EVALUATING COMPLEX GOVERNMENT SAAS THROUGH VALUE FLOW MODEL ESTIMATION

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Track Traditional and Future e-Government

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Abstract

Government agencies are increasingly making use of cloud computing (CC) services, initially simpler infrastructure and platform as a service (IaaS and PaaS) ones, and later more sophisticated software as a service (SaaS) ones. However, with respect to the latter the electronic support of the high complexity government processes is a difficult task and requires highly sophisticated and complex government-specific SaaS offering extensive functionalities for fulfilling the extensive requirements posed by relevant legislation. It is therefore imperative to conduct comprehensive evaluations of such complex government-specific SaaS, in order to assess to what extent they support the targeted government processes and fulfil their extensive and complex requirements, and also identify and prioritize necessary improvements. This paper presents an advanced methodology for evaluating complex government-specific SaaS, which enables comprehensive multi-dimensional evaluation of a wide range of aspects of them that are highly important in the government context, and detailed evaluation of the provided complex and extensive functionality with respect to the requirements defined by relevant legislation; furthermore, it enables a rational identification and prioritization of necessary improvements. It is based on the estimation of multi-layer 'value flow models' of these SaaS from evaluation data collected from users. The proposed methodology has been applied for the evaluation of a complex SaaS aiming to support the wide range of activities of the Greek 'Local School Committees', which are responsible for managing all government funding provided for the operation of all the schools in a specific geographical area, as well as all other income of them, and for covering all kinds of their operating expenses as well as purchases. The research presented in this paper can contribute to a more rational, efficient and effective exploitation of an emerging 'disruptive technology', the CC, and especially its most sophisticated form, the SaaS, in the public sector.

Keywords: government, cloud, software as a service (SaaS), evaluation, value model.

1 Introduction

Cloud computing (CC) constitutes a 'disruptive technology' driving a paradigm shift in the production, delivery and financing of the Information and Communication Technologies (ICT) services that organizations need in order to support their activities and processes; in this new paradigm the required ICT services are not produced internally by the ICT unit of the organization, but externally by various CC services providers, they are delivered from a distance through the Internet, and they are financed not through investments, but through operational expenditures – usually monthly payments to the providers only for the services that have been actually used (Marston et al., 2011; Venders and Whitley, 2012; Mueller et al., 2015). The CC services currently offered can be grouped into three categories: Infrastructure as a Service (IaaS) (= use of providers' remote storage and computing facilities), Plat-

form as a Service (PaaS) (= remote use of providers' platform including the services already mentioned for IaaS and additionally also data base management systems, software development languages and tools for the development and deployment of applications) and Software as a Service (SaaS) (= remote use of software applications running on providers' systems and supported/maintained by them). The CC can provide significant benefits to organizations: reduction of ICT ownership and operation costs, conversion of related capital investments to operating costs, provision of practically infinite computing resources available on demand, provision of flexible cost-effective computing capacity to support growth, flexibility to respond to fluctuating ICT loads (due to fluctuations on organization's activities), quick and low cost development of new information systems (IS) in order to fulfill new needs or support innovations, and quick and low cost access to new technologies (Marston et al., 2011; Mueller et al., 2015). However, at the same time CC poses some security risks, which concern mainly the unauthorized access to or modification of organization's data, the availability of the service and the lack of standardization generating vendor lock-in risks (Marston et al., 2011; Ackerman et al., 2012).

CC has been initially used by private sector firms, and later the public sector started experimenting with this 'disruptive technology', and then proceeding to more extensive use of it (Janssen and Joha, 2011; European Commission, 2012; Kundra, 2011; Shin, 2013; Liang et al., 2017; Jones et al., 2019; European Commission, 2019). Government agencies are shifting to CC-based services in order to reduce their investments in ICT infrastructures and resources and take advantage of the important benefits it provides. In the 'Federal Cloud Computing Strategy' formulated in 2011 by the U.S. Chief Information Officer Vivek Kundra (2011) it is stated that the existing ICT infrastructure of U.S. Federal Government's is characterized by low asset utilization, duplicative systems, and systems that are difficult to manage, and also long procurement lead times; so he argues CC can play a major part in addressing these inefficiencies and improving government service delivery, as well as introducing valuable new innovative services rapidly and at low cost. In this directions a 'Cloud First' policy is instituted for the whole U.S. government, which is intended to accelerate the pace at which the government will realize the value of cloud CC, by requiring government agencies to evaluate safe, secure CC options before making any new ICT investments, especially for the electronic support of innovations. At the same time the abovementioned security risks posed by the CC can have major negative impacts on government operations and services (Paquette et al., 2010).

Government agencies all over the world are increasingly making use of CC services, initially simpler IaaS and PaaS ones, and later more sophisticated SaaS ones as well. However, the electronic support of the high complexity government activities and processes, which have been traditionally much more complex than the private sector ones, and defined in detail by law (Gulledge and Sommer, 2002; MacIntosh, 2003; Jurisch et al., 2010), is a difficult task; it requires highly sophisticated and complex government-specific SaaS offering extensive functionalities for fulfilling the extensive requirements posed by relevant legislation. It is therefore imperative that government agencies conduct comprehensive evaluations of such complex government-specific SaaS, in order to assess to what extent they support the targeted government activities and processes and fulfil their extensive and complex needs and requirements, and also to identify and prioritize improvements; this has to be conducted both in the initial adoption/selection stage, and also in various post-adoption stages (e.g. after a period of productive usage, after the introduction of new versions or major modifications, etc.). However, the existing SaaS evaluation methodologies are oriented mainly to the private sector SaaS, cannot address this high functional complexity of government-specific SaaS, do not take sufficiently into account the specific user requirements and also do not perform 'higher-level' assessments of overall impact on the performance of supported business processes; furthermore, they lack sound theoretical foundations, and focus mainly on the initial adoption/selection stage (see section 2.1 for more details). The research objective of this paper is to contribute to filling these research gaps: to develop an advanced methodology for evaluating complex government-specific SaaS, taking into account the specificities of the government context: highly complex activities and processes, with extensive and complex support requirements, with most of them defined in detail by legislation, which frequently changes. The proposed methodology is based on the estimation of 'value flow models' (see section 2.2) of such SaaS,

building on previous research in the area of value flow models (Loukis et al., 2012); our methodology has sound theoretical foundations: the IS success model of DeLone and McLean (2003). In particular, it offers the following advantages in comparison with existing SaaS methodologies:

i) it enables a comprehensive and highly multi-dimensional evaluation of SaaS, allowing the evaluation of wider range of aspects of them, concerning both the efficiency and effectiveness of SaaS, and both their lower and higher level impact, as well as their impact on users' future behaviour, which are of high importance for government;

ii) it allows the detailed evaluation of the provided complex and extensive functionality with respect to the relevant legislation provisions and the complex and extensive requirements they pose;

iii) it includes also evaluation of the complementary services provided in combination with the SaaS, which are quite necessary due to the complexity of government-specific SaaS, as well as their activities, processes and the legislation they are based on;

iv) it includes assessment of multiple evaluation criteria - value measures, both lower and higher level ones, which concern the specific capabilities offered by the SaaS at a first level (efficiency-oriented evaluation), and also the extent of use and accomplishment of operational objectives (effectiveness-oriented evaluation) at a second level, as well as users' future behaviour at a third level;

v) it exploits not only the average ratings of users concerning the above multiple value measures, but also the existing associations among them; the analysis of the associations among the value measures of the above three layers enables gaining a deeper understanding of how different types of value of one level is transformed to different types of value of higher levels, and also the origins of higher levels value, providing a clear picture of value generation and flow for the specific SaaS;

vi) it can be used both in the initial SaaS adoption/selection stage (for the evaluation of a SaaS under consideration, or for ranking existing alternative SaaS offerings and selecting the most appropriate one), and also in various post-adoption stages (e.g. after a period of productive usage, after the introduction of new versions or major modifications, etc.)

vii) it identifies and prioritizes necessary improvements of the specific capabilities offered by the SaaS, which constitute the first level of value generation, taking into account their impact on the higher levels of value generation, which concern the support provided for the accomplishment of operational objectives at the second level, as well as users' future behaviour at the third level.

The proposed methodology has been applied for the evaluation of a complex SaaS aiming to support the wide range of activities of the Greek 'Local School Committees', which have a wide range of activities concerning the funding of all the schools of a specific geographical. The research presented in this paper is useful on one hand for government agencies using or intending to use SaaS, and on the other hand for SaaS providers for improving their offerings as well as for consulting firms active in this area; it can contribute to a more rational, efficient and effective exploitation of an emerging 'disruptive technology', the CC, and especially its most sophisticated form, SaaS, in the public sector.

This introductory section is followed by section 2 outlining the background of the proposed evaluation methodology, which is then described in section 3. The abovementioned application of it is presented in section 4, and finally in the last section 5 the conclusions are analyzed.

2 Background

2.1 SaaS Evaluation Methodologies

Some methodologies for SaaS evaluation have been developed by previous relevant research. Most of them provide only some basic evaluation dimensions, which need to be further elaborated, and also cannot address the inherent high functional complexity of government-specific SaaS. A typical exam-

ple is the approach for SaaS evaluation aiming to support the selection among several alternative SaaS offerings proposed Godse and Mulik (2009), which includes five main evaluation criteria: functionality, technological architecture (concerning integration capabilities, scalability, reliability and security), usability, vendor reputation, and cost (initial and annual). A more comprehensive methodology for SaaS evaluation has been developed by Lee et al. (2013), based on the Balanced Scorecard approach; the main evaluation dimensions proposed are the impact of the SaaS on internal business processes' performance, customer service, financial performance (distinguishing between operating costs and sales revenue) and also learning (knowledge sharing with other cooperating organizations – trade partners, as well as within the organization). Also, Tan et al. (2013) developed a SaaS evaluation methodology, which includes evaluation criteria concerning on one hand the SaaS offering (functionality, security and availability) and on the other hand the SaaS provider (technological resilience, financial stability, service level agreement, service delivery management infrastructure). Comprehensive reviews of CC evaluation methodologies have been made by Sun et al. (2014) and Alabool et al. (2018), which conclude that there are many methodologies for evaluating the simplest form of CC, the IaaS, but much less for evaluating the most sophisticated form of CC, the SaaS, with most of them focusing on the initial adoption/selection stage, mainly on ranking existing alternative SaaS offerings by different providers, and not providing support and guidance for improvements. Furthermore, the existing SaaS evaluation methodologies have been developed mainly for private sector SaaS, and do not place emphasis on the detailed evaluation of complex functionalities, so they cannot address the high functional complexity of government-specific SaaS. Another interesting conclusion of the above reviews is that existing SaaS methodologies do not take sufficiently into account the specific user requirements, and also have a limited perspective, being oriented mainly towards lower level 'efficiency' evaluation, but not towards higher level 'effectiveness evaluation': they place minimal emphasis on higher level assessments of the overall impact of the SaaS on the performance of supported business processes, and the support provided for the accomplishment of operational objectives. Also, for 'synthesizing' data collected form users concerning various evaluation criteria they use subjective assessments of the 'weights' by the users (= quantifications of importance) of these evaluation criteria, based on methods of multi-criteria decision-making (such as the Analytical Hierarchy Process (AHP), or the Analytical Network Process (ANP), in their basic, fuzzy or hybrid forms); however, they do not attempt to make 'objective' assessments of the importance of their evaluation criteria (e.g. based on their associations/correlations with higher level value measures concerning the perceived overall satisfaction or overall contribution to the accomplishment of operational objectives). Finally, another weakness of the the existing SaaS evaluation methodologies is that they lack sound theoretical foundations.[1]

2.2 Value Flow Models

In order to address the above deficiencies we have adopted the 'value flow model' estimation approach to IS evaluation, which has been developed in previous relevant research (Loukis et al., 2012), and applied successfully for the assessment and improvement of government e-services (Pazalos et al., 2012), as well as open government data systems (Alexopoulos et al., 2016). It aims at conducting a comprehensive multi-dimensional evaluation of an IS from many different both 'efficiency' and 'effectiveness' oriented perspectives, and also at providing and prioritizing directions for improvement of it. In includes initially the definition of a three levels value flow model of the particular IS, which includes the main general dimensions and for each of them specific measures of the value it generates,

[1] It should be noted that there are also empirical studies of factors affecting SaaS adoption (a comprehensive review of them is provided by Oliveira et al. (2019)), and also a few empirical studies of determinants of SaaS business value (reviewed by Loukis et al. (2019)), which use small sets of SaaS value measures (as independent variables the former and dependent variables the latter), however they are quite limited and less comprehensive than the extensive sets of value measures that the SaaS evaluation methodologies include.

concerning: a) the main capabilities it provides to its users at a first level (efficiency related value dimensions/measures); b) the overall level of support it provides to its users for performing important tasks and accomplishing their objectives at a second level (effectiveness related value dimensions/measures); and c) the future behaviour of the users at a third level (future behaviour related value dimensions/measures). This value flow model is used then for collecting IS evaluation data concerning the above multiple value measures of these three levels from users through a questionnaire. Finally, the collected data are processed: first the average users' ratings for all value measures, dimensions and levels are calculated, which allow us to identify the 'strengths' and the 'weaknesses' of the IS at various levels of detail; second, the impact of each first level value dimension and measure (which is an 'independent variable' under the control of the developer of this IS) on the ones of the higher levels (which are 'dependent variables', as they are not under the control of the developer of the IS, but depend on and are shaped by – at least to some extent – the abovementioned independent ones) is estimated, which is an objective indicator of its importance for higher levels' value generation. These measures of impact allow a better understanding of how various types of value of each level (i.e. corresponding to the value dimensions and measures of it) are transformed into various types of value of the next level, providing a useful picture of the whole value generation and flow mechanism of the specific IS. Furthermore, these measures of impact, in combination with the above calculated average ratings of value measures/dimensions, allow the rational definition of improvement priorities; in particular, they allow us to identify the capabilities of this IS (at the first level of its value flow model), which are rated by the users as being of low quality and at the same time have a high impact on the generation of higher levels' value, and assign to them the highest priority for improvement.

Furthermore, in order to define the value dimensions of the first two levels we have used as theoretical foundation the widely recognized in IS research model of IS success developed by DeLone and McLean (2003). The more recent version of it proposes seven interrelated measures of IS success, which are structured in three levels: 'system quality', 'information quality' and 'service quality' at a first level, which affect the 'user satisfaction' and also the 'actual use' of the IS at a second level, that finally determine the 'individual impact' and the 'organizational impact' of the IS at a third level.

3 A Complex Government SaaS Evaluation Methodology

A methodology has been developed for the multi-perspective evaluation of complex government SaaS, which adopts a value flow model approach (Loukis et al., 2012): it includes the definition of a three levels' value flow model of the specific SaaS under evaluation having the basic structure shown in Fig. 1, and then the estimation of it using evaluation data collected from users.

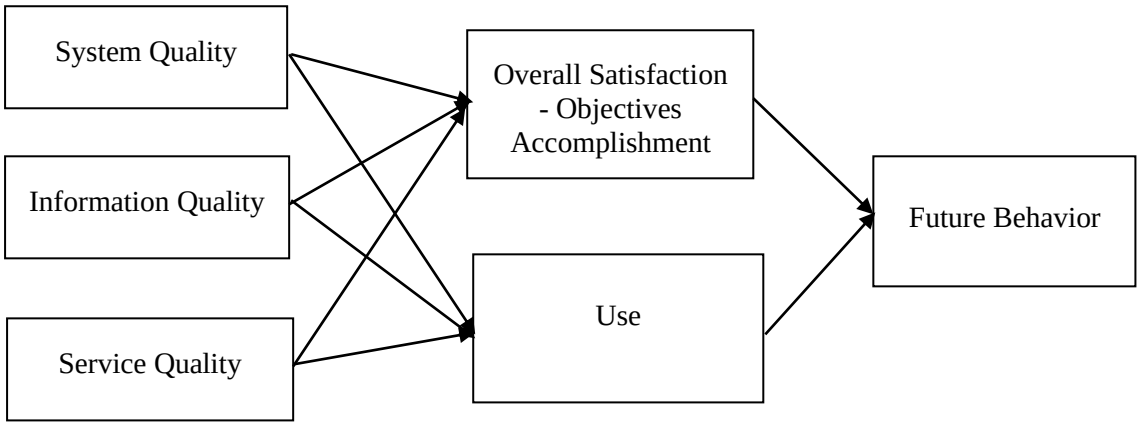

Figure 1. Basic structure of SaaS value flow model

For the definition of the main value dimensions (meant as broad categories/types of value generated) of the first and the second level we have been based on the first two levels of the IS success model developed by DeLone and McLean (2003); so, the main value dimensions of the first level of the value model of a SaaS are 'System Quality', 'Information Quality' and 'Service Quality', and the main value dimensions of the second level will be 'Use' and 'Overall Satisfaction - Objectives Accomplishment'. The third level is influenced by the 'classical' and widely used Technology Acceptance Model (Davis, 1989; Turner et al., 2010), and its main value dimension will be users' 'Future Behaviour'.

Each of the above six main value dimensions will be further elaborated into a number of more detailed value measures based on the specific characteristics of the SaaS under evaluation. The elaboration of the 'System Quality' will be based on the detailed activities, processes and other requirements posed by the legislation: for each of them a separate value measure has to be defined, which assesses to what extent the functionality of the SaaS supports it. This enables a detailed evaluation of the complex and extensive functionality provided by government SaaS with respect to relevant legislation provisions and requirements, which is quite important, as the providers of such government SaaS often do not have a detailed knowledge of relevant legislation, and government procedures and operations in general. Furthermore, we can have some additional value measures assessing the extent of fulfilling some important non-functional requirements, such as availability, reliability, security, accessibility though a variety of devices (e.g. desktops/laptops, mobile phones, PDAs, etc.), ease of use, etc. The elaboration of 'Information Quality' will include value measures assessing to what extent the SaaS provides the main types of required reports for supporting the most important decisions, and also to what extent these reports can be configured to specific needs. The elaboration of 'Information Quality' will include value measures assessing to what extent are provided the main complementary services required, such as training, provision of manuals, support concerning the use of the SaaS, as well as the relevant legislation, and changes/evolution of it, etc. The above value dimensions and measures of the first level aim to assess the main capabilities provided to the user of the SaaS and concern its efficiency. With respect to the second level, the elaboration of 'Overall Satisfaction – Objectives Accomplishment' will be based on the main higher level objectives defined by the relevant legislation for the activities and processes supported by the SaaS; so we can define value measures assessing to what extent the SaaS is useful for accomplishing each of these objectives, and also measuring various aspects of user's overall satisfaction with the SaaS. The elaboration of the 'Use' will include a number of measures assessing to what extent are used the main functionalities provided. These value dimensions and measures of the second level aim to assess the effectiveness of the SaaS. Finally, the elaboration of user's 'Future Behavior' can include value measures of the extent of his/her intention to continue using the SaaS and recommend it to colleagues. For the above value dimensions and measures of these three levels we are interested not only in their average ratings by the users, but also in the associations among them, and especially the associations of the value dimensions and measures of the first level with the ones of the second level, as we can see in Fig. 1, since they quantify the impact of the former on the latter; and also in the associations of the value dimensions and measures of the second level with the ones of the third level. These associations enable a deeper understanding of the value generation and flow mechanism of the specific SaaS.

In particular, our methodology consists of the following nine steps:

Step 1: Initially, the basic structure of the SaaS value flow model shown in Fig. 1 is elaborated for the specific SaaS under evaluation: for each of the six main value dimensions detailed value measures are defined, as described above, which constitute the main types of value created by the SaaS.

Step 2: An online evaluation questionnaire is formulated based on the above value dimensions and measures defined in step 1; it includes one section for each value dimension with one question for each measure. Then it is distributed (e.g. via email) to users of this SaaS.

Step 3: The first step of processing of the evaluation data collected from users aims to investigate the internal consistency of the individual variables/value measures of each value dimension based on the Cronbach alpha internal integrity index of the value dimension. In particular, if Cronbach alpha = 0

there is no internal consistency between the individual variables/value measures that the value dimension includes, while if Cronbach alpha = 1 there is perfect internal consistency, which enables a reliable measurement of this value dimension. Finally, if Cronbach alpha> 0.7 this indicate acceptable level of internal consistency.

Step 4: In this step average user ratings with their standard deviations are calculated for each individual value measure, then for each of the above six dimensions and finally for each of the three levels of the value model of the SaaS (having the general structure shown in Fig.1). This provides a first set of results which allow us to identify strengths and weaknesses of the SaaS at different levels of detail: at the level of individual value measure, value dimension and value level.

Step 5: Then regression models are estimated in order to determine the extent to which the second and third level dimensions are affected by the ones of the previous levels. Therefore, a regression model was estimated for each value dimension variable of the second and third layer (= average of corresponding value measure variables), having as independent variables the value dimension variables of the previous levels. For each of these regressions the coefficient R^2 is examined; if the regressions for the value dimensions of the second and the third level have R^2> 0.5, then we can conclude that the value flow model is characterized by satisfactory coherence among its levels and therefore we can move on to the next steps. On the contrary, if one or several of the second and third level value dimensions are only slightly affected by the ones of the previous levels this indicates that probably some significant value dimensions may have been omitted and we should return to step 1 to redefine the value flow model of the SaaS.

Step 6: For each value dimension of the first level, we estimate its impact on all value dimensions of the second and the third level. We can use for this purpose the bi coefficients of the above regressions, but due to possible multi-collinearity (i.e. high level of correlation between independent variables – see Greene (2018) for more details) these bi coefficients might not be reliable estimates of the impacts of the independent variables on the dependent; so it is better to calculate the correlations of each of the value dimensions of the first level with all the second and third level ones. In this way, a second set of results is calculated that quantify the importance of the value dimensions of first level for higher levels' value generation.

Step 7: By combining the elements of Step 4 and 6 a basic value flow model of the SaaS can be created having the structure shown in Fig. 1, which shows not only the extent of the various types of value generated by the SaaS for the users, but also the relationships between them.

Step 8: The first level value dimensions are classified into four groups, based on one hand on their average ratings by the users, and on the other hand on the impact they have on the value dimensions of the second and the third level (i.e. their impact on higher level value generation): higher rating – higher impact, higher rating – lower impact, lower rating – higher impact, lower rating – lower impact. The highest priority should be assigned to the improvement of the value dimensions of the third group, which received low ratings by the users and had a high impact on the generation of higher-level value. On the other hand, the lowest priority should be assigned to the improvement of the value dimensions of the second group, which received high ratings by the users and yet had a low impact on the generation of higher-level value. Medium priority should be given to improving the value dimensions of the first and fourth groups.

Step 9: Finally, the steps 5, 6, 7 and 8 are repeated for all the individual value measures of our value dimensions. This allows the creation of a more detailed value flow model than the basic one created in step 7, and also to produce a similar classification of the individual value measures of the first level, which correspond to the specific capabilities provided by the SaaS, leading to a more detailed identification and prioritization of specific improvements to be made. In particular, these first level value measures are classified on the basis of their average ratings by the users and their average impacts on the second and third level value measures. This allows us to identify individual first level value measures that receive low ratings from users and at the same time have high impact on the second and third level value measures, which should be given the highest priority for improvement.

4 Application

An application of the methodology described in the previous section has been made for the evaluation of a complex SaaS provided by a private sector firm, which aims to support the wide range of activities of the Greek 'Local School Committees' (LSC), which are quite important for the daily operation of primary and secondary education schools. In particular, according to relevant legislation LSC are responsible for managing all government funding for the operation of all the schools in a specific geographical area, as well as all other income of them (e.g. from school canteens, farms owned by schools, etc.), and covering all kinds of their operating expenses (e.g. for lighting, heating, water supply, sewer, telephone services, consumables, cleaning, buildings and equipment repair and maintenance, etc.) as well as purchases (e.g. equipment, materials, books, etc.). For the above purposes LSC have to make numerous procurements, contracts, payments, as well as book-keeping, following to the relevant complex public sector financial management and procurement regulations. Furthermore, the LSC have to make allocations of the above government funding, taking into account the number of students, the number of departments, the number of classrooms, the operation of sports and multipurpose halls, laboratories and libraries, the condition of the buildings, and the specific needs of each school. For all these numerous and complex activities, the LSC need sophisticated electronic support.

4.1 Value model definition

Initially the basic structure of SaaS value flow model shown in Fig. 1 was elaborated based on the guidelines provided in the second paragraph of section 3: each of the six main value dimensions was elaborated into a number of more detailed value measures; these value measures were then converted to positive statements, which are shown in the first column of the Table of the Appendix, and a questionnaire was developed from them, asking the respondent to answer to what extent he/she agrees to each of them in a five levels Lickert-type scale (where 1 = not at all, 2 = to a small extent, 3 = to a moderate extent, 4 = to a large extent, 5 = to a very large extent). The elaboration of the 'System Quality' and the 'Overall Satisfaction – Objectives Accomplishment' value dimensions was based on the responsibilities, activities and procedures of the LSC described in relevant law. An initial version of the questionnaire we developed was pre-tested by three public servants, who had long experience on LSC and also had used the specific SaaS; they proposed improvements and clarifications in some of the questions, as well as some additional questions, which were taken into account for developing the final version of the questionnaire. The questionnaire was sent to all 122 LSC of Greece, and 100 completed questionnaires were received, which indicates a high response rate of 82%.

4.2 Cronbach's alpha calculation

The Cronbach's alpha coefficients of the value dimension variables were initially calculated based on the value measures of each, and the results are shown in Table 1; we can see that they all exceed the minimal acceptable level of 0.7, so we can conclude that all value dimensions have acceptable internal consistency, therefore they are meaningful synthetic variables.

Value Dimension	**Cronbach Alpha**
System Quality	0.925
Information Quality	0.882
Services Quality	0.899
Use	0.740
Overall Satisfaction – Objectives Accomplishment	0.773
Future Behaviour	0.961

Table 1. Cronbach alpha coefficients for all value dimensions.

4.3 Calculations of average ratings for value dimensions and measures

In the second and third columns of the Table of the Appendix we can see the average ratings and the standard deviations for all the value dimensions and their value measures. With respect to the first level value dimensions we remark that users find the system quality and the service quality good (average rating 2.0), while lower is their perception for information quality, as they find it moderate to good (average rating 3.72). Concerning the second level value dimensions the overall satisfaction of the users from the LSC SaaS and the support they receive for accomplishing the main objectives of the LSC are moderate to good (average rating 3.67), though the extent of using it is high (average rating 4.2). Finally, their future behavior intentions with respect to this LSC SaaS seem to be good (average rating 4.17). By looking at the more detailed value measures we remark that with respect to the first layer among the capabilities provided the main strengths perceived by the users are the high availability (limited interruptions), the easy accessibility through any computer connected to the Internet, the simple and user-friendly work environment, the support of monitoring in real time the treasury, the automated calculation of taxes and deductions (which can be quite complex), the good and efficient support provided through e-mail, telephone, etc. concerning the use of the LSC SaaS, as well as the quick response to users' requests for support. On the contrary, as main weaknesses perceived concern the support for electronic protocol keeping as well as the support of school canteens management, the electronic payments, as well as the lack of sufficient capabilities for entry of requests by the school units and then management of them by the LSC, and for interaction - communication among the school units of a LSC, and also between the LSC and the school units. Furthermore, important weaknesses are the lack of sufficient interoperability between the LSC SaaS and other relevant government information systems, such as payment systems, systems of insurance funds, and especially the one of the 'Youth and Lifelong Learning Foundation'.

4.4 Regression estimation

Four regression models were estimated in order to investigate to what extent the value dimensions of the second and third level are affected by the first level ones. Models 1 and 2 had as dependent variables the use and the overall satisfaction – objectives accomplishment value dimensions of the second level as dependent variables respectively, and as independent variables the three value dimensions of the first level (system quality, information quality and service quality). Model 3 has as dependent variable the future behaviour value dimension of the third level, and as independent variables the two value dimensions of the second layer (use and overall satisfaction – objectives accomplishment); finally Model 4 has the same dependent variable as Model 3, and all five value dimensions of the first two layers as independent variables (system quality, information quality, service quality, use and overall satisfaction–objectives accomplishment). The R^2 coefficients of the four models are shown in Table 2.

Regression Models	**R^2**
Model_1	0.13
Model_2	0.76
Model_3	0.48
Model_4	0.60

Table 2. R^2 coefficients of the four regression models of the second and third level value dimensions.

The above results indicate that the use of the LSC SaaS is affected to a limited only extent (R^2= 0.13) by the three first level value dimensions (system quality, information quality, service quality); this probably means that users make extensive use of this LSC SaaS (as the high average values of the value measures of the use value dimension indicate – see Table in the Appendix) for supporting most LSC works independently of their perceptions of the system, information and service quality, as they prefer to use this SaaS from the alternative option of not using it and performing the multiple and

complex works of the LSC manually. On the contrary, the overall satisfaction from the LSC SaaS and the support it provides for accomplishing the main objectives of the LSC is to a large extent affected by the three first level value dimensions (R^2= 0.76). Finally, the relevant future behaviour of the users concerning this LSC SaaS is affected to a considerable extent by the two value dimensions of the second level (use and overall satisfaction – objectives accomplishment) (R^2= 0.48), which increases if we add the three value dimensions of the first layer (R^2= 0.60) (indicating direct effects of them on future behaviour in addition to indirect ones through the second level value measures).

4.5 Analysis of correlations

In order to analyze the impact of the first level value dimensions on the second and the third level ones we calculated for each of the first level value dimension variables the correlation coefficients with the two value dimensions of the second and the one of the third level, as well as the average of these three correlations. The results are shown in Table 3; all correlations are statistically significant. We remark that the overall satisfaction – objectives accomplishment and the future behavior have quite high correlations with the three first level value dimensions (stronger with system quality, indicating that they are affected most by the functionality provided by the LSC SaaS). On the contrary, the use of it has much smaller correlations with the three first level value dimensions (stronger with service quality), which is in agreement with similar findings reported in the previous section 4.4. In general from the last column of Table 3 we can conclude that all three first level value dimensions have high average correlations with the value dimensions of the higher levels (0.644, 0.600, 0.550), indicating that the capabilities offered by the LSC SaaS contribute significantly to the generation of higher levels value, with the contribution of system quality being the highest.

	Use	**Overall Satisfaction**	**Future Behavior**	**Average**
System Quality	0.298	0.865	0.769	0.644
Information Quality	0.293	0.796	0.718	0.600
Service Quality	0.361	0.688	0.606	0.550

Table 3. Correlation coefficients between the value dimensions of the first level and the value dimensions of the second and third level.

4.6 High- level value flow model

By combining the calculated average ratings of the six value dimensions (section 4.3), as well as the calculated correlations among them, a high-level value flow model of this LSC SaaS was created, which is shown in Fig.2. It provides a useful synthetic picture of the magnitudes of the main types of value generated by the LSC SaaS, and also the relationships among them, quantified through their correlations. This allows a better understanding of the value generation mechanism of this LSC SaaS; it shows the extent to which the types of value of one level affects the ones of the next levels: how different types of value of one level is transformed to different types of value of higher levels, and also the origins of higher levels value. We remark that overall satisfaction – objectives accomplishment is affected quite strongly by all three first level value dimensions, with system quality having the strongest effect, followed by information quality and then service quality. On the contrary the use is affected much less by the three first level value dimensions, with service quality having the largest effect on it, followed by system and information quality having similar effects. It seems that the functionality offered by the LSC SaaS are the main determinant of users' satisfaction, but it is the quality of the services offered that affects more the extent of use of it. Finally, the third level value dimension concerning users' future behaviour intentions is affected more by the overall satisfaction – objectives accomplishment and much less by use.

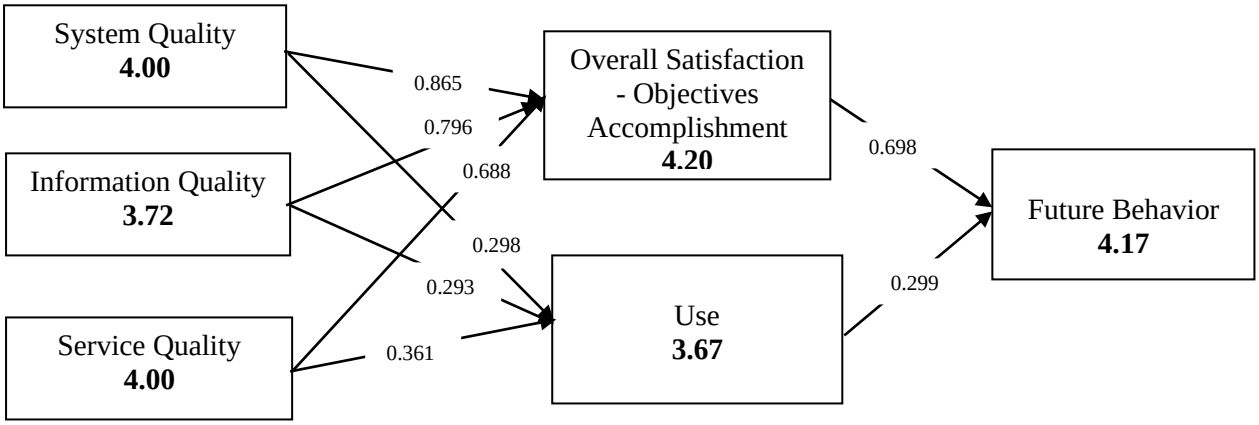

Figure 2. A high-value flow model of the LSC SaaS.

4.7 Definition of improvement priorities

Finally, improvement priorities were identified for this LSC SaaS, initially broad ones concerning general value dimensions and then more detailed ones concerning value measures. With respect to the three first level value dimensions, based on their average ratings by the users they were classified into two groups: the ones higher than the average (equal to (4.00 + 3.72 + 4.00)/3 = 3.90), and the ones lower than the average. The first group includes the information quality, while the second group includes the system quality and the service quality (Fig. 3). Next, they were also classified into two groups, based on their average correlations with the second and third level value dimensions: the ones higher than the average (equal to (0.644 + 0.600 + 0.550) = 0.598), and the ones lower than the average. The first group includes service quality, while the second group includes system quality and information quality (Fig.4). From these two categorizations a broad improvement priority at value dimension level can be distinguished: the highest priority should be assigned to the improvement of the information quality of the LSC SaaS.

3.72	**3.90**	**4.00**
Information Quality	System Quality Service Quality	

Figure 3. Classification of first level value dimensions based on average user rating.

0.550	**0.598**	**0.644**
Service Quality	System Quality Information Quality	

Figure 4. Classification of first level value dimensions based on average correlation with higher levels' value dimensions

In order to identify more detailed improvement priorities the same analysis was performed for the value measures of the first level as well, which correspond to the main capabilities offered by this LSC SaaS. In particular, the 40 value measures of the first layer were initially classified into two groups according to the average ratings received by the users: the ones lower than the average in the first group, and the ones higher than the average in the second group (Fig. 5). Next, they were classified into two groups on the basis of their average correlation with the 11 value measures of the second level and the 2 value measures of the third layer (Fig. 6). Based on these two categorizations we can determine the value measures (capabilities) that belong to the first (lower) group with respect to average

rating, but to the second (higher) group with respect to average correlation with second and third layer value measures, which should be assigned the highest improvement priority, and are shown in Table 4.

1.21	**3.83**	**4.46**
1.4, 1.8, 1.9, 1.10, 1.14, 1.15, 1.16, 1.17, 1.19, 1.22, 1.23, 1.24, 1.25, 1.26, 1.27, 2.2, 2.3, 2.4, 3.1, 3.2	1.1, 1.2, 1.3, 1.5, 1.6, 1.7, 1.11, 1.12, 1.13, 1.18, 1.20, 1.21, 1.28, 1.29, 2.1, 2.5, 3.3, 3.4, 3.5, 3.6	

Figure 5. Classification of first level value measures based on average user rating.

0.000	**0.340**	**0.501**
1.3, 1.4, 1.8, 1.10, 1.11, 1.13, 1.16, 1.17, 1.19, 1.20, 1.21, 1.23, 1.24, 1.25, 1.26, 1.27, 1.28, 1.29, 3.4, 3.6	1.1, 1.2, 1.5, 1.6, 1.7, 1.9, 1.12, 1.14, 1.15, 1.18, 1.22, 2.1, 2.2, 2.3, 2.4, 2.5, 3.1, 3.2, 3.3, 3.5	

Figure 6. Classification of first level value measures based on average correlation with higher levels' value measures

1.14	It offers full support for procurement - vendor management
1.15	It offers full support for school canteens management
1.22	It can produce automatically the required formal annual financial reports according to relevant legislation
2.2	It can create all the necessary reports - statements that have to be submitted to other government organizations in an appropriate form
2.3	It enables customization of the reports in order to meet specialized needs of the users
2.4	The reports provided by LSC SaaS allow having a complete picture of all activities of the School Committee
3.1	Satisfactory training is provided to the users
3.2	The content of this training was appropriate and complete

Table 4. First level value measures (capabilities) with the highest priority for improvement.

The above analysis reveals eight capabilities of the LSC SaaS that should receive the highest priority for improvement. In particular, high priority should be given to the improvement of the functionality of the LSC SaaS for the support of the management of the procurement process (which has to follow the complex public sector procurement regulations)-vendors as well as the management of school canteens (which provide considerable income that can be used for financing LSC activities). Also, high priority should be given to the automated production of the formal annual financial reports required by relevant legislation, and the numerous reports - statements that LSC have to submit to other government organizations (who supervise aspects of their operation, or have some kind of co-operation with them), as well to the enrichment and improvement of reports' customization capabilities. Finally, with respect to the complementary services high priority should be given to the improvement of the training provided to the users of the LSC SaaS, with special emphasis on the appropriateness and the completeness of the educational content. All these capabilities have received low quality ratings by the users, and at the same time are highly important for higher level value generation.

5 Conclusions

Government agencies are increasingly making use of the CC, which constitutes a 'disruptive technology' that drives an important paradigm shift in the production, delivery and financing of the ICT services that organizations need in order to support their activities and processes. Initially government agencies are using the simpler forms of CC, the IaaS and PaaS, but later they proceed to the use of the

most sophistication form of CC, the SaaS. In the previous sections has been described a methodology for evaluating complex government-specific SaaS, which enables comprehensive multi-dimensional evaluation of a wide range of aspects of them that are highly important in the government context, and detailed evaluation of the provided complex and extensive functionality with respect to relevant legislation provisions and requirements, as well as the complementary services (such as users' training and support); also enables the rational identification and prioritization of necessary improvements. It has sound theoretical foundations: the IS success model of DeLone and McLean (2003). A distinctive feature of this methodology is that it exploits not only the average ratings of users concerning a wide variety of value measures, but also the existing associations-correlations among them, in order to extract more value related knowledge from users' evaluation data. The proposed methodology is based on the estimation of 'value flow models' of the SaaS under evaluation, building on previous research conducted in this area. It can be used: a) in the initial SaaS adoption/selection stage, for the evaluation of a SaaS under consideration, or for ranking existing alternative SaaS offerings and selecting the most appropriate one (e.g. by calculating for each of these SaaS an overall rating equal to the sum of average user ratings for the first level value measures multiplied by 'objective' weights, based on their associations/correlations with higher level value measures concerning the perceived overall satisfaction or contribution to the accomplishment of operational objectives); b) in various post-adoption stages (e.g. after a period of productive usage, after the introduction of new versions or major modifications, etc.). An application of our methodology has been made for the evaluation of a SaaS for the support of the extensive activities of Greek LSC, which provides a first validation of its usefulness and value.

The present study has significant implications both for research and practice. With respect to research it makes a contribution to the existing body of knowledge concerning the evaluation of the most sophisticated form of CC, the SaaS, and especially the highly complex government SaaS, aiming to support the complex activities and processes of the public sector, that have to be compliant with quite strict and demanding legislation; it offers significant advantages in comparison with the existing SaaS evaluation methodologies, which are discussed in detail in the 'Introduction' as well as in the following 'Background' section. Furthermore, it makes a contribution to the wider IS evaluation research stream, by proposing an approach for a better exploitation of users' evaluation data, based not only on average user ratings concerning a variety of value measures, but also on the associations-correlations among them, in order to extract more value related knowledge and insightful conclusions. This allows an 'objective' assessment of the importance of the value measures – evaluation criteria, instead of the 'subjective' one that dominates in existing IS evaluation methods (calculation of 'weights' using various multi-criteria decision-making methods). With respect to practice, the present study proposes an approach that can be quite useful to government agencies adopting (or intending to adopt) the 'disruptive technologies' of CC, and especially SaaS, for evaluating from multiple perspectives proposed SaaS solutions by various providers, and assess to what extent they provide support for their complex activities, processes and objectives defined by legislation. Also, the proposed approach enables the rational identification and prioritization of improvements of SaaS, and especially complex government SaaS, which are often quite necessary, as providers usually do not have sufficient knowledge of public sector complex financial management, procurement and other activities' regulations/legislation, or produce public sector SaaS through minor adaptations of existing private sector SaaS.

Further research is required for applying the proposed methodology in other kinds of government SaaS in different thematic areas of government activity (probably more critical ones), in order to identify weaknesses of it and also needs for enhancements. Furthermore, the development and use of more sophisticated value flow models should be investigated, possibly based on extensions of the IS success model of DeLone and McLean (2003), or other more sophisticated models of IS success and value. Finally, research should be conducted in order to extend the proposed methodology for private sector SaaS, by using value dimensions concerning the provided capabilities (or the degree of fulfilling existing requirements) at a first level, and value dimensions based on the Balanced Scorecard in the second level (assessing the extent of support provided by the SaaS for improving internal business processes' performance, customer service, financial performance and also knowledge acquisition and learning).

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Appendix: Average ratings and standard deviations

	Average	**Std. deviation**
System Quality (29 questions)		
1.1. The LSC SaaS functions smoothly without interruptions or other problems	4.27	0.52
1.2. The LSC SaaS is fully reliable	4.2	0.49
1.3. It can be accessed from any computer connected to the Internet, without need for installation of some software or other interventions	4.46	0.79
1.4. It can be accessed through a variety of devices (desktop/laptop, mobile phone, PDA, etc.)	3.57	1.19
1.5. It offers a simple and user-friendly work environment	4.32	0.61
1.6. It was to learn the use of its main capabilities	4	0.76
1.7. The steps of the procedures of using it are easy	3.84	0.69
1.8. It provides capabilities for storing, managing and searching all the documents required for the operation of a LSC	3.18	0.79
1.9. It provides a complete set of template documents for facilitating the activities of the LSC (e.g. for procurement, contracts, payments, etc.)	3.27	0.95
1.10. It offers complete support for electronic protocol keeping	2.66	1.17
1.11. It offers complete support for recording, monitoring and managing fixed assets and materials	3.91	0.99

1.12. It offers complete support for the whole cycle of invoices' management	4.07	0.67
1.13. It offers full support of human resources management	3.92	0.61
1.14. It offers full support for procurement - vendor management	3.50	0.94
1.15. It offers full support for school canteens management	2.69	1.17
1.16. It offers complete support for the management of farms owned by the school units	1.54	0.99
1.17. It provides capabilities for entry of requests by the school units and then management of them by the LSC	2.12	1.42
1.18. It provides capabilities for entry and management of income and expenses for each school unit separately	4.08	0.82
1.19. It enables batch entry, update and delete of data	3.66	0.94
1.20. It provides capabilities for detailed monitoring of treasury in real time	4.27	0.81
1.21. It can perform automated calculation of all possible taxes and deductions	4.44	0.79
1.22. It can produce automatically the required formal annual financial reports according to relevant legislation	3.63	0.89
1.23. It enables making electronic payments	1.51	1.14
1.24. It provides sufficient capabilities for interaction - communication among the school units of a LSC in order to exchange information and knowledge (e.g. through forum, bulletin board, etc.)	2.97	1.12
1.25. It provides satisfactory capabilities for communication between the LSC and the school units under its supervision	2.48	1.47
1.26. The LSC SaaS has interoperability with other relevant government information systems (e.g. payment systems, systems of insurance funds)	1.74	1.05
1.27. It has interconnection with the information system of the 'Youth and Lifelong Learning Foundation'	1.21	0.74
1.28. It provides satisfactory security	3.89	0.85
1.29. It is adapted rapidly to changes of relevant legislation concerning the operation of LSC	3.85	0.78
System Quality Average	4.00	0.63
Information Quality (5 questions)		
2.1. The LSC SaaS provides useful, reliable and comprehensible reports	3.93	0.72
2.2. It can create all the necessary reports - statements that have to be submitted to other government organizations in an appropriate form	3.48	0.85

2.3. It enables customization of the reports in order to meet specialized needs of the users	3.51	0.81
2.4. The reports provided by LSC SaaS allow having a complete picture of all activities of the School Committee	3.78	0.77
2.5. The LSC SaaS provides complete and reliable information about the legislation concerning LSC operation as well as changes and evolution of it	3.9	0.85
Information Quality Average	3.72	0.66
Services Quality (6 questions)		
3.1. Satisfactory training is provided to the users	3.8	0.84
3.2. The content of this training was appropriate and complete	3.77	0.83
3.3. There are complete and understandable instructions about the use of this LSC SaaS	3.84	0.77
3.4. Good and efficient support is provided concerning the use of the LSC SaaS (e.g. through e-mail, telephone, etc.)	4.3	0.65
3.5. Good and efficient support is provided concerning the use of the LSC SaaS (e.g. through call center, e-mail, etc.) about the relevant legislation concerning LSC operation	3.91	0.82
3.6. There is quick response to users' requests for support	4.43	0.67
Quality Service Average	4.00	0.63
Average of first layer value dimensions	3.90	
Use (3 questions)		
4.1. I use the LSC SaaS frequently for the LSC works	4.59	0.58
4.2. I rely on it for performing LSC works	4.21	0.67
4.3. I use all the capabilities provided by this LSC SaaS	3.8	0.72
Use measures Average	4.2	0.53
Overall Satisfaction – Objectives Accomplishment (8 questions)		
5.1. Based on my whole experience with the LSC SaaS I am fully satisfied with it	3.73	0.69
5.2. It completely fulfills my expectations	3.59	0.72
5.3. All the electronic support requirements are covered by the capabili-	3.38	0.76

ties provided by the LSC SaaS		
5.4. The use of it improves the efficiency and effectiveness of performing LSC works and activities	3.98	0.66
5.5. The use of it saves time and money	4.04	0.73
5.6. It is useful for performing the works and activities of the LSC	4.23	0.60
5.7. The use of it eliminates the need for manual work	3.14	0.88
5.8. For performing the works and activities of the SC in addition to the use of this LSC SaaS we also have external support (e.g. by an accounting	3.28	1.07
Overall Satisfaction – Objectives Accomplishment Average	3.67	0.48
Average of second layer value dimensions	3.93	
Future Behavior (2 questions)		
6.1. We intend to continue using the LSC SaaS in the future	4.18	0.62
6.2. I would recommend it to other SC	4.16	0.64
Future Behavior Average	4.17	0.62
Average of third layer value dimensions	4.17	