Simulation Models in eGovernment using System Dynamics: A Literature Survey

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Abstract: System Dynamics (SD) is a method to build simulation models using computers, to study the behaviour of systems, and apply what-if scenarios aiming at achieving optimal policy design. To have an overview of the current state-of-the-art of SD use in the eGovernment field, we have surveyed related literature. Our main goal is to uncover the possibilities for future research by clarifying the shortages. The identified literature is not very large. In most of the literature, SD models use was limited to SD practitioners. We discovered low usage of Group Model Building and workshops despite their usefulness in involving non-SD practitioners in the model building process. Additionally, there is a large untapped potential in using Interactive Learning Environment, in spite of its importance in involving non-technical users in conducting what-if scenario testing, and changing users’ mental models by uncovering the underlying system structure.

Keywords: eGovernment, system dynamics, literature review

1. Introduction

In 2013, Dawes wrote: “the failure rate of investments in ICTs to meet governmental needs remains high and consumes both resources and credibility” [1]. In 2014, another report claimed that –despite little data availability– 60% to 80% of eGovernment projects fail [2].

The failure of eGovernment projects is mainly caused by bad implementation [3], or bad management practices [3]. This in turn, is due to inconsistencies between the targets and needs these projects have been established to suffice, and what happens in reality [3]. Clearly, methods that can help researchers and practitioners in estimating eGovernment projects results, can greatly increase the probability of success [1]. In 1998, during one of the US National Science Foundation Digital Government Research Program workshops, a research wish list was prepared. One of these wishes was: “Intuitive decision support tools for public officials. Technologies and data standards that encourage information search, selection, analysis, and sharing can strongly influence the nature and effectiveness of decision making by elected officials, senior executives, and program managers alike. The use of new tools by decision makers may also have implications for public participation and open government” [4]. In 2013, this list is still relevant [1].

An eGovernment system is –like any other Information System– a socio-technical system, composed of various internal components: software, hardware, telecommunications, data, people, procedures [5]. From a different angle, eGovernment is governed by the mutual interaction between three types of agents: government, businesses and citizens, rendering it as a dynamically changing and complex system [6]. Considering
the interactions among eGovernment components and agents especially from the management point of view, many ways could be proposed to enhance its performance [7]. Taking into consideration that interactions among eGovernment system components are dynamically complex and changing over time, makes System Dynamics (SD) one of the most suitable methods to be used in modelling such a system [5].

SD is a method to build simulation models using computers, to study the behaviour of systems [7]. It is an application of Servomechanism or Information Feedback Systems Theory (Control Theory) [8] to almost all kinds of social systems. SD models enable users to understand how policies and decisions interact with the underlying structure of the system to influence its behaviour [8]. Furthermore, they enable them to apply different what-if scenarios, for different sets of policies aiming at reaching optimal policy design [7].

To stand on the current state-of-the-art of SD use in the eGovernment field; we would like to investigate the accumulated literature on eGovernment models using SD. In addition to knowing the present situation which could have a great impact on our understanding of the depth of SD use in this field, our main goal is to uncover the possibilities for future research by clarifying the shortage. The following section describes the methodology we used to achieve our investigation goal. Afterwards we describe the findings and results. In the last section the paper concludes.

2. Methodology

Our investigation started by searching two popular reference databases; the first is the “E-Government Reference Library (EGRL) version 10.5” published in January 25, 2015, hosted by Hans Jochen Scholl, University of Washington,1 the other is the SD bibliography database ver. 2015a published in 2015 and hosted by the SD Society.2 The EGRL includes 7,237 eGovernment related references, 45% of them are journal articles and 51% are conference papers, book sections and edited books. The SD bibliography database contains 11,046 SD related reference, 23% of them are journal articles and 46% are conference papers, book sections and edited books.

Our main search focused on the eGovernment keyword variants: “electronic government”, “digital government”, “egovernment”, “e-government” and “egov” in all fields of the SD bibliography database. Additionally, we added “Information Technology”, “IT”, “Information and Communication Technology”, and “ICT” to “government” as extra search keywords. For the EGRL database, we used “System Dynamics” and “System Thinking” as search keywords in all fields.

The last step was followed by pairing each eGovernment search keyword with each SD search keyword. These pairs were used to search all databases available from EBSCO Information Services, hosted by EBSCO Information Services.3 Finally, the search process was wrapped up by using Google Scholar.4 Many repetitions were found and removed during the process. The resulted references were skimmed to be sure of their eligibility for this research. The final step we conducted on the filtered publications list was reviewing the citations forward and backward. This step added few extra publications to the final list.

We excluded a couple of SD Society’s conferences papers. Only the abstracts of these two papers were available in the proceedings. We have contacted the SD Society and the first two authors of both papers; however these trails were not fruitful. For one conference paper we could find merely a presentation on the conference website, in addition the issue

1 Available at: https://catalyst.uw.edu/webq/survey/jscholl/22768
2 Available at: http://www.systemdynamics.org/bibliography-download-page
3 Available at: https://search.ebscohost.com
4 Available at: https://scholar.google.com
of the paper was republished by the same authors the following year in a different conference. Only the latter paper was taken into consideration.

3. Results

3.1 – Bird's–Eye View

The overall search process resulted in more than 115 publications, of which more than 80% were not related to our topic and thus eliminated. For example some eGovernment related papers appeared in the search because they quoted one or more SD related references, and vice versa. Only 28 publications were found relevant, and included in the final list.

Conferences accounted for 57% of the used publication channels. 25% of the publications reviewed were journal articles. As shown in figure 1, the overall publication rate is increasing over time. Figure 2 shows the concentration of 75% of eGovernment investigated projects in the United States and Mexico.

Investigated publications differed in their information sources approaches. 71% and 54% of reviewed publications respectively used Case Study and Interviews as a main or one of the main sources, ranking them as the most engaged approaches. Group Model Building followed with 29%. Using Workshops and Surveys as main information source came last.

Authors preferred different tools and methods to analyse and present their results. Stock and Flow diagram was the most frequently used tool with 71% of all reviewed publications. 46% of the investigated publications used Casual Loop diagram to present their understanding about the system under investigation. 61% of the reviewed publications have stepped to present simulation results. The use of the more advanced Interactive Learning Environment technique was limited to 7% of reviewed publications.

79% of the reviewed publications were used in presenting project cases on the local municipal/territorial/city level, while only 21% addressed national/county-wide level. The reviewed publications were almost equally distributed between being used in supporting specific and general eGovernment projects.

Table 1 compiles a list of distribution of investigated publications over all information sources, used tools, scopes, and usages.

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5 Only 5 publications were published in a SD related channel. This could be considered as an indicator on the acceptance of SD in publication channels that are not related to SD domain.
3.2  Deeper Look into the Models

We were able to distribute the models presented in surveyed papers over 4 different topics:
1. Collaboration and knowledge sharing
2. Development and success/failure factors
3. System security
4. Government 2.0 applications

3.2.1 Collaboration and Knowledge Sharing

Like any other project, a successful eGovernment project requires smooth collaboration among involved parties. This includes aspects like trust and consequently data, information and knowledge sharing among these parities. According to our survey, the first SD model focusing on eGovernment was introduced in 2002 by Cresswell et al. [9]. The model explored the dynamics of collaboration and knowledge sharing among different governmental agencies. The model used the data and information retrieved during the implementation of the Homeless Information Management System (HIMS) for the state of New York in the United States. Seven other publications explored the HIMS projects and its SD model [10]–[16].

Information integration in the context of inter-governmental agencies collaboration was tackled in another model that was built by Luna-Reyes et al. [17], [18]. In 2011, Scholl and Luna-Reyes presented a model envisaging the relationships among different government stakeholders (namely, the Congress, the president, the people, and the press) as controlled by the US constitution [19]. This model focused on the effect of transparency and open government in promoting a less secretive government.
3.2.2 Development and Success/Failure Factors

eGovernment development process is affected by many factors in addition to the actions of several parties. Understanding this process, can help in identifying the leverage points, success and failure factors. A theoretical and an analytical framework explaining eGovernment development was embodied in a casual loop diagram introduced by Martinez-Moyano and Gil-Garcia [20]. Their aim was to find leverage points of intervention. In the following year, Luna-Reyes et al. investigated the social and organizational factors causing success and failure of a governmental information systems development based on the New York state’s Multipurpose Access for Customer Relations and Operational Support (MACROS) project findings [21]. The development of the eGovernment organisational and technological sophistication was explored by Martinez-Moyano [22] via a preliminary causal loop diagram to be used later in group model building sessions. Nevertheless, this was never used further.

Kim et al. introduced a model that helps in deciding whether the city of Philadelphia in the United States should compete with private sector providers in the local Wi-Fi market [23]. eMexico program is a Mexican eGovernment initiative that includes different internet service portals. Luna-Reyes and Gil-Garcia combined the institutional theory and SD to build a preliminary model in order to understand the interactions among institutional, organisational, and technological components of the eGovernment in Mexico based on information recovered from the eMexico program [24]. The model was reintroduced in an extended version of the same paper in 2011 [25].

In a couple of papers, Abdelgawad et al. explored the non-technical factors affecting the eAccessibility of Norwegian municipal local government websites. Presenting a casual loop diagram in the first paper, while in the second they introduced a model and an Interactive Learning Environment to be used as a decision support tool [26], [27]. Navarra and Bianchi presented an abstract model to be built and applied in the context of territorial governance, to support sustainable development [28]. They used Hammarby in Sweden as their case-study.

Luna-Reyes, Gil-Garcia and Ramirez-Hernandez proposed a resource-based view of the eGovernment service provider using SD modelling [29]. This was preceded by a preliminary conceptual SD model that renders the fundamental capabilities and resources required to achieve a successful transformation to eGovernment on the local level [30]. This paper was an extended version of the former. The authors used SD and dynamic-capabilities view of the eGovernment service provider [31] to identify the core capabilities and resources necessary to develop a successful eGovernment strategy was introduced as a continuation of the same line of work in and extended version of the two former papers [32].

Rich and Nelson addressed the problems caused by shifting the requirements in large government IT projects using SD modelling [33]. Luis F. Luna-Reyes and Gil-Garcia used SD to present a theory of the co-evolution of technology, organizational networks, and institutional arrangements in government transformation via IT [34]. The same model was reintroduced in an extended version paper [35].

3.2.3 System Security

An eGovernment system is vulnerable to several types of risks. These risks could range from hacking and virus attacks to hardware failures and natural disasters. Understanding the causes and effects of these risks is critical in understanding ramifications and preparing the mitigation strategies. Tang and Jia constructed an open-loop system model for estimating the risks the eGovernment services face, and how to sustain the security of these services
Open-loop systems ignore information feedback. This prevents the model behaviour from being affected by its past values [7]; consequently ignoring that circular causality.

3.2.4 Government 2.0 Applications

Abdelgawad et al. presented a SD model and Interactive Learning Environment depicting the situation of disabled people employment in Norway [37]. This Interactive learning Environment could be used as a tool to promote citizen participation, by involving ordinary citizens in politics and policy-making process.

4. Conclusion

Our goal is to understand the situation of using SD in the eGovernment field, in order to increase our understanding of the depth of that practice, and uncover the possibilities for future research by shedding the light on the shortage. The identified literature applying SD in the context of eGovernment is not very large. Furthermore, it was clear that in the majority of cases, the use of SD models is limited to SD practitioners. Albeit, the real power of SD does not only lie in its powerful modelling capabilities, but also in its ease of use and comprehension by both users involved in the modelling process and users of the final model.

Group Model Building and workshops are vital tools to involve non-SD practitioners in the model building process. Yet, their use in the surveyed literature is low. The cost of involving people in the modelling process both financially and time-wise cannot be ignored, however the benefits are obvious. More focus on using both tools is inevitably required if increasing the use of SD in the eGovernment field is targeted.

With a couple of exceptions, most of the models investigated have no Interactive Learning Environment. Consequently, they can neither be used directly by non-technical users to conduct what-if scenario testing, nor help them in changing their mental models by uncovering the underlying system structure. Perhaps time and costs involved in developing an Interactive Learning Environment play a principal role in this situation, nevertheless extra momentum is a must to increase the models usability especially among non-technical users. Finally, it is worth mentioning that very few models address national level/county-wide projects. Further attention could be devoted to building models that are concerned with situations on that level.

5. Next Step in Africa

In the context of ICT development in developing countries, Dahan wrote that SD “is increasingly proving its applicability and relevance to developing work. Policy-makers need to look for innovative approaches that offer guidance on improving the design and implementation of development programs, and help identify critical activities, knowledge gaps, as well as the highest payoffs to filling those gaps. [SD] seems to be a good candidate in addressing these challenges” [38]. In Europe, many universities teach and use SD in research e.g. University of Bergen in Norway, University of Palermo in Italy, and Radboud University in the Netherlands. Their wide range of SD modelling knowledge and experience could greatly help the growing eGovernment field in African countries in building useful SD decision support tools. Many African students and practitioners have studied SD in these universities; however more cooperation in conducting practical research would be very beneficial. Moreover, if covering the shortage we have shed the light on in SD research is expected to be fruitful in general, we believe that the effect would be manyfold in the context of African eGovernment.
References


