An Evaluation Framework for Traditional and Advanced Open Public Data e-Infrastructures

Alexopoulos Charalampos[1], Euripides Loukis[1], Yannis Charalabidis[1], Anneke Zuiderwijk[2]

[1] Department of Information and Communication Systems Engineering, Faculty of Science, University of the Aegean, Samos, Greece

[2] Department of Information and Communication Technology, Faculty of Technology, Policy and Management, Delft University of Technology, Delft, The Netherlands

alexop@aegean.gr
e.loukis@aegean.gr
yannisx@aegean.gr
a.m.g.zuiderwijk-vaneijk@tudelft.nl

Abstract

Considerable investments are made to develop numerous e-infrastructures for the reuse of open government data for scientific, commercial and political purposes. This necessitates a deeper understanding and assessment of the value these infrastructures generate. For this purpose, our paper presents a framework for evaluating open government data infrastructures, both 'traditional' ones following the web 1.0 paradigm and also advanced ones influenced by the web 2.0 paradigm. The evaluation framework is based on findings of previous research on the evaluation of public projects, information systems and e-services, and also on technology acceptance and IS success models. The proposed evaluation framework consists of an evaluation model with measurable evaluation dimensions and criteria, as well as a comprehensive evaluation procedure for using this evaluation model, which enables both higher level and detailed evaluation. It includes quantitative as well as qualitative methods in order to provide comprehensive and deep insights. Finally, we describe an application of the proposed framework (both the model and the procedure) for the evaluation of a European e-infrastructure for opening government data. This first application has provided some first evidence concerning the applicability and usefulness of the proposed evaluation framework, and at the same time useful directions and ideas for the improvement of the above-mentioned e-infrastructure.

Keywords: Evaluation framework, evaluation model, evaluation procedure, public sector information, open government data, e-infrastructures.

1. Introduction

Public organisations are increasingly publishing their data on the internet (Meijer 2009). According to the (European Commission 2003, 2007), these data should be widely available and useable to all in order to maximise its usefulness for research and innovation. Public sector information (PSI) is the single largest source of information in Europe. It is produced and collected by public bodies and includes financial, education, health, poverty, traffic, crime, meteorological and other types of data. Most of this raw data could be re-used for scientific research, for deeper analysis of the effectiveness of previous government action in order to enable a more substantial political discussion, or even integrated into new products and services, which we may use on a daily basis, such as car navigation systems, weather forecasts and financial and insurance services. Re-use of public sector information means using it in new ways by adding value to it, combining information from different sources, making mash-ups and new applications, both for commercial and non-commercial purposes.

However, a recent conference on the pragmatic approach to the use of Open Data (Open Data: Where to begin? 2012) identified a number of issues which are critical for its success:

- The supply-driven approach is insufficient: Involvement of businesses and citizens in the PSI publishing lifecycle and exploitation is widely accepted as beneficial.
- There are strong barriers regarding data relevance and quality: Publishing data is not on its own sufficient; ideally, they should also be accurate, reusable, timely and comparable.
- The use of Open Data "intermediaries" is more effective than the direct access to them: businesses and citizens sometimes find it difficult to identify what type of information exists and by which public authority it is held.
- Technical complexity: Despite the technical heterogeneity of the various public sector data sources, ease of data discovery and retrieval by the user is a fundamental requirement.
- Organizational barriers: Many EU member state governments and wider public sector organisations still view publishing PSI as an additional burden to their daily working routine, not recognizing the benefits it provides.

These considerable issues are confirmed by literature (Janssen 2012; Zhang 2005; Zuiderwijk 2012). Taking into account the big investments of governments for developing and operating PSI e-infrastructures, and at the same time the above-mentioned inherent difficulties of their exploitation, it

becomes absolutely necessary to conduct a systematic evaluation of such PSI e-Infrastructures aiming at a better understanding and assessment of value they generate (Alexopoulos 2012). Furthermore, the gradual emergence of a second generation of more advanced PSI e-infrastructures, which are influenced by the principles of the web 2.0 paradigm (with users having a stronger role, which is not limited to consuming passively content, but also increasingly includes commenting, rating and improving or adapt it to specialized needs, and also creating their own content – see section 3), and offer new types of value, makes the systematic evaluation of them even more necessary.

However, a structured and comprehensive evaluation framework for PSI initiatives and projects is missing. This paper contributes to filling this gap, by making the following contributions.

- It develops an integrated evaluation framework scoping the overall impact of an open public data e-infrastructure,

- which includes an evaluation model with measurable evaluation dimensions and criteria, taking into account findings from previous public projects', information systems and e-services evaluation research, research on technology acceptance and information systems (IS) success models, as well as the objectives and capabilities of the traditional PSI e-infrastructures following the web 1.0 paradigm and the emerging advanced ones influenced by the web 2.0 paradigm.

- and also a comprehensive evaluation procedure for using the evaluation model, which combines the detailed evaluation it provides with a higher level evaluation (scoping to measure general impact), based on both qualitative and quantitative methods in order to get deeper meaningful insights,

- and finally uses the proposed evaluation framework (both the evaluation model and procedure) for the evaluation of the PSI e-Infrastructure developed in the European project ENGAGE and presents some first results.

The current paper is structured as follows. In the following section the background of the proposed evaluation framework is presented. Subsequently, in section 3 the features of an advanced PSI e-Infrastructure are presented. Section 4 introduces the evaluation framework and describes the formation of the corresponding evaluation model, as well as, of the evaluation procedure for using it is defined. Thereafter, section 5 presents the results from their use for the pilot evaluation of the first version of ENGAGE (1.0) PSI e-infrastructure and finally, in section 6, the conclusions and further research directions are proposed.

2. Background

In this section, is presented the background on which our evaluation framework has been based, which includes previous research on the evaluation of public projects, and on the evaluation of information systems (basic concepts and methods, technology acceptance and IS success models and e-services evaluation).

The Organisation for Economic Co-operation and Development (OECD 1998, p.3) defines public projects' evaluations as *"analytical assessments addressing results of public policies, organisations or programmes, that emphasise reliability and usefulness of findings. Their role is to improve information and reduce uncertainty; however, even evaluations based on rigorous methods rely significantly on judgement. A distinction can be made between ex-ante evaluations (or policy reviews) and ex-post evaluations"*. Since the beginning in the 1970s, literature classifies types of evaluation by their specific aim and therefore distinguishes between formative evaluation (conducted during a project in order to identify strengths and weaknesses and inform/guide following stages) and summative evaluation (guided after the end of the project in order to assess its degree of success) (Neumann 2002). Many different methods are used in public projects' evaluation for information gathering and analysis (Bortz 2002), such as: Quantitative surveys, Web analytics, Usability testing, Focused (semi structured) interviews, In-depth interviews, Collective semi-structured interviews. The examination of the existing literature regarding public projects' evaluation enabled us to design the proposed evaluation framework for supporting both formative and summative evaluation at various levels of detail (enabling both higher and lower level evaluation), and combining all the above methods for this purpose (both quantitative and qualitative ones).

There is long and extensive research on the evaluation of information systems (IS) (Hirschheim 1988; Smithson 1998; Willcocks 1996, 2001; Farbey 1999; Irani 2002, 2006, 2008; Gunasekaran 2006; Stockdale 2006), which has revealed its complexities and difficulties. 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. Thus, it is not possible to formulate one generic IS evaluation method, which

is applicable to all types of IS. The major outcome of this research is that a comprehensive methodology for evaluating a particular type of IS should include evaluation of both its efficiency and its effectiveness, and take into account its particular characteristics, capabilities and objectives.

Moreover, a significant part of the IS evaluation research has been focused on understanding IS acceptance. Extensive research has been conducted in order to identify the characteristics and factors affecting the attitude towards using an IS, the intention to use it and finally the extent of its actual usage, which has lead to the development of the Technology Acceptance Model (TAM) and its subsequent extensions (Davis 1989; Venkatesh 2000, 2003; Schepers 2007). This research stream on IS acceptance provides some important dimensions of IS evaluation (ease of use, usefulness, users' intention for future use and actual use), which can be used as part of our PSI e-infrastructures evaluation model.

Another research stream that can provide useful elements for IS evaluation is the IS success research (DeLone 1992, 2003; Seddon 1997; Rowley 2006; Sumak 2009). The most widely used IS success model has been developed by (DeLone 1992). This research stream suggests that IS evaluation should adopt a layered approach based on the above IS success measures (information quality, system quality, service quality, user satisfaction, actual use, perceived usefulness, individual impact and organizational impact).

Finally, the emergence of numerous Internet-based e-services (e.g. information portals, e-commerce, e-banking and e-government portals) has lead to the development of many models for their evaluation (Rowley 2006; Sumak 2009; Lu 2003; Fassnacht 2006; Saha 2011). These models suggest useful evaluation dimensions and measures either for e-services in general, or for particular types of e-services. (Loukis 2012) proposed an e-services evaluation methodology, which includes a set of value dimensions and measures assessing different types of value generated by the evaluated e-service, organized in a three-layered value model (concerning e-service efficiency, effectiveness and users' futute behaviour) and the relations among them. Our evaluation model has adopted this structure and organization of evaluation dimensions and measures proposed by the above methodology.

3. Advanced public data e-infrastructures

The 'traditional' public data e-Infrastructures have been the first step of opening public data. However, this first generation of PSI provision e-infrastructures are characterized by data publishing in non machine-readable formats (i.e. PDF) without providing any contextual information or linkage to other data in most of the cases. These traditional PSI e-Infrastructures are limited to offering basic functionalities for downloading data to data users, or for uploading data by the data providers, with minor support and flexibility. They are not considering the possibility their published open data to be improved by users (e.g. through cleaning and further processing) and reused, or how they can get feedback on them by the users in order to understand better their needs. The lack of concern about public data improvement by users and reuse and its importance is being shown by the current calls for advanced service e-infrastructures providing such capabilities, i.e. including tools that enable cleaning, analyzing, visualizing and linking datasets (Charalabidis 2011). In general, this first generation of the traditional public data e-infrastructures has been influenced by the Web 1.0 paradigm, in which there is a clear distinction between content producers and content users.

The advent of Web 2.0, in conjunction with current research advances in the domains of Information and Communication Technologies (ICT) and E-government, offer opportunities to exploit the full potential of PSI providing new features for open data reuse and functions that will enhance scientific research, economic growth and citizens' trust to the governments. This gradually leads to the emergence of a second generation of more advanced PSI e-infrastructures, which are influenced by the principles of the Web 2.0 paradigm, giving to users a stronger role, beyond the passive consumption of content. This content increasingly includes commenting, rating and improving or adapting it to specialized needs, and then publishing it again, and also creating their own content. The clear distinction between data consumers and data producers does not exist anymore, leading to the emergence of 'pro-summers', who produce and consume such data. These advanced PSI e-infrastructures are also characterized by machine-readable, linkable and context-aware data and services for the use and the improvement and adaptation of open data by the end-users (Papadakis 2012). Although the reuse of open data can be stimulated in different ways, e-infrastructures are expected to play an important role in this direction by providing functions such as data processing, cleaning, curation and rating to the end-users (European Commission 2011). They are designed to allow communication from users (scientists, citizens, journalists, businesses etc.) to publishers (public

bodies) and back (the feedback loop). Another characteristic of advanced PSI e-Infrastructures is that in order to enhance interoperability they utilize richer metadata schemata.

4. Evaluation framework

An important objective was to propose a unified evaluation framework that can be used for the evaluation of both traditional PSI e-infrastructures based on the web 1.0 paradigm and advanced ones based based on the web 2.0 paradigm. As it is described above, traditional and advanced PSI e-infrastructures are both used by two main groups of stakeholders: the data providers and data users. In the case of traditional PSI infrastructures there are simpler functionalities corresponding either to the data users or to the data providers and these two groups of stakeholders have clearly divided roles. Consequently, diferrent capabilities are provided to each group, so two corresponding evaluation sub-frameworks have to be built. On the other hand, advanced PSI e-Infrastructures are characterized by frequent and repeated role switching when users interact with the platform. The proposed evaluation framework consists of an integrated evaluation model and a comprehensive evaluation procedure that utilises both qualitative and quantitative methods in order to get meaningful insights based on the evaluation variables and measures were identified during the construction of the evaluation model.

4.1. *Evaluation model*

For the above-mentioned reasons we developed an evaluation model for the most complex and difficult case of advanced PSI e-infrastructures 2.0, which is shown in figures 1 and 2. It consists of evaluation dimensions which are further elaborated into evaluation criteria, and covers both data users' and data providers' perspectives. So, if a user interacts with the system taking only the role of data user/provider, he/she will assess only value dimensions/criteria corresponding to data users/providers (denoted with 'U'/'P' respectively in the following Figures 1&2), while if he/she has both roles, he/she will have to assess all value dimensions/criteria. Similarly, if the proposed evaluation framework is used for the simpler case of evaluating a traditional PSI e-infrastructures 1.0, it can be easily divided into two parts, one for the data users and one for the data providers.

		Questions
1. User Experience		
1.1	P + U	The platform provides a user friendly and easy to use environment.
1.2	P + U	It was easy to learn how to use the platform.
1.3	P + U	The web pages look attractive.
1.4	P + U	It is easy to perform the tasks I want in a small number of steps.
1.5	P + U	The platform allows me to work in my own language.
1.6	P + U	The platform supports user account creation in order to personalize views and information shown
1.7	P + U	The platform provides high quality of documentation and online help.
2. Data Provision		
2.1	U	The platform provides a large number of datasets
2.2	U	The platform provides dataset that are useful to me.
2.3	U	The platform provides me with complete data with all required fields and detail
2.4	U	The platform provides accurate data on which I can rely for my studies
2.5	U	There are datasets from many different thematic areas (economy, health, education, etc.)
2.6	U	There are datasets from many different countries
2.7	U	The platform provides sufficiently recent data
3. Performance		
3.1	P + U	The platform is up and available without any interruptions.
3.2	P + U	Services and pages are loaded quickly.
3.4	P + U	I did not notice any bugs while using the platform.
4. Data Search and Download		
4.1	U	The platform provides strong dataset search capabilities using different criteria.
4.2	U	The platform provides several different categorizations of the available datasets, which assists significantly in finding the datasets I need.
4.3	U	The platform enabled me to download datasets easily and efficiently.
4.4	U	The datasets are in appropriate file/data formats that I can easily use for covering my needs.
4.5	U	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.
4.6	U	The platform provides strong API for downloading datasets (data+metadata)

Figure 1: Evaluation dimensions and criteria of the PSI e-Infrastructures evaluation model (continues)

		Questions
5. Data Upload		
5.1	P	The platform enabled me to upload datasets easily and efficiently.
5.2	P	The platform has a good metadata model applicable for all its datasets, that provides full understanding of the data
5.3	P	The platform enabled me to prepare and add the metadata for the datasets I uploaded easily and efficiently.
5.4	P	The platform provides good capabilities for the automated creation of metadata.
5.5	P	The platform provides good capabilities for converting datasets' initial metadata in the metadata model of the platform easily and efficiently.
5.6	P	The platform provides API for uploading datasets (data+metadata)
6. Data Analysis & Feedback		
6.1	U	The platform provides me good capabilities for visualization of datasets.
6.2	U	The platform provides me good capabilities for processing the datasets.
6.3	U	Platform provides good capabilities for giving feedback on the datasets I download, e.g. for rating datasets, for entering textual comments on them.
6.4	U	Platform provides good capabilities for reading available feedback of other users of datasets I am interested in, e.g. ratings, comments.
7. Data Curation		
7.1	P	The platform provides good capabilities for data enrichment (i.e. adding new elements - fields)
7.2	P	The platform provides good capabilities for data cleansing (i.e. detecting and correcting ubiquities in a dataset)
7.3	P	The platform provides good capabilities for linking datasets.
7.4	P	The platform provides me good capabilities for visualization of datasets before uploading.
7.5	P	The platform allows me to collect user ratings and comments on the datasets I publish, and also needs for further datasets provision.
8. Overall Satisfaction		
8.1	U	I think that using this platform enables me to do better research/inquiry and accomplish it more quickly
8.2	U	This platform allows me to draw interesting conclusions on government activity
8.3	U	This platform enables me to create successful added-value electronic services
8.4	P + U	My initial motivations for selecting ENGAGE platform have proved to be true.
8.5	P	The platform enables me to open and widely publish datasets I possess with low effort and cost.
8.6	P + U	I am in general highly satisfied with this platform.
8.7	P + U	I have spent a lot of time on the platform.
8.8	P + U	I would like to use this platform again.
8.9	P + U	I 'll recommend this platform to my colleagues.

Figure 2: Evaluation dimensions and criteria of the PSI e-Infrastructures evaluation model (continued)

It consists of the three evaluation levels proposed by (Loukis 2012) mentioned in section 2. Its first efficiency oriented level aims to assess the ease of use of the platform and also the usefulness of the basic capabilities it offers as proposed by TAM stream of research, covering both data and processing capabilities and also technical performance based on the information quality, system quality and service quality concepts proposed by the IS success stream of research. In particular, the capabilities assesed are: data provision, data search and download, data upload, data analysis and feedback, data curation. The second effectiveness oriented level aims to assess to what extent the platform supports the users to achieve their objectives and level of general satisfaction based on the 'perceived usefulness' concept proposed by both TAM and information success research, and the 'satisfaction' concept by information success research). Finally, the third future behaviour oriented level aims to assess 'users' intention to use' the platform again in the future and recommend it to colleagues. The need for better presentation of the evaluation questionnaires and tools made us to merge the latter two levels in one, this of "overall satisfaction". Each of the above evaluation dimensions has been further elaborated into a number of relevant evaluation criteria.

4.2. Evaluation procedure

In order to finalise the construction of the evaluation framework, a comprehensive evaluation procedure was developed for the use of the evaluation model that was presented in section 4.1, which includes both quantitative and qualitative evaluation methods to get deeper insights.

The evaluation approach is shown in Figure 3. It consists of internal evaluation (by individuals within the e-infrastructure development consortium) and external evaluation (by individuals not belonging to the development consortium). The internal evaluation includes: i) a semi-structured discussion in a group of experts, ii) Web Analytics and iii) a SWOT (Strengths-Weaknesses-Opportunities-Threats) analysis. The external evaluation includes: i) a similar semi-structured discussion in a group of social, political and management sciences researchers (potential users of the platform) not belonging to the project's scientific committee, ii) a structured usability test measuring user's performance on specific tasks (using a 5-Likert scale from very difficult to very easy), iii) a quantitative and structured questionnaire and iv) a Qualitative Discussion with users.

	Internal assessment	External assessment			
ENGAGE Consortium (including Experts Scientific Committee)	Semi-structured Experts Questionnaire	**End user**	Structured Questionnaire	Structured Usability Test	Semi-structured Qualitative Discussion
	Semi-structured SWOT-Analysis	**Experts in the field**	Semi-structured Experts Questionnaire		
	Web Analytics				

Figure 3: Evaluation Approach and Tools

The structured questionnaire follows the complete structure of the evaluation model and could be used for both traditional and advanced PSI e-infrastructures with the appropriate changes. The users who fill the questionnaire are asked to enter the extent of their agreement or disagreement with the statements it includes, 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).

The semi-structured discussions in groups of experts (e.g. researchers from the social, political and management sciences who would be interested in using public sector data), on the topics/questions shown in Figure 4.

Does the platform offer reduction of costs of accessing and using PSI?
Does the platform contribute to the removal of important obstacles concerning the open access to scientific information and data? Are researchers able to perform more easily their research utilizing this platform?
Does the platform contribute towards the establishment of standards and best practices for the publishing and re-use of Public Sector Information in Europe?
Does the platform's Metadata Model contribute to an increased scale of federation and interoperation of data infrastructures?
Does the platform contribute to the progress towards the vision of open and participatory data-intensive science?

Figure 4: Topics/questions of the experts' groups semi-structured discussions

The qualitative discussion can be based on the main evaluation dimensions and criteria of the PSI e-Infrastructures evaluation model described in the previous section, so it focus on the following topics/questions, presented in Figure 5:

Do you find the platform useful for downloading/using open governmental data?
Do you find the platform useful for publishing/uploading your own data, or improved/enriched versions of government data you have downloaded?
Which of the platform features (Searching, Metadata, Downloading, Comments and Rating, Linking, Uploading, Other) are useful for your needs?
Which of the platform features are not useful for your needs?
Which platform's features are easy to use?
Which platform's features are difficult to use?
Which features are not provided by the platform, but would be useful for your needs?
Do you currently participate in communities' formation (based on shared interest in particular types of government data) within the platform?
Would you like to participate in communities' formation within the platform in the future?
Would you be willing to contribute data to the platform?

Figure 5: Qualitative Discussion

For the usability test, a number of potential users are asked to perform a scenario (= a series of tasks) using the PSI e-infrastructure/platform under evaluation. There are three possible ways of practically conducting the usabilility testing:

- Peer testing by users: whilst one user is testing the platform and performing the tasks, the other user is monitoring and providing feedback to the session leader by filling in the evaluation form.
- Session leaders evaluate a random sample of users according to their choice.
- Individuals test and evaluate themselves (self-organization principle): users perform the tasks and fill in the evaluation sheet themselves.

5. Application of the evaluation framework and results

In this section we report on the application of the proposed evaluation framework and procedure to the first version of the open public sector data e-infrastructure developed in the ENGAGE project. In total, 21 students from Delft University of Technology and 33 students from the University of Aegean performed the student usability test by executing a series of tasks that require most of the available infrastructure functionalities, filled out the online user questionnaire and participated in a qualitative discussion. In addition, students of Delft University of Technology and the University of Aegean wrote reports about the usability of the ENGAGE e-infrastructure for conducting open data download, process and upload scenarios. Five project members conducted the internal experts SWOT analysis. The results of these evaluation activities are as follows.

The application of the applied evaluation framework and procedure showed that the current ENGAGE e-infrastructure (ENGAGE 1.0) provides a good basic e-infrastructure to start an open data project. The current e-infrastructure enables searching, downloading, analyzing, uploading and rating data and also the manual linkage of data. Moreover, the ENGAGE e-infrastructure provides a comprehensive overview of which open data e-infrastructures currently exist in Europe. In addition, the ENGAGE infrastructure enables the usage of Application Programming Interface (API) for searching data, as well as, of a Wiki including tutorials. This means that the ENGAGE infrastructure manage to accomplish its technical objectives till the pilot evaluation.

Nevertheless, the e-infrastructure could be improved in many ways. The application of the evaluation model and procedure showed that future versions of the ENGAGE e-infrastructure should mainly focus on 1) difficulties in searching, need for more information about datasets, multilinguality, capabilities for combining datasets, and also for doing more complex analysis and performance, 2) more information about the quality of the data, for instance by providing a comprehensive rating systems for the data and 3) more information about which data can be linked, in order to meet users' expectations for using the platform. This means that this first version of the ENGAGE PSI e-infrastructure did not achieve to attract sustainable interest.

In general, the first application of the proposed evaluation framework showed that meaningful insights can be obtained by applying the proposed evaluation framework and infrastructure to such an advanced open public data e-infrastructure 2.0. The insights concern both managerial (categorizing priorities, decision making) and technical aspects of the e-infrastructure. The evaluation results appeared to be useful for defining priorities for improvements and enrichments required for developing the future versions of the ENGAGE e-infrastructure. They provide very detailed information about the features of the e-infrastructure and information about possibilities for improvement. One advantage of the evaluation framework was that the evaluation results are based on users experience with the actual ENGAGE e-infrastructure, instead of feedback on mock-ups of the e-infrastructure and/or presentations about the e-infrastructure. In addition, the evaluation results clearly show that user experience is a critical success factor for the community uptake of the e-infrastructure (navigation, search, user interface, services and features for non-Information Technology savvy users). Furthermore, some ideas were mentioned to improve the e-infrastructure that the consortium had not thought of. For instance, the idea of a 'shopping cart', where the user can add different datasets to make the linking process easier, could be considered for future versions of the ENGAGE e-infrastructure. Finally, several other inventive recommendations and solutions were provided by the potential users of the infrastructure.

6. Conclusions

This paper presented an evaluation framework for both traditional PSI e-infrastructures and advanced ones following the web 2.0 paradigm, which consists of an evaluation model and a procedure for applying it. A first application of the evaluation framework to an open public sector data e-

infrastructure developed in the ENGAGE project has provided some first evidence for the applicability and usefulness of the proposed framework, as well as useful directions and ideas for the improvement of the above-mentioned e-infrastructure. Further research on this is in progress by the authors, mainly in three directions: i) application of the proposed evaluation framework in the following stages of the ENGAGE project and the next versions of the PSI e-infrastructure it develops, ii) application of this evaluation framework for evaluating other PSI e-infrastructures, both traditional and advanced ones, and iii) estimation of value models of such infrastructures, by elaborating and extending the approach proposed by Alexopoulos et al. (2012) and Loukis et al. (2012). This further research is expected to lead to improvements and extensions of the proposed evaluation framework.

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