGD web presence
	Users	Distinction between data providers and data users	Distinction between data providers and data users	Data pro-sumers	Data pro-sumers
	Open government level	Initial: Information broadcasting	Data transparency: Processes and performance	Open participation: Data quality, public feedback, conversation, voting, interactive communications, crowd-sourcing	Open collaboration: Interagency and with the public, co-creating value-added services
	Value	N/A	Transparency & accountability	Participation	Efficiency & innovation
Information quality	**Thematic perspective**	N/A	Statistical, economical, census	Law, transportation, GIS	All categories with proper data modelling
	Format	.xls, .pdf	html, .xls, .pdf	+ .csv + URLs	+ Linked data
	Metadata	Metadata ignorance or closed flat metadata	Metadata ignorance or closed flat metadata	Open metadata for humans or open reusable metadata + contextual or detailed metadata models	Linked open metadata 3-layer metadata model (flat, contextual, detailed)
	RDF-compliance	No	No	Partially yes	Yes
System quality	**Functionality**	N/A	Basic Web 1.0	Advanced Web 2.0	Supporting value creation
	Type	N/A	OGD direct provision portals	OGD direct provision & OGD aggregators	Collaboration spaces

Table 8.4 Framework for assessing institutional readiness

Measure	Definition
Governance readiness	This sub-dimension seeks to assess the presence of supporting mechanisms that will govern the process of preparing for the desired change
Legal & policy	The existence of relevant legal and policy framework that can aid or impede the desired change
Adaptive leadership	The availability of leaders within the organisation that can adapt, innovate and thrive in complex, challenging and uncertain environments
Resource readiness	Degree to which the resources of the agency can support the change. It assess whether the agency has effective financial policies and systems to support the viability and sustainability of the new change
Innovation capability	The degree to which the agency can create values from implementing new ideas and support the idea from conception to delivery.
Information sharing	Degree to which agency's policies, practices, legal framework support information sharing and willingness to embrace information sharing.
Collaboration & engagement	Degree to which the agency is willing to collaborate within itself and with other agencies as well as engage stakeholders and the public in the delivery of its services.
Open data readiness	Degree to which the agency is ready to make data available to other agencies and the public in a transparent way
Change management readiness	Degree to which the agency is prepared to adapt to the anticipated or desired change and evolve.
People readiness	The people factor is a critical component and perhaps the singular most important element of any organization's readiness to accept change. This section of the assessment will cover evaluation of leadership support readiness, the quality and competence level of staff, leadership development policy, etc.

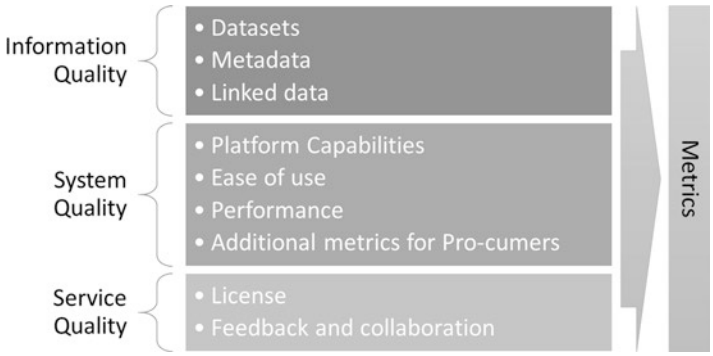

Fig. 8.5 Evaluation metrics classification

Additionally, different evaluation benchmarks for open data have been identified and categorised based on the following three aspects:

(i) The approaches and frameworks from previous relevant IS, concerning: IS evaluation (including in the methodology both efficiency and effectiveness

measures), IS acceptance (including measures of ease of use, usefulness and future intentions), IS success (adopting a layered evaluation approach, and including measures of both information and system quality, and also of user satisfaction and individual impact) and e-services evaluation (including measures of both the quality of the capabilities offered to the users, and the support provided to them for achieving their OGD related objectives).

(ii) Potential users' requirements, which include data search, provision and download capabilities, data processing capabilities, data upload capabilities, and also users – providers feedback capabilities.

(iii) The high level technological aspects proposed in the methodologies for country and government agency level OGD initiatives' evaluation (such as data completeness, quality, quantity, format and metadata, search capabilities, users-providers communication capabilities, users' satisfaction, platform availability).

8.4.1 Information Quality

Information quality metrics are distinguished in three main dimensions: The datasets, the metadata and the linked data where relevant.

8.4.1.1 Data Sets

The dataset metrics are used to assess the data quality of the OGD. They examine the properties and the characteristics of the data (Table 8.5).

8.4.1.2 Metadata

Metadata: In addition to data quality, the second dimension examines the quality of the metadata including the necessary information for the description of the published data (Table 8.6).

8.4.1.3 Linked Data

The third aspect of information quality evaluation is the Linked Data where it is applicable. This dimension includes metrics to assess the quality of public data when they are linked (Table 8.7).

Table 8.5 Evaluation Metrics for Dataset

Dataset			
1	Uniqueness	Uniqueness is defined as the "degree to which data is free of redundancies, in breadth, depth and scope."	Behkamal, Kahani, Bagheri, and Jeremic (2014)
2	Primary	Data is as collected at the source, with the highest possible level of granularity, not in aggregate or modified forms.	https://public.resource.org/8_principles.html (2007)
3	Machine processable	Data is reasonably structured to allow automated processing	https://public.resource.org/8_principles.html (2007)
4	Non-discriminatory	Data is available to anyone, with no requirement of registration.	https://public.resource.org/8_principles.html (2007)
5	Non-proprietary	Data is available in a format over which no entity has exclusive control	https://public.resource.org/8_principles.html (2007)
6	Online and free	Information is not meaningfully public if it is not available on the internet at no charge, or at least no more than the marginal cost of reproduction. It should also be findable.	https://opengovdata.org/ (n.d.)
7	Permanent URI	Data should be made available at a stable internet location indefinitely and in a stable data format for as long as possible.	https://opengovdata.org/ (n.d.)
8	Safe to open	The Association of Computing Machinery's recommendation on open government (February 2009) stated, "government bodies publishing data online should always seek to publish using data formats that do not include executable content." executable content within documents poses a security risk to users of the data because the executable content may be malware (viruses, worms, etc.).	https://opengovdata.org/ (n.d.)
9	Designed with public input	The public is in the best position to determine what information technologies will be best suited for the applications the public intends to create for itself. Public input is therefore crucial to disseminating information in such a way that it has value.	https://opengovdata.org/ (n.d.)
10	Accessibility	Data is available to the widest range of users for the widest range of purposes. This information is easily retrievable. This information is easily accessible. This information is easily obtainable. This information is quickly accessible when needed.	Lee, Strong, Kahn, and Wang (2002)

(continued)

Table 8.5 (continued)

Dataset			
11	Appropriate amount	This information is of sufficient volume for our needs. The amount of information does not match our needs. The amount of information is not sufficient for our needs. The amount of information is neither too much nor too little.	Lee et al. (2002)
12	Completeness	All public data is made available. Public data is data that is not subject to valid privacy, security or privilege limitations. This information includes all necessary values. This information is incomplete. This information is complete. This information is sufficiently complete for our needs. This information covers the needs of our tasks. This information has sufficient breadth and depth for our task.	Lee et al. (2002)
13	Concise representation	This information is formatted compactly. This information is presented concisely. This information is presented in a compact form. The representation of this information is compact and concise.	Lee et al. (2002)
14	Consistent representation	This information is consistently presented in the same format. This information is not presented consistently. This information is presented consistently. This information is represented in a consistent format.	Lee et al. (2002)
15	Ease of operation	This information is easy to manipulate to meet our needs. This information is easy to aggregate. This information is difficult to manipulate to meet our needs. This information is difficult to aggregate. This information is easy to combine with other information.	Lee et al. (2002)
16	Accurate & Objective	This information is objective, correct and accurate.	Lee et al. (2002)
17	Reliable & Trustwothy	This information is believable, credible, and reliable with a good reputation and comes from good sources. The Association of Computing Machinery's recommendation on open government (February 2009) stated, "published content should be digitally signed or include attestation of publication/creation date, authenticity, and integrity." digital signatures help the public validate the source of the data they find so that they can trust that the data has not been modified since it was published. Since provenance is for originally-published documents, it is not a reason to prevent the public from modifying government documents.	Lee et al. (2002)
18	Interpretability	It is easy to interpret what this information means. This information is difficult to interpret. It is difficult to interpret the coded information. This information is easily interpretable. The measurement units for this information are clear.	Lee et al. (2002)

(continued)

Table 8.5 (continued)

Dataset			
19	Timeliness	Data is made available as quickly as necessary to preserve the value of the data. This information is sufficiently current for our work. This information is not sufficiently timely. This information is not sufficiently current forour work. This information is sufficiently timely. This information is sufficiently up-to-date for our work.	Lee et al. (2002)
20	Understandability	This information is easy to understand. The meaning of this information is difficult to understand. This information is easy to comprehend. The meaning of this information is easy to understand.	Lee et al. (2002)
21	Delay in publication	Dataset: Indicates the ratio between the delay in the publication (number of days passed between the moment in which the information is available and the publication of the dataset) and the period of time referred by the dataset (week, month, year).	Vetrò, et al. (2016)
22	Delay after expiration	Dataset: Indicates the ratio between the delay in the publication of a dataset after the expiration of its previous version and the period of time referred by the dataset (week, month, year).	Vetrò, et al. (2016)
23	Comparability of today's data versus yesterday's data	Being able to rollback modification would allow historical analysis.	Lorenzo, Simone, Raimondo, and Federico (2015)

Table 8.6 Metrics – Metadata

Metadata			
1	Metadata availability	Documentation about the format and meaning of data goes a long way to making the data useful.	https://opengovdata.org/ (n.d.)
2	Title and description	Datasets should be provided together with their description and also how and for what purpose they were collected	Máchová and Lnénicka (2017)
3	Addressability & contactability	The extent to which the data publisher provide contact information. Addressability is another important dimension of open data since it emphasizes the extent to which contact information about the dataset's creator/ maintainer is made available. Formally, the proposed metric defines the degree (%) to which datasets provide a value, an email address or HTTP URL to contact the data publisher [19].	Máchová and Lnénicka (2017)
4	Publisher	Datasets should be provided together with their publisher to verify authenticity of their source	Máchová and Lnénicka (2017)

(continued)

Table 8.6 (continued)

Metadata			
5	Release date and up to date	Datasets should be explicitly associated with a specific time or period tag. All information in the dataset should be up to date	Máchová and Lnénicka (2017)
6	Geographic coverage	Datasets should be determined if the coverage of data is on the national, regional or local level	Máchová and Lnénicka (2017)
7	Dataset URL	A URL must be provided in the metadata descriptions	Máchová and Lnénicka (2017)
8	Dataset (file) size	Datasets (file) size should be available	Máchová and Lnénicka (2017)
9	Number of views (visits)	Total number of online views should be available for a dataset	Máchová and Lnénicka (2017)
10	Number of downloads	Total number of downloads should be available for a dataset	Máchová and Lnénicka (2017)
11	Metadata completeness	Number of completed fields. The completeness metric deals with the number of completed fields in a metadata record. A meta-data record is considered complete, if the record contains all the information required to have an ideal representation of the described resource.	Reiche (2013)
12	Weighted completeness	Number of completed fields + weight. While the completeness metric is straightforward it comes with the drawback of treating every field with the same importance. The relevance of a certain metadata field depends strongly on the context. Not all fields might be relevant for the user when deciding whether the metadata record describes the resources he/she is looking for	Reiche (2013)
13	Metadata accuracy	The extent to which certain meta data values accurately describe the resources. Measures the semantic distance. The accuracy of a metadata record states whether the field values are correct with respect to the resources. In other words, how well does the metadata describe the actual resources?	Reiche (2013)
14	Richness of information	Measures the information content. The vocabulary terms and the description used in a metadata record should be meaningful to the user. For that the metadata need to contain enough information for describing uniquely the referred resource. From the user perspective, the metadata record is of high quality if he/she is confident enough about what the referenced resources contain	Reiche (2013)

(continued)

Table 8.6 (continued)

Metadata			
15	Metadata accessibility	Measures the readability. Accessibility measures the degree to which a metadata record is accessible in terms of cognitive accessibility, but also physical, respectively logical accessibility. The cognitive accessibility describe show easy a user can comprehend what the resource is about after reading the metadata record. In the matter of search ability this could decide, whether the user finds what he/she is looking for or not. Due to the domain-specific vocabulary of government it might be difficult to understand the description with ease. Thus, the readability might be an indicator for the general cognitive accessibility. To implement this metric several readability indexes could be used.	Reiche (2013)
16	Resource availability	Checks the availability of resources. With the availability not the metadata record itself is meant, but its resources. Metadata records define URLs which point to the actual resources. The availability metric assesses the number of reachable resources. A resource is available, if the resource can be retrieved. This could also mean, if the accessed page actually returns the described format. That would, however, rather be task of the accuracy metric. Different concerns are kept separated between different metrics	Reiche (2013)
17	Intrinsic precision	Number of spelling mistakes. The intrinsic precision is about the content of textual fields. Similar to the accessibility metric, this metric is about the reading fluency. The reading fluency is directly influenced by orthography of a text. Readers which are proficient in a language might halt for a moment on words written incorrectly. The number of spelling mistakes might not be a very important measure, as opposed to the availability of resources, nevertheless it influences the information quality.	Reiche (2013)
18	Track of creation	Dataset: Indicates the presence or absence of metadata associated with the process of creation of a dataset.	Vetrò et al. (2016)
19	Track of updates	Dataset: Indicates the existence or absence of metadata associated with the updates done to a dataset.	Vetrò et al. (2016)
20	Qr retrievability	The extent to which meta data and resources can be retrieved.	Umbrich, Neumaier, and Polleres (2015)
21	Qu usage	The extent to which available meta data keys are used to describe a dataset.	Umbrich et al. (2015)
22	Qc completeness	The extent to which the used meta data keys are non empty.	Umbrich et al. (2015)
23	Qo openness	The extent to which licenses and file formats conform to the open definition.	Umbrich et al. (2015)

Table 8.7 Metrics for linked data

Linked data			
1	COMP	Comparison between two literal values of a resource.	Kontokostas, Westphal and Auer (2014)
2	MATCH	The literal value of a resource matches/ does not match a certain regex pattern	Kontokostas, Westphal and Auer (2014)
3	LITRAN	The literal value of a specifically typed resource must (not) be within a given range	Kontokostas, Westphal and Auer (2014)
4	TYPEDEP	Type dependency: The type of a resource may imply the attribution of another type.	Kontokostas, Westphal and Auer (2014)
5	TYPRODEP	A resource of a specific type should have a certain property.	Kontokostas, Westphal and Auer (2014)
6	PVT	If a resource has a certain value V assigned via a property P1 that in some way classifies this resource, the existence of another property P2 can be assumed	Kontokostas, Westphal and Auer (2014)
7	TRIPLE	A resource can be considered erroneous if there are corresponding hints contained in the dataset	Kontokostas, Westphal and Auer (2014)
8	ONELANG	A literal value should contain at most one literal for a certain language	Kontokostas, Westphal and Auer (2014)
9	RDFSDOMAIN	The attribution of a resource's property (with a certain value) is only valid if the resource is of a certain type	Kontokostas, Westphal and Auer (2014)
10	RDFSRANGE	The attribution of a resource's property is only valid if the value is of a certain type	Kontokostas, Westphal and Auer (2014)
11	RDFSRANGED	The attribution of a resource's property is only valid if the literal value has a certain datatype	Kontokostas, Westphal and Auer (2014)
12	INVFUNC	Some values assigned to a resource are considered to be unique for this particular resource and must not occur in connection with other resources	Kontokostas, Westphal and Auer (2014)
13	OWLCARD	Cardinality restriction on a property	Kontokostas, Westphal and Auer (2014)
14	OWLDISJC	Disjoint class constraint	Kontokostas, Westphal and Auer (2014)
15	OWLDISJP	Disjoint property constraint	Kontokostas, Westphal and Auer (2014)
16	OWLASYMP	Asymmetric property constraint	Kontokostas, Westphal and Auer (2014)
17	OWLIRREFL	Irre exive property constraint	Kontokostas, Westphal and Auer (2014)

8.4.2 System Quality

System quality is divided into three dimensions; open data platforms capabilities dimension, the ease of use dimension and the performance dimension. When we are dealing with advanced Open Data platforms there could be one additional dimension referring to the data pro-cumers category of users; the data processing, enrichment and upload capabilities, which allows the users to further process the data upgrading them to more usable forms.

8.4.2.1 Open Data Platforms Capabilities

This category of evaluation metrics refers to the assessment of open data platforms capabilities. It could be used either from subjective (To what extend do you agree with the following statements? [7-point Likert scale]) or objective (Does the platform include the following functionality? [YES/NO]) models. It includes descriptive information about datasets and sources, functionalities provided by the Open Data portals in terms of dataset discovery, data provision capabilities, data visualization and multilingualism (Table 8.8).

8.4.2.2 Ease of Use

The ease of use metrics is forming a general dimension that could be used in the appraisal of every information system and service including open data platforms. These metrics are used mostly for subjective evaluation (Table 8.9).

8.4.2.3 Performance

The performance metrics is forming a general dimension that could be used in the appraisal of every information system and service including open data platforms. These metrics are used mostly for subjective evaluation but includes also metrics that could be used in objective evaluation (existence of API [YES/NO]) (Table 8.10).

8.4.2.4 Additional Dimension for Pro-Sumers

An additional dimension of evaluation metrics refer to the data procumers category of users as it is presented in Chap. 2. Data Processing and Upload Capabilities include functionalities provided by the open data portals in terms of enrichment, data cleansing, data linking and data format conversions. The pro–sumers concept was first introduced in (Charalabidis et al., 2014). It refers to subjects who concurrently provide and consume data and its quality. Subjects access the quality of data they

Table 8.8 Metrics for open data platforms capabilities

Search, provision and download			
1	Number of datasets	Portals should provide the number of datasets they include	Máchová and Lnénicka (2017)
2	Authority and responsibility	Portals should provide information about the authority, which hosts the portal and the governance model or institutional framework supporting data provision models	Máchová and Lnénicka (2017)
3	Number of applications (re-uses)	Portals should provide number of applications developed based on the open data re-used	Máchová and Lnénicka (2017)
4	Diversity of information	There are datasets from many different domains and/or countries	Charalabidis et al. (2014)
5	Thematic categories	PSI thematic categories: Economic and business information geographic information legal information meteorological and environmental information social information traffic and transport information tourist and leisure information agricultural, farming, forestry and fisheries information natural resources information	Alexopoulos et al. (2017)
6	RDF-compliance	It concerns the use of technologies that support RDF, including technical products of open data initiatives publishing structured data in a way that it can be interlinked, which as mentioned in the previous 'background' section is quite important for enabling more effective browsing and discovery of datasets, and for linking and combining OGD from multiple sources (e.g. see Villazón-Terrazas et al. (2011); Bauer and Kaltenböck (2012)); it is a binary indicator	Alexopoulos et al. (2015)
7	Download	The platform enabled me to download datasets easily and efficiently	Charalabidis et al. (2014)
8	Datasets discovery	It concerns the tools provided for discovering the datasets the user is interested in; its main possible values (not mutually exclusive) were: Simple document list, free text search, browsing through categories, browsing through filters, browsing through interactive map and SPARQL search.	Alexopoulos et al. (2017)
9	Visualizations	It concerns the datasets' visualization capabilities provided; one possible value is 'not existing', while other main possible values (not mutually exclusive) are visualizations in charts and visualizations in maps.	Alexopoulos et al. (2017)
10	Language	Portals should offer more language versions to gain more users (attention) and improve the overall quality of this portal	Máchová and Lnénicka (2017)

consume and are in position to mention weakness in them, and new needs they have. This concept eliminates the clear distinction between 'passive' content users/consumers and the 'active' content producers. In particular, next generation Open Data Infrastructures increasingly offer to data users capabilities for commenting and rating datasets, and also for processing them in order to improve them, adapt them to

Table 8.9 Metrics for ease of use

Ease of use			
1	Friendlyness	The platform provides a user friendly and easy to use environment	Charalabidis et al. (2014)
2	Easiness of use	It was easy to learn how to use the platform	Charalabidis et al. (2014)
3	Attractiveness	The web pages look attractive.	Charalabidis et al. (2014)
4	Design	It is easy to perform the tasks I want in a small number of steps.	Charalabidis et al. (2014)
5	Language adaptability	The platform allows me to work in my own language.	Charalabidis et al. (2014)
6	Personalisation	The platform supports user account creation in order to personalize views and information shown	Charalabidis et al. (2014)
7	Documentation	The platform provides high quality of documentation and online help.	Charalabidis et al. (2014)

their specialized needs, or link them to other datasets (public or private), and then uploading-publishing new versions of them, or even their own new datasets. In general, second generation of OGD infrastructures aim at fulfilling the needs of the emerging OGD 'pro-sumers' (Zuiderwick & Janssen, 2013) (Table 8.11).

8.4.3 Service Quality

Service quality consists of two dimensions; the license dimension and the feedback and collaboration dimension. When used for pro-cumers, it is expanded in the second one.

8.4.3.1 License

License dimension concerns license information related to the use of the published datasets. This is one of the most important characteristic of OGD sources, since it defines the allowed ways of OGD utilization and exploitation for generating various types of social and economic value, and reduces all relevant legal uncertainties (Table 8.12).

8.4.3.2 Feedback and Collaboration

Feedback and collaboration dimension concerns capabilities for users to communicate to the other users and the providers the level of quality of the datasets that they perceive. Also capabilities for users to get informed on the level of quality of the datasets perceived by other users through their ratings (e.g. five stars rating system).

Table 8.10 Metrics – performance

Performance			
1	Efficiency	The platform is always up and available without any interruptions.	Charalabidis et al. (2014)
2	Effectiveness	Services and pages are loaded quickly.	Charalabidis et al. (2014)
3	Bugs	I did not realize any bugs while using the platform.	Charalabidis et al. (2014)
4	API	Portals should provide API for stakeholders to develop applications using open data	Máchová and Lnénicka (2017)
5	Sources rating	According to the 5-stars Berner Lee's rating scheme for open data: *Make your stuff available on the web (whatever format) **Make it available as structured data (e.g. excel instead of image scan of a table) ***Using non-proprietary format (e.g. csv instead of excel) ****Use URLs to identify things, so that people can point at your stuff *****Link your data to other people's data to provide context	Alexopoulos et al. (2015)
6	Sources metadata rating	According to the 5-stars maturity scheme of metadata management. *Metadata ignorance **Scattered or closed metadata ***Open metadata for humans ****Open reusable metadata *****Linked open metadata	Alexopoulos et al. (2015)
7	Data management system	Portals should provide information about the data management system, which is used to power the portal	Máchová and Lnénicka (2017)
8	Social media	Portals should be connected to a social media platform to create a social distribution channel for open data. OGD users and providers can inform each other about what they did with and learned from a dataset	Máchová and Lnénicka (2017)
9	User account	Portals should support user account creation in order to personalize views and information shown	Máchová and Lnénicka (2017)

In addition it includes capabilities for users expressing their needs for additional datasets; getting informed about the needs of other users and getting informed about datasets extensions and revisions (Table 8.13).

8.5 Conclusions

The big investments made by governments of many countries for the development of OGD infrastructures, makes it necessary to evaluate them systematically, in order to understand better and assess the various types of value they generate, and identify

Table 8.11 Metrics for data pro-cumers

1	The platform provides good capabilities for data enrichment (i.e. adding new elements – fields)	Charalabidis et al. (2014)
2	The platform provides good capabilities for data cleansing (i.e. detecting and correcting ubiquities in a dataset)	Charalabidis et al. (2014)
3	The platform provides good capabilities for linking datasets.	Charalabidis et al. (2014)
4	The platform enabled me to upload datasets easily and efficiently.	Charalabidis et al. (2014)
5	The platform enabled me to prepare and add the metadata for the datasets I uploaded easily and efficiently.	Charalabidis et al. (2014)
6	The platform provides good capabilities for the automated creation of metadata.	Charalabidis et al. (2014)
7	The platform provides good capabilities for converting datasets' initial metadata in the metadata model of the platform easily and efficiently.	Charalabidis et al. (2014)
8	The platform provides strong API for uploading datasets (data and metadata	Charalabidis et al. (2014)

Table 8.12 Metrics for licencing

1	A presumption of openness	The presumption of openness rests on laws like the Freedom of Information Act, procedures including records management, and tools such as data catalogs.	https://opengovdata.org/ (n.d.)
2	Data license	It concerns license information related to the use of the published datasets	Alexopoulos et al. (2017)
3	Security	Provide information about restricted information. This information is protected against unauthorized access.	Lee et al. (2002)

the required improvements for increasing this value as it is presented in Chap. 7. In Chap. 3, we presented the major policies towards the achievement of this value. Policies should be evaluated measuring the impact of their developments. The expected impact of the Open Data policies and the development of data portals is to drive economic benefits and further transparency. These benefits have been largely outlined by a number of studies trying to develop evaluation models and metrics aiming at the assessment of those developments (impact and value assessment) as well as to drive next developments in the domain (maturity models, readiness assessment).

The studies have concentrated on the issues of open data quality assessment or the assessment of the portals offering them. The evaluation of an open data initiative or portal is a difficult task. Firstly, there are no objective and absolute (wide-accepted) metrics and targets (higher/lower values) for measurement. Secondly, there are too many perspectives for evaluation and each one of them provides different kind of insights.

As an evaluator, you first need to build the required evaluation model to fit your evaluation objectives. Then moving towards the finalization of the evaluation framework, a comprehensive evaluation procedure has to be developed for the use of the

Table 8.13 Metrics for feedback and collaboration

1	Quality rating	The platform provides good capabilities for giving feedback on the datasets I download, e.g. for rating datasets, for entering textual comments on them.	Charalabidis et al. (2014)
2	Feedback readability	The platform provides good capabilities for reading available feedback of other users of datasets I am interested in, e.g. ratings, comments.	Charalabidis et al. (2014)
3	Find users	The platform enables searching for and finding other users having similar interests with me in order to have information and knowledge ex-change and cooperation	Alexopoulos, Zuiderwijk, Charalabidis, Loukis, and Janssen (2016)
4	Groups of users	The platform enables forming groups with other users having similar interests with me in order to have information and knowledge exchange and cooperation	Alexopoulos et al. (2016)
5	Personalisation	The platform enables maintaining datasets/ working on datasets within one group	Alexopoulos et al. (2016)
6	Communication	The platform enables communicating with other users through messages in order to exchange information and knowledge	Alexopoulos et al. (2016)
7	Instant update	The platform enables getting immediately updated about the upload of new versions and enrichments of datasets maintained/worked on within the group, or new relevant items (e.g. publications, visualizations, etc.)	Alexopoulos et al. (2016)
8	Forum (feedback)	Portals should provide an opportunity to submit feedback on the data from the users to providers and forum to discuss and exchange ideas among the users	Máchová and Lnénicka (2017)
9	Request form	Portals should provide a form to request or suggest new type of format type of open data	Máchová and Lnénicka (2017)
10	Help	Portals should include high quality of documentation and help functionality to learn how to use the portal and improve the usability	Máchová and Lnénicka (2017)
11	Frequently Asked Questions (FAQ)	Portals should provide a FAQ section to help resolve any potential issues	Máchová and Lnénicka (2017)
12	Relevancy	This information is useful to our work. This information is relevant to our work. This information is appropriate for our work.	Lee et al. (2002)
Additional metrics for data pro-sumers in feedback and collaboration dimension			
13	Comments	The platform enables me to read interesting thoughts and ideas of the users on the datasets and the extensions I have uploaded by reading the comments they entered on them.	Alexopoulos et al. (2016)

(continued)

Table 8.13 (continued)

14	Rating	The platform enables me to get informed on the level of quality of the datasets and the extensions I have uploaded that is perceived by the users of them by reading their ratings	Alexopoulos et al. (2016)
15	Needs	The platform enables me to get informed about the needs of the users of the datasets and the extensions I have uploaded for additional ones	Alexopoulos et al. (2016)
16	Feedback	It concerns the existing tools allowing feedback from OGD users to the providers; its two main possible values were 'not existing' and 'existing'	Alexopoulos et al. (2015)

evaluation model (Alexopoulos et al., 2013). The procedure should include both quantitative and qualitative evaluation methods and tools to get deeper insights.

In this chapter we have presented quantitative models for objectively and subjectively evaluate an open data initiative. The metrics and models could be also used to develop tools for qualitative evaluation getting deeper insights by the end-users. Tools for qualitative evaluation such semi-structured questionnaires for discussion in a group of users, interviews and SWOT (Strengths-Weaknesses-Opportunities-Threats) analysis could be used for assessing various aspects of open data (impact, readiness, usability etc.).

A taxonomy of evaluation metrics has been developed in order to be used in alternative applications of the evaluation models based on the specific functionality of a platform or the quality of linked open data. Higher level models and tools have been presented towards the identification of the maturity and the evaluation of impact.