Qualitative system dynamics modelling of the impacts of maintenance, effort, competence and collaboration on e-government website availability

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Abstract: E-government websites have become the main gateways for accessing government services. To be constantly or highly available, these websites require ongoing quality maintenance. E-government websites are complex; its maintenance necessitates a complex undertaking. Further understanding about e-government website maintenance remains necessary, especially relating to the required effort and competence of government staff and organisations, as well as collaboration. This research aims to propose a qualitative system dynamics model which conceptualises the feedback relationships of website maintenance, staff and organisational effort as well as competence, and the collaborative factors in influencing e-government website availability. As part of the broader context of system dynamics study, the conceptual model needs to be validated with actual data and will be used as a basis for developing a system dynamic simulation model.

Keywords: e-government; website availability; website maintenance; staff and organisation effort; staff and organisation competence; collaboration; qualitative system dynamics.

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1 Introduction

Delivery of many government services currently depends highly on e-government websites (eGW) (Cataldo et al., 2017; Dolson and Young, 2012; Fath-Allah et al., 2014; Luna-Reyes and Gil-García, 2011; Mayedwa and Belle, 2016; United Nations, 2016). Therefore, an eGW must be constantly or highly available over time to maximise its benefits for citizens and businesses; that is, the website exists whenever it is accessed, all information on the website is of high quality, and all services delivered through the website function as intended (Schultheiss et al., 2011). However, the level of eGW availability in delivering services changes over time: the quality of its contents could degrade because of changes to the law and regulations (Manoj and Jaffar, 2016), hyperlinks may be damaged or become invalid, undetected programming errors emerge, website integrity deteriorate because of undertaken maintenance, and new organisational requirements may also surface (Peters, 2010). These changes may threaten the value of e-government services. For these reasons, continual and quality website maintenance is necessary for an eGW (Manoj and Jaffar, 2016), as a response to dynamic levels of website availability, primarily to avoid diminished eGW services delivery. Furthermore, successful eGW maintenance requires high competence among internal e-government staff (Abdelgawad et al., 2010; Detlor et al., 2010) and close collaboration between such staff and other eGW stakeholders (Detlor et al., 2010) as well as highly motivated internal staff (França et al., 2014).

In general, much research has studied website maintenance from various points of view: the technological facets of maintenance (Fitzgerald et al., 2013); the cost of maintaining web applications (Ivan and Despa, 2016); the common features, contents and maintenance problems of websites (Ganaee and Rafiq, 2016); the degree of flexibility in web information systems for maintenance (Peters, 2010); decision-making to maintain or replace an organisation's website (Nagy et al., 2017); and the significant role of main stakeholders (Coomes and Liew, 2007). In the context of e-government especially, Abdelgawad et al. (2010) modelled the maintenance of dynamic accessibility of an eGW. In the specific area of eGW, many studies have been undertaken to investigate factors influencing eGW services delivery, including the security of the website (Alsmadi and Abu-Shanab, 2016), involvement of citizens in government policy formulation and government data transparency programs (Al-Jamal and Abu-Shanab, 2016), and institutional and organisational dimensions (Gil-García, 2006; Luna-Reyes and Gil-García, 2011).

Such previous research indicates that there has been much attention on how to successfully deliver services through eGWs; however, the relevant literature suggests eGW maintenance studies lack focus on the level of availability of service delivery over time, especially regarding the role of individual and organisational factors, and the relationships between them, in eGW maintenance.

Distinct from previous studies, this research aims to propose a conceptual model that can accommodate and explain the complexity of eGW maintenance involving dynamic feedback relationships between the level of availability of eGW over time and factors associated with website maintenance such as organisational effort, competence and collaboration. The model will be constructed with reference to the available relevant literature. This research is motivated first, by the fact that e-government management needs to ensure that eGWs used to deliver e-government services are always available at high levels (Sá et al., 2016). High capability of e-government systems to produce services

can be useless if the website that functions as front office is not available. Second, maintaining eGW is a complex undertaking. It involves not only technological dimensions of eGW but also individual and organisational factors (Abdullah et al., 2016; Luna-Reyes and Gil-García, 2011; Nurdin et al., 2014). Third, the method of qualitative system dynamics (SD) could capture and model dynamic behaviour over time and feedback relationships between factors under investigation (Walters et al., 2016). The formulation of a conceptual model is an important and necessary stage of SD method implementation (Sterman, 2000).

This research contributes to advancing the understanding, knowledge and practice of e-government, especially with regard to eGW maintenance. First, this research extends our comprehension of the dynamic availability of eGW by conceptualising feedback relationships between individual and organisational factors, website maintenance and website availability. Second, it also complements existing research which primarily focuses on e-government development but pays less attention to maintenance and operations through the e-government life cycle. Third, once the conceptual model is tested using empirical data, it can assist e-government management to achieve more effective results in maintaining high level availability of eGWs.

Following this introduction section, the paper is organised into four sections. In Section 2, the notion of e-government is briefly reviewed, followed by issues and challenges faced by eGW management as well as the reasons why maintenance is necessary for website service availability. Section 3 describes the qualitative SD modelling adopted by this study. Section 4 presents the conceptual model and how it works. The last section concludes.

2 Literature review

2.1 E-government

E-government is a government information system consisting of information technology (IT), people and processes integrated in government organisations, used to deliver government services to citizens and the private sector and improve citizen participation and facilitate effective government decision-making (Gunadi et al., 2013). An e-government is a socio-technical system emphasising the existence of inter-relationships between 'task, technology, people, and structure' [Laudon and Laudon, (2012), p.93] that involves government organisations, government processes, IT implementation, and individual, social, political, economic, marketing, and other factors (Shareef et al., 2011).

In general, implementation of e-government encompasses a wide range of purposes: for use by government staff to perform internal tasks and processes, to provide efficient services to citizens, to deliver streamlined processes for companies dealing with government, to enable efficient collaboration among government units, and to facilitate citizen participation in government policymaking (Beynon-Davies, 2007). The scope of services delivered through the e-government system range from an integrated system providing various services through a single website (Bhattacharya et al., 2010; United Nations, 2016) to very specialised systems such as public hospital service information systems (Handayani et al., 2016). The level of e-government services delivered through a website depends on its degree of sophistication, from merely static information provision to a fully integrated single website service where users can interact and complete their

transactions with government (United Nations, 2016). The range of different types of eGW indicates the different degrees of complexity in the technology and resources required to develop and maintain them.

To achieve any level of e-government sophistication, an e-government system will follow a system life cycle consisting of, broadly, a development stage and a maintenance stage (April and Abran, 2008). A successfully developed and maintained e-government system is very important to sustaining the benefits for government, citizens and business. The benefits include improving civil service performance and services delivery, reducing corruption, improving transparency, enabling community empowerment, and so on (Bhatnagar, 2004). Further efforts are required to realise e-government success in the long-term to maximise these various benefits (Klischewski and Lessa, 2015), as an enormous amount of resources has been allocated to supporting e-government service delivery.

2.2 E-government websites

From a technology perspective, a website can be defined as "a collection of documents or files that are published on the World Wide Web and intended for use by the general public" [Diffily, (2006), p.9]. It is a virtual place where people can interact and collaborate, through a web of documents organised non-sequentially as hypertext (Scavo, 2003). The documents or files visible to the public are known as web pages. Any eGW can be composed as a homepage consisting of concise and general information and some web pages where details of the information or services are delivered (Manuel et al., 2009). It must be noted that although new IT has continued to improve in capability and interactivity, eGW technology is still the pillar of e-government services delivery (Chen, 2017).

In many cases, each web page is associated with a particular government sub-organisation which is then integrated with other web services from other government sub-organisations, to comprise a single eGW functioning as a single portal where people can access and obtain various government services, including information, communication and relevant transactions (Gil-García, 2005; Rorissa et al., 2010). Therefore, an eGW has become a vital channel for government services delivery because of its capacity to provide highly efficient processes as well as effective services (Bhattacharya et al., 2010; Scavo and Baumgartner, 2007).

However, to realise sustained eGW capability, managers of eGWs must confront a significant number of issues and challenges, as indicated in existing studies, and classifiable into three categories: technological, managerial and organisational challenges [Laudon and Laudon, (2012), Ch.1].

To be able to achieve the objectives of e-government, eGWs must always be available over time (Kienle and Distante, 2014) for citizens and business. It must be operational without error, easy to use, and always be adapted to new users or regulatory requirements (Bhattacharya et al., 2010). The eGW must also be accessible for people with limited physical ability (Abdelgawad et al., 2010). As software, an eGW must be flexible enough for enhancement and perfection as new requirements continually emerge (Peters, 2010). However, adding new requirements or changing the website may well cause unintended errors in other parts of the website (Rajabi et al., 2014). A further challenge for e-government managers is that website technology continually evolves (Kienle and

Distante, 2014), causing additional difficulties for management. For example, the design of the website must adapt to technology and enable access by users through mobile devices (Kaur and Dani, 2017). The website must also be equipped with technology that maintains high levels of security to maintain user trust (Alsmadi and Abu-Shanab, 2016).

From the managerial point of view, that of e-government managers, guaranteeing service availability involves having to ensure that the website features, content and executable services are appropriately provided and mixed (Rorissa et al., 2010) and are effectively delivered to those who need the services (Bhattacharya et al., 2010). For this, they must address critical issues of competence and motivation of internal e-government specialists who develop, operationalise and maintain the eGWs (Evika and Dimitris, 2014; Gunadi et al., 2013). Also, to be effectively and efficiently delivered, eGW services must be appropriately aligned with back-end processes which might involve multiple government sub-organisations (Scavo and Baumgartner, 2007). Therefore, collaboration among sub-organisations and its people is a crucial aspect that has to be managed (Evika and Dimitris, 2014; Gil-Garcia, 2012; Nurdin et al., 2014). Collaboration is necessary because the services from different sub-organisations have to be presented in a single eGW: the website content has to be reliable and consistent, the content author must be trackable, and the website must not contain data duplication (Barnes et al., 2001).

Organisational arrangements and the dynamic interdependence between related factors or units are other critical challenges that must be orchestrated by e-government managers to achieve the full capabilities of an eGW (Luna-Reyes and Gil-García, 2011). E-government managers must also pay close attention to the cultural dimensions of designing an eGW (Moura et al., 2016; Wan Adnan et al., 2017). E-government managers have to confront the external factors that challenge usability and usefulness of the eGW, including the digital infrastructure divide, digital skills divide and demographic divide (United Nations, 2016), as well as socio-economic factors that affect differential online access (Dias and Costa, 2013).

This review indicates that the eGW is complex and constructed by many important factors, including those that are interdependent. To actualise the benefits of e-government, eGW must always be available to deliver services in the long-term, which necessitates continual maintenance.

2.3 eGW maintenance and service availability

Considering the nature of the eGW, its service availability in the long run very much depends on regular and periodic maintenance. Following Gaj and Germani (2008) and Leonard and Sittig (2007), maintenance is necessary to ensure the availability of website services remains at a particular or increasing level. By their definition, the overall eGW service is composed of sub-services which in turn are divided into sub-service components. Accordingly, the availability of eGW services can be defined as a function of the availability of sub-services and sub-service components. This notion of service availability is adopted in this study because of its plausibility and intuitive meaning. In a simple way, an eGW service is highly available if an external user can access the website fully as indicated by its uniform resource locator (URL), the information provided in the website can in fact be accessed and is of high quality, the links to other web pages on the website can be opened properly, and services presented on the website can operate and be completely utilised.

Considering this definition of eGW service, its level of availability is dynamic; it can be up or down during its operational time. Some possible exogenous factors in this dynamic can be identified. First, a successful website development project (Alshehri et al., 2012; Melin and Axelsson, 2009) improves its level of availability: it is less prone to error, the business processes represented in the website and presentation design are in accordance with user requirements, the site is easy to operate, and it is invulnerable from harmful attack by malicious software. Second, organisational and environmental pressures (Peters, 2010) cause the level of availability to decrease. Such pressures include outdated or inaccurate content because of changes in the subjects being presented. Also, users' needs concerning the type and amount of information as well as the look and feel of the website's presentation change over time. The pressures can also come from internal organisational dynamics caused by the persistent emergence of new requirements (Mach, 2004) as well as the implementation of new organisational rules or regulations. Third, the reliability of website infrastructure can be disrupted (Roy et al., 2015), making the eGW unavailable. During the operation of the eGW, infrastructure can fail such that the services cannot be delivered through the website. These infrastructure failures can include hardware, software and connection problems in the e-government's computer network (Pertet and Narasimhan, 2005).

These factors suggest that eGW maintenance must be conducted regularly and consistently to ensure a high level of eGW service availability (eGWSA) over time. The maintenance of eGW can be defined as activities undertaken, once the website is launched, to maintain high levels of service availability. Maintenance activities can consist of "exploration, development, testing and deployment of web features" [Kong et al., (2005), p.5]. They are never-ending activities, unless a complete redevelopment of the whole eGW system takes place. Regular and continual website maintenance is required to ensure information accessible by the user is current, accurate, relevant (Vasconcelos and Cavalcanti, 2004) and legally reliable, to correct programming errors or prevent them from occurring, to adapt or perfect the website design to suit new requirements (Bailey, 2007; Peters, 2010). For example, Peters (2010, p.140) showed empirically that "image, function, admin function, navigational function, textual navigational hyperlink, multimedia hyperlink, scrolling device, textual user interface content format, textual user interface content, database data, style issue and business analysis" of the website always require maintenance.

In addition to the identified factors and according to the definition of maintenance, maintenance itself is a critical endogenous factor that determines the dynamic availability level (Black et al., 2003; Kong et al., 2005). Any eGW maintenance that is undertaken can lead to further maintenance requests, because of unintended errors, incomplete maintenance or maintenance that is of substandard quality, has improperly addressed the original request, or has affected the navigational structure because of inserted disorganised content and new pages. Furthermore, previous studies show that successful maintenance depends on the efforts and competence levels of internal e-government staff (Gunadi et al., 2013), as well as collaboration between them (Luna-Reyes and Gil-García, 2011).

Therefore, modelling these factors and their dynamic feedback relationships will improve understanding of the dynamics of eGWSA and assist e-government managers to maintain that level at a high standard. The dynamic complexity of eGW maintenance and its level of availability reflects the nature of e-government, for which systems thinking is considered conceptually appropriate (Scholl, 2007; Shareef et al., 2011). Further,

understanding these factors and their interdependent relationships, especially the importance of dynamic feedback relationships or causal loop, is emphasised by Dawes and Eglene (2004), Luna-Reyes and Gil-García (2011) and Scholl et al. (2009), and is a necessary condition to achieving e-government success (Luna-Reyes and Gil-García, 2011).

3 Qualitative SD modelling

To realise the research aim, acknowledge the complexity of factors that could influence eGW maintenance and the dynamic pattern of levels of eGWSA over time, this research implements a qualitative SD approach (Maani and Cavana, 2009). The approach is chosen because the resulting causal loop diagram (CLD) is capable of explicitly revealing feedback structures of complicated processes of eGW maintenance. It indicates the way in which two or more factors are related to each other, though they may not be close in time and distance (Sterman, 2000).

The resulting conceptual CLD of this research represents a dynamic hypothesis of the overall cycle of the SD method. The iterative steps of the SD method can be described as "problem articulation, formulation of a dynamic hypothesis, formulation of the simulation model, testing, and policy design and evaluation" [Morecroft, (2015), p.106; Sterman, (2000), pp.86–87]. As a dynamic hypothesis, a CLD provides provisional explanation of the feedback structure (Morecroft, 2015; Stave and Kopainsky, 2015; Sterman, 2000) of the complex eGW maintenance process, and suggests an endogenous elucidation of how individual and organisational effort, competence and collaboration and the eGW maintenance relate to each other, to influence dynamic level of eGWSA over time. The CLD will also be used to provide direction and guidance for data collection (Coyle, 2000) and simulation model construction (Morecroft, 2015) in the later phase of this research.

The CLD modelling has been extensively used in various research and managerial decision-making processes. For example, Fatema and Sakib (2017) identified factors influencing the dynamic productivity of agile software development teams. Schoenenberger et al. (2016) elicited the systemic structure of complex problems of crowding in the Emergency Department. Kunze et al. (2016) addressed logistics problems to indicate the feedback influence of various important factors. Macmillan et al. (2016) discussed how factors of a government housing program dynamically interacted with each other and led to some failures in the program.

A CLD consists of words or phrases representing factors, linked by curved arrows, each of which has attached polarity and time delay symbols (Sterman, 2000). The arrow represents a causal relationship between two factors. The polarity is symbolised by '+' indicating that the two related factors change in the same direction, or '–' showing that the two linked factors vary in two different directions; the time delay is shown by '//' crossing the arrow. A causal loop or feedback relationship between factors can be identified in the model when a cause factor eventually becomes an effect factor by tracing the arrows that link the factors.

The relationship can be a reinforcing or balancing loop. The first loop shows an exponential increase or decrease in system behaviour (denoted by *R*), and the second one indicates goal-seeking behaviour (denoted by *B*). By identifying its possible causal loops,

a CLD that consists of interaction of multiple balancing and reinforcing loops can generate insight into a dynamic structure of the system through time (Madachy, 2008; Sterman, 2000).

4 Conceptual model development

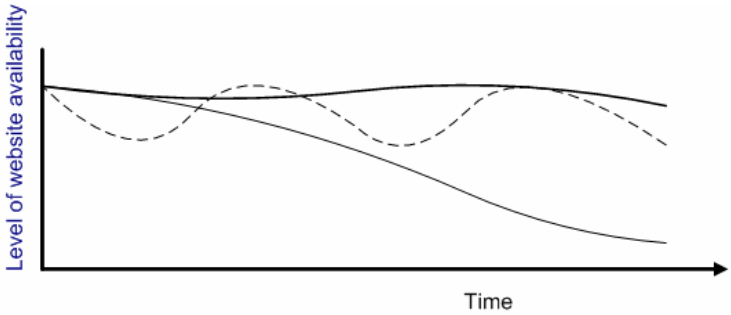
In developing the CLD, available models from previous research will be explored and adapted. Factors and relationships are derived from existing literature and well-established models or theories. The development also involves the researcher's mental model incorporation (Sterman, 2000). The development will result in a CLD that conceptualises feedback relationships of factors that capture the hypothesis about the dynamic level of eGWSA over time (Morecroft, 2015). The steps of model construction involve formulating the dynamic problem, identifying the main factors, presenting the reference mode, developing a CLD, and identifying and analysing the workings of the causal loops (Maani and Cavana, 2007; Sterman, 2000).

4.1 Dynamic problem definition, main factors and reference mode

Dynamic problem definition articulates the issues and purposes addressed by the model (Sterman, 2000). The complexity of eGW presented in Section 2.2, and interdependence between the level of eGWSA and its maintenance, described in Section 2.3, indicate the dynamic problem that will be addressed by the model. While it is understood that the proposed model involves many important factors and feedback relationships, this conceptual model development will focus on the level of eGWSA and how it affects, and is affected by, factors associated with website maintenance, organisational effort and competence, as well as successful collaboration.

Presentation of a reference mode which characterises the dynamic behaviour of the level of eGWSA over time is provided in Figure 1. Once the eGW is delivered for public access, its level of availability fluctuates depending on the characteristics of the website itself and on website maintenance undertaken in response to required changes. Any successful maintenance could bring about a steady high level of eGWSA over time. On the other hand, without appropriate and continual website maintenance, its level of services availability will decrease over time.

Figure 1 Dynamic behaviour of the level of eGWSA over time (see online version for colours)



For the analysis, an e-government system of the city of Surabaya, a capital city of the East Java Province of Indonesia will be used as a reference case. The website address of the e-government system of city of Surabaya (eGoS) is http://www.surabaya.go.id. Preliminary data collection was undertaken through website observation and a short interview with staff responsible for website management. This preliminary data indicates that the website is continually maintained, and the website services, which include information, communication and transactions, keep improving over time. The availability of eGW services over recent years has been maintained at high levels. Some international and national organisations awarded the government for these achievements. The homepage of the website is maintained by an IT unit, while some web pages and services delivered through the pages are managed by its associated functional government units; therefore, they collaborate in delivering and handling the services.

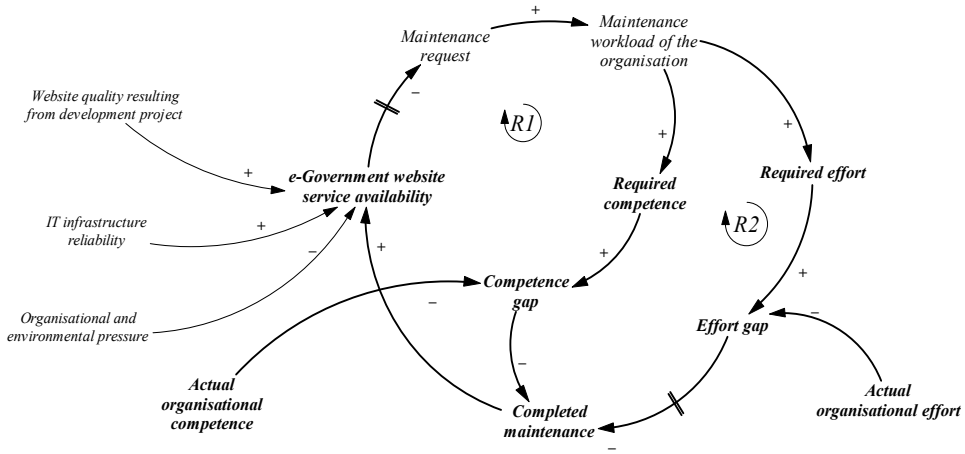
By reference to the eGoS, the workings of the proposed dynamic hypothesis can be demonstrated by identifying the causal loops that show how causal factors affect service availability which in turn, feeds back to influence these factors. This analysis uncovers the feedback structure that explains the dynamic behaviour of high levels of eGWSA.

In the following sections, proposed CLDs are presented and are organised separately into website maintenance, staff and organisational effort, staff and organisational competence, and collaboration sub-models. Arranging these sub-models into one CLD will provide a holistic explanation within the boundaries of the model. The presence of the same factors within different sub-models indicates the relationships between factors from the different sub-models.

4.2 Website maintenance

Figure 2 presents a proposed primary CLD which conceptualises the feedback relationships between eGW maintenance and its level of service availability. This sub-model is adapted from the software maintenance literature (Gunadi et al., 2013).

Figure 2 Website maintenance and level of service availability sub-model



Exogenously, website quality resulting from its development project, IT infrastructure reliability, and organisational and environmental pressures influence levels of e-government website service availability (eGWSA), as argued in Section 2.3. As a result of dynamic changes in these factors, the eGWSA fluctuates over time. The first two factors have a positive effect while the last factor affects the level negatively. Endogenously, there are two reinforcing loops, R1 and R2 that explain the dynamic behaviour of the level of eGWSA over time.

4.2.1 R1 – competence

Exogenous factors can decrease the level of *eGWSA*, which in turn increases *maintenance requests*. The requests can be initiated by internal or external users who need a response from IT staff or others who are responsible for website maintenance. Often, the occurrence of *eGWSA* problems does not become maintenance requests instantly but takes time. For example, users who find a broken link on a web page may just ignore or fail to inform the webmaster (or those responsible for web maintenance) immediately. If the link is not of interest to users, they may not even report it. An increase in *maintenance requests* will also increase *maintenance workloads of the organisation*. Workloads are maintenance jobs that must be undertaken and completed by staff of the sub-organisation that own the web pages requiring maintenance, as well as other sub-organisations which are also responsible for those pages, or pages connected to the pages being maintained. The increase in workload also increases *required competence* from the organisation. Further, this tends to create a widening *competence gap* if *actual organisational competence* cannot address the increased workload. The widening gap causes low quality or substandard *completed maintenance*, which eventually causes the level of *eGWSA* to drop further, requiring further maintenance (Cresswell et al., 2002; Gunadi et al., 2013; Luna-Reyes et al., 2008).

4.2.2 R2 – effort

The increase in workload also raises the level of *required effort* from the organisation, which in turn widens the *effort gap* if the gap is not addressed. This gap causes the quantity of *completed maintenance* to reduce and eventually causes the level of *eGWSA* to decrease further.

Both causal reinforcing loops suggest the need for organisational intervention to close the *competence gap* and the *effort gap* in response to continuous pressure from exogenous factors. In the case of eGoS, it seems that its e-government strategy has been able to continually respond in a way such that its *actual organisational competence* and *actual organisational effort* could close the *competence gap* and *effort gap*, resulting in high levels of *eGWSA* over time.

Organisational competence and effort require that individual staff have the competence and exert sufficient effort, as well as concerted organisational undertaking involving coordination, collaboration, organisational rule establishment, leadership, and so on (Gil-García, 2006; Luna-Reyes and Gil-García, 2011).

4.3 Staff and organisational effort

For successful maintenance, staff and organisational effort are required. A CLD in Figure 3 conceptualises the complex feedback relationships between effort, performance and reward factors, and their dynamic impact on levels of the *eGWSA*. This sub-model is constructed based on the well-established expectancy theory (Vroom, 1995) and its representation of SD (McGrath and More, 1998). This theory proposes that staff members are motivated to exert effort, individually or collaboratively, to achieve a certain level of performance when they understand that this performance will result in certain rewards and outcomes that they value (Robbins et al., 2009).

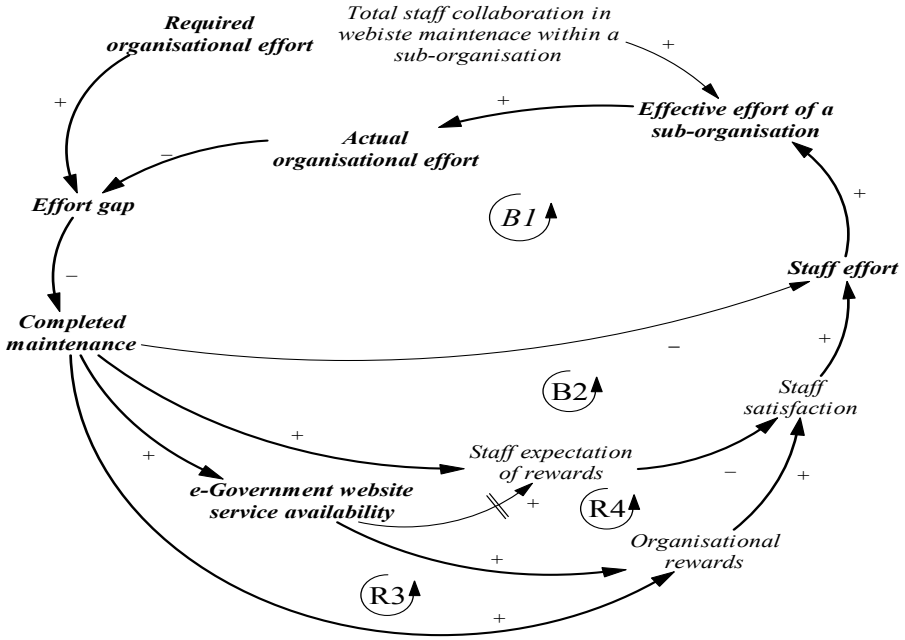
In Figure 3, the *actual organisational effort* is the actualisation of collaboration among sub-organisations, each of which is represented by individual staff of the sub-organisation. This organisational effort is a function of staff effort and the number of sub-organisations involved (Luna-Reyes and Gil-García, 2011; Nurdin et al., 2014). Staff effort is the time and resources devoted by staff in undertaking the required maintenance, individually or collaboratively. In many cases, website maintenance is an organisational effort. The *effective effort of a sub-organisation* is a function of *total staff collaboration in website maintenance within a sub-organisation* and *staff effort*. *Completed maintenance* represents organisational performance, while the level of *eGWSA* measures the level to which organisational objectives have been achieved. Organisational performance and achievement will result in *organisational rewards*. The rewards can be intrinsic or extrinsic, short- or long-term, depending on the organisation's rules (Laumer, 2009; Mahaney and Lederer, 2006). In providing rewards, the organisation should acknowledge the role of each party who has worked collaboratively on the maintenance of the eGW (Bedwell et al., 2012; Boughzala and Vreede, 2015).

Endogenously, there are two balancing loops, B1 and B2, and two reinforcing loops, R3 and R4, that elucidate the complexity of the feedback relationships of effort-related factors, and elicits the dynamic behaviour of levels of the eGWSA over time. In the case of the eGoS, the operation of the proposed sub-model can be described as follows.

4.3.1 B1 – staff want to perform

Completed maintenance indicates the achieved level of performance of collaborating staff. Over time, staff members of the eGoS observe the level or quantity of *completed maintenance*. If the level decreases, according to the theory, they are motivated to increase *staff effort* to a certain level, resulting in a rise in *effective effort of a sub-organisation*, which in turn increases *actual organisational effort*. This, therefore, reduces the *effort gap* and increases *completed maintenance*. However, as the *completed maintenance* improves, staff will tend to reduce their effort to a certain level. This loop underlines the importance of maintaining staff motivation sufficiently high over time.

Figure 3 Staff and organisational effort sub-model



4.3.2 B2 – staff expect rewards for their performance

If *completed maintenance* and the level of *eGWSA* are high, the eGoS staff make economic-rational calculations by increasing their level of *staff expectation of rewards* (Hirschfeld et al., 2002) and vice versa. In turn, this expectation factor determines *staff satisfaction* negatively, in that a high expectation of rewards is difficult to satisfy. If the reward is constant, then a high level of expectation causes *staff satisfaction* to decrease which then reduces *staff effort*. This eventually reduces the quantity of *completed maintenance* which can lower expectations of reward. This balancing loop posits the critical role of managing staff expectations of rewards over time.

4.3.3 R3 – performance-based rewards

A high level of *completed maintenance*, representing a high level of performance, can trigger high *organisational rewards* regardless of the level of *eGWSA*. This, in turn, increases *staff satisfaction* which further raises *staff effort*. By following this reinforcing loop, this *staff effort* will further increase the level of *completed maintenance*. In the case of the eGoS, it seems that rewards are provided in such a way that levels of *staff effort* can be kept high.

4.3.4 R4 – organisational achievement-based rewards

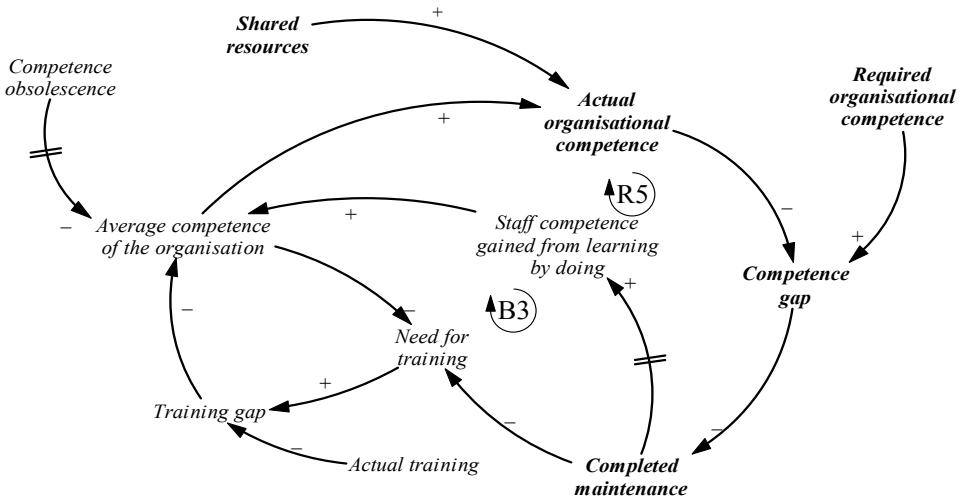
A high level of *eGWSA* over time in eGoS indicates that it has achieved its objective of delivering eGW services. Therefore, for this achievement, greater *organisational rewards* are provided which improve *staff satisfaction* and then *staff effort*. And, by tracing the loop, this eventually further increases the level of *eGWSA*.

Both *R3* and *R4* emphasise the necessity of maintaining appropriate levels of organisational rewards such that they outweigh levels of staff expectation over time. Such levels of reward are required to keep high levels of staff motivation to exert sufficient effort.

4.4 Staff and organisational competence

In addition to effort factors, staff competence is another necessary factor in levels of *eGWSA* (Abdelgawad et al., 2010; Madachy, 2008). The availability of an appropriate number of staff members (Coursey and Norris, 2008; Schwester, 2009) with the required skills and knowledge (Hussein et al., 2007; Rashid and Rahman, 2010) dedicated to website maintenance are necessary for successful maintenance. In general, competence can be defined as "the set of skill and knowledge that an individual need in order to effectively perform a specific job" [Baker et al., (1997), p.266].

Figure 4 Staff and organisational competence sub-model



The *average competence of the organisation* reflects the competence level in the context of a collaborative undertaking in website maintenance (Bedwell et al., 2012). This competence is affected by three factors: *learning by doing* gained by staff through accomplishing maintenance tasks (Abdelgawad et al., 2010; Luna-Reyes et al., 2008); the training undertaken by staff because of limited knowledge gained from *learning by doing*

(Abdelgawad et al., 2010); unavoidable *competence obsolescence* pressure that continually occurs from the progressive nature of IT (Fu and Chen, 2015). *Shared resources* (Janssen and Kuk, 2007) are resources of different sub-organisations, including human resources with different possible levels of competence that are devoted to eGW maintenance. When competence inequality exists across sub-organisations, the ability to know who is competent in which areas of website maintenance and ability to share competence across sub-organisations are critical to the successful completion of maintenance workload (Bedwell et al., 2012). For these problems, training must regularly be provided to enhance staff competence in website maintenance, collaborative work and sharing of resources (Bedwell et al., 2012).

The sub-model in Figure 4 suggests that, endogenously, there is one reinforcing loop, R5, and one balancing loop, B3, that explain dynamic feedback relationships between staff competence and the quality of *completed maintenance*.

4.4.1 R5 – learning by doing

An improvement in *shared resources* and *average competence of the organisation* will increase the level of *actual organisational competence*. This increase causes the *competence gap* to narrow, therefore raising the quality of *completed maintenance*. Over time, the later factor will improve *staff competence gained from learning by doing*, which results in an increase in *average competence of the organisation*, which is expected to be sufficient to overcome *competence obsolescence*.

4.4.2 B3 – training

On the other hand, the persistent exogenous pressure from *competence obsolescence* can reduce the *average competence of the organisation*, which can in turn lower *actual organisation competence*; therefore, widening the *competence gap* because of inability to satisfy the *required organisational competence* that causes the reduction in *completed maintenance*. This reduction, along with decrease in average competence, will increase a *need for training*. For the case of eGoS, high levels of quality and quantity of *actual training* were maintained. Therefore the *average competence of the organisation* increased, leading to, by tracing the loop, high levels of *eGWSA* over time.

4.5 Collaboration within and between sub-organisations

Because of the complexity of an eGW, its maintenance necessitates collaboration between and within sub-organisations (Luna-Reyes et al., 2008; Yang and Maxwell, 2011). Staff with different roles, such as those responsible for technological, legal and operational aspects of the eGW, work together within a sub-organisation to maintain a particular website service that requires attention. Various staff representing different sub-organisations interact and cooperate in a certain way to complete common tasks for mutual benefit (Thomson et al., 2009). Collaborative performance (Dawes and Eglene, 2004) is characterised by the ability of such staff members to work together to complete common goals. This is the degree of *actual organisational effort* which involves all sub-organisations associated with the required maintenance. To achieve productive collaboration, a number of significant factors have been identified, including shared resources, trust (Mayer and Kenter, 2015), communication and coordination (Alsharo and

Gregg, 2012; Mayer and Kenter, 2015; Nurdin et al., 2014), organisational culture (Borges, 2012), and legitimacy of standard operating procedures (Luna-Reyes and Gil-García, 2011).

A high level of trust indicates that staff have mutual understanding and are willing to work together (Sayogo et al., 2017). Therefore, they can communicate and coordinate their work (Choi, 2016; Nurdin et al., 2014; Yang and Maxwell, 2011), resulting in a more probable fruitful collaboration (Chang et al., 2014); that is, a high level of *eGWSA*. Over time, proven collaboration will gradually improve trust.

Additionally, a suitable organisational culture is necessary to enable staff to communicate and coordinate smoothly and to exert effort as a team (Borges, 2012). Each of the various sub-organisations may have its own culture, either formal or informal, that profoundly affects how people in the organisation view and perceive maintenance jobs and how they are accomplished (Borges, 2012; Dawes and Eglene, 2004). In a sub-organisation, supportive culture is necessary in order for staff to work as a solid team. Furthermore, different sub-organisations with cultural proximity tend to have small and insignificant cultural differences, enabling them to more efficiently collaborate as if in a single organisation.

As in any other formal organisation, legal rules and procedures guide activities in a government sub-organisation (Luna-Reyes and Gil-García, 2011). Diverse staff collaborating within and between sub-organisations should adhere to applicable rules and procedures when conducting eGW maintenance (Gil-Garcia et al., 2018). If such rules and procedures can be followed and is practicable, then they can be effective and legitimate, which in turn encourage staff to further rely on them. As they gain legitimacy, the rules and procedures are accepted and firmly adhered to by the staff, and become one of the main references for staff communication and coordination.

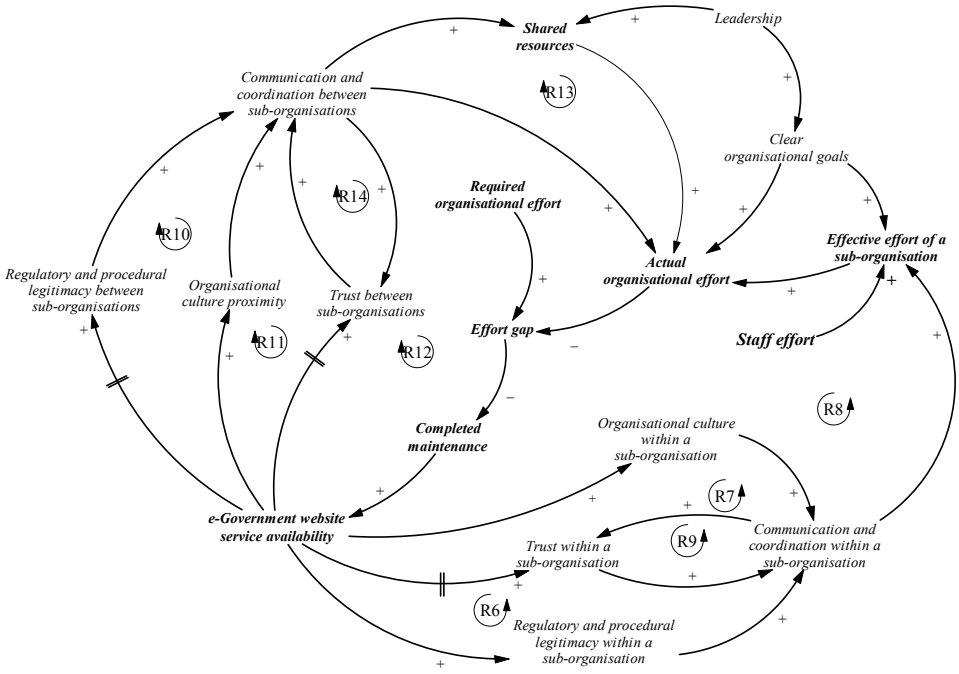
A CLD sub-model in Figure 5 proposes a dynamic hypothesis that endogenously explains the complex feedback relationships of the factors related to collaboration and the dynamic level of eGWSA over time. The sub-model conceptually consists of two main parts; that is, staff collaboration within a sub-organisation and staff collaboration between sub-organisations (Yang and Maxwell, 2011).

Collaboration within a sub-organisation is required when there are some staff members with different responsibilities working together to maintain the eGW. Exogenously, this collaboration is influenced by sound *leadership* which directs the e-government organisation with *clear organisational goals* (Gil-Garcia et al., 2018).

4.5.1 R6 – legitimate rules and procedures matter

A high level of *regulatory and procedural legitimacy within a sub-organisation* makes *communication and coordination within a sub-organisation* easier; therefore, along with *staff effort*, this improves *effective effort of a sub-organisation*. In turn, this increases overall *actual organisational effort*, closes the *effort gap*, raises the *completed maintenance* which increases the level of *eGWSA*. Eventually, this increased level of *eGWSA* in turn positively influences *regulatory and procedural legitimacy within a sub-organisation*. In the case of eGoS, high levels of *eGWSA* indicate that its rules and procedures are legitimate and firmly adhered to by staff members in order to overcome possible differences in understanding, interpretation when undertaking maintenance tasks.

Figure 5 Collaboration factors sub-model



4.5.2 R7 – high level of trust within a sub-organisation

A high level of *trust within a sub-organisation* in the eGoS can ease *communication and coordination within a sub-organisation* among staff members of the eGoS. By tracing causal relationships, this leads to a high level of *eGWSA*, which eventually positively influences trust. Accordingly, increased trust improves the level of *eGWSA* over time, and vice versa.

4.5.3 R8 – culture within sub-organisations

The highly appropriate *organisational culture within a sub-organisation* for eGW maintenance, adopted by staff of the eGoS, improves *communication and coordination within a sub-organisation*. Following the causal relationships, this eventually increases the level of *eGWSA*, which in turn further enhances the suitability of the culture.

4.5.4 R9 – trust, communication and coordination loop

There is a reinforcing feedback relationship between trust, communication and coordination within a sub-organisation. It is important to note the critical role of the reinforcing loop of trust and communication and collaboration. Any decrease in these two factors will result in a further reduction in the level of *eGWSA*. By experiencing high levels of *eGWSA*, eGoS management has been able to ensure that the levels of trust and communication improve over time.

Collaboration between sub-organisations is needed when maintenance involves a website that belongs to several different sub-organisations. This collaboration is in fact collaboration between staff members representing the different sub-organisations. The sub-model in Figure 5 also proposes a dynamic hypothesis to explicitly explain collaboration between sub-organisations.

4.5.5 R10 – sub-organisations consider rules and procedures legitimate

A high level of *regulatory and procedural legitimacy between sub-organisations* of the eGoS improves its level of *communication and coordination between sub-organisations* which then enhances *actual organisational effort*. This eventually makes the level of *eGWSA* in the eGoS high over time which in turn increases the regulatory and procedural legitimacy even more.

4.5.6 R11 – organisational culture

An improvement in *organisational culture proximity* of the eGoS makes *communication and coordination between sub-organisations* easier. This eventually improves the level of *eGWSA* which in turn gradually increases a feeling of mutual need to succeed (Dawes and Eglene, 2004) and a sense of confidence that they can successfully work together across cultures.

4.5.7 R12 – sub-organisations trust each other

An improvement in *trust between sub-organisations* eases *communication and coordination between sub-organisations*, which eventually increases the level of *eGWSA*.

For these three endogenous factors, better *communication and coordination between sub-organisations* enhances *actual organisational effort*, which closes the *effort gap*; therefore increasing *completed maintenance*. Eventually, this enables the *eGWSA* to be kept at high levels over time, which in turn influences and improves these three exogenous factors. These three potentially reinforcing causal loops signify the critical role of these three factors in achieving a high level of *eGWSA* over time. The ability to manage these factor dynamics at high levels ensures the attainment of successful eGW maintenance over time.

4.5.8 R13 – resource sharing

Collaborative works require the availability of *shared resources*. Seamless *communication and coordination between sub-organisations* make it easier to increase *shared resources*. The resources include highly capable human resources of a sub-organisation, shared with other sub-organisations that may be lacking (Borges, 2012; Mayer and Kenter, 2015), which can bridge differences in IT capability between sub-organisations. This, therefore, improves *actual organisational effort*. The degree to *shared resources* can be used, and the ability of staff across sub-organisations to form *shared resources*, will be positively affected by the *leadership* factor (Akkermans and van Helden, 2002). Strong *leadership* improves the probability of *clear organisational goals* (Gil-Garcia et al., 2018) which in turn causes an increase in the *effective effort of a*

sub-organisation, and means that *actual organisational effort* can be more fruitfully directed.

5 Conclusions

Supporting the view of the complexity of an eGW and the importance of its maintenance to sustaining a high level of eGWSA, this paper presents a qualitative SD model to understand the complex feedback relationships affecting website maintenance. The proposed model and sub-models highlight the dynamics of effort, competence and collaboration factors that affect, and are being affected by, the level of eGWSA over time.

The model suggests some causal loops that emphasise the importance of organisational rewards policy to maintain high levels of motivation among staff to exert effort over time. Also, the model implies the existence of feedback relationships that dynamically link the level of eGWA to trust, culture, rules and procedures, and communication and coordination within and between sub-oganisations. Organisational policies must be designed such that actual organisational effort can satisfy the required level of effort to dynamically achieve successful website maintenance.

On the other hand, the model also advises, through understanding identified causal loops, how to realise the required organisational competence to achieve sustained levels of eGWSA over time. A sufficient level of dynamic intervention in the form of training and resource sharing is also necessary over time to achieve the quality of completed maintenance.

Given the scope of this research, some critical factors were inevitably absent from the model. In the broader context, the proposed model here also needs to be validated with actual data to be useful, especially for helping e-government managers to achieve successful website service delivery over time. A validated model can be a basis for developing an SD simulation model that is capable of providing an explicit explanation of the dynamics of the problem.

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