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Evaluating Second Generation Open Government Data Infrastructures Using Value Models

Yannis Charalabidis
University of the Aegean
yannisx@aegean.gr

Euripides Loukis
University of the Aegean
eloukis@aegean.gr

Charalampos Alexopoulos
University of the Aegean
alexop@aegean.gr

Abstract

Recently, a second generation of advanced open government data (OGD) infrastructures has emerged, influenced by the principles of the Web 2.0 paradigm, and oriented towards the elimination of the clear distinction between providers and consumers of such data, and the support of data 'pro-sumers'. This paper presents and validates a methodology for evaluating these advanced second generation of ODG infrastructures, which is based on the estimation of value models of them from users' ratings. This value model includes assessments of the various types of value generated by such an infrastructure, and also of the relations among them as well. This enables a deeper understanding of the whole value generation mechanism and a rational definition of improvement priorities. The proposed methodology has been used for the evaluation of an advanced second generation ODG e-Infrastructure developed in the European project ENGAGE.

Keywords: open government data; e-Infrastructures; web 2.0; evaluation; value model.

1. Introduction

Governments are increasingly opening to the society important data they possess in order to be used for scientific, commercial and political purposes [1]-[3]. According to the European Commission these data can be quite valuable for scientific research in many different domains, and contribute critically to the development of the 'e-Science' paradigm [4]-[5]. This large amount of data can be very useful for conducting advanced scientific research in the social, political, economic, administrative and management sciences, which can lead to a better understanding of the serious problems that modern societies face, and the development of solutions for them. Furthermore, these data have a significant — currently untapped — potential for re-use for developing new products and services, possibly in creative combinations with other data resources [6]. Also, opening up government data will promote openness, transparency, accountability and more close co-operation among government agencies and the 'wider society' (civil society organizations, scientific community, private sector, etc.), and will have positive impact the quality and effectiveness of political debate [1].

For the above reasons many countries all over the world design and implement open government data (OGD) initiatives, which include legislative interventions and development of digital infra-structures for this purpose [1-2]. With respect to the latter, initially a first generation of Internet-based OGD infrastructures has been developed, which offer basic functionalities for downloading data by interested users, and for uploading data by their providers. In general, this first generation of OGD e-infrastructures has been influenced by the Web 1.0 paradigm, in which there is a clear distinction between content producers and content users.

However, recently a second generation of more advanced OGD infrastructures is under development, which provide a wider range of functionalities, influenced by the principles of the new Web 2.0 paradigm [7-8]. They support the main feature of this new paradigm: the elimination of the clear distinction between on one hand the 'passive' content users/consumers and on the other hand the 'active' content producers (which characterises Web 1.0), and the shift towards highly active users (who assess the quality of the data they consume and mention weaknesses of them and new needs they have), who often become data 'pro-sumers' (both consumers and providers of data). In particular, this second generation of OGD 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 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, this second generation of OGD infrastructures aim at fulfilling the needs of the emerging OGD 'pro-sumers' [8].

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The big investments made by governments of many countries for the development of OGD infrastructures, makes it necessary to evaluate them systematic, in order to understand better and assess the various types of value they generate, and identify the required improvements for increasing this value. However, there has been quite limited activity in this direction. A recent study of the OECD on OGD initiatives [1] concludes that 'So far, little has been done to analyse and prove the impact and accrued value of these initiatives', and calls for action in this direction. It also states that an important barrier for this is the lack of a structured and comprehensive evaluation methodology. For filling this gap it proposes an analytical framework for assessing country-level OGD initiatives, which includes three main assessment dimensions: strategy and legal-institutional framework, implementation framework, and value creation (social, political and economic). Also, in [9] is described an open data maturity model to be used for assessing the commitment and capabilities of particular government agencies in pursuing the principles of open data; it includes three evaluation domains (each of them being divided into several sub-domains consisting of several individual variables): establishment and legal perspective, technological perspective and citizen-enterpreneurial perspective. Therefore, though there are some first methodologies for evaluating OGD initiatives at the level of country and individual government agency (which include some high level technological aspects among others), there is not a methodology for evaluating OGD infrastructures, which is the most critical level for value creation from OGD.

So the main research question of this study is to develop a methodology for evaluating this second advanced generation of OGD infrastructures, which i) takes into account the main complexities of them, ii) allows assessing the multiple types of both data use related value (=capabilities concerning the download and use of such data) and also data provision related value (=capabilities concerning the provision of such data) they generate, and iii) enables identifying priorities for improvements (which is quite important, as this is a relatively new type of IS).

In this direction this paper describes and validates an evaluation methodology for these second generation OGD infrastructures, which adopts the 'value model' approach to IS evaluation proposed in [10-11]. According to this approach the evaluation of IS should include not only the assessment of various measures of generated value (as in the 'conventional' IS evaluation approaches), but also the relations among them as well, leading to the formation of a value model of the IS; this provides highly important advantages: it enables a deeper understanding of the whole IS value generation mechanism and also a rational definition of IS improvement priorities (see section 2 for more details on this approach).

In particular, the proposed methodology is based on the estimation of a three layers' value model of a second generation OGD infrastructure from users' ratings, following the value model structure proposed in [10-11]. Its first layer includes measures of the value associated with the quality of the data use and provision capabilities it offers. Its second layer includes measures of the value associated with the support it provides to users for achieving their data use related objectives and their data provision related objectives. Finally, its third layer includes measures of the value associated with users' future behavior with respect to the OGD infrastructure. For each of the above layers its particular value measures are selected taking into account previous relevant IS research (see section 2) and also the particular capabilities that this new generation of OGD infrastructures offers. Furthermore, our methodology includes the estimation and exploitation of not only all the above types of value generated by the OGD infrastructure, but also (going beyond the 'conventional' IS evaluation approaches) of the relations among them as well (neglected by the conventional approaches). This leads to the formation of a value model of the OGD infrastructure, which shows how capabilities value lead to the creation of objectives' achievement support value, and finally to the creation of users' future behaviour value. Also, this value models allows identifying the capabilities of the OGD infrastructure (at the first layer of the value model) that should take the highest improvement priority.

The proposed methodology has been used for the evaluation of an advanced second generation OGD e-Infrastructure developed in the European project ENGAGE (for more details see http://www.engagedata.eu/about/).

In the following section 2 the theoretical background of the proposed methodology is outlined. Then in section 3 the proposed methodology is described, while in section 4 the abovementioned application of it is presented. Finally in section 5 the conclusions are summarized and future research directions are proposed.

2. Theoretical Background

For the development of our methodology we have taken into account approaches and frameworks developed from four relevant streams of previous IS research on: i) IS evaluation, ii) IS acceptance, iii) IS success and iv) e-services evaluation. A brief review of them is provided in this section.

Extensive research has been conducted on IS evaluation in the last twenty years [12] – [17]. 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. [12] distinguishes 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.

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 lead to the development and extensive validation of the Technology Acceptance Model (TAM) and its subsequent extensions [18] – [22]. 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.

Another research stream that can provide useful elements is the IS success research [23]-[25]. 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. In [25] is 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 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 [26] – [30]; extensive reviews of this research are provided in [27] and [29]. 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). 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.

Only recently some research in this direction has been conducted. In [10-11] is proposed and verified a structured approach for assessing and improving e-services, which is based on the estimation of value models of them from users' ratings. Such a value model consists of a set of value measures, assessing different types of value generated by the evaluated e-service, and also the relations among them. These value measures are organized in three layers:

(a) Efficiency layer: it includes 'efficiency' measures, which assess the quality of the basic capabilities offered by the e-service to its users.

(b) Effectiveness layer: it includes 'effectiveness' measures, which assess to what extent the e-service assists the users for completing their tasks and achieving their objectives.

(c) Future behaviour layer: it includes measures assessing to what extent the e-service influences the future behaviour of its users (e.g. to what extent they intend to use the e-service again in the future, or recommend it to friends and colleagues).

The above value model shows how value generation starts through capabilities offered to the users, and then how this is transformed to support for completing users' tasks and achieving their objectives, and finally how this affects their future behaviour; in this sense a value model enables a better understanding of the whole mechanism of value generation by the e-service. Also, it enables a rational definition of priorities for improvements in the capabilities it offers to users (in the first layer of the model), by giving highest priority to the improvement of the capabilities receiving lower users' ratings and at the same time having higher impact on the measures of the higher levels value (i.e. on the ones of the second and third layer). Such an approach can be useful for the development of a comprehensive methodology for evaluating second generation OGD infrastructures, after appropriate adaptations: inclusion in the first layer of quality measures of the main capabilities offered by these advanced OGD infrastructures, and in the second layer of measures of the support they provide to their users for achieving their multiple objectives (associated with OGD 'pro-sumption' as mentioned in the Introduction).

3. An Evaluation Methodology

A methodology for evaluating this advanced second generation of OGD infrastructures was developed based on one hand on the above three layers' value model approach [10-11], and on the other hand on:

i) The approaches and frameworks from previous relevant IS research outlined in the previous section, 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) The results of the analysis of potential users' requirements conducted as part of the above ENGAGE project (which, as described in more detail in [7-8], include data search, provision and download capabilities, data processing capabilities, data upload capabilities, and also users – providers communication capabilities).

iii) The high level technological aspects proposed in the methodologies for country and government agency level OGD initiatives' evaluation proposed in [1] and [9] respectively (such as data completeness, quality, quantity, format and metadata, search capabilities, users-providers communication capabilities, users satisfaction, platform availability).

Our methodology includes the definition of a value model for these advanced second generation OGD infrastructures (section 3.1), and also an algorithm for estimating this value model based on users' evaluation ratings, adopting the approach proposed in [10-11] (section 3.2).

3.1. Value Model Definition

The value model consists of the main dimensions of the value that these advanced second generation OGD infrastructures generate, and the relations among them, which are shown in Fig 1.

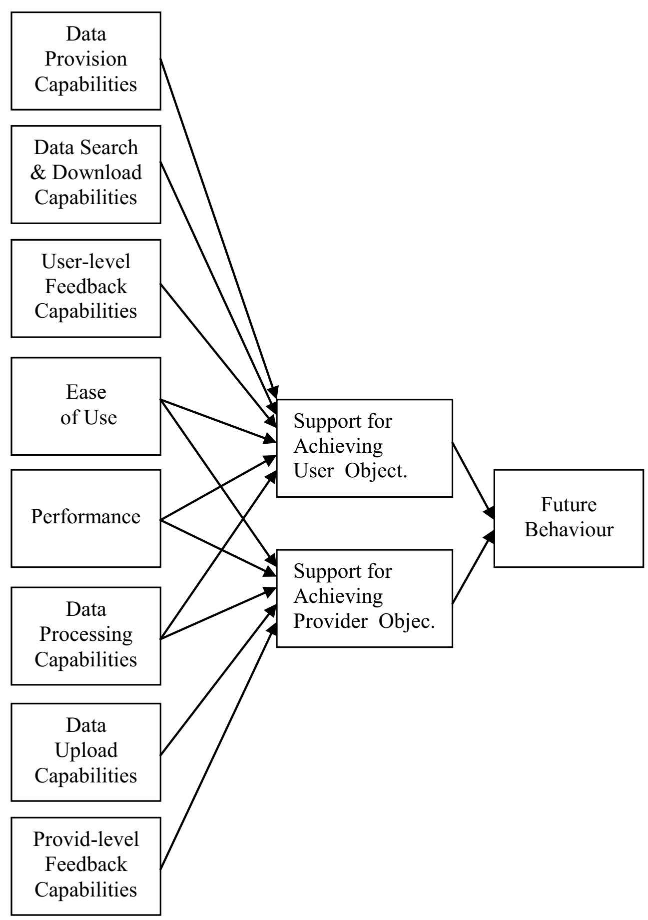

Figure 1. Definition of value model of second generation OGD infrastructures (main value dimensions per layer and relations among them)

We remark that these value dimensions are organized in three value layers, adopting the structure proposed by [10-11], 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 data user (consumer) level capabilities offered by the OGD infrastructure: data provision capabilities (based on the 'information quality' proposed by the the IS success model of DeLone and McLean [23-24], and also on [1] and [7-9]), data search and download capabilities (based on [1] and [7-9]) and user-level feedback capabilities (also based on [1] and [7-9]). These value dimensions are expected to affect the 'support for achieving user-level objectives' value dimension of the second layer (we can see the corresponding relations in the value model of Fig.1). The next three value dimensions of the first layer are ease of use (based on the TAM [18]), performance (based on the 'system quality' proposed by the IS success model of DeLone and McLean [23-24]), and data processing capabilities for users (based on [7-8]). These value dimensions 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 (so we can see the corresponding relations of them with both these second layer value dimensions in Fig.1). The final two value dimensions of the first layer concern the provider-level capabilities offered by the OGD infrastructure: data upload capabilities (based on [7-8]) and provider-level feedback capabilities (based on [1] and [7-9])). These two value dimensions are expected to affect the 'support for achieving provider-level objectives' value dimension of the second layer (we can see the corresponding relations in the value model of Fig.1). 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. Finally, the third layer includes one value dimension associated with users' future behavior (based on the the TAM [18]).

It should be noted that the value dimensions of the first efficiency layer are independent variables, which are under the direct control of the infrastructure developer, who can take direct actions for improving them if necessary. In contrast, the value dimensions of the other two layers (effectiveness and future behavior ones) are not under the direct control of the infrastructure developer, and are dependent to some extent on the first level ones.

The above eleven value dimensions were further elaborated, and for each of them a number of individual value measures were defined (again based on the foundations i to iii mentioned in the beginning of this section). 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. All these questions have the form of statements, and the users are asked to enter the extent of their agreement or disagreement with them, answering the question: "To which extend do you agree with the following statements?". A five point Likert scale is used to measure agreement or disagreement with (i.e. positive or negative response to) such a statement (1=Strongly Disagree, 2= Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree). In Table 1 we can see the questions that correspond to the value measures of each value dimension.

Table 1. Questions for Value 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
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.

The above value model 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 characterised 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.

3.2. Value Model Estimation Algorithm

The users' evaluation data collected through the above questionnaire will be processed, in order to estimate the value model of the OGD infrastructure and identify improvement priorities, using the algorithm described in this section. It consists of seven steps, which are shown n Figure 2:

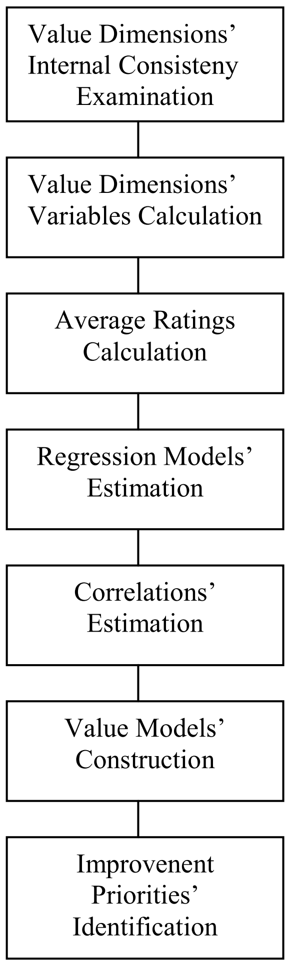

Figure 2. Value Model Estimation Algorithm

1. Initially for each value dimension we examine the internal consistency of its value measures by calculating the Cronbach Alpha of the variables corresponding to its value measures [31]. This coefficient quantifies to what extent a set of variables measure different aspects of the same single uni-dimensional construct, and is calculated as:

$$\text{Alpha} = (k/(k-1)) * [1- (s^2_i)/s^2_{sum}]$$

where the s^2_i (i = 1, 2, …, k) denote the variances of the k individual variables, while the s^2_{sum} denotes the variance of the sum of these variables. A widely accepted and used practical 'rule of thumb' is that values of Cronbach Alpha exceeding 0.7 indicate 'acceptable' levels of internal consistency of the variables [31]. Therefore if for a value dimension its calculated value of Cronbach Alpha exceeds 0.7, we can conclude that all its measures have acceptable internal consistency; if this does not happen, we can conclude that some of the measures are not sufficiently related to this value dimension (they can be detected if for each of the individual variables is calculated the Cronbach Alpha without it, which is a standard calculation offered by all statistical packages), so they must be removed and not taken into account, or probably that this dimension should be split into two or more sub-dimensions.

2. For each value dimension an aggregate variable is calculated as the average of its individual measures' variables.

3. Average ratings are calculated for all value measures and dimensions (using for the latter the aggregate variables calculated in the previous step); this allows us to identify 'strengths' and 'weaknesses' of the OGD infrastructure.

4. For each aggregate variable – value dimension of the second and third layer, we estimate a regression having it as dependent variable, and having as independent variables all the aggregate variables-value dimensions of the previous layers, in order to estimate to what extent this value dimension is affected by value dimensions of previous layers; this is quantified by the R^2 coefficient of the regression [32]. If we find that all value dimensions of the second and third layer are affected to a large extent by the value dimensions of the previous layers (e.g. having $R^2 > 0.50$), then we can conclude that this value model is characterized by coherence among its layers, so we can proceed to the following stages. On the contrary, if some value dimensions of the second or third layer are affected only to a small extent by the value dimensions of the previous layers, this indicates that some important value dimensions have been omitted in the previous layers, so we have to redefine the value model of the OGD infrastructure.

5. For each value dimension of the first level we calculate its impact on the higher level value dimensions (of the second and the third layers) (using again the aggregate variables calculated in step 2). For this purpose we can use the corresponding standardised coefficients of the regressions of the above step 4. However, according to econometric literature [32], if there are high levels of correlation between the independent variables of a regression, then the estimated regression coefficients are not reliable measures of the impacts of the independent variables on the dependent variable (multi-collinearity problem). For this reason we decided to use correlations instead; so as measure of the impact of a first layer value dimension on a higher layer value dimension has been used the correlation

coefficient between them. Furthermore we calculated the correlations of all first level value measures with all second and third layers' value dimensions and measure, as measures of their impact on higher level value generation.

6. By combining the average ratings calculated in step 2 with the correlations calculated in step 3 we can construct one value model of the OGD infrastructure at the level of value dimensions, and also a more detailed one at the level of value measures. These models enable a deeper understanding of the value generation mechanism of the OGD infrastructure.

7. Finally the value dimensions and the value measures of the first layer, which are the only 'independent variables' within the control of the OGD infrastructure developer, are classified, based on their average ratings by users and their impacts on the value dimensions of the second and the third level, into four groups: low rating – high impact, low rating – low impact, high rating – high impact and high rating – low impact. The highest priority should be given to the improvement of the value dimensions and individual value measures of the first group, which receive low ratings and at the same time have a high impact on the generation of higher level value; so it is on them that we should focus our scarce human and financial resources.

4. Application

The proposed methodology has been applied for the evaluation of the first version of an advanced second generation OGD infrastructure developed in the abovementioned ENGAGE project. The evaluation questionnaire shown in Table 1 was initially tested by three colleagues highly experienced in quantitative research in the IS domain, who found it clear and understandable, and did not report any important problems. Then 42 postgraduate students of the University of the Aegean (Greece) and the Delft University of Technology (The Netherlands) (both partners of the above project) in the IS domain were trained in the capabilities of this OGD infrastructure (in a two hours session), and then used it for implementing a representative scenario, which included both data user and data provider tasks (in an one hour session). Immediately after the end of these tasks they all filled the questionnaire in paper form. We believe that since all these postgraduate students had some experience in quantitative IS research, they are satisfactory sources of information concerning various aspects of value of this OGD infrastructure.

Initially for each value dimension the Cronbach Alpha coefficient of the variables corresponding to its value measures was calculated (step 1), using the formula given in the previous section, and the results are shown in Table 2. We remark that for all value dimensions the Cronbach Alpha coefficient exceeds the minimum acceptable level of 0.7 [31]. This indicates that for all our value dimensions their value measures are sufficiently consistent, measuring different aspects of the same uni-dimensional construct. This allowed us to proceed to the calculation for each value dimension of an aggregate variable, which is equal to the average of the individual variables of its measures (step 2).

Table 2. Cronbach Alpha of Value Dimensions

Value Dimension	Alpha
Data Provision Capabilities (DPV)	0.834
Data Search and Download Capabilities (DSD)	0.805
User-level Feedback Capabilities (UFB)	0.770
Ease of Use (EOU)	0.716
Performance (PER)	0.719
Data Processing Capabilities (DPR)	0.811
Data Upload Capabilities (DUP)	0.858
Provider-level Feedback Capabilities (PFB)	-
Support for Achieving User-level Objectives (SUO)	0.843
Support for Achieving Provider-level Objectives (SPO)	-
Future Behaviour (FBE)	0.876

Next for all value measures and dimensions the average ratings over all respondent students were calculated (step 3), and the results are shown in the second column of Table 3 (results for value dimensions are shown in bold). We remark that according to the respondents the strongest points of this OGD are the provider-level feedback capabilities (for collecting ratings and comments on the datasets they publish from their users), its ease-of use, and its data processing capabilities, all perceived between moderate and good (average ratings 3.44, 3.35 and 3.27 respectively). Its weakest point is its performance (with respect to its availability, response time and bugs), which is perceived as problematic (average rating 2.15). The remaining four first layer value dimensions (i.e. data provision, data search and download, capabilities for user-level feedback, and data upload) are regarded as moderate (average ratings 3.03, 3.03, 2.97 and 2.93 respectively).

Table 3. Average ratings of value dimensions and measures, and correlations with 2nd and 3rd layer value dimensions

Measure/ Dimension	Average ratings	Correl SUO	Correl SPO	Correl FBE	Average Correl.
DPV	**3.03**	**0.639**	**0**	**0.511**	**0.383**
DPV1	2.68	0.502	0	0.378	0.293
DPV2	3.00	0.537	0	0.426	0.321
DPV3	2.51	0.593	0	0.606	0.400
DPR4	3.02	0.544	0	0.375	0.306
DPV5	3.71	0.329	0	0.159	0.163
DPV6	3.37	0.148	0	0.226	0.125
DPV7	2.95	0.574	0	0.418	0.331
DSD	**3.03**	**0.760**	**0**	**0.747**	**0.502**
DSD1	2.68	0.516	0	0.520	0.345
DSD2	3.24	0.422	0	0.386	0.269
DSD3	3.24	0.598	0	0.662	0.420
DSD4	3.10	0.576	0	0.603	0.393
DSD5	2.90	0.589	0	0.549	0.379
DSD6	3.05	0.515	0	0.425	0.313
UFB	**2.97**	**0.651**	**0**	**0.410**	**0.354**
UFB1	2.90	0.622	0	0.284	0.302
UFB2	3.05	0.624	0	0.442	0.355
EOU	**3.35**	**0.730**	**0.479**	**0.448**	**0.552**
EOU1	3.39	0.684	0.362	0.430	0.492
EOU2	3.80	0.539	0.359	0.295	0.398
EOU3	3.00	0.515	0.311	0.378	0.401
EOU4	3.39	0.487	0.213	0.293	0.331
EOU5	3.61	0.193	0.190	0.196	0.193
EOU6	3.44	0.220	0.318	0.213	0.250
EOU7	2.83	0.634	0.356	0.592	0.527
PER	**2.15**	**0.379**	**0.135**	**0.377**	**0.297**
PER1	2.10	0.363	0.113	0.371	0.282
PER2	2.15	0.310	0.185	0.328	0.274
PER3	2.20	0.278	0.126	0.209	0.204
DPR	**3.27**	**0.735**	**0.632**	**0.640**	**0.669**
DPR1	3.29	0.483	0.395	0.460	0.446
DPR2	3.26	0.644	0.593	0.581	0.606
DPR3	3.17	0.599	0.488	0.652	0.580
DPR4	3.41	0.619	0.527	0.354	0.500
DUP	**2.93**	**0**	**0.680**	**0.543**	**0.408**
DUP1	2.92	0	0.566	0.433	0.333
DUP2	3.00	0	0.573	0.380	0.318
DUP3	2.89	0	0.445	0.210	0.218
DUP4	2.79	0	0.562	0.538	0.367
DUP5	3.08	0	0.544	0.515	0.353
PFB	**3.44**	**0**	**0.307**	**0.291**	**0.199**
SUO	**3.17**	**-**	**0**	**0.624**	
SUO1	3.27	-	0	0.513	
SUO2	3.17	-	0	0.570	
SUO3	3.07	-	0	0.548	
SPO	**3.12**	**0**	**-**	**0.489**	
FBE	**3.19**	**0.624**	**0.489**	**-**	
FBE1	3.24	0.472	0.383	-	
FBE2	3.15	0.702	0.540	-	

Then we examined to what extent the value dimensions of the second and third layer are affected by the ones of the first layer (step 4). For this purpose initially we estimated two regression models having as dependent variables the two value dimensions of the second layer SUO and SPO, and as independent variables the eight value dimensions of the first layer. Also, we estimated one regression model having as dependent variable the value dimension of the third layer FBE and as independent variables the two value dimensions of the second layer, and finally another similar regression model having as additional independent variables the eight value dimensions of the first layer. In Table 4 are shown the R^2 coefficients of these regression models.

Table 4. R^2 coefficients of second and third layer value dimensions' regression models

Regression Models	R^2
SUO model (8 indep. variables)	0.776
SPO model (8 indep. variables)	0.599
FBE model (2 indep. variables)	0.412
FBE model (10 indep. variables)	0.647

We can see that the R^2 coefficients of the first two SUO and SPO models are 0.776 and 0.599 respectively, indicating that both second layer value dimensions are affected to a large extent by the ones of the first layer. On the contrary the R^2 coefficient of third FBE model has the much lower value 0.412, indicating that the third layer value dimension is affected to a smaller extent by the ones of the second layer. However, the last FBE model has a much higher R^2 coefficient 0.647, which indicates that the first and second layer value dimensions affect to a large extent the one of the third layer; therefore the first layer value dimensions affect users' future behavior not only through the value dimensions of the second layer, but also directly as well. From the above results we can conclude that this value model is characterized by high coherence among its layers.

Finally, we calculated the correlations of the first layer value dimensions and their value measures with the value dimensions of the second and third layer (step 5), and the results are shown in the third, fourth and fifth column of Table 3; for each first level entity – value dimension or measure - we can see its correlations with the second and third level dimensions it affects according to the value model definition shown in Figure 1 - e.g. for the DPV we can see its correlations with the SUO and the FBE –

and 0s in the other cells. In the sixth column we can see for the first level value dimensions and measures the average of their correlations with SUO, SPO and FBE, as an indicator of its overall impact on higher level value generation. We remark that with respect to the support of user-level objectives by the OGD infrastructure, the data search and download capabilities, the data processing capabilities and the ease of use are the first layer value dimensions that have the strongest impact on it (correlation coefficients 0.760, 0.735 and 0.730 respectively), while the performance has the weakest impact on it (correlation coefficient 0.379). With respect to the support of provider-level objectives by the OGD infrastructure, the data upload and the data processing capabilities are the first layer value dimensions that have the strongest impact on it (correlation coefficients 0.680 and 0.632), while the performance has the weakest impact on it (correlation coefficient 0.135). Finally looking at the last column of Table 3, we remark that the first layer value dimensions having the strongest overall impact on higher level value generation are the data processing capabilities and the ease of use (correlation coefficients 0.669 and 0.552); the performance and the provider-level feedback capabilities have the weakest impacts (correlation coefficients 0.297 and 0.199).

Using the average ratings and correlations shown in Table 3 we can construct the value model of the OGD infrastructure (step 6) at the level of value dimensions, which is shown in the Appendix (while similarly we can construct a more detailed value model at the level of value measures). It provides a compact visualization of the main dimensions/types of value generated by this e-service (quantified through the corresponding average users' ratings) and the relations among them (quantified through the corresponding correlation coefficients). This enables a better understanding of the value generation mechanism of OGD infrastructure, as it shows how value of one layer is transformed to value of higher layers, and also the origins of higher layers' value.

Furthermore, based on these average ratings and correlations of Table 3 priorities for improvements were identified (step 7). For this purpose we classified the first layer value dimensions into two groups according to their average rating: a higher ratings group and a lower ratings group (Table 5).

Table 5. Classification of first layer value dimensions according to their average ratings by the users

Lower Ratings Group	Higher Ratings Group
data provision capabilities data search-download cap. data upload capabilities performance	provider-level feedback cap. ease of use data processing capabilities user-level feedback capabil.

Also, we classified them into two groups according to their impact on (average correlation with) second and third layers' value dimensions: a higher impact group and a lower impact group (Table 6).

Table 6. Classification of first layer value dimensions according to their impact on higher level value dimensions.

Lower Impact Group	Higher Impact Group
data provision capabilities user-level feedback capab. performance provider-level feedback cap.	data processing capabilities ease of use data search-download cap. data upload capabilities

From these two classifications we can conclude that our highest priority should be given to the improvement of the data upload and data search-download capabilities, since they received low ratings from the users, and at the same time they have high impact on higher layers' value generation.

5. Conclusions

In the previous sections has been presented and validated a methodology for evaluating the emerging second generation of OGD infrastructures, which has been influenced by the principles of the Web 2.0 paradigm, being oriented towards the elimination of the distinction between providers and consumers of such data, through the support of data 'pro-sumers' (i.e. users who both consume and produce such data). However, it can be used, with some adaptations, for the evaluation of the 'traditional' first generation OGD infrastructures as well.

Our study makes the following contributions:

- It fills the research gap concerning methodologies for the evaluation of the OGD infrastructures, which constitute an increasingly high government investment.
- It focuses on the second generation of more advanced Web 2.0 OGD infrastructures.
- The proposed evaluation methodology adopts a novel approach, based on the estimation of value models of these advanced OGD infrastructures, which include assessments of both the main types of value they generate, and also the relations among them (which are neglected and not exploited by the 'conventional' IS evaluation approaches).

- It enables not only the identification of strengths and weaknesses of an OGD infrastructure, but also a deeper understanding of the whole value generation mechanism of it.
- It also allows a rational definition of improvement priorities, which is quite important, as this is a relatively new type of IS.
- The first application of the proposed evaluation methodology for the evaluation of an advanced second generation OGD Infrastructure, lead to interesting insights into this new type of IS, especially with respect to their novel features.

In particular, it has been concluded that the data processing capabilities, a key novel feature of this new generation of OGD Infrastructures, has the strongest impact on the generation of higher level value, associated with the achievement of fundamental objectives of users, and their future behaviour. Another novel feature, the user-level feedback capabilities (concerning rating and commenting datasets that users download and use, and also reading other users' ratings and comments on datasets they are interested in), was found to have considerable impact on higher level value generation. Therefore, these novel Web 2.0 oriented capabilities (active data pro-sumers support) seem to be valuable and promising.

Further research is required concerning the application of the proposed methodology for the evaluation of the next versions of the same OGD infrastructure, and also of other advanced second generation OGD infrastructures, after appropriate adaptations. Also, further research is required towards the adaptation and application of this methodology for the evaluation of 'traditional' first generation OGD infrastructures as well, since currently they constitute a big investment for many government agencies. Furthermore, the above future research should be based on larger and more 'professional' users' groups (more experienced than the postgraduate students' group we used in the present study), taking into account all the main segments targeted by such OGD infrastructures (e.g. professional researchers in the political, economic, administrative and management sciences, developers of added-value electronic services, political analysts and journalists).

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Appendix

Value Model of the evaluated Second Generation OGD Infrastructure