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E-Government Challenges: Methods Supporting Qualitative and Quantitative Analysis

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Abstract. To develop robust and achievable e-government strategies that build the grounds for sustainable solutions, decision makers need to have a good understanding of their country's socio-economic, political and legal contexts. Particularly, they need to be well aware about challenges that might hinder successful implementation of their strategy. To make valuable contributions in e-government strategy development, analysis of e-government challenges needs to be comprehensive and informative by including insights of qualitative and quantitative analysis. Although numerous studies in e-government challenges exist, they fail to do a systematic and structured qualitative analysis of the challenges in regards to interdependencies among challenges or to measure the wider impact of challenges. Methods to support such a comprehensive analysis are scarce. In this contribution, we propose a novel mix of three methods for qualitative and quantitative analysis of e-government challenges, combining the PESTELMO analysis method, DEMATEL and ANP. The results show that this mixed approach is suitable and significant to provide the complementarity needed for a comprehensive understanding of e-government challenges.

Keywords: E-government strategy planning, PESTELMO, DEMATEL, ANP, E-government challenges, Interdependencies, Qualitative / quantitative analysis

1 Introduction

Governments around the world strive for sustainable development of their economy, societies and welfare, and of their environments. The contributions of e-government to support governments in transforming towards better public service delivery, greater interaction between their citizens and government, and improving the efficiency of public organisations while saving taxpayers' money are well received [8, 9]. The new eGovernment Action Plan 2016-2020 of the EU commits the Member States to continue investments in e-government to modernise public administrations, to promote open data

and to enhance cross-border and cross-sector interoperability.¹ With this Action Plan, the EU and the Member States continue to deploy innovative measures to reduce administrative burdens to citizens and businesses. For administrative burdens reduction, the Action Plan will include the implementation of the Once-Only principle, and in turn generate saving at EU level of approx. 5 billion Euro per year by 2017.² Hence, e-government is expected to help resolve the complex and multi-faceted challenges embodied with achieving above ultimate goals.

To continue leveraging on the advantages of implementing e-government, governments in developed and developing countries make significant investments to develop and implement e-government strategies. E-government strategy planning and analysis form necessary and fundamental steps to ensure that the investments yield the expected outcomes. Responsible authorities need to ensure they formulate well-grounded, robust and achievable e-government strategies. To do this, the responsible authorities need to be aware of their countries' context and, in particular, about the challenges that might hinder realisation of the strategies.

Several studies on e-government challenges exist, which look into challenges encountered at different levels of government in developed countries (see e.g. [2, 3, 4], [6], [28]) and in developing countries (see e.g. [13], [15, 16], [22]). Two important weaknesses are observed in these studies (see detailed analysis of the studies in section 2). The first weakness is a lack of a systematic structuring of the challenges. This way of representing the challenges, i.e. without any systematic structuring, does not inform decision makers about the challenges in depth. For example, some challenges are political and others are economic, which need to be understood and dealt with differently. Some challenges may be interdependent, such as the lack of available telecommunication infrastructure may be based on a weak economy and the lack of financial resources. Second, the existing studies in e-government challenges do not include a quantitative analysis of the challenges. In lacking a quantitative analysis, the studies do not provide insights into how the challenges could be measured in order to determine their weights and importance (of the challenges).

From these weaknesses, we argue that it is not sufficient for decision makers to only be aware of e-government challenges in their countries. The decision makers also need to know about existing interdependencies among these challenges, which can be identified through a systematic structuring of the challenges. Furthermore, the decision makers need to be able to quantitatively evaluate the interdependencies among the challenges. Therefore, the existing mere representation of the challenges needs to be extended to include qualitative and quantitative analyses.

In this paper, we introduce a novel methodical mix of analysing e-government challenges through qualitative and quantitative methods. By combining the two types of empirical analyses, the decision makers' understanding of e-government challenges will be deepened, and this can enhance their decision making processes during strategy

¹ <https://ec.europa.eu/digital-agenda/en/news/egovernment-action-plan-2016-2020-public-consultation-faq> [Last accessed on 22 February 2016]

² Ibid.

formulation. Additionally, the analyses will support decision makers in developing sustainable and better solutions for addressing the challenges through a better understanding of their interdependencies. In consequence, decision makers can make more informed and grounded decisions on what might or might not work in long term considering the existing challenges and, especially, the interdependencies among them. Accordingly, the contribution is directed towards e-government strategy planners and analysts to support them in making more informed decisions when formulating e-government strategies. The paper also demonstrates the value-add of using the different methods and the complementarity needed for a comprehensive understanding of e-government challenges. The paper is exploratory and it applies literature review and the lessons learned from previous research work to achieve its objectives.

The remainder of the paper is as follows: section 2 sets the grounds of the research and provides insights into existing analysis of e-government challenges. Based on this, section 2 elaborates the need for methods to support qualitative and quantitative analysis of e-government challenges. Section 3 presents the selected methods for qualitative and quantitative analysis of e-government challenges and explains their application and combination. The value-add of the presented methods is reflected in the discussion of the findings in section 4. Section 4 also concludes the paper and provides directions for future research.

2 Setting the grounds and related work

An e-government strategy defines a set of actions that are to be carried out in programmes and projects in order to realise the vision set by a government [14], [21], [24]. E-government strategy development involves processes through which decision makers derive strategic actions. For effective development of an e-government strategy, decision makers need to have a good understanding of their countries' context, i.e. of aspects such as politics and democracy, economy, culture, people, infrastructure etc. For example, the decision makers need to take into account the political sphere and existing democratic processes when developing an e-government strategy and its objectives. In analysing the context of their countries, the decision makers need to particularly identify and analyse e-government challenges that exist in their countries ([12] p. 123). Only then, it is possible to develop a strategy that is robust and achievable and to invest in e-government solutions that are sustainable.

Scanning the literature reveals that e-government challenges are either categorised in certain groups or mentioned without any categorisation. This section reviews and compares eleven studies in order to identify any pattern, in which e-government challenges are analysed. The aims are to provide insights into the existing analysis of e-government challenges in literature and to identify research gaps. From these gaps, the section emphasises the need for using different methods to support systematic qualitative and quantitative analyses of e-government challenges.

Table 1 presents the eleven studies that investigate e-government challenges in developed and developing countries and that are published in 2009 or later. **Table 1** also provides insights into the number of challenges mentioned by each of the studies and

whether any scheme has been applied to categorise the challenges. Six out of eleven studies mention less than ten challenges, and among them, the one by Belachew [5] has categorised the challenges. The other five studies list between eleven and thirty-two challenges. Among these, only Sæbø [17] does not provide a systematisation through categories.

Table 1. Literature studies on e-government challenges with insights into the number of challenges mentioned and categorisation of the challenges

Literature sources (sorted alphabetically)	Year of publication	No. of key challenges mentioned	Are the challenges categorised? (Yes/No), and if Yes, what categories are used?
Angelopoulos et al.[2]	2010	6	No
Anthopoulos et al. [3]	2015	9	No
Asogwa [4]	2012	8	No
Belachew [5]	2010	7	Yes Infrastructure; Human resources; Standards, guidelines and legal issues; Leadership commitment; Public-private partnership
Bhuiyan [6]	2010	7	No
Mkude [12] (embarking on Yüksel's PESTEL method [27]) ³	2016	32	Yes Political; Economic; Socio-cultural; Technological; Environmental; Legal; Managerial and organisational
Nkohkwo & Islam [15]	2013	20	Yes Financial; Organisational; Political; Socio-economic; Human resources; Infrastructure
Rashid and Rahman [16]	2010	11	Yes Institutional; Resource-related; Access-related; Legal
Sæbø [17]	2012	11	No
Schuppan [22]	2009	20	Yes Political; Social and demographic; Economy; Infrastructure; Institutional/ organisational
Zhao et al. [28]	2012	4	No

Among the common categories shown in **Table 1**, the following occur at minimum 3 times: organisational (institutional), technological (infrastructure), social, political, legal and economic. The results depict a lack of a common scheme for categorising the challenges. This gap is contributed by a lack of a systematic method to qualitatively analyse and structure e-government challenges.

³ An earlier version is published in Mkude and Wimmer [13], which is not yet including the category 'managerial and organisational' challenges.

In addition, the studies investigated in **Table 1** do not investigate the interdependencies among the challenges, except the study of Mkude [12] (see also [13]). The investigation of the interdependencies among e-government challenges is a nascent subject in e-government literature, which is conceptualised in [12, 13] – embarking on Yüksel's PESTEL method [27] – and grounded in the mutual influence of challenges. In this regard, the authors also argue that a holistic analysis of e-government challenges is needed to enhance our understanding of the challenges. Through such an analysis, it is possible to assess whether the challenges influence each other and to measure the interdependencies. It is also possible to determine any causal relationships among the challenges. As a step forward towards addressing this weakness, the authors propose the use of PESTEL [13], which is amended with managerial and organisational challenges to PESTELMO ([12] p. 72), to analyse, identify and structure e-government challenges in a holistic way so to support the assessment of the interdependencies (cf. section 3.1 for more details on the method).

A third weakness identified is that none of the studies investigated in **Table 1** provides means to quantitatively analyse the challenges identified therein. None of the eleven studies indicates any metrics to evaluate and weigh the challenges in order to prioritise them in decision making. Accordingly, we identify the need to add quantitative aspects in the analysis of e-government challenges.

To tackle the identified weaknesses towards a comprehensive analysis of e-government challenges, we propose a mix of qualitative and quantitative analysis methods as introduced in the next section.

3 Methods supporting qualitative and quantitative analysis of e-government challenges

The analysis of e-government challenges forms a crucial part in e-government strategy planning and development (cf. section 2). Decision makers need to go beyond being aware of existing political and legal challenges. They need to have a profound understanding, if such challenges influence one another, and what will be the impacts of any interdependencies among these challenges. To achieve such an understanding, we propose a mix of the PESTELMO (Political, Economic, Socio-cultural, Technological, Environmental, Legal, Managerial and Organisational) analysis method [12], DEMATEL (Decision Making Trial and Evaluation Laboratory) [23], [26, 27] and ANP (Analytic Network Process) [27]. This methodical mix supports in carrying out a comprehensive analysis of e-government challenges to better inform decision making in e-government strategy development. The rationale for this combination is driven by the research aim, which is to provide means for comprehensive and more meaningful analysis of e-government challenges (see sections 1 and 2).

Based on a literature review, insights from the authors' previous work (see [12, 13] and the objective of this research, the above three methods were identified as most appropriate to ensure the complementarity needed to achieve the aim of the research. The methodical mix combines qualitative and quantitative analysis methods. Qualitative

analysis involves a systematic identification and structuring of e-government challenges encountered in a country. We propose the PESTELMO analysis method for this as the first step of analysing e-government challenges. Then, the structured challenges are analysed quantitatively to investigate interdependencies and to weigh the challenges and interdependencies. First, the interdependencies among the challenges are analysed using the DEMATEL method. Second, the weights of the challenges and the interdependencies among them are calculated using the ANP. The methods DEMATEL and ANP are widely used to solve complicated problems in Multiple Criteria Decision Making (MCDM) [26, 27]. The methods allow decision makers to determine and measure the interrelations among different criteria/alternatives with respect to their effects in decision making. The methods have been used to solve many problems in different fields such as project selection, product planning, development of marketing strategies and safety problems [10, 11], [23], [26]). Subsequently, the objectives of the methods and their functions in the analysis of e-government challenges are described.

3.1 PESTELMO analysis method: identifying and structuring challenges

To identify and structure e-government challenges in a systematic way, the PESTELMO analysis method is proposed. PESTELMO embarks on PESTEL [27] and extends the method with managerial and organisational categories (MO), therewith stressing the importance of these two aspects in holistic e-government strategy development and implementation. In relying on the PESTEL method, organisations and decision makers are supported in analysing their internal and external environments in which they operate [27] and in determining the context, in which the e-government strategy is expected to be implemented.

The steps for the application of the PESTELMO analysis method are as follows:

1. *Identify e-government challenges.* In this step, decision makers identify challenges that might hinder successful implementation of an e-government strategy. To identify the challenges, qualitative analysis methods such as interviews, surveys and desk research are used. In this step, the research can already be designed in line with the eight categories of PESTELMO (political, economic, socio-cultural, technological, environmental, legal, managerial and organisational).
2. *Categorise the challenges into PESTELMO* (if not yet categorised after step 1).
3. *Form a hierarchical model of PESTELMO* to depict the challenges in PESTELMO's categories as shows in **Fig. 1**. The first level of the model contains a title of the model (the decision makers specify in (N) the name of a country or an organisation). The second level of the model contains the main categories of PESTELMO. The third level contains the challenges identified in step 1. This level depicts the work done in step 2 graphically.

Following these three steps, the decision makers will have a hierarchical model of systematically structured e-government challenges. These steps complete a qualitative analysis of the challenges.

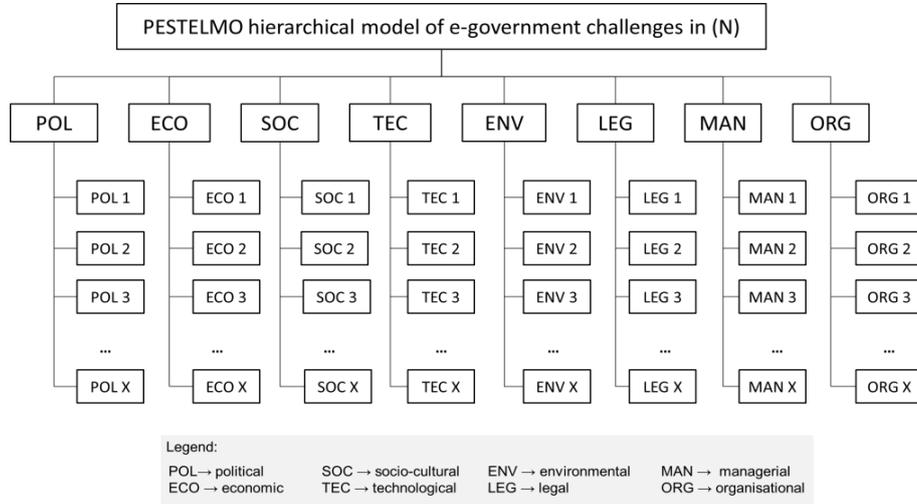


Fig. 1. PESTELMO hierarchical model of e-government challenges

Next, the quantitative analysis follows using DEMATEL and ANP in order to determine existing interdependencies among the identified challenges and to provide decision makers the priority values of the challenges and the interdependencies.

3.2 DEMATEL: analysing interdependencies among e-government challenges

DEMATEL is a method to identify interdependencies and interrelations among the criteria/alternatives being studied through a causal diagram and to determine the degree of influence of the criteria [23, 26], [27]. DEMATEL supports in handling the inner dependencies within a set of criteria through a visual structural model [23], [25]. We propose DEMATEL to support a comprehensive assessment of the interrelations, interdependencies and causal relations among e-government challenges and to determine the degree of influence of the challenges. The method is widely used in different applications in MCDM (see e.g. [23], [25, 26, 27]). In e-government strategy development, the method supports decision makers to make more informed strategy decisions and to find sustainable solutions for the challenges to be resolved.

The proposed steps for using DEMATEL are as follows (cf. [23], [25, 26, 27]):

1. *Calculate the initial average matrix.* This step requires evaluation of the degree of direct influence between the identified e-government challenges by experts on a scale 0-4, where the higher value indicates greater influence. The results from each respondent then produces a matrix stated as $X^k = [X_{ij}^k]$, where k is the number of experts involved in the study with $1 \leq k \leq H$, and i and j are different challenges. The average matrix is then produced through the mean of the same challenges in the various matrices of the experts. The average matrix A is represented as the following equation:

$$a_{ij} = \frac{1}{H} \sum_{k=1}^H x_{ij}^k \quad (1)$$

2. Calculate the normalised initial direct-relation matrix. The initial direct matrix D is normalised by $D=AxS$, where S is:

$$S = \frac{1}{\max_{1 \leq i \leq n} \sum_{j=1}^n a_{ij}} \quad (2)$$

Where

3. *Derive the direct and indirect influence matrix T by $T=D(I-D)^{-1}$* , where I is the $n \times n$ identity matrix. In T , the sum of rows and the sum of columns are represented by vectors r and c , respectively. r_i denotes the row sum of the i^{th} row of matrix T and shows the sum of direct and indirect effects of challenge i on the other challenges. Similarly, c_j denotes the column sum of the j^{th} column of matrix T and shows the sum of direct and indirect effects that challenge j has received from the other challenges. When $i = j$, (r_i+c_i) provides an index of the strength of influences given and received, that is (r_i+c_i) shows the degree of the central role that challenge i plays in the problem. If (r_i+c_i) is positive, then challenge i is affecting other challenges, and if (r_i+c_i) is negative, then challenge i is being influenced by other challenges [23], [25, 26, 27].
4. *Set a threshold value to obtain a digraph.* Matrix T provides information on how one challenge affects another. Hence, a threshold value needs to be set to filter out negligible effects. Effects greater than the threshold value are chosen and shown in the digraph. The digraph can be acquired by mapping the dataset of $(r+c, r-c)$.

At
DEMATEL

3.3 ANP method: supporting quantitative evaluation of the challenges and the interdependencies among the challenges

In 1996, Saaty proposed the use of Analytical Network Processing (ANP) to overcome the restrictions of the AHP (Analytic Hierarchy Process) by including analysis of dependencies among different criteria/alternatives ([20] cited in [27]). AHP was developed by Saaty [18] to support MCDM [27]. In AHP, the general assumption is that the criteria exist in independence of each other and can be structured hierarchically; hence, lacking considerations of the interdependencies, which is added in ANP [19]. To complement the analysis of e-government challenges with PESTELMO and DEMATEL, we propose the use of ANP to quantitatively analyse the interrelations, independencies and interdependencies among e-government challenges.

The proposed steps for using ANP are proposed as follows, basing on Yüksel [27]:

1. *Determine the local weights of the independent PESTELMO categories by forming a pairwise comparison matrix.* Here, experts respond to questions such as “which challenge should be emphasized more in a macro environment, and how much

more?" [27], and the responses are assessed using Saaty's 1-9 scale [20]. Then, the local weight vector $w1$ is computed as follows:

$$A_{w1} = \lambda_{max} w1 \quad (3)$$

2. Where, λ_{max} is the largest eigenvalue of the pairwise comparison matrix A . The obtained vector is further normalized by dividing each value by its column total to represent the normalized local weight vector $w2$ [27].
3. *Determine the inner dependence matrix* of PESTELMO's main categories based on the digraph derived using DEMATEL (see step 4). The inner dependence matrix of PESTELMO's main categories is then formed according to the weights of the inner dependence of the factors.
4. *Calculate the interdependent weights of the PESTELMO categories* by multiplying the local weights calculated in step 1 by the inner dependence matrix from step 2.
5. *Determine the weights of the PESTELMO challenges*. The weights are determined by forming a pairwise comparison matrix of the challenges, evaluating each matrix using the scale 1-9 (according to the evaluation provided by the experts in step 1), calculating local weights and determining consistent ratio. This step calculates the weight of each challenge in PESTELMO.
6. *Compute the global weights of the PESTELMO challenges* by multiplying the interdependent weights of the challenges from step 3 by the local weight of challenges obtained from step 4.

At the end of step 5, decision makers are provided with a quantitative evaluation and measurement of the PESTELMO challenges identified for a given context. They are informed about the interdependent weights of PESTELMO categories, and the local and global weights of the PESTELMO challenges. These insights inform decision makers about the extent of the interdependencies among the challenges and the weights of the challenges. Accordingly, decision makers will be able to make more informed and well-grounded decisions during strategy development and in finding solutions for the challenges.

The proposed methodical mix of PESTELMO, DEMATEL and ANP supports in comprehensively analysing e-government challenges. In the next section, we reflect on the proposed methodical mix of analysing e-government challenges and discuss the findings.

4 Reflection of findings and outlook for further research

E-government challenges are widely known and documented in literature. However, the challenges are only either listed or categorised following a certain scheme (cf. **Table 1** in section 2). These studies have left out key and valuable aspects that need to be included in analysis of e-government challenges. First, the studies do not take into account the interdependencies among the challenges. The assumption is that the challenges are independent, which is not the case in the real world. Second, they do not include methods to measure and evaluate the challenges and the interdependencies.

A combination of the PESTELMO analysis method, of DEMATEL and of ANP has been proposed in this study to analyse e-government challenges in a more comprehensive way to better inform decision makers in e-government strategy development and implementation. These methods are proposed to enhance the current research in which e-government challenges are investigated (cf. **Table 1**). Extending from a mere representation of e-government challenges that is found in most studies, this study goes a step further to include systematic qualitative and quantitative analyses of the challenges and their interdependencies.

To identify the challenges encountered in a country, the widely applied research methods such as interviews, surveys and desk research are used. From here, the identified challenges still need to be systematically represented and analysed in order to provide more valuable insights during strategy development. Particularly, the interdependencies among the challenges need to be identified and measured. For instance, if the legal challenges are highly influenced by the political challenges, then a more comprehensive approach is needed to tackle the legal challenges while taking into account the political ones. Even so, the possibility of tackling the political challenges first and assessing the resulting impacts on the legal challenges can also be examined. The research methods that are currently used to identify the challenges do not support such an analysis. Accordingly, the proposed combination of the three methods adds value to e-government research.

In a qualitative analysis, PESTELMO systematically categorizes e-government challenges. This holistic approach can also be used to highlight potential interrelations and interdependencies among the challenges as depicted in **Fig. 1**. Yet, PESTELMO does not construct the interrelations and interdependencies among the challenges in a structural and visual way. To complement PESTELMO in this regard, DEMATEL is proposed.

In quantitative analysis, first the DEMATEL method is used to identify and structure the potential interdependencies among the challenges through its four steps outlined in section 3.2. DEMATEL identifies and structures the interdependencies among e-government challenges. Therewith, decision makers are better able to understand the complexity of e-government challenges in terms of existing interdependencies and how the challenges influence one another. However, for more comprehensive and accurate results, the interdependencies and the challenges need to be measured and evaluated with metrics. Accordingly, the ANP method is proposed to measure the local and global weights of the challenges (see steps 1, 4 and 5 in section 3.3), to resolve the matrices resulting from DEMATEL (see step 2 in section 3.3), and to measure the weight of the interdependencies (see step 3 in section 3.3).

To sum up, the proposed combination of PESTELMO, DEMATEL and ANP is expected to provide valuable results that will deepen the decision makers' understanding of the challenges of a country's (or organisation's) context, in which an e-government strategy is to be defined and implemented. With this understanding, decision makers get help in developing more robust, achievable and sustainable e-government strategies.

The paper at hand proposes a methodical mix for qualitative and quantitative analysis of e-government challenges. It also explains the rationale for proposing the methods and their expected contributions in e-government strategy planning and development.

However, future research will need to exemplify the methods in case study research. The lessons learned will help to streamline and improve the application of the methods. Moreover, it will be interesting to investigate how the decision makers benefit from case study results and how the results are fed into the decision making processes in e-government strategy development.

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